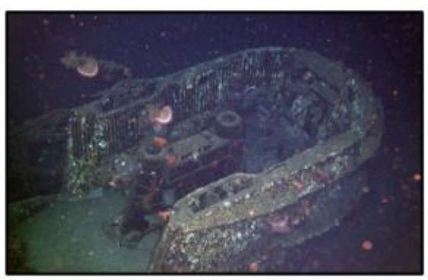
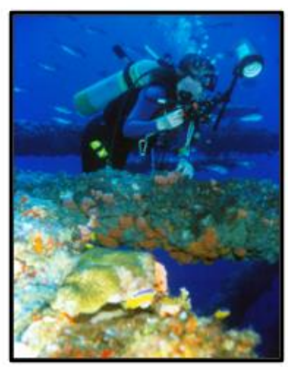
OCS Report
BOEM 2023-053

Programmatic Description of the Potential Effects from Gulf of Mexico OCS Oil- and Gas-Related Activities

A Supporting Information Document





U.S. Department of the Interior
Bureau of Ocean Energy Management
New Orleans Office

BOEM
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Outer Continental Shelf

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ABSTRACT

This *Programmatic Description of the Potential Effects from Gulf of Mexico OCS Oil- and Gas-Related Activities: A Supporting Information Document* (Gulf of Mexico OCS Oil- and Gas-Related Activities SID) is intended to provide subject-matter experts, decisionmakers, and the public with a broad characterization of the Gulf of Mexico OCS, the potential activities associated with oil and gas leasing in the Gulf of Mexico OCS, other activities and environmental factors not associated with OCS oil and gas leasing, and how these various activities and factors might interact with resources in the physical, biological, and human environments. This document is intended to assist with streamlining future environmental documents prepared by the Bureau of Ocean Energy Management (BOEM) under the National Environmental Policy Act (NEPA), such as Gulf of Mexico oil and gas leasing environmental impact statements by providing supporting information that can be incorporated by reference, consistent with the Council on Environmental Quality's NEPA implementing regulations. The Area of Analysis includes the Federal OCS waters of the Gulf of Mexico that are within BOEM's Gulf of Mexico Western Planning Area, Central Planning Area, and Eastern Planning Area. The Area of Analysis also includes the State waters and coastal regions of Texas, Louisiana, Mississippi, Alabama, and Florida. This document analyzes the potential effects to air and water quality; coastal, benthic, and pelagic habitats and communities; fishes and invertebrates; birds; marine mammals; sea turtles, commercial and recreational fisheries; recreational resources; archaeological resources; economics; land use; and other social factors.

EXECUTIVE SUMMARY

PURPOSE AND OBJECTIVES

The Secretary of the Interior (Secretary) has designated the Bureau of Ocean Energy Management (BOEM) as the administrative agency responsible for the administration of energy and mineral exploration and development of the Outer Continental Shelf (OCS). BOEM's responsibilities include leasing; plan administration; environmental studies, consultations, and analyses in compliance with the National Environmental Policy Act (NEPA) and other statutes; resource evaluation; economic analysis; and administration of the OCS Marine Minerals and Renewable Energy Programs.

The purpose of this *Programmatic Description of the Potential Effects from Gulf of Mexico OCS Oil- and Gas-Related Activities: A Supporting Information Document* (Gulf of Mexico OCS Oil- and Gas-Related Activities SID) is to provide subject-matter experts, decisionmakers, and the public with a broad characterization of the Gulf of Mexico (GOM) OCS, description of the activities associated with oil and gas operations in the Gulf of Mexico OCS, other activities and environmental factors not associated with OCS oil and gas activities, and how these various activities and factors might interact with resources in the physical, biological, and human environments. This document will provide a robust baseline characterization of the Gulf of Mexico OCS that can be used for any future BOEM projects across all program areas (i.e., oil and gas, renewables, marine minerals, and alternative uses) and identify any major gaps or information needs to address in a future environmental review. The document will also document the resources with little to no potential for impact, helping to narrow the focus of future environmental impact analyses. Furthermore, additional supporting technical reports have been developed and are summarized and incorporated by reference, along with previous NEPA documents as appropriate. All of these documents can be found on BOEM's website at https://www.boem.gov/nepaprocess.

LEASE SALE NEPA ANALYSIS

Chapter 1 describes the NEPA and coordination that occurs prior to an OCS oil and gas lease sale. Prior to holding an oil and gas lease sale, BOEM ensures all necessary reviews and opportunities for public input have taken place under the Outer Continental Shelf Lands Act (OCSLA), Coastal Zone Management Act (CZMA), and NEPA (refer to **Chapter 1.3**). BOEM typically conducts a NEPA evaluation of a representative GOM lease sale, which concludes with the issuance of a Record of Decision at least 30 days prior to each individual lease sale date.

AREA OF ANALYSIS

The Area of Analysis includes the Federal OCS waters of the GOM that are within BOEM's Gulf of Mexico Western Planning Area (WPA), Central Planning Area (CPA), and Eastern Planning Area (EPA). The Area of Analysis also includes the State waters and coastal regions of Texas, Louisiana, Mississippi, Alabama, and Florida. State waters extend from the coastline outside of estuaries seaward 3 nautical miles (nmi) (3.5 miles [mi]; 5.6 kilometers [km]) from Louisiana, Mississippi, and Alabama, and seaward to 9 nmi (10.4 mi; 16.7 km) from the coastlines of Texas and Florida (**Figure ES-1**).

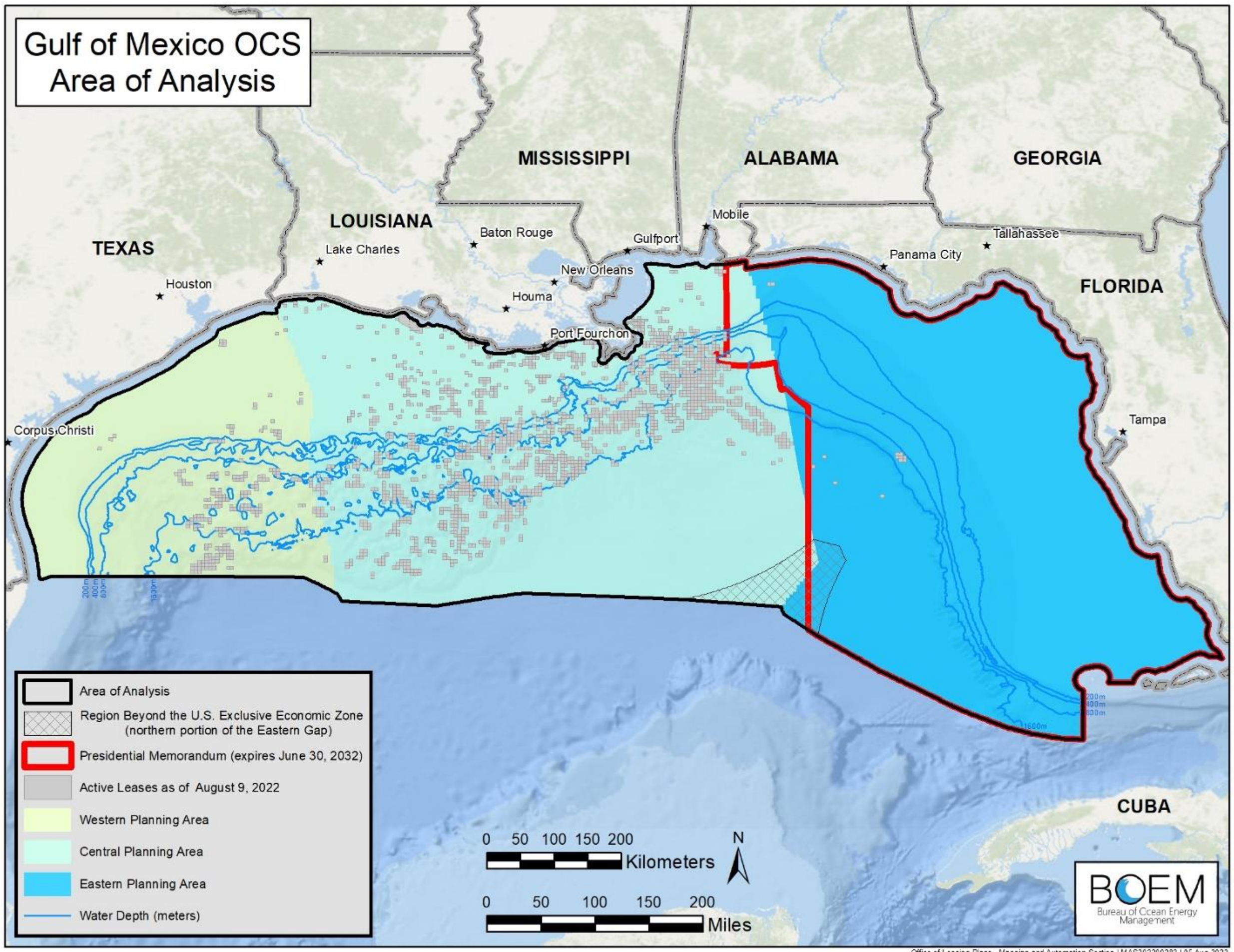

Figure ES-1. Area of Analysis Overlaid with Currently Leased Blocks as of August 9, 2022.

GULF OF MEXICO OCS OIL AND GAS PROGRAM OVERVIEW

Lease sales have been held in the WPA and CPA of the GOM since 1954 and, with a few exceptions (1956, 1957, 1958, 1961, 1963, 1965, and 2022), lease sales have occurred at least annually (and usually two or three times a year). Beginning in 2017, BOEM began offering regionwide lease sales twice a year for the WPA, CPA, and EPA with certain restrictions (e.g., excluding areas under moratorium). The OCS leasing process administered by BOEM consists of five stages: (1) National Program planning; (2) lease sale planning; (3) exploration; (4) development and production; and (5) decommissioning (**Figure 1.3-1**).

A NEPA review must be completed before each lease sale can occur.

Given the maturity of the GOM oil and gas program and background information available from previous and ongoing analyses, BOEM streamlined the NEPA process for those GOM lease sales considered routine and common in the GOM beginning in 2017 (e.g., GOM Regionwide Lease Sale 256). Currently, the streamlined process includes the preparation of a programmatic environmental impact statement for the initial proposed lease sale in a National OCS Oil and Gas Program, and subsequently the preparation of Determinations of NEPA Adequacy (DNA) for each subsequent GOM lease sale included in the National OCS Oil and Gas Program. Refer to **Chapter 1** for more information on the OCS oil and gas program and leasing process, including reviews under the OCSLA, NEPA, and other statutes and regulations.

PHASES OF OIL AND GAS DEVELOPMENT

The OCS oil and gas operations generally occur in four phases: (1) exploration to locate viable oil or natural gas deposits; (2) development well drilling, platform construction, and pipeline infrastructure placement; (3) operation (oil or gas production and transport); and (4) decommissioning of facilities once the reservoir(s) in a field is no longer productive or profitable (refer to **Chapter 1.3.3**). Geological and geophysical (G&G) activities can occur during all four phases and can also be permitted to be done on unleased OCS land; however, all other exploration and development activities (e.g., drilling, infrastructure emplacement) within the four phases would only occur following the acquisition of an OCS lease as described above and once all required permitting and approval processes are completed (refer to **Figure 1.3.3-1** and **Chapter 5**).

ISSUES AND IMPACT-PRODUCING FACTORS

Both OCS and non-OCS oil- and gas-related activities can contribute to one or multiple IPF categories.

An impact-producing factor (IPF) is the outcome or result of activities with the potential to positively or negatively affect physical, biological, cultural, and/or socioeconomic resources. The IPFs described in **Chapter 2** do NOT include specific scenario estimates regarding future OCS exploration, development, and production activities; however, there are general IPFs that manifest regardless of activity levels and location. Therefore, the magnitude and severity of potential effects are not addressed in this document but could be addressed in future NEPA analyses when specific exploration and development scenarios are analyzed. BOEM will use this preliminary identification and disclosure of the potential range of effects to each resource, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development in the Gulf of Mexico OCS. These IPFs are grouped into the following “issue” categories based on BOEM’s internal scoping and consideration of the extensive history of public input received through previous and ongoing assessments and outreach efforts:

- **air emissions and pollution** associated with offshore and onshore activity (Chapter 2.1);
- **discharges and wastes** associated with offshore and onshore activity (**Chapter 2.2**);
- **bottom disturbance** associated with drilling, infrastructure emplacement, and removal (**Chapter 2.3**);

- **noise** from G&G surveys, ship and aircraft traffic, drilling and production operations, trenching, construction, and decommissioning (**Chapter 2.4**);
- **coastal land use/modification** associated with infrastructure emplacement and vessel traffic (**Chapter 2.5**);
- **lighting and visual impacts** of the physical presence of infrastructure and vessel and aircraft traffic (**Chapter 2.6**);
- **offshore habitat modification/space use** associated with infrastructure emplacement and removal and multiple-use areas on the seabed, in the water column, at the sea surface, or in the airspace (**Chapter 2.7**);
- **socioeconomic changes and drivers** associated with variables like job loss and creation, public perceptions, etc. (**Chapter 2.8**); and
- **accidental events** that include oil spills, chemical spills, pipeline failures, losses of well control, accidental air emissions, hydrogen sulfide and sulfurous petroleum releases, trash and debris, spill response associated with unintended releases, and collisions and strikes (**Chapter 2.9**).

REGIONAL SETTING

Programmatic environmental issues and processes (e.g., climate change and major storms) and their influence on the various IPF categories are described in greater detail in **Chapter 3**, which describes the regional setting of the GOM. In this document, BOEM characterized these issues programmatically as part of the existing and future baseline conditions rather than as unique IPF categories. BOEM also evaluated cascading effects potentially caused by these IPFs on marine ecosystems through additive or synergistic effects with the other stressors as described in **Chapter 2**.

ENVIRONMENTAL EFFECTS

Potential effects from previous or existing routine OCS oil- and gas-related activities including past and reasonably foreseeable accidental events from OCS oil- and gas-related activities, as well as potential effects from past and reasonably foreseeable non-OCS oil- and gas-related activities were evaluated by the following resource categories and sub-categories in **Chapter 4**:

- Air Quality (**Chapter 4.1**)
- Water Quality (**Chapter 4.2**)
- Biological Resources and Habitats (**Chapter 4.3**)
  - Coastal Communities and Habitats (**Chapter 4.3.1**)
  - Benthic Communities and Habitats (**Chapter 4.3.2**)
  - Pelagic Habitats and Communities (**Chapter 4.3.3**)
  - Fish and Invertebrates (**Chapter 4.3.4**)
  - Birds (**Chapter 4.3.5**)

- Marine Mammals (**Chapter 4.3.6**)
- Sea Turtles (**Chapter 4.3.7**)

- Social and Economic Factors (**Chapter 4.4**)
  - Land Use and Coastal Infrastructure (**Chapter 4.4.1**)
  - Commercial Fisheries (**Chapter 4.4.2**)
  - Recreational Fishing (**Chapter 4.4.3**)
  - Subsistence Use (**Chapter 4.4.4**)
  - Tourism and Recreational Resources (**Chapter 4.4.5**)
  - Social Factors including Environmental Justice (**Chapter 4.4.6**)
  - Economic Factors (**Chapter 4.4.7**)
- Cultural, Historical, and Archaeological Resources (**Chapter 4.5**)

The GOM in its entirety, including coastal zones, is a large marine ecosystem under the jurisdiction of three countries, i.e., the United States (2/3 control), Mexico (1/3 control), and Cuba (marginal control). The biological components of the GOM's large marine ecosystem within U.S. jurisdiction are evaluated in this report. The components are described within the context of three habitat regimes, i.e., coastal, pelagic, and benthic, as well as within the context of organism or community type, including fish and invertebrates, marine mammals, sea turtles, and birds. Organisms that do not fall into one of these categories are discussed in context of their relevant habitat(s). For biological resources, the stand-alone *Biological Environmental Background Report for the Gulf of Mexico OCS Region* (Biological Environmental Background Report) was also prepared, which is incorporated by reference (BOEM 2021b).

Effects on a resource may exist even though lease stipulations, Notices to Lessees and Operators (NTLs), and other guidance from BOEM may prevent the IPF from affecting the resource. Where applicable, these existing laws and regulations to prevent effects on resources from the IPFs were discussed in the analysis. Detailed description of the commonly applied mitigations and potential lease sale stipulations can be found in **Chapters 6 and 7**, respectively. A determination of the *potential* for effects to a resource by an IPF in this document does not indicate the impact determination for any subsequent NEPA analyses (e.g., negligible, minor, moderate, and major) but rather provides an initial screening of what effects should be considered more closely in a subsequent NEPA analysis and which effects could likely be screened from additional detailed future NEPA analyses.

The potential ranges and types of effects described in **Chapter 4** and highlighted below do not pre-suppose, nor propose or authorize, any specific OCS oil- and gas-related activities nor do they make any conclusive impact determinations as a result of future oil and gas leasing. The magnitude and severity of the potential effects discussed in this document could vary depending on numerous factors such as location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. Impact determinations were not determined in this document;

however, future environmental reviews could incorporate the effects screening conducted in this report, applying project- or action-specific information, in order to reach impact-level determinations.

Table ES-1 provides a comparison of the possible effects by resource category and is derived from the analysis of each resource in **Chapter 4**. The shading and symbols in **Table ES-1** correspond to the shading and symbols throughout the **Chapter 4** analysis. In **Chapter 4**, the effects from each IPF are shown visually in a “pie diagram” at the beginning of the effects analysis for each resource. Example pie diagrams and potential effects definitions are shown in **Figures 4.0-2 and 4.0-3**. NOTE: For biological resources, hashed blue or green coloring was used to distinguish IPFs where potential effects were identified; however, based on currently available information and the conclusions reached in the BOEM’s Biological Environmental Background Report, it would not be expected to create a potential for population-level effects to organismal resources (i.e., fish and invertebrates, birds, sea turtles, and marine mammals) or long-term consequences to habitat function or use by biota for coastal, pelagic, and benthic habitats (**Figure 4.0-3**).

Table ES-1. Leopold Matrix Outlining the Cause-Effect Relationships Between the IPF Categories Described in **Chapter 2** and the Resource Categories Analyzed in **Chapter 4**.

IPF Category / Resource Category (Chapter #)		Air Emissions & Pollution		Noise		Socio-Economic Changes and Drivers[1]		Discharges & Waste		Bottom Disturbance		Coastal Land Use/Modification		Lighting & Visual Impacts		OCS Habitat Modification/Space Use		Unintended Releases into the Environment[2]	Response Activities[2]	Strikes & Collisions[2]
		OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	Non-OCS O&G	OCS O&G	OCS O&G	OCS O&G
Physical	**Air Quality (4.1)**	-	-															-	-	
	Water Quality (4.2)	-	-					-	-	-	-	-	-					-		-
Biological	**Coastal Communities & Habitats (4.3.1)**		-			N/A	N/A	-	-	-	-	-	-					-	-	
	Benthic Communities & Habitats (4.3.2)			-	-	N/A	N/A	-	-	-	-			-	-	-/+	-/+	-	-	-
	Pelagic Communities & Habitats (4.3.3)	-[3]	-	-	-	N/A	N/A	-	-	-	-			-	-	-	-	-	-	-
	Fish & Invertebrates (4.3.4)		-	-	-	N/A	N/A	-	-	-	-	-	-	-	-	-	-	-	-	-
	Birds (4.3.5)			-	-	N/A	N/A	-	-			-	-	-	-	-	-	-	-	-
	Marine Mammals (4.3.6)			-	-	N/A	N/A		-				-				-	-	-	-
	Sea Turtles (4.3.7)			-	-	N/A	N/A		-				-	-	-	-	-	-	-	-
Socio-Economic	**Land Use and Coastal Infrastructure (4.4.1)**					-/+	-/+	-/+	-/+			-/+	-/+	-/+	-/+			-	-/+	-
	Commercial Fisheries (4.4.2)		-	-	-	-/+	-/+		-	-/+	-/+	-	-	-	-	-/+	-/+	-	-	-
	Recreational Fishing (4.4.3)		-	-	-	-/+	-/+		-	-/+	-/+	-	-/+	-/+	-/+	-/+	-/+	-	-	-
	Subsistence Fishing (4.4.4)		-	-	-	-/+	-/+		-	-/+	-/+	-/+	-/+	-/+	-/+	-/+	-/+	-	-/+	-
	Tourism and Recreational Resources (4.4.5)	-	-			-/+	-/+		-/+	-/+	-/+	-	-/+	-/+	-/+	-/+	-/+	-	-/+	-
	Social Factors and EJ (4.4.6)	-	-	-	-	-/+	-/+	-	-/+	-/+	-/+	-/+	-/+	-/+	-/+	-/+	-/+	-	-/+	-
	Economic Factors (4.4.7)					-	-/+											-	-/+	-
	Cultural, Historic & Archaeological Resources (4.5)	-	-					-	-	-	-	-	-	-	-			-	-	-

Potential for Negative (-) Impacts | **Potential for Positive (+) Impacts** | **Potential for Small/Temporary Negative (-) Impacts[3]** | **No Effects**

[1] The Socio-Economic Changes and Drivers IPF is limited to potential effects to human and societal aspects and, therefore, does not apply to biological resources (refer to **Chapter 4.3.0**).

[2] Accidental events associated with non-OCS oil- and gas-related activities were not evaluated separately as they are not subject to BOEM's regulatory authority. However, BOEM does acknowledge that accidental events associated with non-OCS oil- and gas-related activities can occur and considered these within the assessment of these activities under the other IPF categories where applicable.

[3] The hashed IPF categories have a reasonable, scientifically supportable *potential* to effect individuals or small groups of organisms; or cause small and/or temporary effects to habitats. These IPFs would not be expected to have significant and/or long-term effects to the identified resource category and, therefore, would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

POSTLEASE OR SITE-SPECIFIC REVIEWS AND OTHER PROTECTIVE MEASURES

Chapter 5 describes site-specific postlease approval activities, including: geological and geophysical surveys; exploration and development plans; permits and applications; inspection and enforcement; pollution prevention, oil-spill response plans, and financial responsibility; air emissions; flaring and venting; hydrogen sulfide contingency plans; archaeological resources regulation; coastal zone management consistency review and appeals for postlease activities; best available and safest technologies, including at production facilities; personnel training and education; structure removal and site clearance; marine protected species NTLs; and the Rigs-to-Reefs program.

Chapter 6 describes commonly applied mitigations developed to address continuing OCS Oil and Gas Program activities in the Gulf of Mexico. These are mitigations that BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) could apply to permits and approvals. These mitigating measures address concerns such as endangered and threatened species, geologic and manmade hazards, military warning and ordnance disposal areas, archaeological sites, air quality, oil-spill response planning, chemosynthetic communities, artificial reefs, operations in hydrogen sulfide-prone areas, and shunting of drill effluents in the vicinity of biologically sensitive features. Operational compliance of the mitigating measures is enforced through BSEE's onsite inspection program.

Chapter 7 describes the potential lease stipulations that were developed as a result of numerous scoping efforts for the OCS Oil and Gas Program in the Gulf of Mexico. The lease stipulations considered are the Military Areas Stipulation; Evacuation Stipulation; Coordination Stipulation; Protected Species Stipulation; Topographic Features Stipulation; United Nations Convention on the Law of the Sea Royalty Payment Stipulation; Agreement between the United States of America and the United Mexican States Concerning Transboundary Hydrocarbon Reservoirs in the Gulf of Mexico (Transboundary Stipulation); Live Bottom (Pinnacle Trend) Stipulation; Blocks South of Baldwin County, Alabama, Stipulation; and the Restrictions due to Rights-of-Use and Easements for Floating Production Facilities Stipulation. The United Nations Convention on the Law of the Sea Royalty Payment Stipulation is applicable to a proposed lease sale even though it is not an environmental or military stipulation.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

What is in This Chapter?

- An overview of the assessment framework and purpose of this document.
- History of oil and gas leasing on the Outer Continental Shelf (OCS) and overview of the leasing process, beginning with the National Program through an individual lease sale and subsequent phases of development.

Key Points

- Oil and gas lease sales have been held in the Gulf of Mexico's Western and Central Planning Areas (WPA and CPA) since 1954 and have been managed by BOEM or its predecessor agencies.
- Beginning in 2017, the Bureau of Ocean Energy Management (BOEM) began offering regionwide lease sales twice a year for the WPA, CPA, and Eastern Planning Area (EPA) with certain restrictions (e.g., excluding areas under moratorium).
- The OCS leasing process consists of five distinct stages: (1) National Program planning; (2) lease sale planning; (3) exploration; (4) development and production; and (5) decommissioning. BOEM conducts environmental reviews at all stages.
- The phases of OCS oil and gas development are described in this chapter, while the potential resulting impact-producing factors and their potential effects to the human environment are discussed in subsequent chapters.

1 INTRODUCTION

The Secretary of the Interior (Secretary) has designated the Bureau of Ocean Energy Management (BOEM) as the administrative agency responsible for the administration of energy and mineral exploration and development of the Outer Continental Shelf (OCS). BOEM is responsible for managing development of the Nation's offshore mineral and energy resources in an environmentally and economically responsible way. BOEM's responsibilities include leasing; plan administration; environmental studies, consultations, and analyses in compliance with the National Environmental Policy Act (NEPA) and other statutes; resource evaluation; economic analysis; and administration of the OCS Marine Minerals and Renewable Energy Programs.

The purpose of this *Programmatic Description of the Potential Effects from Gulf of Mexico OCS Oil- and Gas-Related Activities: A Supporting Information Document* (Gulf of Mexico OCS Oil- and Gas-Related Activities SID) is to provide a broad description and assessment of the potential effects that could occur within the Area of Analysis due to activities arising from oil- and gas-related activities, which could then be used to inform future NEPA analyses for such activities. The Area of Analysis is the area in which OCS oil- and gas-related activities as a result of past or future OCS oil and gas leasing would take place and, therefore, the area of potential effect. The Area of Analysis includes the Federal OCS waters of the GOM that are within BOEM's Gulf of Mexico Western Planning Area (WPA), Central Planning Area (CPA), and Eastern Planning Area (EPA). The Area of Analysis also includes the State waters and coastal regions of Texas, Louisiana, Mississippi, Alabama, and Florida. State waters extend from the coastline outside of estuaries seaward 3 nautical miles (nmi) (3.5 miles [mi]; 5.6 kilometers [km]) from Louisiana, Mississippi, and Alabama, and seaward to 9 nmi (10.4 mi; 16.7 km) from the coastlines of Texas and Florida (**Figure 1.0-1**).

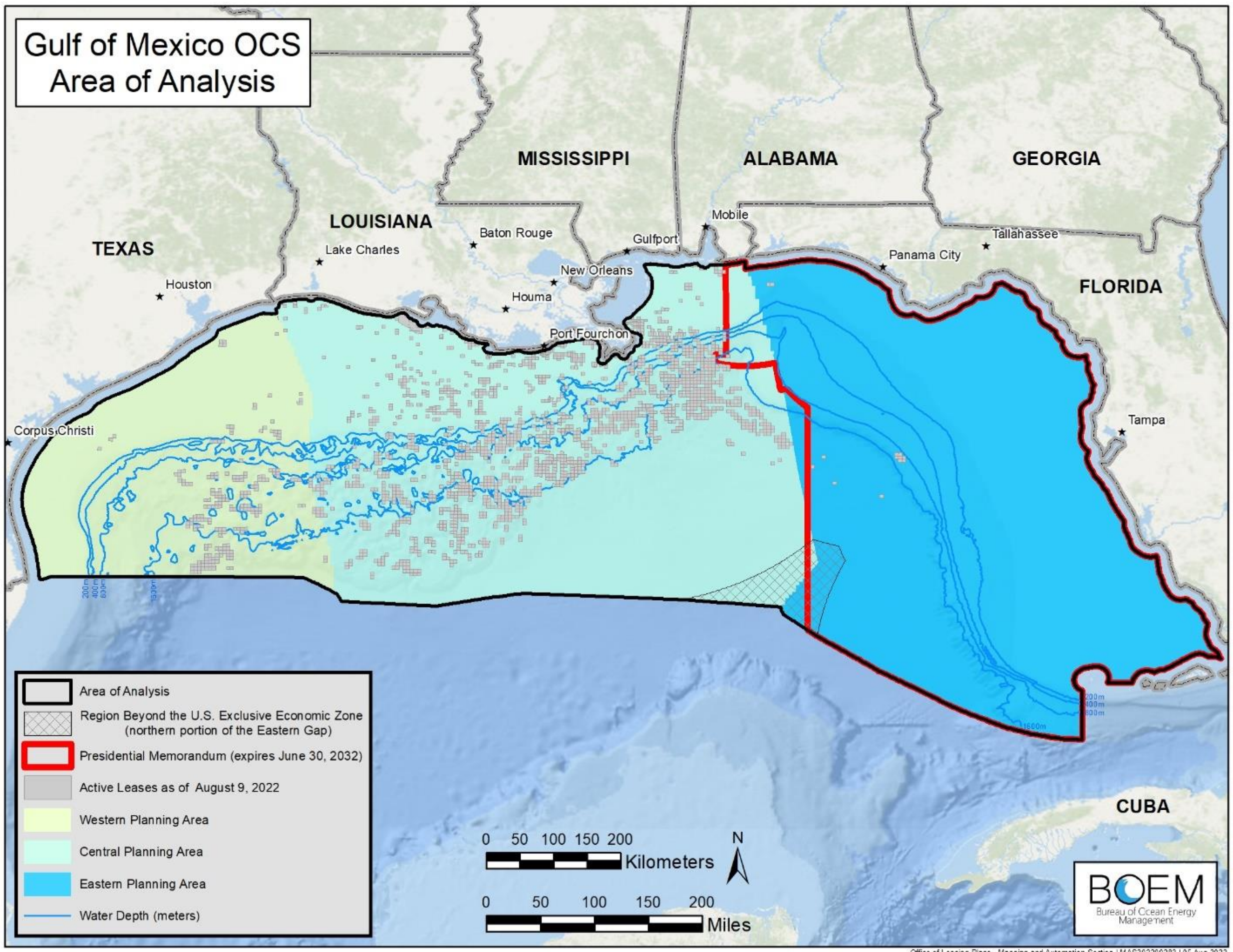


Figure 1.0-1. Area of Analysis Overlaid with Currently Leased Blocks as of August 9, 2022.

This document will help in understanding the unique and varied resources in the Gulf of Mexico (GOM) geographic area and in analyzing how they could be affected by oil and gas leasing and related activities in the Gulf of Mexico OCS. This process is part of an internal review and scoping process to identify and eliminate from detailed analysis in future NEPA documents the potential issues not likely to affect a resource or that have been adequately covered by prior environmental review in accordance with 40 CFR § 1506.3. Additionally, it will aid in narrowing the discussion of these potential issues and focus future NEPA analyses on the most relevant issues/concerns to consider in making informed decisions.

1.1 DOCUMENT AND ASSESSMENT FRAMEWORK

The information provided herein was not analyzed for a specific exploration and development scenario or OCS oil and gas lease, but under the assumption that certain activities would transpire as a result of an OCS lease sale, should one occur. The chapters and appendices in this document are outlined below.

Chapter 1 describes the historical background of oil and gas leasing in the Gulf of Mexico (GOM), current leasing trends, and the typical phases of oil and gas activities following a lease sale. It also provides an overview of the leasing process.

Chapter 2 describes the various oil- and gas-related activities within the phases described in this chapter, as well as the potential cumulative activities in the GOM, grouped by discrete impact-producing factor categories. Accidental events are also discussed.

Chapter 3 describes the regional setting of, and programmatic topics related to, the GOM, including geological setting, physical oceanography, meteorological conditions, and climate change.

Chapter 4 describes the physical, environmental, cultural, and socioeconomic settings of the GOM and the potential cause-effect interactions of OCS oil and gas development and cumulative activities on the various resource categories.

Chapter 5 describes the additional BOEM and Bureau of Safety and Environmental Enforcement (BSEE) approval and permitting processes that occur at each stage of oil and gas exploration and development.

Chapter 6 describes the suite of mitigating measures commonly considered and applied by BOEM and/or BSEE through permits/approvals.

Chapter 7 describes the suite of lease sale stipulations commonly applied in the GOM that could be considered and applied to any future OCS oil and gas lease sales.

Chapter 8 provides an alphabetical list of the references cited in this document.

Appendix A provides an alphabetical list of abbreviations and acronyms used in this document.

Appendix B provides an alphabetical list of specialized or technical words and their assumed definitions for purposes of this document.

Appendix C provides a conversion chart of equivalent values for various units of measure assumed throughout this document.

1.2 HISTORICAL BACKGROUND

Under Executive Order 9633, the Federal Government declared authority of OCS energy and mineral resources in the late 1940s, but its authorization to exploit the mineral resources of the OCS was not firmly established until passage of the Outer Continental Shelf Lands Act (OCSLA) of 1953. In 1953, Congress enacted the Submerged Lands Act and the OCSLA, the latter of which was significantly amended in 1978. The OCSLA defines the OCS as all submerged lands lying seaward of State coastal waters (3 mi; 4.8 km offshore) which are under U.S. jurisdiction. The only exceptions are Texas and the west coast of Florida, where State jurisdiction extends from the coastline to no more than 3 marine leagues (10.4 mi; 16.7 km) into the Gulf of Mexico. Under the OCSLA, the Secretary is responsible for the administration of mineral exploration and development of the OCS. The OCSLA empowers the Secretary to grant oil and gas leases to the highest qualified responsible bidder based on sealed competitive bids and to formulate regulations as necessary to carry out the provisions of the Act. A brief history of offshore milestones and legislation through 2019 can be found in **Figure 1.2-1**.

In 1954, the Federal Government held the first offshore oil and natural gas lease sale in the GOM. As offshore activities expanded in the years following adoption of the OCSLA, environmental awareness was also increasing across the Nation. Responding to this increased awareness, Congress passed NEPA in 1969 and the Coastal Zone Management Act (CZMA) of 1972. In 1978, Congress passed significant amendments to OCSLA to allow expedited offshore oil and gas exploration and production through a competitive bidding and leasing process in order to achieve national energy goals while also providing for environmental protection and opportunities for State and local governments affected by offshore activity to have their voices heard. These statutes are briefly summarized below and discussed in further detail in the *Gulf of Mexico OCS Regulatory Framework* technical report for the Gulf of Mexico region (BOEM 2020c).

- The NEPA requires that all Federal agencies use a systematic, interdisciplinary approach to protection of the human environment; this approach ensures the integrated use of the natural and social sciences in any planning and decision-making that may have an impact upon the environment. The NEPA also requires Federal agencies to prepare an environmental impact statement (EIS) to evaluate the potential environmental impacts of any proposed major Federal action that would significantly affect the quality of the human environment and to consider alternatives to such proposed actions.

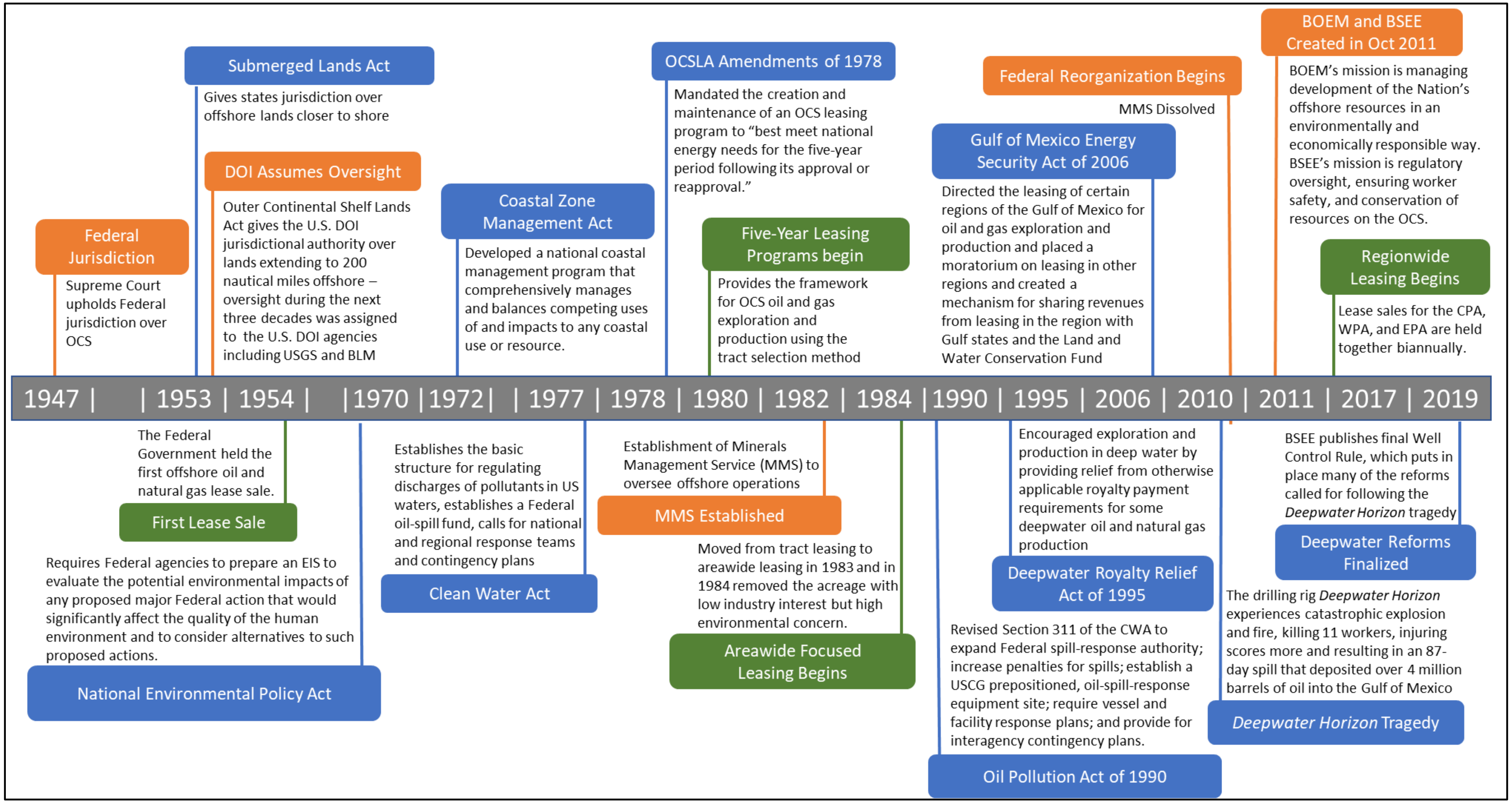


Figure 1.2-1. Regulatory History of the OCS Oil and Gas Program.

- The CZMA was enacted by Congress in 1972 (16 U.S.C. §§ 1451 *et seq.*) to develop a national coastal management program that comprehensively manages and balances competing uses of and impacts to any coastal use or resource. The CZMA Federal consistency regulations require that Federal activities (e.g., OCS lease sales) be consistent to the maximum extent practicable with the enforceable policies of a State's coastal management program. The Federal consistency regulations also require that other federally approved activities (e.g., activities requiring Federal permits, such as activities described in OCS plans) be consistent with a State's federally approved coastal management program. Refer to **Chapter 5** for more detail on the CZMA process for postlease activities.
- The 1978 OCSLA amendments added a number of new provisions, including Section 18, which mandates the creation and maintenance of an OCS leasing program to "best meet national energy needs for the 5-year period following its approval or reapproval."

Lease sales have been held in the WPA and CPA of the GOM since 1954 and, with a few exceptions (1956, 1957, 1958, 1961, 1963, 1965, and 2022), lease sales have occurred at least annually (and usually 2 or 3 times a year.)

Hydrocarbon Exploration History in the Gulf of Mexico

Technological advances have allowed exploration in the Gulf of Mexico to move gradually from the nearshore, shallow-water areas off Louisiana to leases in water depths exceeding 2,300 meters (m) (about 7,500 feet [ft]). To date, most of the producing wells have been located on the continental slope in water depths ranging from 200 to 400 m (656-1,312 ft). It is common for the leasing activity on the continental slope to precede the lessees' ability to drill and develop by several years. Advances in seismic data acquisition, processing, and interpretation have reduced the risks inherent to exploration in frontier areas. Enhancements in development and production techniques (e.g., spar, tension-leg platform, and subsea completions) for deepwater fields, coupled with the available volume of hydrocarbons and the rate of production, determine the long-term viability of the deepwater OCS.

Atlantic Richfield drilled the first well in the deeper waters of the continental slope in November 1974, on Mississippi Canyon Block 148, in a water depth of 212 m (696 ft). The well not only encountered economically viable hydrocarbons but proved the feasibility of drilling in water depths greater than 200 m (656 ft). Since then, over 1,677 additional wells have been spudded in the water depths greater than 200 m (656 ft). For the GOM specifically, 91 percent of the oil production and 70 percent of the natural gas production in 2019 were from wells in deep water (water depth greater than 1,000 ft [305 m]). Ten years prior, deepwater production accounted for 70 percent of OCS oil production. Twenty years prior, deepwater production accounted for only 26 percent of OCS oil production (BSEE 2019b).

Although the 1978 amendments were the last major overhaul of OCSLA, Congress has taken other actions since that time that have altered the scope of offshore oil and gas exploration and production. For some time, industry had only a low-level interest in leasing in the deepwater areas in the GOM; however, industry interest and deepwater leasing increased significantly following the passage of the Deep Water Royalty Relief Act of 1995 (DWRRA). The DWRRA defines deepwater leases as those in water depths greater than 200 m (656 ft). For purposes of this document, however, deep water is considered greater than 305 m (1,000 ft), consistent with BOEM's *Deepwater Gulf of Mexico: December 31, 2014* report (Nixon et al. 2016). The DWRRA establishes three zones based on water depth for different levels of royalty relief: 200-400 m, 400-800 m, and 800 m or greater (656-1,312 ft; 1,3121-2,625 ft; and 2,625 ft or greater). The DWRRA encouraged exploration and production in deep water by providing relief from otherwise applicable royalty payment requirements for some deepwater oil and natural gas production. In 1995, the overall number of blocks bid on and later awarded leases (in water depths >400 m [1,312 ft]) multiplied fourfold (400%) from the average of the previous 2 years, and these deepwater leases accounted for 33 percent of all leases awarded (**Figure 1.2-2**). In 2020, 64 percent of all active leases in the GOM were in water depths of 1,000 ft or greater (**Figure 1.2-4**). Nixon et al. (2016) provides a summary of notable events outlining the progression of deepwater oil and gas development in the GOM. BOEM has since published the updated *Deepwater Gulf of Mexico: December 31, 2019* report in January 2021 (BOEM 2021c).

Historically, the CPA was typically offered as a March lease sale, and the WPA was offered as an August lease sale. This led to fluctuating bidding throughout the years as industry sought more leases in the CPA. Therefore, beginning in 2017, BOEM began offering regionwide lease sales twice a year for the WPA, CPA, and EPA with certain restrictions (e.g., excluding areas under moratorium). Trends in the number of blocks with bids (overall bidding) has declined through the last several programs, while the ratio of blocks with bids per water depth has remained relatively constant through the years (**Figures 1.2-2 and 1.2-3**).

Hydrocarbon resources can be designated as discovered or undiscovered. **Discovered resources** are hydrocarbons whose location and volume are known or estimated using specific geologic evidence. Discovered resources include cumulative production, remaining reserves, and contingent resources. **Undiscovered resources** are resources thought to exist outside of known fields/accumulations. These are also described as undiscovered technically recoverable resources (UTRR) and are more specifically defined as an estimate of the potential presence and amount of technically recoverable oil and gas resources on the OCS.

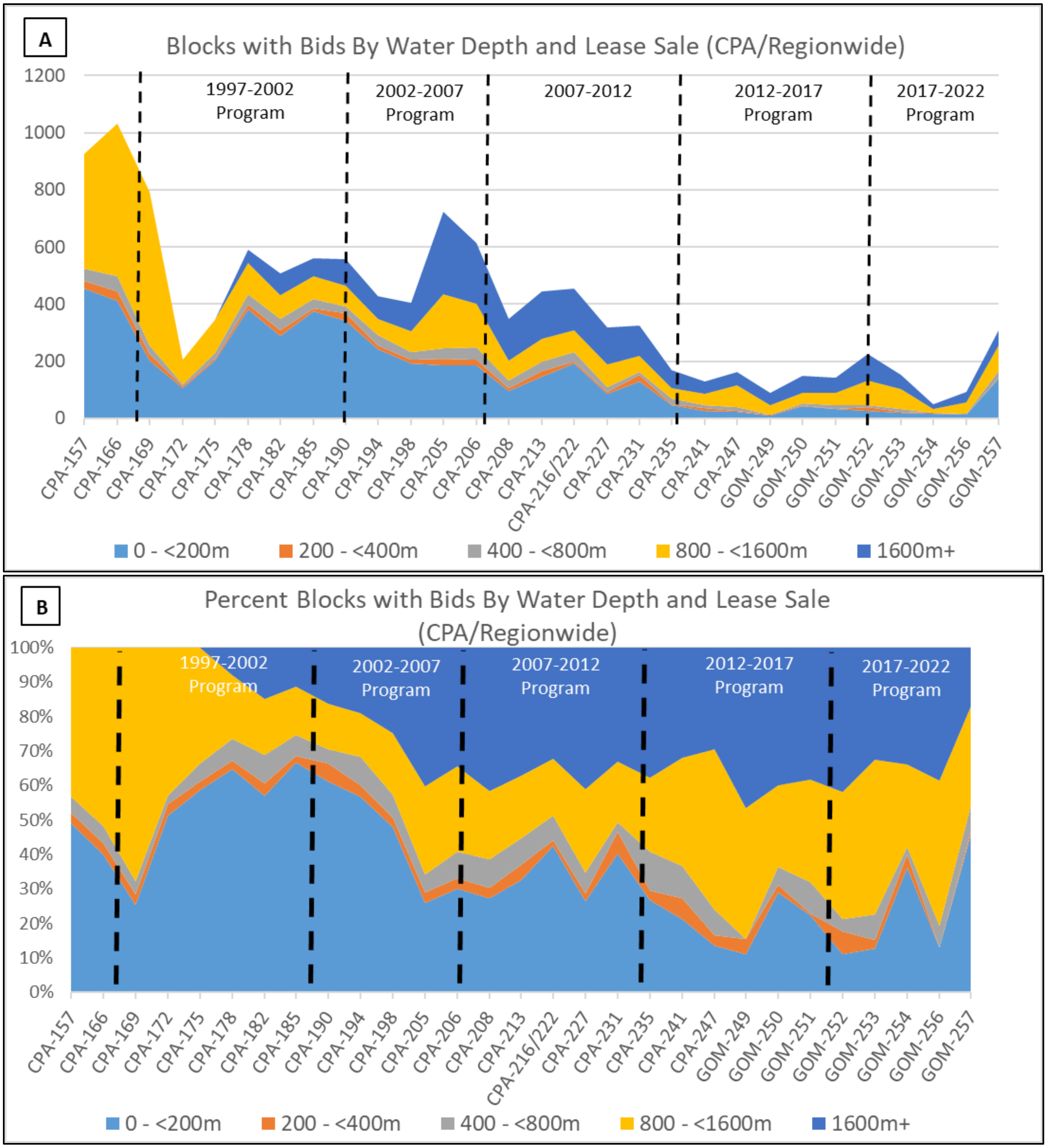


Figure 1.2-2. Trends for Blocks Receiving Bids in the CPA, and Later the Gulf of Mexico, by Lease Sale and Water Depth Ranges.

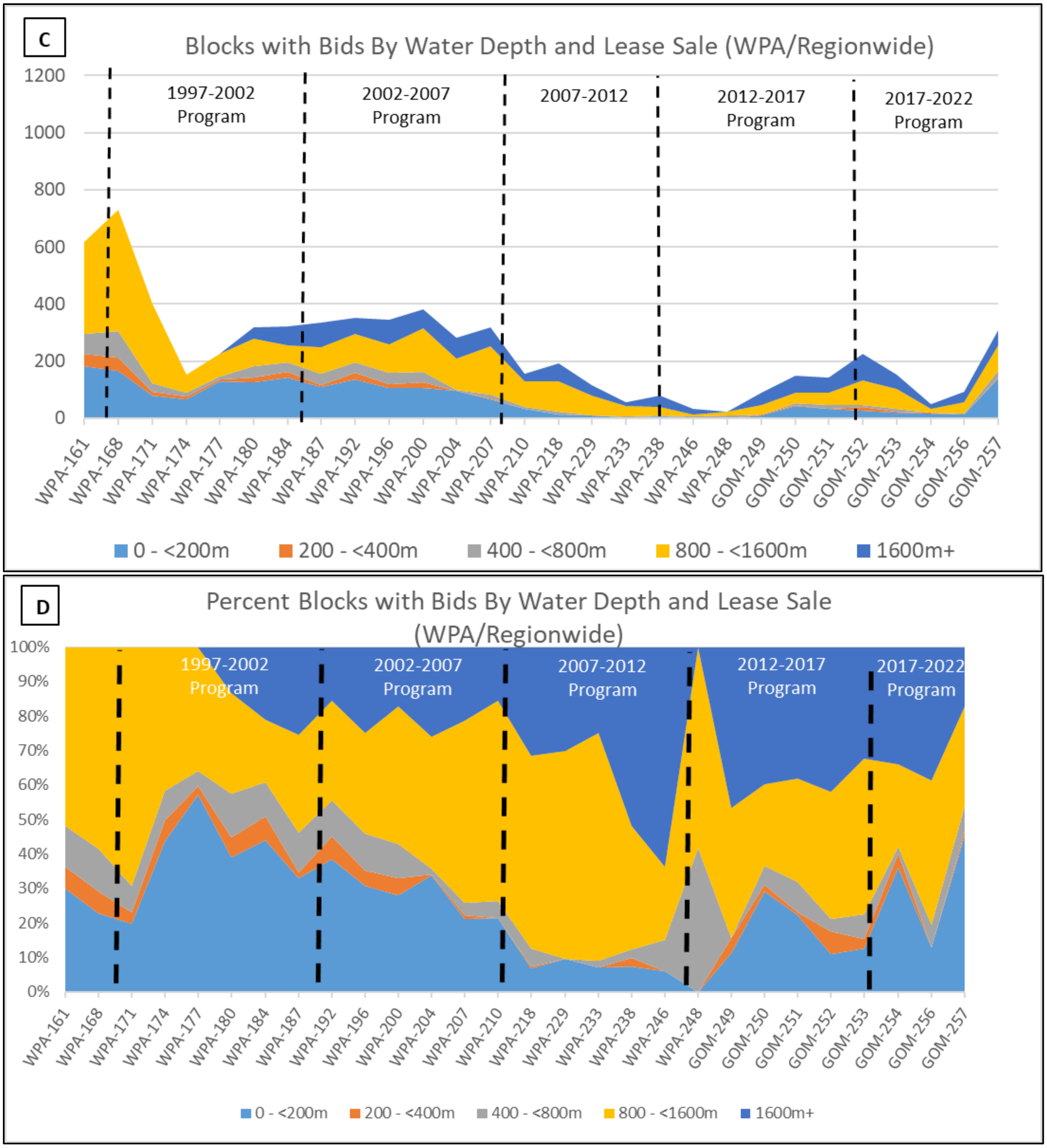


Figure 1.2-3. Trends for Blocks Receiving Bids in the WPA, and Later the Gulf of Mexico, by Lease Sale and Water Depth Ranges.

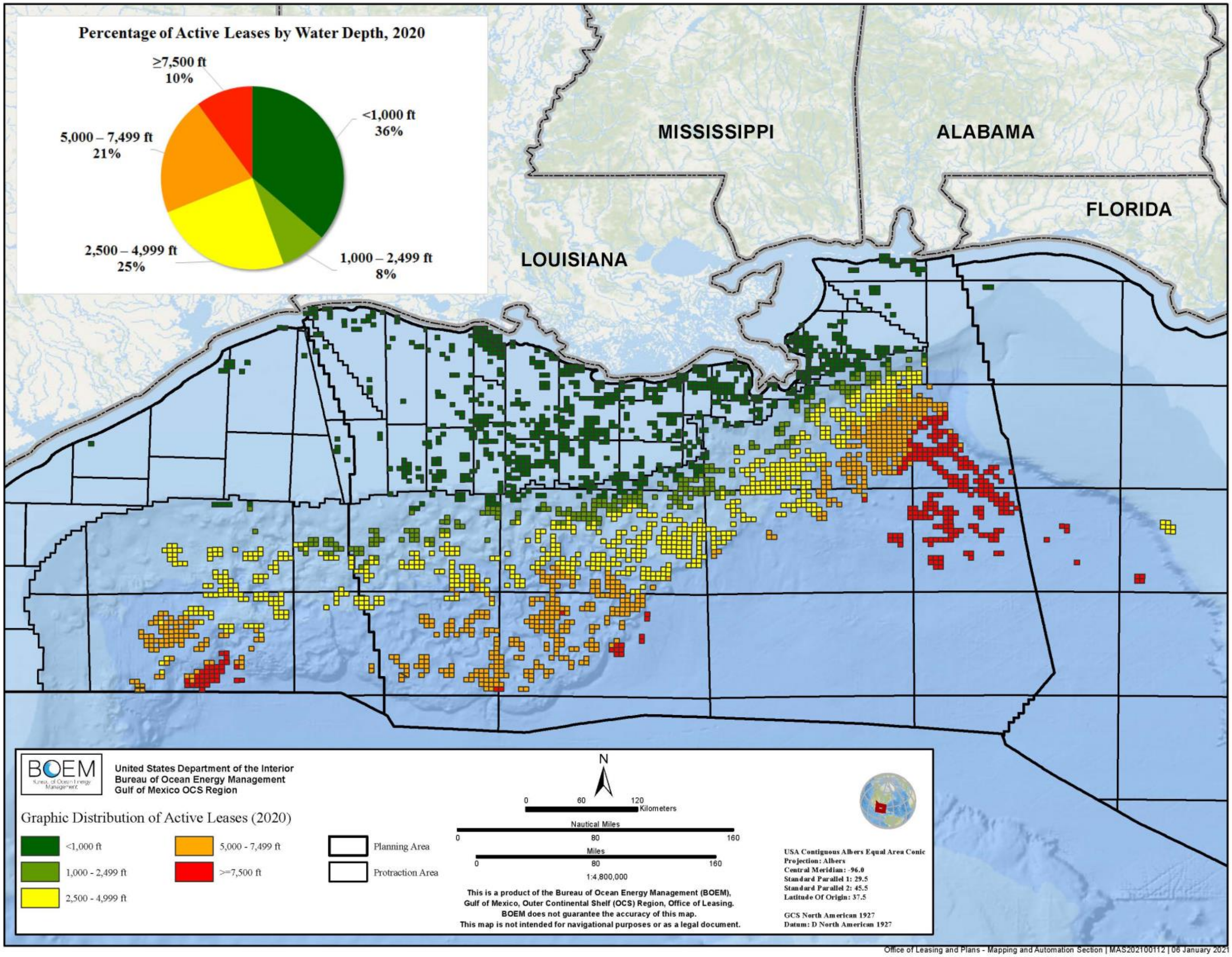


Figure 1.2-4. Active Leases by Water Depth at the End of 2020.

BOEM's *2021 Assessment of Technically and Economically Recoverable Oil and Natural Gas Resources of the Gulf of Mexico Outer Continental Shelf*, estimates the total volume of UTRR oil in the GOM is 29.59 billion barrels of oil, and the total volume of UTRR gas is approximately 54.845 trillion cubic feet. On a combined basis, the mean volume of UTRR oil and gas resource in the Gulf of Mexico OCS is 39.345 billion barrels of oil equivalent (BOEM 2021a).

1.3 Overview of the Oil and Gas Leasing Process

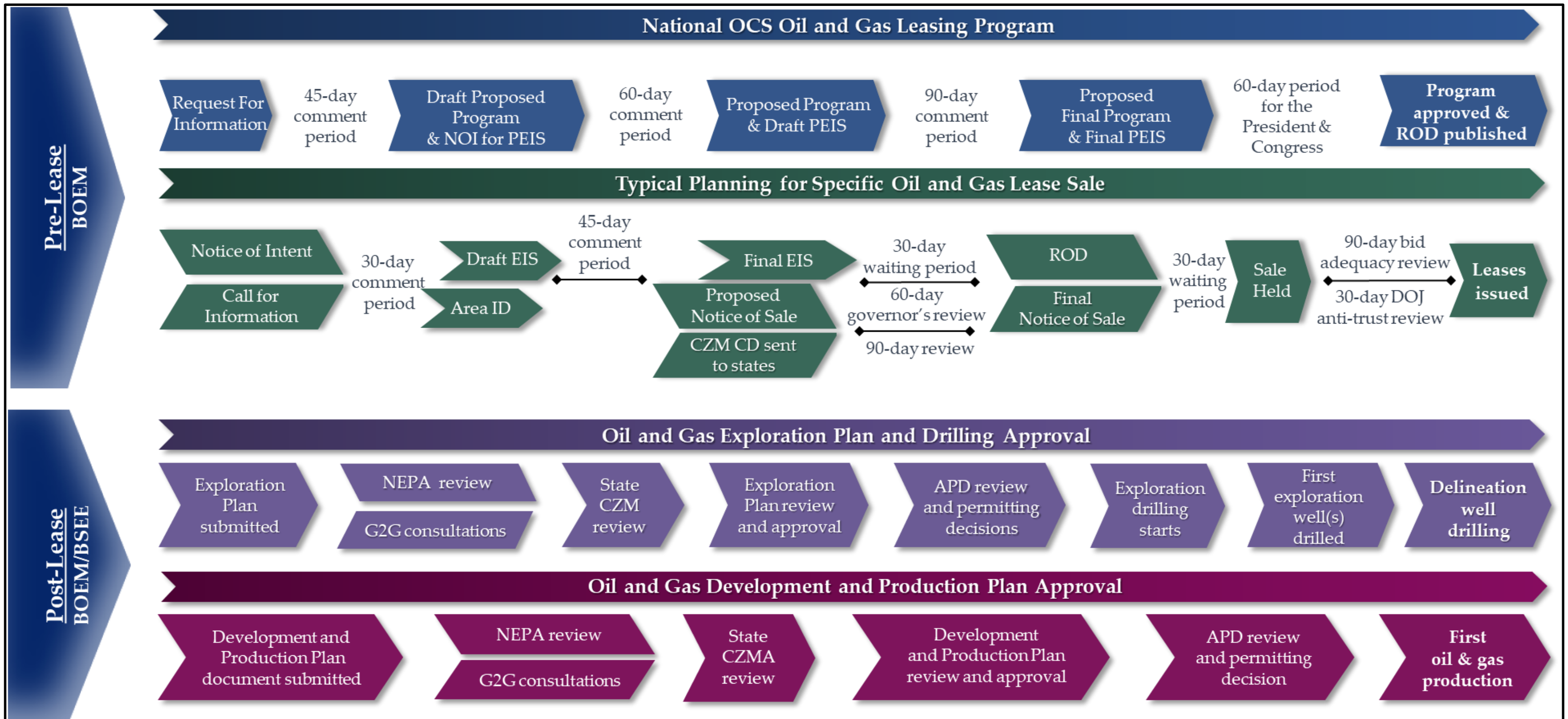
The OCS leasing process consists of five stages: (1) National Program planning; (2) lease sale planning; (3) exploration; (4) development and production; and (5) decommissioning (**Figure 1.3-1**). The leasing process begins when a set of areas within the Federal offshore lands are announced as available for leasing. These areas are divided into blocks or tracts, which are typically 5,000 or 5,760 acres, i.e., up to 9 square miles (23 square kilometers). Activities occurring throughout these phases are generally termed pre- or postlease based on whether they occur or are associated with development on a leased block(s).

BOEM conducts environmental reviews at all the stages outlined below. These environmental reviews include site-specific analysis under NEPA at each subsequent stage of activity, as well as evaluations and coordination with other agencies the CZMA, Endangered Species Act (ESA), National Historic Preservation Act (NHPA), Magnuson-Stevens Fishery Conservation and Management Act, and Marine Mammal Protection Act (MMPA).

1.3.1 National OCS Oil and Gas Programs

BOEM administers oil and gas leasing on the OCS. In accordance with Section 18 of the OCSLA (as amended), the Secretary of the Interior prepares an oil and gas leasing program that consists of a 5-year schedule of proposed lease sales that shows the size, timing, and location of leasing activity as precisely as possible. Section 18(a) of the OCSLA contains four subsections that set forth specific principles and factors that guide National OCS Oil and Gas Program formulation and that, together, provide the foundation for BOEM's analysis that is used in the development of Program Options for a schedule of proposed lease sales included in each national OCS oil and gas leasing program.

A lease sale cannot be added later to an existing National OCS Oil and Gas Program without an act of Congress.



Key: APD = Application for Permit to Drill; BOEM = Bureau of Ocean Energy Management; BSEE = Bureau of Safety and Environmental Enforcement; CD = Consistency Determination; CZM = Coastal Zone Management; G2G = government-to-government; NEPA = National Environmental Policy Act; NOI = Notice of Intent; OCS = Outer Continental Shelf; PEIS = programmatic environmental impact statement; ROD = Record of Decision

Notes: Publishing the Draft and Final EISs must occur after the Area ID and prior to the issuance of the ROD/Final Notice of Sale. The ROD and Final Notice of Sale publish simultaneously. Usually, the Proposed Notice of Sale and CDs are finalized after the Draft EIS is issued but at least 90 days prior to Final Notice of Sale/ROD signature.

Figure 1.3.1-1. BOEM's OCS Oil and Gas Leasing, Exploration, and Development Process.

Planning Area *– a specific and spatially discrete portion of the OCS used by BOEM for administrative and planning purposes.*

Once a National OCS Oil and Gas Program is approved, offshore areas included in the program can be made available for leasing through scheduled lease sales. For any specific lease sale to be held, it must first be included in an approved National OCS Oil and Gas Program. Whether a lease sale is held depends on sale-specific analyses. In the past, though not required, BOEM (or its predecessor) prepared a Programmatic EIS in conjunction with the National OCS Oil and Gas Program. For example, to support the 2017-2022 National OCS Oil and Gas Program, BOEM prepared the *Outer Continental Shelf Oil and Gas Leasing Program: 2017-2022; Final Programmatic Environmental Impact Statement* (BOEM 2016).

The National OCS Oil and Gas Programs, which provide the schedule for lease sales, have provided the framework for OCS oil and gas exploration and production since the first one was adopted by the Department of the Interior (DOI) in 1980. That initial program included 36 lease sales in 16 OCS planning areas for the period of September 1980 through June 1985. These lease sales were held using the tract selection approach. Tract selection lease sales were based on tract-specific nominations submitted by the oil and gas industry, and generally offered up to 2 million acres. The actual acreage offered in these lease sales depended on the magnitude of the nominations, hydrocarbon potential, and environmental and multiple-use considerations.

During development of the National OCS Oil and Gas Program, the tendency is to include more areas for consideration early in the process and then reduce the scope of the program later in the process or even following its approval. For planning purposes, it is practical to defer decisions to exclude areas until later in time as the information on which to base such decisions becomes more reliable and geographically focused at later stages in the OCS leasing process. Likewise, projections of hydrocarbon potential, the levels of OCS activities, and possible environmental effects become more specifically and realistically assessable. Furthermore, as program activities proceed, there are numerous opportunities for stakeholder engagement and for BOEM to refine areas under consideration when the program is implemented as outlined in subsequent sections.

1.3.2 Lease Sales

Prior to holding an oil and gas lease sale, BOEM must ensure that all necessary reviews and/or opportunities for public input have taken place under the OCSLA, CZMA, and NEPA (refer to **Figure 1.3.2-1**).

1.3.2.1 OCSLA Process

Generally, the OCSLA leasing process begins with the publication of a Call for Information (Call) in the *Federal Register*, where BOEM solicits public input on areas of interest or concern, and specifically solicits industry interest on areas that should be considered for leasing. Some proposed lease sale areas may include an additional first step — a request for industry to express interest in the specific area before BOEM proceeds with the lease sale process. After the Call, BOEM completes and announces its Area Identification (Area ID), which determines the discrete area that will be considered for leasing and for further environmental analysis. BOEM then prepares and publishes a Proposed Notice of Sale (NOS), which announces the proposed lease sale's size, timing, and terms and conditions, including any mitigating measures necessary to protect the environment and reduce potential conflicts-of-use. Meanwhile, BOEM engages in consultations and environmental reviews required under the OCSLA, and once completed, BOEM publishes a Final NOS, which includes the date, time, and location of the bid opening, the OCS blocks being offered, and the terms and conditions of the lease sale.

Call for Information

Currently for GOM lease sales, a Call is published for the first proposed lease sale in a National OCS Oil and Gas Program. The Call solicits public input on areas of interest or concern, and specifically solicits industry interest on areas that should be considered for leasing. The Call also solicits comments about geological conditions; archaeological sites; multiple uses of the area; sociological, biological, and other environmental information; and asks the public for information on areas of special concern that should be analyzed. The entire process from the Call to the lease sale may take 2 or more years; therefore, BOEM must plan for any proposed lease sales at the beginning of a new National OCS Oil and Gas Program in parallel with the development of the program itself. This is commonly the case for the first GOM lease sale of each new National OCS Oil and Gas Program.

Area Identification

After the Call, BOEM completes and announces its Area Identification (Area ID), which determines the discrete area that will be considered for leasing and for further environmental analysis. Based on information gathered from responses to the Call and Notice of Intent (NOI) (discussed further in "Review Under NEPA"), BOEM will also identify the proposed action to be analyzed in the NEPA document. BOEM publishes the Area ID decision in the *Federal Register*, and it is factored into the proposed action and NEPA analysis.

Proposed Notice of Sale

The Proposed NOS, which is published in the *Federal Register*, describes the timing, size, and location of a proposed oil and gas lease sale, and includes the terms and conditions proposed for the lease sale. Proposed NOS publication typically coincides with the publication of the Draft Multisale EIS so that comments received on the Proposed NOS can be incorporated into the EIS, as applicable. The Proposed NOS is the first public document stating the proposed time and location of the proposed lease sale with the terms and conditions, as well as the recommended mitigating measures. Section 19 of the OCSLA (43 U.S.C. § 1345) requires BOEM to solicit input on the size, timing, and location of lease sales from governors of affected states. BOEM sends the Proposed NOS to governors of affected states requesting their recommendations on the proposed lease sale's size, timing, and location. The governors have 60 days to submit their recommendations to BOEM.

Final Notice of Sale

BOEM will publish a Final NOS in the *Federal Register* at least 30 days before a lease sale is held. The Final NOS includes information on (1) how to submit bids; (2) the date, time, and location of the bid opening and reading; (3) the OCS blocks being offered; and (4) terms and conditions of the lease sale, including required stipulations and other mitigating measures. The Record of Decision (ROD) for the EIS is typically issued concurrent with the Final NOS.

1.3.2.2 NEPA Process

In addition to the OCSLA process, BOEM completes a NEPA evaluation, which concludes with the issuance of a ROD at least 30 days prior to the actual lease sale. The ROD informs the Final Notice of Sale Decision issued under OCSLA as outlined above. The process below outlines BOEM's process for a GOM lease sale within a given National OCS Oil and Gas Program followed by the typical NEPA process for subsequent GOM lease sales.

Notice of Intent and Public Scoping

Similar to the leasing process under the OCSLA, the NEPA process for a lease sale early in a National OCS Oil and Gas Program is typically initiated and conducted in parallel with the development of the actual Program. As such, BOEM in the past has published an NOI to prepare a region-specific Multisale EIS in conjunction with or soon after the Call is published for the first proposed GOM lease sale of a National OCS Oil and Gas Program. The NOI is accompanied with a minimum 30-day comment period, which can be extended at the discretion of the agency. BOEM may also hold one or more public scoping meetings in communities that could be affected if leasing, exploration, or development were to occur. The purpose of the NOI is to solicit input on the relevant issues, alternatives, mitigating measures, and analytical tools available so that they can be incorporated into the EIS. BOEM plans to prepare a programmatic GOM region-specific EIS. The proposed action would be to hold an oil and gas lease sale on the Federal OCS in the GOM. This programmatic EIS is expected to be used to inform the decision for the first GOM lease sale proposed in the next National OCS Oil and Gas Program, to be used and supplemented as appropriate for decisions on future proposed GOM lease sales, to be used for tiering purposes for associated site- and activity-specific OCS oil- and gas-related activity NEPA (typically EAs) and approvals, and/or to help inform extraordinary circumstance reviews to ensure categorical exclusions are used appropriately. The decision on whether and how to proceed for the first proposed GOM lease sale in the next National OCS Oil and Gas Program would be made following the completion of this NEPA analysis. Decisions on future GOM lease sales would be made in the normal course and may be based on additional NEPA review that may update this programmatic EIS as appropriate.

Draft EIS

Following the NOI and public comment period, BOEM plans to develop a draft programmatic EIS. This EIS analyzes the hypothetical scenario(s) developed for the proposed alternatives, along with the concerns identified during internal and external scoping. The objective of the analysis is to estimate the nature, severity, and duration of impacts that might occur and to compare the impacts of the various alternatives for a proposed lease sale. The EIS typically incorporates technical aids such as this document; studies sponsored by BOEM as well as other government and academic institutions; consultation documents, and other peer-reviewed literature. The EIS also incorporates various computer models that simulate the movements of accidental oil spills or air emissions from operations as part of the assessment. Once the EIS is completed, a Notice of Availability is published in the *Federal Register*, along with a minimum 45-day public comment period, which can be extended at the discretion of the agency. During the public comment period, BOEM will solicit public input through various techniques that could include any or all of the following: social media; press releases; newspaper ads; conferences; mailing lists; and/or public meetings or "open-house" style forums. Comments received on the proposed NOS will also be considered and incorporated, as applicable (refer to **Chapter 1.3.2.1**).

Final EIS

The Final EIS addresses public comments on the Draft EIS and includes a summary of all comments and BOEM's responses. After the comments on the Draft EIS are reviewed, BOEM revises the document to correct technical errors and update the analysis based on public input and any other relevant new information that became available since publication of the Draft EIS. The Final EIS would also include BOEM's preferred alternative for the proposed action. Once completed, the Final EIS is published with a minimum 30-day review period prior to issuing a ROD.

Record of Decision

Following the 30-day review period for the Final EIS, BOEM can then issue a ROD for the first proposed GOM lease sale of the National OCS Oil and Gas Program. An EIS, from NOI publication to ROD publication, should be completed within 2 years, absent a waiver being granted by the DOI Secretary's Office (refer to 40 CFR § 1501.10). The ROD should also be published at least 30 days prior to holding the actual lease sale but no sooner than 30 days following publication of the Final EIS.

NEPA Reviews for Subsequent Lease Sales

A NEPA review for each individual lease sale must be completed before the lease sale can occur.

BOEM has a mature OCS Oil and Gas Program in the GOM, with decades of NEPA documentation providing a great deal of baseline information. Lease sales have occurred in the same areas for decades, and consistent lease sales have provided continual updates on scenario, resources, and possible impacts associated with OCS oil- and gas-related activities. Following the *Deepwater Horizon* event, BOEM began preparing an EIS for each lease sale in the GOM in anticipation of rapidly emerging new information associated with studies being conducted after this event. Over time, new substantial information decreased, the Programmatic Damage Assessment and Restoration Plan was completed, and BOEM found this approach to result in unnecessarily duplicative analyses of similar actions (i.e., lease sales) with no substantial differences in the analyses or conclusions being made, which is contrary to the spirit and intent of NEPA (refer to 40 CFR § 1508.25).

Given the inefficiency of these repetitive NEPA reviews, the maturity of the GOM oil and gas program, and background information available from previous and ongoing analyses, BOEM developed a streamlined NEPA process for GOM lease sales considered routine and common in the GOM. Under this streamlined NEPA process, following the first lease sale supported by the Final GOM Programmatic EIS, BOEM would prepare a Determination of NEPA Adequacy (DNA) for subsequent GOM lease sales within a National OCS Oil and Gas Program. The DNA for each lease sale would identify and determine whether new information or circumstances bearing on a proposed lease sale or its impacts would trigger BOEM's obligation to supplement the EIS. BOEM may also choose to prepare an environmental assessment (EA) to determine whether the proposed lease sale triggers BOEM's obligation to supplement the EIS. If additional NEPA review is warranted, BOEM would supplement the EIS prior to issuing a Record of Decision or holding the lease sale. If additional supplementation is not triggered, BOEM would rely on the EIS and the DNA or EA, which summarizes the EIS conclusions and any pertinent new information, to support a ROD for a proposed lease sale. This NEPA review process is repeated for subsequent GOM lease sales. This process would not apply to any proposed lease sales in the area of the EPA currently under Presidential Withdrawal or for any other GOM lease sales that would consider areas outside of those that have been historically offered for leasing in previous programs (e.g., blocks within transboundary areas).

The Draft EIS may incorporate technical aids such as this document, studies sponsored by BOEM as well as other government and academic institutions, consultation documents, peer-reviewed literature, and feedback received during public scoping. Following a minimum 45-day public review period of the Draft EIS, BOEM would then prepare and publish a Final GOM Programmatic EIS incorporating and responding to public comments on the Draft EIS as well as any other new information that may have become available since publication of the Draft EIS. The Final EIS would also include BOEM's preferred alternative for the proposed action. Once completed, the Final EIS would be published with a minimum 30-day review period prior to issuing a ROD.

Following the review period for the Final EIS and at least 30 days prior to holding the actual lease sale, BOEM could issue a ROD for the first proposed GOM lease sale of the National OCS Oil and Gas Program. Once published, the Final EIS would provide the environmental review foundation for each proposed GOM lease sale within the National OCS Oil and Gas Program, unless and until supplementation of the EIS is necessary. Tiering to the Final EIS and ROD, BOEM could prepare a DNA for each subsequent GOM lease sale included in a National OCS Oil and Gas Program (refer to **Figure 1.3.1-1**). Each DNA would identify and determine whether new information since publication of the Final Multisale EIS and ROD triggers BOEM's obligation to supplement under NEPA. BOEM may also choose to prepare an EA to determine whether a proposed lease sale triggers BOEM's obligation to supplement the EIS. If so, BOEM would supplement the EIS prior to issuing a ROD or holding the proposed lease sale. If additional supplementation is not triggered, then the Final Multisale EIS and the DNA or EA, which summarizes the EIS conclusions and any pertinent new information, would be used to support a ROD for that proposed lease sale. Refer to the "NEPA Reviews for Subsequent Sales" section of **Chapter 1.3.2.2** for more information on the EIS process.

Holding the Lease Sale and Acquiring a Lease

No less than 30 days after the Final NOS is published in the *Federal Register*, sealed bids submitted by qualified bidders are publicly opened and read at the lease sale in accordance with 30 CFR § 556.308. BOEM opens the sealed bids at the place, date, and hour specified in the Final NOS for the sole purpose of publicly announcing and recording the bids. BOEM does not accept or reject any bids at that time. High bids are subject to further evaluation regarding the receipt of fair market value for the United States and adequate competition before a lease can be issued.

The lease sale is a transparent process. Bids are not accepted or rejected at the time of the lease sale. BOEM accepts or rejects all bids within 90 days, although the time may be extended if necessary. The DOI reserves the right to reject any and all bids, regardless of the amount offered, if the bid does not meet BOEM's fair market value criteria. If a bid is rejected, any money deposited will be refunded with the bid, plus any interest accrued. If the bid is accepted, the remaining four-fifths of the bonus and first year rentals are due no more than 11 days after the high bidder's receipt of the lease from BOEM in accordance with 30 CFR § 556.520.

Bid adequacy procedures have consistently resulted in higher returns in subsequent lease sales for tract bids rejected in prior lease sales.

Following each lease sale, BOEM determines whether a bid will be accepted, and a lease issued. The leases are not issued until BOEM has completed an extensive bid evaluation process to ensure that the Federal Government receives fair market value for the lease. Issued leases grant lessees the right to explore, develop, and produce oil and/or natural gas for a specific period and from a specific tract of OCS land. Since 1983, bid adequacy reviews and fair market value determinations have resulted in an average bid rejection rate of 4 percent. From 1983 through 2019, BOEM rejected approximately $731 million in total high bids. Subsequently, the same blocks were re-offered and drew high bids of $1.9 billion, a total net dollar gain of $1.2 billion, and a return on rejected high bid amounts of 190 percent.

Companies purchase leases anticipating there will be commercial quantities of oil or natural gas available, to make for economically viable production. Companies can spend millions of dollars to purchase a lease and then explore and develop it, only to find that it does not contain oil and natural gas in commercial quantities. It is not unusual for a company to spend in excess of $100 million only to drill a dry hole (American Petroleum Institute 2017). Only after the lease is acquired would the company be able to fully evaluate it, usually with a very costly seismic survey followed by an exploration well (refer to **Chapter 1.3.3.1**).

If a company does not find oil or natural gas in commercial quantities, the company may relinquish the lease back to the government, incurring the loss of invested money, and move on to more promising leases. If a company finds resources in commercial quantities, however, it will most likely produce the lease. But there sometimes can be delays between lease acquisition and making a profit — often as long as 10 years — for environmental and engineering studies, to acquire permits, to install production facilities (or platforms for offshore leases), and to build the necessary infrastructure to bring the resources to market (American Petroleum Institute 2017). If a discovery is made within the primary term of the lease, the lease is extended for as long as oil and/or natural gas is being produced in paying quantities or approved drilling operations are conducted.

1.3.3 Phases of Oil and Gas Development Resulting from Lease Sales

The following chapters analyze all activity associated with offshore oil and gas exploration and development that could potentially occur in the Gulf of Mexico should a lease sale occur. The phases of development are discussed here, and the potential resulting activities and impact-producing factors are discussed more thoroughly in the following chapters. OCS oil and gas operations generally occur in four phases: (1) exploration to locate viable oil or natural gas deposits; (2) development well drilling, platform construction, and pipeline infrastructure placement; (3) operation (oil or gas production and transport); and (4) decommissioning of facilities once the reservoir(s) in a field is no longer productive or profitable (**Figure 1.3.3-1**). Geological and geophysical (G&G) activities can occur during all four phases and can also be permitted to be done on unleased OCS land; however, all other exploration and development activities (e.g., drilling, infrastructure emplacement) within the four phases would only occur following the acquisition of an OCS lease as described above and once all required permitting and approval processes are completed (**Chapter 5**).

Activity in each of these phases is correlated. For example, oil and gas development and production depends on how much oil and gas resource is discovered during the exploration phase. Although unusual cases exist where activity on a lease may continue beyond the average lifespan of 50 years, forecasts indicate that the significant activities associated with exploration, development, production, and abandonment of leases in the GOM occur well within this timeframe, which is considered the analysis period for a single lease sale.

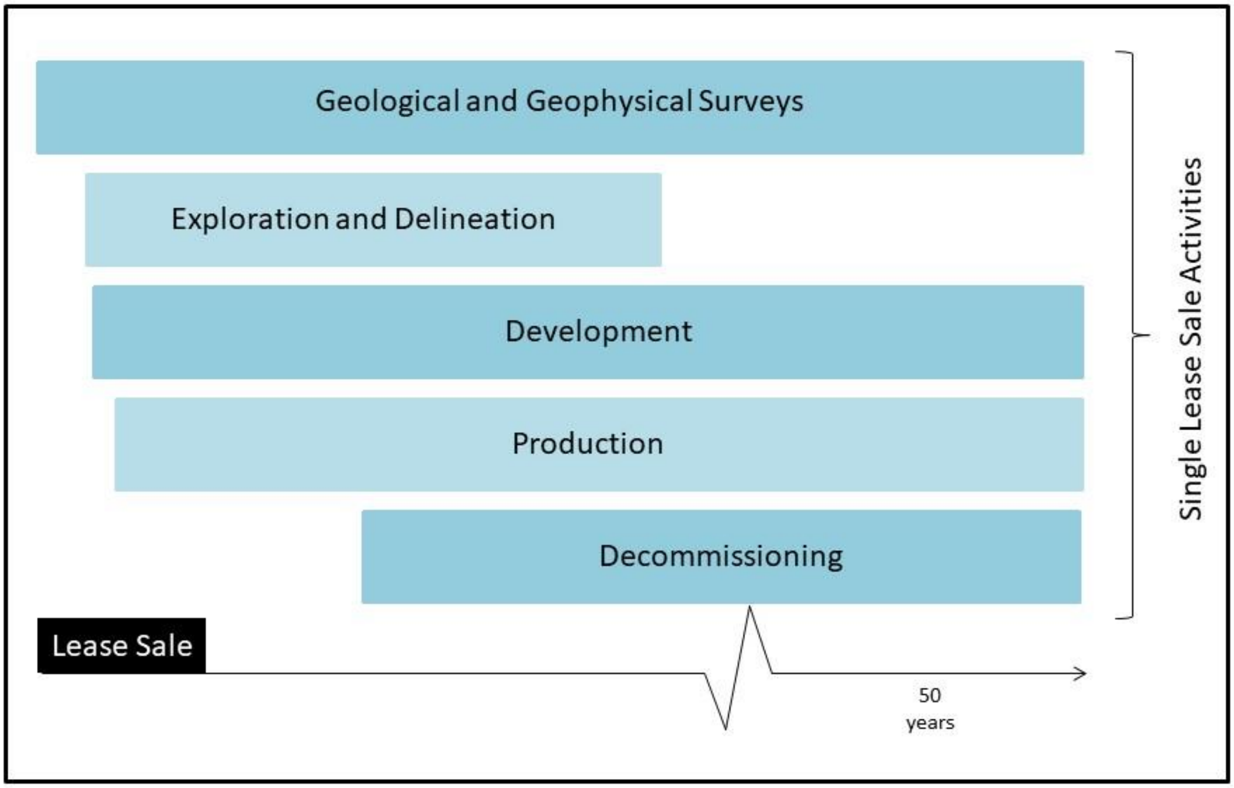


Figure 1.3.3-1. Phases of OCS Activity Resulting from a Single Proposed Lease Sale over a 50-Year Average Lifespan.

1.3.3.1 Geological and Geophysical Surveys (including Ancillary Activities)

Before a lease sale, companies interested in bidding on blocks in unexplored areas may either hire a geophysical company to "shoot" a seismic survey of blocks in an area or conduct their own survey. They are not permitted, however, to drill wells prior to acquiring a lease and the proper approvals. Historically, the interpretation of seismic data varied across companies and typically caused them to focus on different blocks and to bid different amounts. Most of the seismic surveys conducted before 1990 were limited to two dimensions, or 2D, vertical cross sections of strata, or three-dimensional (3D), time-migrated data. These data provided information about the likelihood of a deposit containing oil or gas, or the size of any given deposit. Costs could be a couple of hundred thousand dollars per block and they were typically shared among several companies. Advances in computing power have made 3D seismic analysis possible, and while 3D surveys are more informative, they are also more expensive.

Seismic surveys use a controlled sound source, such as an airgun, to transmit sound waves to the ocean floor. The pattern of reflected waves reveals subsurface features that can indicate the presence or potential for hydrocarbons. Seismic surveys can vary in sound intensity and in the amount of geographic area covered. In general, 2D seismic surveys are used to collect seismic data over a broad area, 3D surveys are used to collect a larger set of measurements over a smaller area, and four-dimensional (4D, or time lapse) surveys are used to collect dense measurements in the same small area repeatedly over time. Wide-azimuth seismic surveys collect geophysical data from many different angles and are used primarily in the GOM to investigate oil trapped below salt and other subsurface structures.

As discussed further in **Chapter 5.2.5**, BOEM oversees G&G data acquisition and permitting activities pursuant to regulations at 30 CFR parts 550 and 551. The G&G activities for oil and gas exploration are authorized on the basis of whether or not the proposed activities are (1) before leasing takes place (offlease) and authorized by permits or (2) on an existing lease (onlease or ancillary) and authorized by OCS plan approvals, plan revisions, or by a requirement for notification of BOEM before certain onlease activities are undertaken. There are a variety of G&G activities that are conducted for oil and gas exploration and development as onlease ancillary activities:

- various types of deep-penetration seismic airguns used almost exclusively for oil and gas exploration;
- electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods in support of oil and gas exploration;
- high-resolution geophysical (HRG) surveys (airgun and non-airgun) used to detect and monitor geohazards, archaeological resources, and certain types of benthic communities; and
- geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, and cables), as well as to identify environmental resources such as chemosynthetic communities, gas hydrates, buried channels and faults, and archaeological resources.

BOEM/BSEE regulations and permitting/authorization processes for G&G activities are discussed further in **Chapter 5.2.5**.

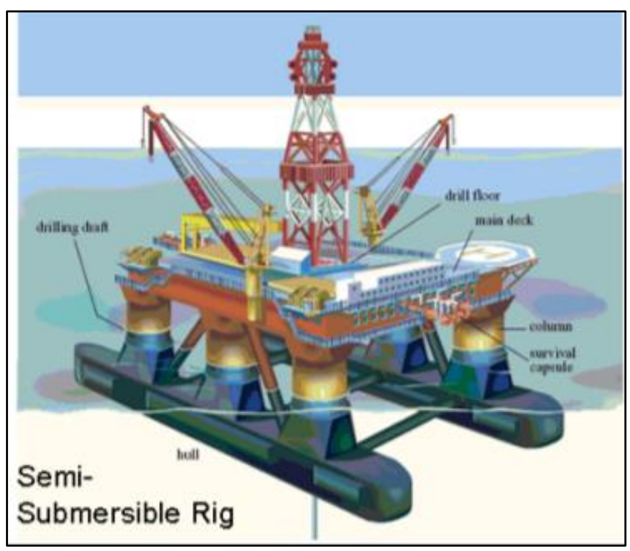
1.3.3.2 Exploration

*The term **exploration well** generally refers to the first well drilled on a prospective geologic structure to confirm that a resource exists.*

Exploration for oil and gas is the process of searching for and characterizing hydrocarbon reserves. The exploration stage involves G&G surveys (including seismic surveys, high-resolution geophysical surveys, and gravity and magnetic surveys), sediment sampling, and exploratory drilling. The only reliable way to determine whether the identified formations contain hydrocarbons is to drill into them. However, the decision to drill is not taken solely on geological grounds. Government requirements, economic factors (drilling costs, transport costs, market opportunities, relative merit/financial risk), and technical feasibility (including safety and environmental considerations) are all factored into the decision. Oil and gas operators use drilling terms that represent stages in the discovery and development of hydrocarbon resources. Refer to **Figure 1.3.3-1** above for a relative exploration timeline for an oil or gas lease.

In the GOM, exploration and delineation wells are typically drilled from three general types of mobile offshore drilling units (MODUs). The MODUs are self-contained with their own power generation, utilities, and accommodation facilities. Supplies are brought to the rig and wastes are returned to shore by supply boat; crews are transferred on and off the rig by helicopters and/or service vessels.

Jack-up rigs are based on a buoyant steel hull with three or more lattice legs up and down upon which the hull can be "jacked." The rig is towed to location by two or more tugs with the legs jacked up so that the hull floats. On reaching the drilling location, the rig jacks its hull up the legs until the base of the legs are firmly in contact with the seafloor and its deck positioned above wave height. The rig's position is maintained by the legs, which are in firm contact with the seafloor. No anchors are deployed, although in areas of strong seabed currents where sediment scour may be expected, gravel or rock may be dumped around the base of the legs to stabilize the sediments. Jack-ups can operate in open water or can be designed to move over and drill through conductor pipes in a production platform. Jack-up rigs come with various leg lengths and depth capabilities (based on load capacity and power ratings). Jack-up rigs are depth limited, with most only able to operate in water depths of around 100 m (300 ft) or less (American Petroleum Institute 2017). A special class of rigs known as premium or ultra, however, can operate in water depths up to about 450 ft (137 m).



Semi-submersible rigs are floating vessels supported on large pontoon-like structures submerged below the sea surface and are the most common type of offshore drilling rig used in water depths greater than 100 m (300 ft). The pontoons contain ballast tanks, and the height of the deck above the sea surface can be altered by pumping ballast (sea) water in or out of the pontoons. During drilling operations, the deck is lowered but kept above wave height. Rigs used in deepwater, harsh environments maintain position over the drilling location either by anchors (and where fitted, with rig thruster assistance as necessary) or by dynamic positioning using a series of computer-controlled thrusters and the deployment of eight or more seabed penetrating anchors. The anchors are attached to the rig by cable and near the anchor by chain of which portions lay on the seabed. Hauling in of the cables by the rig "sets" the anchors in the seabed after which minor adjustments to the rig position can be made by hauling in or paying out (slacking) cable. The precise arrangement of anchors around a rig is defined by a mooring analysis, which takes account of factors including water depth, tidal and other currents, winds, and seabed features. Refer to **Chapter 2.3.1.2** for more information on anchoring and the potential associated effects.

Drillships are large ships designed for offshore drilling operations and can operate in deep water, with some specially designed rigs able to drill in waters over 10,000 ft (3,048 m) deep. They are built on the same traditional ship hulls used for supertankers and cargo ships, which are adapted to allow the deployment of the drill through the hull. These rigs float and can be attached to the ocean bottom using traditional mooring and anchoring systems; however, the larger, more capable ship designs are dynamically positioned. Dynamically positioned ships maintain their position by using a computer-controlled system and thrusters to counteract winds, waves, and currents. Drillships can be quite large with many being 800 ft (244 m) in length and over 100 ft (30 m) in width. Because of their large sizes, drillships can work for extended periods without the need for constant resupply. Drillships also offer greater mobility and can move quickly (approximately 12-13 knots [kn]; 14-15 miles per hour [mph]) under their own propulsion from drill site to drill site in contrast to semi-submersibles, jack-up rigs, and platforms.

1.3.3.2.1 Drilling Operations

Once the rig is fixed in position, the drilling of the well is commenced. Drilling operations are typically conducted around-the-clock, generally over one to two months depending on the depth of the hydrocarbon formation and the geological conditions. A wide conductor (typically 30" or 36") is installed (spudded) into the surface of the seabed either by piling or using a water jet. The well is drilled in a series of steps with the hole sizes and casing getting progressively smaller (Kaiser et al. 2013). The upper section(s) of oil and gas wells is normally drilled “open” without a riser so that displaced sediments and rock are discharged directly around the wellbore. The uppermost section of the well is sometimes made by water jetting rather than drilling. The methods used and the depths to which a surface hole is drilled are dependent on several factors, particularly well design and intended function and the nature of surface sediment/rock types. The number and type of casing strings and the depth for each string is determined by evaluating each interval for the subsurface rock stress and pore pressure, the strength of the casing that would be run, anticipated hole problems, required hole size at total depth, and the type of completion to be used (**Figure 1.3.3-2**).

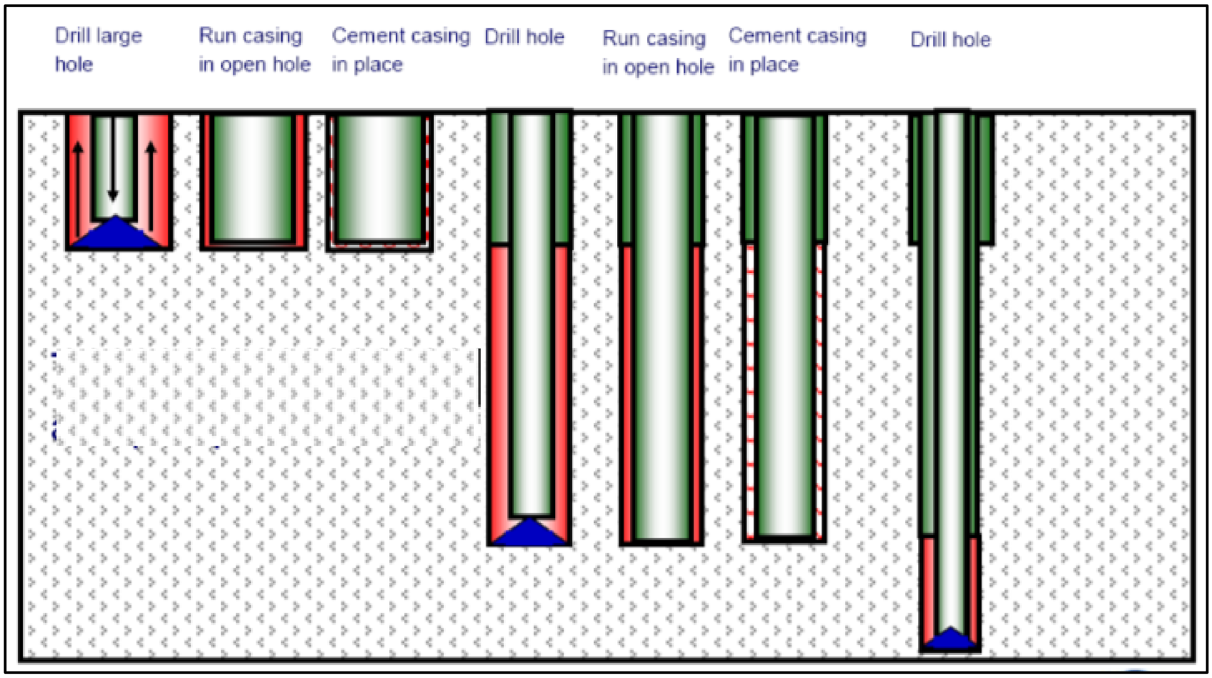


Figure 1.3.3-2. Simplified View of Installing Casing and Cementing a Well (adapted from Nergaard 2005).

Cementing

Steel casing is run into completed sections of the borehole and cemented into place. The casing provides structural support to maintain the integrity of the borehole and isolates underground formations. A measured amount of quick drying cement slurry is pumped into the casing and a plug inserted above it. The cement is forced down to the bottom of the casing and then up the annulus (i.e., the space between the outside of the casing and the wall of the well) by pumping mud on top of the cementing plug. Pumping ceases once some cement is observed returning with the mud returns indicating that all the mud in the annulus has been replaced with cement. Drilling activity is suspended, until the cement has set, the actual time being dependent on the cement additives used.

A blowout preventer (BOP), comprising a series of hydraulic rams that can close off the well in an emergency, is also installed (**Figure 1.3.3-3**). For drilling from permanent installations and jack-up rigs, a conductor pipe is installed and secured to the seabed for circulation of the drilling fluid to remove cuttings. For those applications, BOPs are installed just below the drilling rig. For deepwater operations, after drilling the first casing interval, a drilling riser is attached to the wellhead and used to circulate drilling fluid to remove cuttings. The BOPs and riser are installed at the seafloor onto a wellhead system. The wellhead system is run while attached to the first string of casing run inside a large-diameter conductor pipe that accommodates the jetting or drilling action. The first string of casing is usually conducted as “riserless drilling,” namely with no riser connection and therefore with fluid and cuttings exhausted to the seafloor.

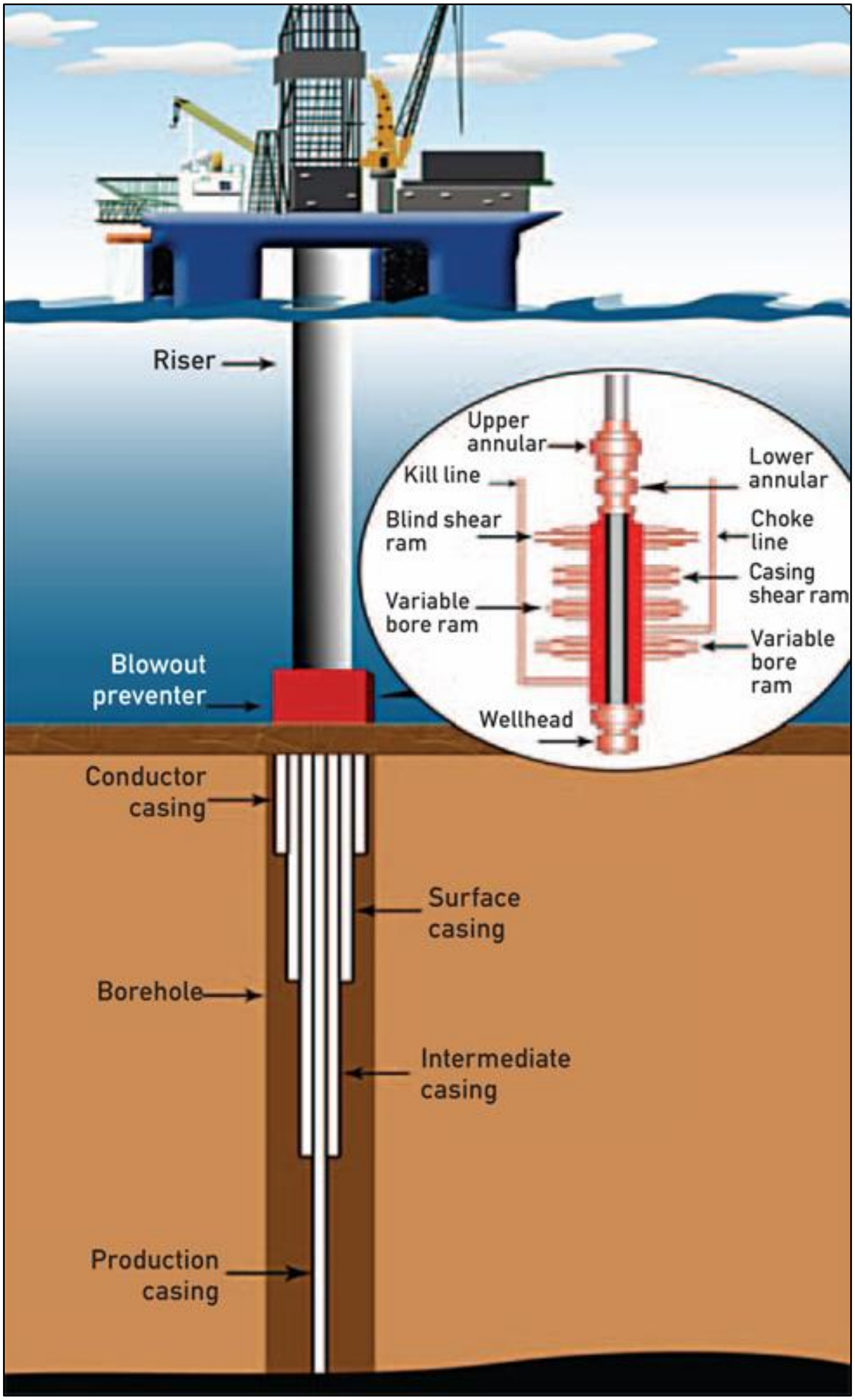


Figure 1.3.3-3. General Well Schematic Including the Blowout Preventer.

Once drilling commences, drilling fluid or mud is continuously circulated down the drill pipe and back to the surface equipment to (1) balance underground hydrostatic pressure, (2) cool the bit, and (3) flush out rock cuttings. Drilling grinds up the rock into tea-leaf-sized cuttings that are brought to the surface by the drilling mud. The drilling mud is passed over a shale shaker, which sieves out the cuttings. A riser (pipe) is deployed from the rig and connected via the wellhead so that drill mud and cuttings from lower sections can be returned to the rig for separation and treatment. Muds may be premixed onshore and transported in the mud tanks of the rig, or via supply vessel, or alternatively they can be mixed on the rig. If gas, oil, or water pressures exceed the hydrostatic head and invade the well (commonly referred to as a "kick"), the back pressure is detected on the rig. Normally, the mud weight is increased through the addition of weighting material to the point where downhole pressures are balanced and contained. In extreme circumstances the BOP is operated. The composition, use, and disposal of drilling fluid, muds, cuttings, and wastes are discussed further in **Chapter 2.2.1**.

1.3.3.2.2 Well Testing

Where significant hydrocarbons are encountered, an exploratory well may be tested by installing a section of production liner in the lower hole and flowing the well to the surface for a short period to measure pressures and flow rates and take samples of well fluids (well test or drill stem test). Prior to a well test, the well is cleaned using a combination of high-density brines and clean-up chemicals to remove all traces of mud and cuttings debris from the bore. The brines are circulated to the rig via the riser and may be contained for reuse/disposal or they may be discharged overboard in accordance with National Pollutant Discharge Elimination System (NPDES) permitting. The liner is then perforated in the reservoir section allowing reservoir fluids to flow into the liner bore and up to the rig. A gravel pack may be installed to prevent production of unconsolidated sand from the reservoir with the fluids. The well fluids are processed on the rig, through a surge tank and a test separator, to provide information on the relative proportions of gas, oil and water. The hydrocarbons produced during a well test are either burned in a high efficiency burner or in the case of oil produced during extended well tests, contained typically in a specialist storage vessel for transport to shore for treatment.

1.3.3.3 Development

A development well is drilled to extract resources from a known hydrocarbon reservoir.

Development drilling differs from exploration drilling in that data acquisition is no longer the primary function of the well. In development drilling, the objective is to drill targets as efficiently as possible. The drilling procedure for development wells involves similar techniques to those described for exploration; however, if a larger number of wells are drilled, the level of activity would increase in proportion. Likewise, the well sites would be occupied for longer, and support services, water supply, waste management, and other services would correspondingly increase. After a development well is drilled, the operator must decide whether or not to complete the well without delay, delay completion with the rig on station so that additional tests may be conducted, or temporarily abandon the well site and move the rig off station to a new location and drill another well. Sometimes an operator may decide to drill a series of development wells, move off location, and then return with a rig to complete all the wells at one time (refer to **Chapter 1.3.3.5.1**).

1.3.3.3.1 Delineation and Development Wells

When exploratory drilling is successful, more wells (commonly called "delineation" or "appraisal" wells) are drilled to determine the size and the extent of the field. The technical procedures in delineation/appraisal drilling are the same as those employed for exploration wells, and the description provided above applies equally. A number of wells may be drilled from a single site, which increases the time during which the site is occupied. Deviated or directional drilling at an angle from a site adjacent to the original discovery borehole may be used to appraise other parts of the reservoir. If the exploratory drilling has discovered commercial quantities of hydrocarbons, a wellhead valve assembly would likely be installed. Most appraisal wells would normally include extensive logging and involve a well test. Because of the cost, as few appraisal wells as possible would be drilled, the actual number being dependent on the unique circumstances of the field.

1.3.3.3.2 Well Completions

The completion process includes the suite of activities carried out to prepare a development well for production.

Should an operator decide to move forward with developing a well, completion operations must be undertaken. If it is decided that the well will not be completed, then it would be plugged and abandoned (**Chapter 1.3.3.5.1**). A well would be completed immediately if it is a development well, while for exploratory wells, completion activity would await field delineation and additional planning. When the decision is made to perform a well completion, a new stage of activity begins to convert an individual borehole into an operational system for controlled recovery of underground hydrocarbon resources. Those activities include installation of the final well casings that isolate fluid migrations along the borehole length while also establishing perforated sections where needed to capture the hydrocarbons from the geologic reservoir into the production casing (Operations & Environment Task Group and Offshore Operations Subgroup 2011).

There is a wide variety of well completion techniques performed in the GOM. The type of well completion used to prepare a drill well for production is based on the rock properties of the reservoir as well as the properties of the reservoir fluid. However, for the vast majority of well completions, the typical process includes installing or "running" the production casing; cementing the casing; perforating the casing and surrounding cement; injecting water, brine, or gelled brine as carrier fluid for a "frac pack"/sand proppant pack and gravel pack; treating/acidizing the reservoir formation near the wellbore; installing production screens; running production tubing; and installing a production tree. During completion, production casing is set across the reservoir interval and the blowout preventer (**Chapter 2.9.1.4**) is removed and replaced with a dry tree or subsea wellhead. Refer to **Chapter 2.2.1.4** for more detail on the various completion techniques and associated fluids and wastes.

1.3.3.4 Production

Offshore production systems may be placed over development wells to facilitate production from a prospective hydrocarbon reservoir. These structures provide the means to access and control wells. They serve as a staging area to process and treat produced hydrocarbons from wells, initiate export of produced hydrocarbons, conduct additional drilling or reservoir stimulation, conduct workover activities, and carry out eventual abandonment procedures.

1.3.3.4.1 Offshore Production Platforms

There is a range of offshore infrastructure installed for hydrocarbon production. Among these are pipelines, fixed and floating platforms, caissons, well protectors, casing, wellheads, and conductors. **Table 1.3.3-1** and **Figures 1.3.3-4 and 1.3.3-5** discuss the types of production facilities used at various water depths. More information and illustrations of each structure are presented in **Chapter 3.1**.

Table 1.3.3-1. Descriptions of Offshore Platforms (summarized from Regg et al. [2000] and American Petroleum Institute [2017]).

Offshore Platform	Description
Fixed Platform	A platform consisting of a welded tubular steel jacket, deck, and surface facility secured by piles driven into the seafloor to secure the jacket. Modules may be added to the surface system. The deck provides space for crew quarters, a drilling rig, and production facilities. The fixed platform is economically feasible for installation in water depths up to 1,500 ft (457 m).
Caisson	A fixed platform that consists of a single vertical column that rises from the seabed and supports a small surface facility above the water.
Compliant Tower	A similar structure to fixed platforms, but the structure may yield to the water and wind movements in a manner similar to floating structures. These are usually used in water depths between 1,000 and 2,000 ft (305 and 610 m).
Tension-Leg Platform (TLP)	A buoyant platform held in place using moorings held in tension by the buoyancy of the hull and connected to the sea floor by pile-secured templates. Larger TLPs have been successfully deployed in water depths approaching 4,000 ft (1,219 m). A mini Tension-Leg Platform (Mini-TLP) is a relatively low-cost TLP developed for production of smaller deepwater reserves that would be uneconomical to produce using more conventional deepwater production systems. It can also be used as a utility, satellite, or early production platform for larger deepwater discoveries. The world's first Mini-TLP was installed in the GOM in 1998.
SPAR	A deep-draft single floating caisson that relies on a traditional mooring system (i.e., anchor-spread mooring) to maintain its position. It has a typical fixed platform topside (surface deck with drilling and production equipment), three types of risers (production, drilling, and export), and a hull that is moored using a system of six to twenty lines anchored into the seafloor. SPARs are presently used in water depths up to 3,000 ft (914 m), although existing technology can extend its use to water depths as great as 7,500 ft (2,286 m).

Offshore Platform	Description
Semi-submersible or Floating Production Structure (FPS)	The FPS consists of a semi-submersible unit that is equipped with drilling and production equipment. It is anchored in place with wire rope and chain, or it can be dynamically positioned using rotating thrusters. Production from subsea wells is transported to the surface deck through production risers designed to accommodate platform motion. The FPS can be used in ultra-deep water.
Subsea Production System	These production systems do not have surface facilities directly supporting them during their production phases and rely on a "host" facility for support and well control. A subsea production system can range from a single well producing to a nearby platform, FPS, or TLP; or a multi-well template connected to a nearby manifold or to a distant production facility. The equipment on the seafloor is maintained using robots, known as remotely operated vehicles (ROVs), which are tethered to a vessel. These systems can be used in all water depths but are generally used in water depths greater than 1,000 ft (305 m). These systems are being installed at depths of almost 10,000 ft (3,048 ft) of water in the GOM, where deepwater development plays a significant role in current and future energy production. Using this advanced technology, producers can use a single platform to develop resources from 40 mi (64 km) away.
Floating Production, Storage, and Offloading Systems (FPSOs)	Ship-shape vessels (tankers) that have been retrofitted (conversions) or purpose built (new built) to act as a floating production structure. An FPSO is designed to process and stow production from nearby subsea wells and to periodically offload the stored oil to a smaller shuttle tanker. The shuttle tanker then transports the oil to an onshore facility for further processing. An FPSO may be suited for marginally economic fields located in remote deepwater areas where a pipeline infrastructure does not exist.

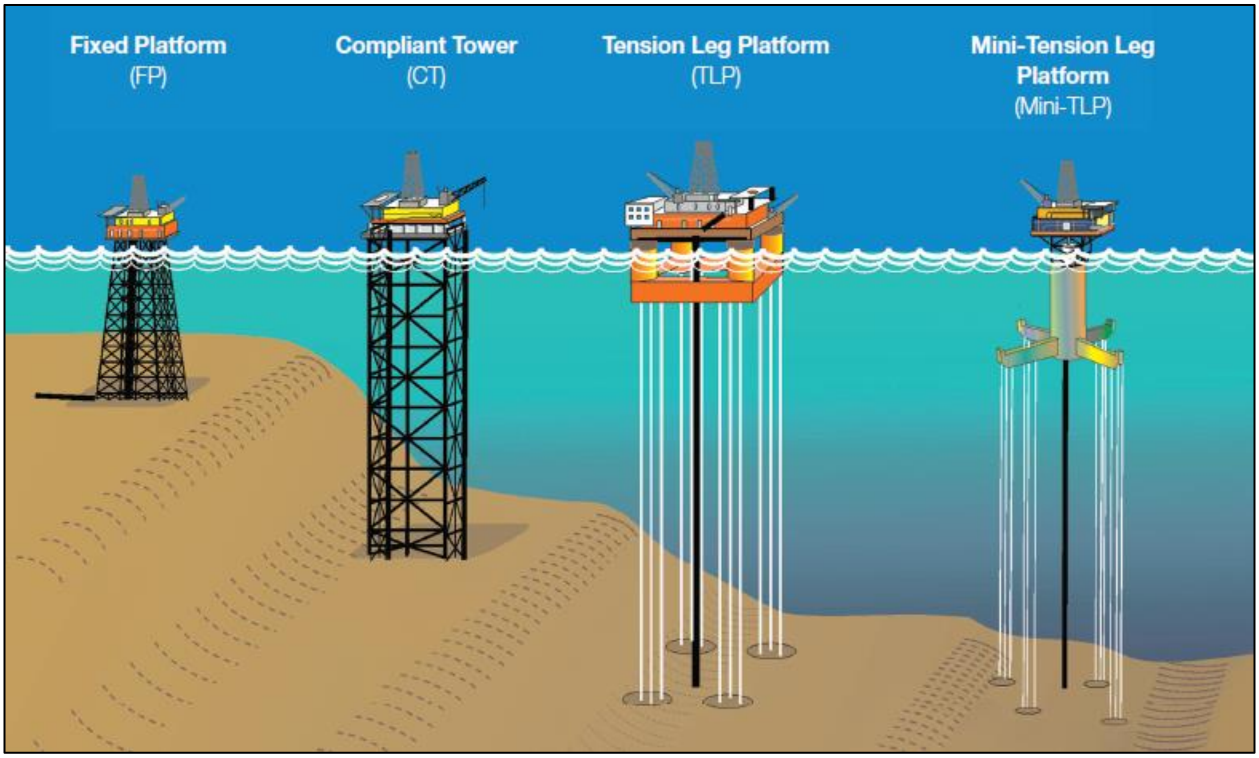


Figure 1.3.3-4. Production Facilities Commonly Used in Shallow to Moderately Deep Waters.

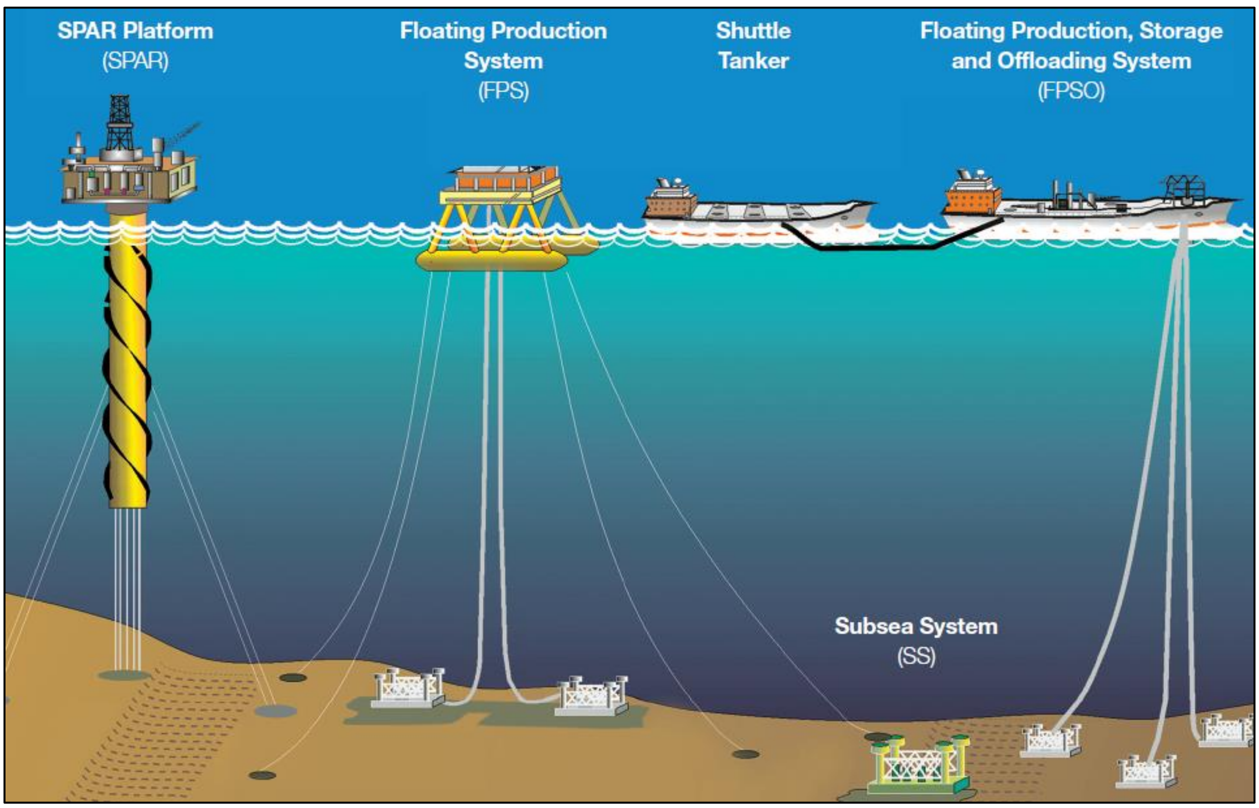


Figure 1.3.3-5. Production Facilities More Commonly Used in Deep to Ultra-deep Waters.

1.3.3.4.2 Pipelines

Pipelines are the primary means of transporting produced hydrocarbons from offshore oil and gas fields to distribution centers or onshore processing points. Pipelines on the OCS are designated as either gathering lines or trunklines. Gathering lines are typically shorter segments of small-diameter pipelines (generally 4-12 inches [in]; 10-30 centimeters [cm]) that transport the well stream from one or more wells to a production facility or from a production facility to a central facility serving one or several leases (e.g., a trunkline or central storage or processing terminal). Trunklines are typically large-diameter pipelines (as large as 36 in [91 cm]) that receive and mix similar production products and transport them from the production fields to shore. A trunkline may contain production from many production wells drilled across several hydrocarbon fields. The OCS-related pipelines near shore and onshore may merge with pipelines carrying materials produced in State territories for transport to processing facilities or to connections with pipelines located farther inland. During initial stages of production, it is also possible that some oil could be barged or tankered; however, it is most likely that any gas that is produced would be piped to shore, as liquefied natural gas facilities are typically a more expensive transportation option.

The BSEE evaluates the design, fabrication, installation, and maintenance of pipelines. Proposed pipeline routes would be evaluated for potential seafloor or subsea geologic hazards and other natural or manmade seafloor or subsurface features or conditions (including other pipelines) that could have an adverse impact on the pipeline or that could be adversely impacted by the proposed operations. Routes are also evaluated for potential impacts on archaeological resources and biological communities. In the GOM, no pipeline route is approved by BSEE if any bottom-disturbing activities (from the pipeline itself or from the anchors of lay barges and support vessels) encroach on any biologically sensitive areas.

According to BSEE regulations (30 CFR § 250.1003(a)(1)), pipelines with diameters $\geq 8^5/_8$ in that are installed in water depths <200 ft (61 m) are to be buried to a depth of at least 3 ft (1 m) below the mudline. The regulations also provide for the burial of any pipeline, regardless of size, if BSEE determines that the pipeline may constitute a hazard to other uses of the OCS. In the GOM, BSEE has determined that all pipelines installed in water depths <200 ft (61 m) must be buried. The purpose of these requirements is to reduce the movement of pipelines by high currents and storms, protect the pipeline from the external damage that could result from anchors and fishing gear, reduce the risk of fishing gear becoming snagged, and minimize interference with the operations of other users of the OCS. For lines $\geq 8^5/_8$ in, a waiver of the burial requirement may be requested and may be approved if the line is to be laid in an area where the character of the seafloor would allow the weight of the line to cause it to sink into the sediments (self-burial). For water depths ≤200 ft (61 m), any length of pipeline that crosses a shipping fairway or anchorage in Federal waters must be buried to a minimum depth of 10 ft (3 m) below mudline across a fairway and a minimum depth of 16 ft (5 m) below mudline across an anchorage area. Refer to **Chapter 2.3.1** for more information on the installation and removal of pipelines on the OCS.

1.3.3.4.3 Workovers Operations

Completed and producing wells may require periodic reentry that is designed to maintain or restore a desired flow rate. These procedures are referred to as a well "workover."

Workover operations are also carried out to evaluate or reevaluate a geologic formation or reservoir (including recompletion to another stratum) or to permanently abandon a part or all of a well. Workovers on subsea completions require that a rig be moved on location to provide surface support. Workovers can take from 1 day to several months to complete depending on the complexity of the operations, with a median of 7 days. Current oil-field practices include preemptive procedures or treatments that reduce the number of workovers required for each well. Based on historical data, BOEM projects that a producing well may have seven workovers or other well activities during its active lifetime (typically every 3-5 years).

1.3.3.5 Decommissioning, Abandonment, and Removal Operations

1.3.3.5.1 Well Abandonments and Suspensions

There are two types of well abandonment operations—temporary and permanent—that can occur at any of the phases of a well. For example, if an exploration well is clearly a dry hole and contains no oil or gas, the operator would typically permanently abandon the well without delay. On the other hand, an operator may temporarily abandon or "suspend" a well to (1) allow detailed analyses or additional delineation wells while deciding if a discovery is economically viable, (2) save the wellbore for a future sidetrack to a new geologic bottom-hole location, or (3) wait on design or construction of special production equipment or facilities. Abandoned wells are also sometimes converted into injection wells to store carbon dioxide (CO_2), dispose of wastewater, enhance oil production and mining, or prevent saltwater intrusion. The operator would be expected to meet specific requirements to temporarily abandon a well in accordance with BSEE regulations at 30 CFR §§ 250.1710-1717 (refer to **Chapter 5.2.8**).

Permanent abandonment operations are undertaken when a wellbore is of no further use to the operator (i.e., the well is a dry hole or the well's producible hydrocarbon resources have been depleted). During permanent abandonment, equipment is removed from the well, and specific intervals in the well that contain hydrocarbons are plugged with cement. A cement surface plug is also required for the abandoned wells. This serves as the final isolation component between the wellbore and the environment.

On occasion a mechanical failure of the tools in the well or a fracture of the drill pipe may occur. A range of "fishing" techniques and tools may be used to recover the equipment to the surface so that drilling can recommence. Should this be unsuccessful then the well may be plugged with cement, and a (mechanical) sidetrack well drilled is usually drilled from just above the plug and down to the target location (Hartley Anderson Limited 2001).

1.3.3.5.2 Structure Decommissioning and Removal Operations

During exploration, development, and production operations, the seafloor around activity sites within a proposed lease sale area becomes the repository of temporary and permanent equipment and structures. In compliance with Section 22 of BOEM's Oil and Gas Lease Form (BOEM-2005) and BSEE regulations (30 CFR § 250.1710—*Wellheads/Casings* and 30 CFR § 250.1725—*Platforms and Other Facilities*), operators need to remove seafloor obstructions from their leases within 1 year of lease termination or after a structure has been deemed obsolete or unusable. These regulations also require the operator to sever bottom-founded objects and their related components at least 5 m (15 ft) below the mudline (30 CFR § 250.1716(a)—*Wellheads/Casings* and 30 CFR § 250.1728(a)—*Platforms and Other Facilities*). Kaiser and Narra (2018) provides a robust overview of GOM oil and gas infrastructure inventories and trends, as well as a decommissioning forecast. Between 704 and 1,199 structures were forecasted to be decommissioned in shallow waters through 2027, while 27 to 51 deepwater structures were forecasted to be decommissioned through 2031 (Kaiser and Narra 2018).

The severance operations are generally categorized as explosive or nonexplosive. The structures are generally grouped into two main categories depending upon their relationship to the platform/facilities (i.e., piles, jackets, caissons, templates, mooring devises, etc.) or the well (i.e., wellheads, casings, casing stubs, etc.). A varied assortment of severing devices and methodologies has been designed to cut structural targets during decommissioning activities. These devices are generally grouped and classified as either nonexplosive or explosive, and they can be deployed and operated by divers using remotely operated vehicles, or from the surface. The severing tool that the operators and contractors use takes into consideration the target size and type, water depth, economics, environmental concerns, tool availability, and weather conditions.

Nonexplosive severing tools are used on the OCS for a wide array of structure and well decommissioning targets in all water depths. Many decommissions use both explosive and nonexplosive technologies (prearranged or as a backup method). Common nonexplosive severing tools consist of abrasive cutters (e.g., sand cutters and abrasive water jets), mechanical (carbide) cutters, diver cutting (e.g., underwater arc cutters and the oxyacetylene/oxy-hydrogen torches), and diamond wire cutters. Explosive severance tools can be deployed on almost all structural and well targets in all water depths. The BSEE expects explosive severing methods to be used in at least 63 percent of all removals for the foreseeable future (NMFS 2020b), often as a back-up cutter when other methodologies prove unsuccessful. Explosives work to sever their targets by using (1) mechanical distortion (ripping), (2) high-velocity jet cutting, and (3) fracturing or "spalling."

1.3.3.5.3 Other Appurtenances

Federal regulations require that offshore leases be cleared of all structures within 1 year after production on the lease ceases, but a producing lease can hold infrastructure idle for as long as the lease is producing (30 CFR § 250.112). While production structures are removed, many appurtenances or types of equipment (e.g., subsea systems, pipelines, umbilical lines, etc.) would not be removed from the seafloor (i.e. decommissioned in place), as allowed under certain conditions in 30 CFR part 250 and which typically includes additional NEPA review by BOEM (refer to **Chapter 5**).

CHAPTER 2

ISSUES AND IMPACT-PRODUCING FACTORS

What is in This Chapter?

- A description of the OCS oil- and gas-related and non-OCS oil- and gas-related activities, and resulting impact-producing factors (IPFs) that could potentially affect the physical, biological, and human environment.
- The IPFs are grouped into the following "issue" categories:
  - Air Emissions and Pollution (**Chapter 2.1**);
  - Discharges and Wastes (**Chapter 2.2**);
  - Bottom Disturbance (**Chapter 2.3**);
  - Noise (**Chapter 2.4**);
  - Coastal Land Use/Modification (**Chapter 2.5**);
  - Lighting and Visual Impacts (**Chapter 2.6**);
  - Offshore Habitat Modification/Space Use (**Chapter 2.7**);
  - Socioeconomic Changes and Drivers (**Chapter 2.8**); and
  - Accidental OCS Oil- and Gas-Related Events (**Chapter 2.9**).

Key Points

- Each IPF category could occur during any phase of oil and gas development described in **Chapter 1.3.3**; and both OCS oil- and gas-related and non-OCS oil- and gas-related activities can contribute to one or multiple IPF categories.
- The IPFs described in this chapter are derived from historical information and trends; however, specific scenario estimates regarding future OCS exploration, development, and production activities is NOT included.
- Programmatic issues and processes (e.g., climate change) and their influence on the various IPF categories are acknowledged throughout this chapter and are described in greater detail in **Chapter 3**, which describes the regional setting of the GOM.

2 ISSUES AND IMPACT-PRODUCING FACTORS

2.0 IMPACT-PRODUCING FACTORS AND CONTRIBUTING ACTIVITIES OR PROCESSES

BOEM's interdisciplinary team of subject-matter experts apply knowledge and experience to develop cause and effect relationships between the categories of impact-producing factors described below and a wide variety of physical, biological, cultural, and socioeconomic resources in the OCS and adjacent coastal areas addressed in **Chapter 4**.

This document considers past, ongoing, and assumed future activities, including the estimated amounts, timing, and potential locations of OCS exploration, development, and production activities and facilities. This assessment does not utilize more specific information attained from modeling exploration and development scenarios. It also does not estimate impact levels (e.g., the context and intensity) of any effects from potential future OCS oil and gas leasing and related activities. These levels would be defined and considered in more detail in future NEPA analyses for oil and gas leasing in the GOM, which would incorporate this document as an initial screening tool. There are, however, general impact-producing factors typical of offshore oil and gas that manifest regardless of activity levels and where such activity occurs. This document aims to disclose and screen those potential effects, as well as potential effects from other past, present, or future activities in or near the Gulf of Mexico OCS, in order to better inform the issues and resources that should be analyzed further in any future NEPA analysis, consultation, or other environmental assessments associated with oil and gas leasing and development.

2.0.1 Impact-Producing Factor Definitions and Categories

An impact-producing factor (IPF) is the outcome or result of any proposed activities with the potential to positively or negataively affect physical, biological, cultural, and/or socioeconomic resources. These IPFs are grouped into "issue" categories based on BOEM's internal scoping and consideration of the extensive history of public input received through previous and ongoing assessments and outreach efforts. Both OCS and non-OCS oil- and gas-related activities can contribute to one or multiple IPF categories.

BOEM currently has a mature and active OCS oil and gas program in the GOM and has analyzed the potential impacts from OCS oil- and gas-related activity for over 40 years. To develop this document, BOEM identified activities that commonly occur as a result of oil and gas exploration, development, production, and decommissioning on the Gulf of Mexico OCS as discussed in **Chapter 1.3.3**. BOEM's subject-matter experts then identified the IPFs associated with those activities by analyzing past environmental impact analyses and studies. This effort yielded a large list of IPFs that could affect the environment. BOEM also analyzed the input received from years of public participation. Based on these efforts, BOEM decided to group related IPFs to more meaningfully discuss the potential effects of OCS oil- and gas-related activity. The activities and associated potential effects or interactions with the human environment described in this document are applicable to oil and gas activities resulting from a single lease sale, as well as activities resulting from BOEM's cumulative OCS oil and gas program (i.e., past or other future lease sales in the GOM).

Existing or potential future activities or stressors not related to OCS oil and gas development, but which are also IPFs, were also identified and discussed within the "Non-OCS Oil- and Gas-Related Activities" subsection of each IPF category as well. These IPFs were also identified and categorized in the same manner as the oil- and gas-related IPFs. BOEM will evaluate the estimated context and intensity of any potential effects from a proposed lease sale (i.e., incremental effects) while taking into consideration the cumulative effects of the OCS Oil and Gas Program and other activities not related to OCS oil and gas development in future NEPA analyses for proposed lease sales. Future NEPA analyses can incorporate this document to refine the factors that should be focused on in greater detail and those that could be screened from in-depth analysis.

2.0.1.1 Impact-Producing Factor Categories

The following IPF categories were identified:

- **air emissions and pollution** associated with offshore and onshore activity (**Chapter 2.1**);
- **discharges and wastes** associated with offshore and onshore activity (**Chapter 2.2**);
- **bottom disturbance** associated with drilling, infrastructure emplacement, and removal (**Chapter 2.3**);
- **noise** from G&G surveys, ship and aircraft traffic, drilling and production operations, trenching, construction, and decommissioning (**Chapter 2.4**);
- **coastal land use/modification** associated with infrastructure emplacement and vessel traffic (**Chapter 2.5**);
- **lighting and visual impacts** of the physical presence of infrastructure and vessel and aircraft traffic (**Chapter 2.6**);
- **offshore habitat modification/space use** associated with infrastructure emplacement and removal and multiple-use areas on the seabed, in the water column, at the sea surface, or in the airspace (**Chapter 2.7**);
- **socioeconomic changes and drivers** associated with variables like job loss and creation, public perceptions, etc. (**Chapter 2.8**); and
- **accidental events** that include oil spills, chemical spills, pipeline failures, losses of well control, accidental air emissions, hydrogen sulfide and sulfurous petroleum releases, trash and debris, spill response associated with unintended releases, and collisions and strikes (**Chapter 2.9**).

Each IPF category could occur during any phase of oil and gas development described in **Chapter 1.3.3**.

OCS Oil- and Gas-Related Activities. The operations are broken down by phase and include exploration, development, oil or gas production and transport, and decommissioning as discussed in **Chapter 1.3.3**. These activity descriptions would apply to past, present, and any future OCS oil- and gas-related activities.

Non-OCS Oil- and Gas-Related Activities. Non-OCS oil- and gas-related past, present, and reasonably foreseeable cumulative activities occurring within the same geographic range and timeframes as the aforementioned OCS oil and gas activities and potential accidental events. *These other activities are those that are considered independent of OCS oil and gas leasing and reasonably expected regardless of whether OCS oil and gas leasing and associated activities occur*. BOEM attempted to include all reasonably foreseeable future activities regardless of what agency (Federal or non-Federal) or person undertakes such activities. These other related stressors or activities are described within each IPF category under the subheading "Non-OCS Oil- and Gas-Related Activities."

Accidental OCS Oil- and Gas-Related Events. Historically, accidents have occurred as a result of oil and gas activities and, therefore, potential for accidents in the future continue to exist. Types of accidental events include releases into the environment (e.g., oil spills, loss of well control, accidental air emissions, pipeline failures, and chemical and drilling fluid spills), spill-response activities, and collisions or vessel strikes (e.g., vessel to vessel and vessel striking a marine mammal). Reasonably foreseeable accidental events associated with OCS oil and gas development are discussed in **Chapter 2.9**.

2.1 AIR EMISSIONS AND POLLUTION

Criteria Air Pollutants and Other Air Pollutants

The Clean Air Act (CAA) Amendments of 1990, require the U.S. Environmental Protection Agency (USEPA) to set the National Ambient Air Quality Standards (NAAQS) for six common air pollutants of concern called "criteria air pollutants." The USEPA identified the following criteria air pollutants: carbon monoxide (CO); lead (Pb); ozone (O_3); nitrogen dioxide (NO_2); particulate matter (PM); and sulfur dioxide (SO_2). For PM, particulate matter 10 micrometers or less in aerodynamic diameter (PM_{10}) and particulate matter 2.5 micrometers or less in aerodynamic diameter ($PM_{2.5}$) are of most concern for health reasons as they can transport over long distances and can be inhaled into the lungs (USEPA 2019b).

There are numerous air pollutants; however, nitrogen oxides (NO_x), sulfur oxides (SO_x), PM, Pb, CO, volatile organic compounds (VOCs), and ammonia (NH_3) contribute, whether directly or through chemical reactions, to increased levels of the NAAQS criteria air pollutants and are commonly controlled through laws and regulations. For more information on laws and regulations pertaining to OCS air emissions, refer to BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) and **Chapter 5.6**. Other air pollutants of concern that are discussed and their emission amounts estimated in this chapter, where possible, include hazardous air pollutants (HAPs) and greenhouse gases (GHGs). For more information on the potential effects associated with these air pollutants, refer to **Chapter 4.1**.

2.1.1 OCS Oil- and Gas-Related Activities

The activities associated with OCS oil and gas leasing could potentially affect air quality include (1) use of G&G survey vessels, (2) use of drilling and production and associated vessels, (3) use of support helicopters, (4) pipelaying operations, (5) flaring and venting, and (6) decommissioning of facilities and pipelines. These routine activities result in air pollutant emissions. Emissions of air pollutants from these activities would occur during exploration, development, production, installation, and decommissioning activities. **Table 2.1.1-1** lists the phase types and related equipment that are sources of emissions. For more information on how air emissions from OCS oil- and gas-related activities are regulated, refer to **Chapter 5.6**.

Table 2.1.1-1. Sources of Emissions from OCS Oil- and Gas-Related Activities.

Phase Type	Source Type of Emissions	Potential Air Pollutants
Geological and Geophysical Surveys (including ancillary activities)	Diesel or gasoline engines	PM, CO, SO_2, NO_x, NH_3, VOCs, Pb, GHGs, and some HAPs
Exploration	Diesel or gasoline engines; fugitives (i.e., leaks from equipment components); losses from flashing (i.e., unrecovered gas); mud degassing; natural gas engines; natural gas, diesel, or dual fuel turbines; pneumatic controllers; and pneumatic pumps	PM, CO, SO_2, NO_x, NH_3, VOCs, Pb, GHGs, and some HAPs
Development	Diesel or gasoline engines; fugitives (i.e., leaks from equipment components); losses from flashing (i.e., unrecovered gas); mud degassing; natural gas engines; natural gas, diesel, or dual fuel turbines; pneumatic controllers; and pneumatic pumps	PM, CO, SO_2, NO_x, NH_3, VOCs, Pb, GHGs, and some HAPs
Production	Diesel or gasoline engines; fugitives (i.e., leaks from equipment components); losses from flashing (i.e., unrecovered gas); mud degassing; natural gas engines; natural gas, diesel, or dual fuel turbines; pneumatic controllers; pneumatic pumps; amine units; boilers/heaters/burners; cold vents; glycol dehydrator units; loading operations (i.e., losses of vapors from tanks); and storage tanks	PM, CO, SO_2, NO_x, NH_3, VOCs, Pb, GHGs, and some HAPs
Decommissioning, Abandonment, and Removal Operations	Diesel or gasoline engines	PM, CO, SO_2, NO_x, NH_3, VOCs, Pb, GHGs, and some HAPs

2.1.1.1 Emissions Estimates from OCS Oil- and Gas-Related Sources

The *Year 2017 Emissions Inventory Study* used activity data and USEPA-approved emission factors compiled in USEPA's AP-42, "Fifth Edition Compilation of Air Pollutant Emissions Factors," to calculate emissions (USEPA 2020b). An emission factor is "a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant" (RTI International 2007). Uncertainties associated with emission inventories could arise due to facilities that did not report (Wilson et al. 2019a) emission factors.

Wilson et al. (2019a) reported OCS oil and gas source emissions per air pollutant listed in **Table 2.1.1-2**. The highest criteria air pollutant (CAP) and criteria precursor air pollutant (CPAP) emissions were reported from natural gas engines and support vessels, while the lowest CAP and CPAP emissions were reported from diesel and gasoline engines used for drilling, combustion flares, and mud degassing. Overall, the OCS oil- and gas-related CAP and CPAP emissions (except for Pb and NH_3, which are unknown) reported in year 2017 decreased in comparison with year 2014 and 2011 emission inventories (Wilson et al. 2019a).

Overall, the OCS oil- and gas-related CAP and CPAP emissions reported in 2017 decreased from year 2014 and 2011 emission inventories.

In addition to CAPs and CPAPs, there are 187 HAPs that could cause cancer or other adverse human health effects (USEPA 2020k). Of those 187 HAPs, 28 were identified as being emitted by offshore sources (Wilson et al. 2019a). The highest HAP emissions were reported from OCS oil and gas support vessels and glycol dehydrators, while the lowest HAP emissions were reported from helicopters, boilers, and pneumatic pumps (Wilson et al. 2019a).

The three major GHG air pollutants include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The highest GHG emissions were reported from natural gas, diesel, and duel-fuel turbines; cold vents; and support vessels, while the lowest GHG emissions were reported from mud degassing and amine units (Wilson et al. 2019a). The OCS oil and gas GHG emissions reported in year 2017 for CO_2, CH_4, and N_2O decreased in comparison with year 2014 and 2011 emission inventories.

Table 2.1.1-2. Air Emissions from OCS Oil and Gas Sources in 2017 (Wilson et al. 2019a).

Air Pollutant Type	Air Pollutant	Total Amount (tons per year) of OCS Oil and Gas Sources*
CAP	CO	59,435.0000
CAP	Pb	0.1518
CAP/CPAP	NO_x	84,266.0000
CAP	PM_{10}	1,706.0000
CAP	$PM_{2.5}$	1,656.0000
CPAP	NH_3	19.0000
CAP	SO_2	1,410.0000
CPAP	VOC	39,886.0000
HAP	2,2,4-Trimethylpentane	9.8302
HAP	Acenaphthene	0.0103
HAP	Acenaphthylene	0.0158
HAP	Acetaldehyde	182.9700
HAP	Anthracene	0.0158
HAP	Arsenic	0.0320
HAP	Benz(a)anthracene	0.0171
HAP	Benzene	233.4850
HAP	Benzo(a)pyrene	0.0031

Air Pollutant Type	Air Pollutant	Total Amount (tons per year) of OCS Oil and Gas Sources*
HAP	Benzo(b)fluoranthene	0.0062
HAP	Benzo(g,h,l)perylene	0.0039
HAP	Benzo(k)fluoranthene	0.0031
HAP	Beryllium	0.0002
HAP	Cadmium	0.2444
HAP	Chromium	0.5134
HAP	Chrysene	0.0030
HAP	Ethylbenzene	18.9490
HAP	Fluoranthene	0.0094
HAP	Fluorene	0.0210
HAP	Formaldehyde	764.6400
HAP	Indeno(1,2,3-c,d)pyrene	0.0062
HAP	Naphthalene	1.0300
HAP	Hexane	767.9900
HAP	Mercury	0.2301
HAP	Phenanthrene	0.0240
HAP	Pyrene	0.0167
HAP	Toluene	228.1820
HAP	Xylenes	104.1020
GHG	CO_2	10,091,006.0000
GHG	CH_4	187,910.0000
GHG	N_2O	303.0000

*short tons
CAP = criteria air pollutant, CPAP = criteria precursor air pollutant, HAP = hazardous air pollutant, and GHG = greenhouse gas

2.1.2 Non-OCS Oil- and Gas-Related Activities Causing Air Emissions and Pollution

This chapter discusses and provides emission estimates for natural and anthropogenic sources that are not associated with OCS oil- and gas-related activities. These sources are divided and analyzed based on their occurrence offshore or onshore.

2.1.2.1 Offshore Non-OCS Oil- and Gas-Related Sources

Offshore sources of air pollution not related to OCS oil and gas activities that cause degradation to the air quality come from natural (biogenic and geogenic) and anthropogenic sources. Natural offshore sources include, but are not limited to, lightning, sea salt, bacterial processes, and natural oil seeps. Anthropogenic offshore sources include, but are not limited to, commercial vessels (including cruise ships and lightering services), military vessels and aircraft, commercial and recreational fishing vessels, and the Louisiana Offshore Oil Port (LOOP).

The most recent *Year 2017 Emissions Inventory Study* reported offshore non-OCS oil and gas source emissions per air pollutant listed in **Table 2.1.2-1** (Wilson et al. 2019a). The offshore non-OCS oil and gas source that contributes the most CAP and CPAP emissions was reported from commercial marine vessels. The offshore non-OCS oil and gas sources with the lowest CAP and CPAP emissions included military vessels and biogenic/geogenic sources. Other air pollutants of concern from offshore non-OCS oil and gas sources include HAPs and GHGs. The offshore non-OCS oil and gas source with the highest levels of HAP emissions was commercial marine vessels. The offshore non-OCS oil and gas sources with the lowest or no HAP emissions included commercial and recreational fishing, U.S. Coast Guard (USCG) activities, and biogenic/geogenic sources. The offshore non-OCS oil and gas sources with the highest levels of GHG emissions were commercial marine vessels and natural (biogenic and geogenic) sources. The offshore non-OCS oil and gas sources with the lowest levels of GHG emissions were commercial and recreational fishing, and USCG activites (Wilson et al. 2019a).

Table 2.1.2-1. Air Emissions from Offshore Non-OCS Oil- and Gas-Related Sources in 2017 (Wilson et al. 2019a).

Air Pollutant Type	Air Pollutant	Total Amount (tons per year) from Offshore Non-OCS Oil and Gas Sources*
CAP	CO	20,418.000
CAP	Pb	0.456
CAP/CPAP	NO_x	164,681.000
CAP	PM_{10}	3,087.000
CAP	$PM_{2.5}$	2,867.000
CPAP	NH_3	48.000
CAP	SO_2	5,281.000
CPAP	VOC	27,612.000
HAP	2,2,4-Trimethylpentane	1.680
HAP	Acenaphthene	0.010
HAP	Acenaphthylene	0.020
HAP	Acetaldehyde	130.870
HAP	Anthracene	0.020
HAP	Arsenic	0.280
HAP	Benz(a)anthracene	0.020
HAP	Benzene	35.640
HAP	Benzo(a)pyrene	0.010
HAP	Benzo(b)fluoranthene	0.010
HAP	Benzo(g,h,l)perylene	0.010
HAP	Benzo(k)fluoranthene	0.010
HAP	Beryllium	0.001
HAP	Cadmium	0.020
HAP	Chromium	0.380
HAP	Chrysene	0.004
HAP	Ethylbenzene	8.430
HAP	Fluoranthene	0.010
HAP	Fluorene	0.030
HAP	Formaldehyde	267.550

Air Pollutant Type	Air Pollutant	Total Amount (tons per year) from Offshore Non-OCS Oil and Gas Sources*
HAP	Indeno(1,2,3-c,d)pyrene	0.010
HAP	Naphthalene	0.830
HAP	Hexane	23.170
HAP	Mercury	0.000
HAP	Phenanthrene	0.030
HAP	Pyrene	0.020
HAP	Toluene	13.480
HAP	Xylenes	20.220
GHG	CO_2	9,943,805.000
GHG	CH_4	1,940.000
GHG	N_2O	2,466.000

*short tons
CAP = criteria air pollutant, CPAP = criteria precursor air pollutant, HAP = hazardous air pollutant, and GHG = greenhouse gas

2.1.2.2 Onshore Non-OCS Oil- and Gas-Related Sources

Onshore sources of air pollution from non-OCS oil- and gas-related activities include power generation, industrial processing, manufacturing, refineries, waste disposal, pesticides, fertilizers, commercial and home heating, and motor vehicles. Natural sources include, but are not limited to, lightning, volcanos, pollen, dust, and other biogenic and geogenic sources.

The most recent year 2017 national emissions inventory (USEPA 2020a) reported the Gulf Coast States' (i.e., Alabama, Florida, Louisiana, Mississippi, and Texas) onshore source emissions per air pollutant (**Table 2.1.2-2**). The onshore sources that contribute the most CAP and CPAP emissions were reported from on-road light-duty vehicles, diesel heavy-duty vehicles, aircraft, road dust, biomass activities, vegetation and soil, livestock waste, fertilizer, and coal combustion. The onshore sources with the lowest CAP and CPAP emissions were fuel combustion from natural gas, wildfires, and solvents. Overall, the onshore CAP and CPAP emissions for the Gulf Coast States reported in year 2017 decreased in comparison with year 2014.

Other air pollutants of concern from onshore sources can also include HAPs and GHGs. Of the 187 HAPs, 28 were reported (**Table 2.1.2-2**) to be consistent with the HAPs reported from offshore sources. The onshore sources with most HAP emissions were wildfires, electricity generation, on-road light-duty vehicles, industrial processes, and vegetation and soil. The onshore sources with the lowest HAP emissions were industrial pulp and paper processes, and solvents. Overall, the onshore HAP emissions for the Gulf Coast States reported in year 2017 decreased in comparison with year 2014. The onshore sources with the most GHG emissions were reported from industrial processes (e.g., power plants, waste, and chemical processes), on-road light-duty vehicles, and diesel heavy-duty vehicles. The onshore sources with the lowest GHG emissions included solvents and industrial biomass and natural gas boilers. Overall, the onshore GHG emissions for the Gulf Coast States reported in year 2017 increased in comparison with year 2014.

Table 2.1.2-2. Air Emissions from Onshore Sources of the Five Gulf Coast States in 2017 (database query of the 2017 National Emissions Inventory) (USEPA 2020a).

Air Pollutant Type	Air Pollutant	Total Amount (tons per year) from Onshore Sources*
CAP	CO	11,501,737.00
CAP	Pb	110.00
CAP/CPAP	NO_x	2,420,897.00
CAP	PM_{10}	2,878,592.00
CAP	$PM_{2.5}$	852,146.00
CPAP	NH_3	670,723.00
CAP	SO_2	691,774.00
CPAP	VOC	10,158,903.00
HAP	2,2,4-Trimethylpentane	24,475.27
HAP	Acenaphthene	38.68
HAP	Acenaphthylene	124.62
HAP	Acetaldehyde	131,240.38
HAP	Anthracene	97.42
HAP	Arsenic	8.18
HAP	Benz(a)anthracene	94.73
HAP	Benzene	35,006.12
HAP	Benzo(a)pyrene	29.83
HAP	Benzo(b)fluoranthene	6.53
HAP	Benzo(g,h,l)perylene	89.86
HAP	Benzo(k)fluoranthene	40.25
HAP	Beryllium	1.66
HAP	Cadmium	5.26
HAP	Chromium	40.74
HAP	Chrysene	92.83
HAP	Ethylbenzene	11,158.63
HAP	Fluoranthene	141.24
HAP	Fluorene	86.93
HAP	Formaldehyde	206,447.00
HAP	Indeno(1,2,3-c,d)pyrene	53.98
HAP	Naphthalene	8,407.94
HAP	Hexane	23,712.05
HAP	Mercury	6.82
HAP	Phenanthrene	314.03
HAP	Pyrene	209.96
HAP	Toluene	78,421.47
HAP	Xylenes	45,744.29
GHG	CO_2	1,440,338,474.00
GHG	CH_4	1,460,404.00
GHG	N_2O	63,779.00

*short tons

CAP = criteria air pollutant, CPAP = criteria precursor air pollutant, HAP = hazardous air pollutant, GHG = greenhouse gas

2.2 DISCHARGES AND WASTES

2.2.1 OCS Oil- and Gas-Related Activities

This chapter focuses on the routine wastes and discharges that are permitted or regulated by BOEM, BSEE, and/or other Federal and State agencies. Water pollution associated with oil and gas activities in the Gulf of Mexico is permitted by the USEPA through the issuance of NPDES general permits under the Clean Water Act (CWA). Refer to **Chapter 5.11** and BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for more information about the CWA and BOEM and BSEE's permitting and approval processes pertaining to water quality and OCS oil- and gas-related discharges and wastes.

Accidental oil spills and other types of unintended releases that can occur as a result of existing or future oil and gas operations in the GOM are addressed separately in **Chapter 2.9**. The primary operational wastes and discharges generated during offshore oil and gas exploration and development are drilling fluids, drill cuttings, various waters (e.g., bilge, ballast, fire, and cooling), deck drainage, sanitary wastes, and domestic wastes. During production activities, additional waste streams include produced water, produced sand, and 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, several fluids used in subsea production, and uncontaminated freshwater and salt water.

2.2.1.1 Drilling Muds and Cuttings

Drilling fluids (also known as drilling muds) and cuttings represent a large quantity of the discharge generated by drilling operations. Drilling fluids are used in rotary drilling to remove cuttings from beneath the bit, control well pressure, cool and lubricate the drill string and its bit, and seal the well. Drill cuttings are the fragments of rock generated during drilling and carried to the surface with the drilling fluid. Drilling discharges of muds and cuttings are regulated by the USEPA through the NPDES permitting process.

Types of Drilling Muds and Discharge Rules

Drill fluids begin with a base fluid. The base fluids used on the OCS are divided into two categories: water based and nonaqueous based. Water-based fluids (WBFs) have a water-soluble continuous phase while nonaqueous-based fluids have a continuous phase that is not soluble in water. In WBFs the base fluid can be freshwater or saltwater. In nonaqueous-based fluids, the base fluid can be mineral oil or diesel oil (OBFs) or a synthetic oil (SBFs). Clays, barite, and other chemicals are added to the base fluid to improve the performance of the drilling fluid (Boehm et al. 2001a).

On the OCS, the WBFs have been used for decades in drilling and are the most commonly used drilling fluids for exploration and production wells. The discharge of WBFs and cuttings associated with WBFs is allowed on the OCS under the general NPDES permits issued by USEPA Regions 4 and 6 as long as the discharge meets the conditions required in the permit. Discharge of WBFs results in increased turbidity in the water column, alteration of sediment characteristics because of coarse material in cuttings, and the input of trace metal into the environment. Occasionally, formation oil may be discharged with the cuttings, adding hydrocarbons to the discharge. However, as noted in the NPDES permits, no free oil shall be discharged; static sheen tests must be performed once per week when discharging. In shallow environments, WBFs are rapidly dispersed in the water column immediately after discharge and rapidly descend to the seafloor (Neff 1987). In deep waters, fluids dispersed near the water surface would disperse over a wider area than fluids dispersed in shallow waters.

The OBFs were first developed as nonaqueous drilling fluids. They were occasionally used for directional drilling and in drill-bore sections where additional lubricity was needed. Crude, diesel, and mineral oil were used. Diesel OBFs contain light aromatics such as benzene, toluene, and xylene. Mineral oil is advantageous over diesel because it is less toxic. Hydrocarbon concentration and impacts to benthic community diversity and abundance have been observed within 200 m (656 ft) of the drill site with diminishing impacts measured to a distance of 2,000 m (6,562 ft) (Neff 1987). Due to the environmental concerns of OBFs, SBFs were created in the 1990s (Bakhtyar and Gagnon 2012). The OBFs are now used sparingly because of the many advantages of SBFs. If used, all OBFs and associated cuttings must be transported to shore for recycling or disposal unless reinjected.

The SBFs are composed of manufactured hydrocarbons. The SBF mud system also contains additives such as emulsifiers, clays, wetting agents, thinners, and barite. Since the SBFs are not petroleum based, they do not contain the aromatic hydrocarbons and polycyclic aromatic hydrocarbons that contributed to OBF toxicity and persistence on the seafloor (Bakhtyar and Gagnon 2012). In fact, SBFs have several additional advantages over OBFs, which include that they are well characterized, have lower toxicity and bioaccumulation potentials, and biodegrade faster. Since 1992, SBFs have been increasingly used, especially in deep water, because they perform better than WBFs and OBFs. The SBFs reduce drilling times and costs incurred from expensive drilling rigs. By 1999, about 75 percent of all wells drilled in water depths greater than 305 m (1,000 ft) were drilled with SBFs in the GOM (Continental Shelf Associates Inc. 2004a). Although there are many types of SBFs, esters, internal olefins, and linear alpha olefins are most commonly used in the GOM.

The discharge of the base SBF drilling fluid is prohibited. 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 polycyclic aromatic hydrocarbons.

A literature review discussed knowledge about the fate and effects of SBF discharges on the seabed (Neff et al. 2000). Like OBFs, the SBFs are hydrophobic, meaning they are not soluble in the water column and therefore are not expected to adversely affect water quality. The SBF-wetted cuttings settle close to the discharge point and affect the local sediments. Cuttings piles with a maximum depth of 8-10 in (20-25 cm) were noted in a seabed study of shelf and slope locations where cuttings drilled with SBF were discharged. The SBF discharge can alter sediment grain size and add organic matter, which can result in localized anoxia while SBF degrades (Melton et al. 2004). Different formulations of SBFs use base fluids that degrade at different rates, thus affecting the duration of the impact. Esters and olefins are the most rapidly biodegraded SBFs. Ongoing research is aimed at understanding the relationships between the chemical structure in SBFs and the environmental fates and effects, which would provide the design basis for fluids with better environmental performance. For example, testing showed that less branching of alpha and internal olefins positively impacted both sediment toxicity and anaerobic biodegradation (Dorn et al. 2011).

Bioaccumulation tests indicate that SBFs and their degradation products should not bioaccumulate (Neff et al. 2000). In a study to measure degradation rates of SBFs on the seafloor, biodegradation proceeded after a lag period of up to 28 weeks, which was influenced by both the SBF type and prior exposure of the sediments to SBFs (Roberts and Nguyen 2006). Sediment sulfate depletion due to microbial activity coincided with SBF degradation. Decreased SBF concentrations indicated that recovery in sediments occurred in the year between sample collections. Deposited cuttings and measurable sediment effects indicative of organic enrichment were concentrated within a distance of 250 m (820 ft) in both shelf and slope sites (Continental Shelf Associates Inc. 2004a).

Typically, the upper portion of the well is drilled with WBF and the remainder is drilled with SBF. The upper sections would be drilled with a large diameter bit; progressively smaller drill bits are used with increasing depth. Therefore, the volume of cuttings per interval (length of wellbore) in the upper section of the well would be greater than the volume generated in the deeper sections.

Barite

Barite, a barium sulfate mineral, is used as a weighting agent to increase the hydrostatic pressure of drilling muds in order to control high-pressure zones encountered during drilling. Because barite is also soft, it does not erode equipment but instead acts essentially as a lubricant (Mills 2006). Additionally, barite is inert and does not react with other additives in the drilling fluid. Because of barite's useful qualities, barite is a major component of all types of drilling fluid, but its use has somewhat declined due to advances in synthetic-based mud formulations and drilling technology. A study of 81 wells noted that, from 1998 to 2002, the quantity of barite discharged for a shallow well (2,936 m; 9,634 ft average) to a deep well (5,140 m; 16,864 ft average) is 110 tons barite per well and 586 tons barite per well, respectively (Candler and Primeaux 2003).

Since barite is a natural mineral, it can have natural impurities associated with it. The impurities of concern in barite are trace metals such as mercury (Hg), cadmium (Cd), copper (Cu), zinc (Zn), and lead (Pb) that are often found in other mineral phases that were formed on or in the barite mineral deposit (Crecelius et al. 2007). However, the American Petroleum Institute (API) has set specifications for the barite used in the oil industry, which includes that the amount of water-soluble alkaline earth metals must be below 250 milligrams/kilogram (parts per million [ppm]) (Mills 2006). More importantly, since 1993, the USEPA has required the concentrations of Hg and Cd to be less than or equal to 1 ppm and 3 ppm, respectively, in the stock barite used to make up drilling muds (USEPA 1993; 2000b). Through Hg and Cd regulation, the USEPA can also control levels of other trace metals in barite. This may reduce the addition of Hg to sediments to values similar to the concentration of Hg found in marine sediments throughout the Gulf of Mexico OCS (Neff 2002).

Despite atmospheric Hg deposition being considered the main source of anthropogenic Hg inputs into the marine environment, the availability of Hg in barite was studied to confirm that barite in drilling muds was not a significant or available source of Hg in the marine environment (Crecelius et al. 2007). Furthermore, barite is nearly insoluble in seawater, which means that it remains in the solid form where it is not readily available to biota unless the mineral particles themselves are directly digested.

In addition to laboratory studies, field studies have also been conducted to examine the role that barite plays in sediment Hg levels. Concentrations of total mercury in uncontaminated estuarine and marine sediments generally are 0.2 micrograms/gram dry weight or lower. Surface sediments collected 20-2,000 m (66-6,562 ft) away from four oil production platforms in the northwestern GOM contained 0.044-0.12 micrograms/gram total mercury. These amounts are essentially background concentrations for mercury in surficial sediments on the Gulf of Mexico OCS (Neff 2002). A comparative study of surface and subsurface sediment samples from six offshore drill locations showed higher levels of total mercury found in the sediments closest to the drilling sites as compared with the sites >3 km (1.9 mi) distant. Higher total mercury concentrations corresponded to higher barium concentrations also present. Higher total mercury levels in nearfield sediments, however, did not translate to higher methylmercury concentration in those sediments, with a few exceptions (Trefry et al. 2007). Methylmercury, once produced, disperses to pelagic organisms very quickly and is more likely to bioaccumulate and be ingested by humans who consume these pelagic organisms (Hong et al. 2012). Sediment redox conditions and organic content influence methylmercury formation. These results indicate that elevated methylmercury concentrations in sediments around drilling sites do not occur commonly in the Gulf of Mexico (Trefry et al. 2007).

Additionally, Crecelius et al. (2007) confirmed that trace metal contaminants in barite were in sulfide mineral inclusions dispersed within the barite matrix. In seawater with a pH of 7.3 to 8.3 over the period of 1 week, <1 percent of the Cu and Pb, 3 percent of the Zn, and 15 percent of the Cd dissolved from the inclusions within the barite. Thus, a small amount of these metals are soluble in seawater at this pH range. Since low-metal barite (barite that meets current USEPA standards) releases little of these metals to seawater, low-metal barite is not likely to cause environmental effects to organisms living in the water column.

2.2.1.2 Production-Treating Chemicals

Several chemicals, serving various functions, are used in offshore oil and gas production systems and pipelines. Production-treating chemicals can be classified into 14 functional categories. **Table 2.2.1-1** lists these categories, describes the function of each, and shows some of the generic types of chemical used in each.

Table 2.2.1-1. Production-treating Chemicals: Codes, Functional Categories, Descriptions, and Material Types.

Code	Functional Category	Description	Material Types Used
P-B	Biocides	Chemicals used to control the growth of bacteria that can generate hydrogen sulfide and cause corrosion and bacteria that produce slime and biomass	Quaternary amine salt and amine acetate, aldehydes, THPS, sodium hypochlorite
P-CI	Corrosion inhibitors	Used to prevent or minimize internal corrosion in offshore production systems	Amides/Imidazolines, amines and amine salts, quaternary ammonium salts, nitrogen heterocyclics
P-SI	Scale inhibitors	Used to prevent water-formed scales (calcium carbonate, barium sulfate, and strontium sulfate)	Phosphate esters, phosphonates, polymers
P-EB	Emulsion breakers	Used to destabilize water in oil emulsions to make oil saleable.	Oxyalkylated resins, polyglycol esters, alkyl aryl sulfonates
P-RB	Reverse breakers	Used to de-stabilize oil in water dispersions and facilitate gravity separation. Used to reduce the interface tension, allowing the oil droplets to coalesce into large drops.	Polyamines, polyamine quaternary compounds
P-A	Antifoams	Used to de-stabilize foam in the separation of gas and liquids in separators. Used to reduce foaming of water during de-oxygenation for waterfloods.	Silicones, polyglycol esters
P-CF	Coagulants, flocculants	Used to make small solids agglomerate so that they can be separated by filtration or flotation. Applied to the removal of solids from injection water and to improve oil removal for overboard discharge.	Aluminum sulfate, other metal compounds, polymeric amides
P-S	Surfactants	Used to remove small amounts of oil or grease from the platform and/or equipment.	Alkyl aryl sulfonates, ethoxylated alkyl phenols
P-TC	Paraffin treating chemicals	Used to prevent solid organic deposits from depositing on the walls of the piping and equipment. Also includes solvents for removing such deposits.	Hydrocarbon polymers, solvents
P-SA	Solvents and additives	Used as carriers in the various chemical formulations. Hydrocarbon solvents are used for those chemicals meant to reach the oil phase. Alcohols and glycols are used as mutual solvents in both water-soluble and oil-soluble formulations.	Naphtha, light aromatic naphtha, heavy aromatic naphtha, kerosene, ethylene glycol, other low molecular weight glycols, methanol, isopropanol
P-OS	Oxygen scavengers	Used to remove oxygen from waterflood water.	Sodium bisulfite, ammonium bisulfite
P-HIC	Hydrate inhibition chemicals	Used to control the formation of gas hydrates in gathering piping systems.	Methanol, ethylene glycol
P-DC	Dehydration chemicals	Used to remove water vapor from natural gas.	Triethylene glycol
P-SC	Sweetening chemicals	Used to remove carbon dioxide and hydrogen sulfide from natural gas.	Proprietary products; the most common systems are monoethanolamine (MEA) or diethanolamine (DEA)

2.2.1.3 Produced Waters

Produced water is brought up from the hydrocarbon-bearing strata along with produced oil and gas. It is the largest volume waste stream from oil and gas production. This waste stream can include formation water; injection water; well-treatment, completion, and workover compounds added downhole (including flowback water); and compounds used during the oil and water separation process. Formation water (brine) originates in the permeable sedimentary rock strata and is brought up to the surface commingled with the oil and gas. Injection water is water that was injected to enhance oil production and is used in secondary oil recovery. Flowback fluid (or water) is fluid that has been returned uphole after being injected into the formation for stimulation purposes. This includes water and chemicals used for hydraulic fracturing practices, as that would be considered a stimulation practice.

In addition to the added chemical products, produced water contains chemicals that have dissolved into the water from the geological formation where the water was stored. The amount of dissolved solids can be more concentrated than is found in seawater. Produced water may contain inorganic and organic chemicals and radionuclides known as technologically enhanced naturally occurring radioactive materials (226Ra and 228Ra). The composition of the discharge can vary greatly in the amounts of organic, inorganic, and radioactive compounds.

Produced-Water Discharge

Produced-water requirements vary across USEPA regions for OCS oil- and gas-related activities, but all requirements start with national oil and grease limits, add effluent toxicity testing requirements for several species, and add other monitoring, studies, or operational controls to meet regional needs and interests (Veil 2015). In the Gulf of Mexico, both USEPA Region 4 and Region 6 general permits allow the discharge of produced water on the OCS provided that they meet discharge criteria. The produced water is treated to separate free oil from the water. Since the oil and water separation process does not completely separate all of the oil, some hydrocarbons remain with the produced water and often the water is treated to prevent the formation of sheen. Produced water may be discharged if the oil and grease concentration does not exceed 42 milligrams per liter (mg/L) daily maximum or 29 mg/L monthly average. The discharge must also be tested for toxicity; the toxicity test is primarily for chronic exposure, but it can include acute exposure. The 2017 USEPA Region 4 and Region 6 permits require no discharge within 1,000 m (3,281 ft) of an area of biological concern (areas of biological concern are identified by USEPA in consultation with DOI). Region 4 also requires no discharge within 1,000 m (3,281 ft) of any federally designated dredged material ocean disposal site. Produced waters are rapidly diluted with distance from their source of discharge (Gittings et al. 1993; Neff 2005).

As noted above, completion fluids, including fluids from fracture packs or “frac packs,” not returned to the deck of the platform during the completion job may be co-mingled and discharged with produced water if they meet the conditions of the appropriate NPDES permit. However, if the fluid composition is not compatible with the production system, the operator may decide to separate the returning well fluids from the production fluids and treat the fluids in temporary treatment systems or collect the fluids for onshore disposal depending upon logistics (e.g., treatability of well fluid, volume of fluid, personnel limitations, treatment unit capacity, space on deck, weather, etc.).

Nitrogen and Phosphorus Loading from Produced Water

The USEPA Region 6 NPDES 2017 permit required participation in the Produced Water Hypoxia Study, in which produced water was collected from 50 platforms that discharge into the hypoxic zone and was analyzed for oxygen-demanding characteristics (Rabalais 2005; The University of Chicago et al. 2005). In comparison to loadings from the Mississippi and Atchafalaya Rivers, the total nitrogen loading from produced water is about 0.16 percent, and total phosphorus loading is about 0.013 percent of the nutrient loading coming from the rivers. More information on hypoxia and water quality in the Gulf of Mexico can be found in **Chapter 3.3.2**.

Produced-Water Volumes

Estimates of the volume of produced water generated per well vary because the percent of water is related to well age and hydrocarbon type. Usually, produced-water volumes are small during the initial production phase and increase over time as the formation approaches hydrocarbon depletion. Produced-water volumes range from 2 to 150,000 barrels (bbl)/day (USEPA 1993). In some cases, a centralized platform is used to process water from several surrounding platforms. Some of the produced water may be reinjected into the well. Reinjection occurs when the produced water does not meet discharge criteria or when the water is used as part of operations. However, the vast majority of produced water is discharged per the conditions of the relevant U.S. Environmental Protection Agency NPDES permit. Approximately 509,159,846 bbl of produced water were generated in the Gulf of Mexico in 2012 (which is representative of an average year based on historic trends), of which about 52,043,434 bbl were injected and 457,116,412 bbl were discharged (Veil 2015).

BOEM maintains records of the volume of water produced from each block on the OCS and its disposition—injected onlease, injected offlease, transferred offlease, or discharged overboard. In the Gulf of Mexico, the total yearly volume for all water depths during the 15-year period of 2005-2019 ranged from 474.2 to 595.2 million barrels (MMbbl), with the largest contribution (55-78%) coming from operations on the shelf. The total volume of produced water generally decreased after 2005, reflecting an overall decrease in contributions from operations on the shelf. The contribution of produced water from operations in deep water (>400-m [1,312-ft] water depth) and ultra-deepwater (>1,600-m [5,249-ft] water depth) production has been increasing. From 2005 to 2019, the contribution from these operations (deep and ultra-deepwater together) increased from 22 percent (105.5 MMbbl) to 44 percent (211.5 MMbbl) of the total produced-water volume. The low-temperature and high-pressure conditions found in deeper water can result in flow problems such as hydrate formation in the lines. In these cases, additional quantities of chemicals are used to correct or prevent flow problems. Despite the use of recovery systems, some of these chemicals will be present in produced water (Regg et al. 2000). For deepwater operations, new technologies are being developed that may discharge or reinject produced water at the seafloor or at "minimal surface structures" before the production stream is transported by pipeline to the host production facility. The benefits of reinjection and seabed discharge of produced water and/or solids include (1) eliminating the need and cost to transport huge volumes of water from deepwater production sites to the tieback hosts; (2) decreasing the hydrostatic pressure on the subsea production flowlines, ultimately allowing for more production;

and (3) minimizing the topside equipment footprint and protecting the equipment from weather damage (Daigle and Cox 2012).

2.2.1.4 Well Treatment, Workover, and Completion Fluids

Well Treatment Fluids

Well treatment fluids are chemicals applied during the oil and gas extraction process. Production chemicals are used to dehydrate produced oil or treat the associated produced water for reuse or disposal. A wide variety of chemicals are used, including corrosion and scale inhibitors, bactericides, paraffin solvents, demulsifiers, foamers, defoamers, and water treatment chemicals (Boehm et al. 2001a). Some of the production chemicals mix with the production stream and are transported to shore with the product for proper disposal. Other chemicals mix with the produced water. Most produced water cannot be discharged without some chemical treatment. Even water that is reinjected downhole must be cleaned to protect equipment. The types and volumes of chemicals that are used change during the life of the well. In the early stages, defoamers are used. In the later stages, when more water than oil is produced, demulsifiers and water-treatment chemicals are used more extensively.

Well Workover Fluids

Workover fluids are used to maintain or improve existing well conditions and production rates on wells that have been in production. Workover operations include casing and subsurface equipment repairs, re-perforation, acidizing, and stimulating via hydraulic fracturing. During some of the workover operations, the producing formation may be exposed, in which case fluids like the aforementioned completion fluids are used. In other cases, such as acidizing and hydraulic fracturing, including “frac packs” (also considered stimulation or well treatment), hydrochloric and other acids are used. Both procedures are used to increase the permeability of the formation. The acids dissolve limestone, sandstone, and other deposits. Because of the corrosive nature of acids, particularly when hot, corrosion inhibitors are added. Since the fluids are altered with use, they are not recovered and recycled; however, these products may be mixed with the produced water and disposed of in accordance with NPDES permit requirements.

Well Completion Process

Should the operator decide to move forward with developing a well, completion operations must be undertaken. If it is decided that the well would not be completed, then it would be plugged and abandoned. When the decision is made to perform a well completion, a new stage of activity begins to convert an individual borehole into an operational system for controlled recovery of underground hydrocarbon resources. Those activities include installation of the final well casings that isolate fluid migrations along the borehole length while also establishing perforated sections where needed to capture the hydrocarbons from the geologic reservoir into the production casing (Operations & Environment Task Group and Offshore Operations Subgroup 2011).

Different geologic and reservoir properties affect the completion process. The primary drivers of offshore completions in the GOM are sand control and formation stimulation with an extensive history of successful application. As described below, there is a wide range of variability in the particular activities that might be used in the completion process, depending on the specific characteristics of the well. Many of the terms used to describe these activities (e.g., fracking and acidization) do not have precise, fixed definitions in all contexts. Accordingly, two very different processes with different potential environmental impacts may both be called by the same name. For these reasons, the description of these activities in this chapter is meant to be a general description of the range of activities that may be involved in well completion. Most wells drilled as development wells are expected to become producing wells. The majority of these production wells are anticipated to undergo some form of well stimulation during their production life, with many >65 percent; (Sanchez and Tibbles 2007) being "frac-pack" completions. Implementation of the well stimulation activities included in a proposed action would largely use existing infrastructure and would not result in bottom-disturbing activities, except potentially the drilling of new injection wells.

There is a wide variety of well completion techniques performed in the Gulf of Mexico. The type of well completion used to prepare a drill well for production is based on the rock properties of the reservoir as well as the properties of the reservoir fluid. However, for the vast majority of well completions, the typical process includes installing or "running" the production casing; cementing the casing; perforating the casing and surrounding cement; injecting water, brine, or gelled brine as carrier fluid for a "frac pack"/sand proppant pack and gravel pack; treating/acidizing the reservoir formation near the wellbore; installing production screens; running production tubing; and installing a production tree. Cement is pumped into the well both to displace drilling fluids that remain in the well and also to fill in the space that exists between the casing and the face of the rock formations in the wellbore. The casing and cement would be perforated adjacent to the reservoir to allow the reservoir fluids to enter the wellbore.

A gravel pack (a nonfracturing treatment) is a filtration system in which a metal screen is placed in the wellbore and the surrounding annulus is packed with prepared gravel of a size designed to provide a barrier preventing formation sand from entering the well with the hydrocarbons. The main objective of gravel packs is to stabilize the formation while causing minimal impairment to well productivity. The term "frac pack" has become an industry-recognized term for the completion process of fracturing and gravel packing, and it is the most widely used completion technique for sand control in the Gulf of Mexico. The "frac-pack" process, which has been used in the Gulf of Mexico for more than 25 years, combines the production improvement from hydraulic fracturing (refer to the "Well Completion Fluids" section below) with the sand control provided by gravel packing. Typically, about 30-35 percent of the oil present in GOM reservoirs at the start of production is recovered during primary recovery (Hyne 2019). The use of well stimulation treatments supports the continued recovery of oil as primary recovery from an oil and/or gas reservoir declines. These activities are covered by a permit known as an Application for Permit to Modify. All Applications for Permit to Modify are reviewed and approved by BSEE. BOEM carries forward any established mitigating measures based upon lease stipulations/terms, regulatory requirements, etc., to the individual plan actions.

For moderate to high permeability reservoirs, today's most technologically advanced well treatment and stimulation processes are designed not only to mitigate flow restrictions caused by a reduction in permeability in the near-wellbore region (also known as formation "damage") but also to serve as another mechanism to help control the flow of sand into the wellbore and to enhance the flow rate of the well. Production tubing is run inside the casing, protects the casing from wear and corrosion, and provides a continuous conduit for the reservoir fluid to flow from the reservoir to the wellhead. The production tree is a wellhead device that is used to control, measure, and monitor the conditions of the reservoir and the well from the surface.

The term hydraulic fracturing covers a broad range of techniques used to stimulate and improve production from a well. Fracture fluid is injected into a wellbore at high pressure to break open the rock to create/improve the flow path for hydrocarbons to flow into the well. The pressurized high-density, gelatin-like fluid also serves as the carrier agent for the mechanical agent or proppant that is mixed with the completion fluids. The mechanical agents, typically sand, manmade ceramics, or small microspheres (tiny glass beads), are injected into the small fractures and remain lodged in the fractures when the process is completed. The proppant serves to hold the fractures open, allowing them to perform as conduits to assist the flow of hydrocarbons from the reservoir formation to the wellbore. Well-treatment chemicals are also commonly used to improve well productivity. For example, acidizing is a common well-treatment procedure in the GOM as well.

Acidizing is commonly performed on new wells to maximize their initial productivity and on aging wells to restore productivity and maximize the recovery of the energy resources. Acidizing improves the flow of reservoir fluids into the wellbore by cleaning out and/or dissolving debris that accumulates in the wellbore and near-wellbore reservoir formation as a result of the drilling process. There are three general categories of acid treatments: acid washing; matrix acidizing; and fracture acidizing. In acid washing, the objective is simply tubular and wellbore cleaning. Treatment of the formation is not intended. Acid washing is most commonly performed with hydrochloric acid mixtures to clean out scale (such as calcium carbonate), rust, and other debris restricting flow in the well. Matrix and fracture acidizing are both formation treatments. In matrix acidizing, the acid treatment is injected below the formation fracturing pressure. In fracture acidizing, acid is pumped above the formation fracturing pressure. The purpose of matrix or fracture acidizing is to restore or improve an oil or gas well's productivity by dissolving material in the productive formation that is restricting flow, to dissolve formation rock itself to enhance existing, or to create new flow paths to the wellbore (American Petroleum Institute 2014).

In contrast to the large-scale, induced hydraulic fracturing procedures, commonly referred to as "fracking," used in onshore oil and gas operations for low-permeability "tight gas," "tight oil," and "shale gas" reservoirs, the vast majority of hydraulic fracturing treatments carried out on the OCS in the GOM are fracture packs, which are small scale by comparison and most commonly used for high-permeability formations to reduce the concentration of sand and silt in the produced fluids and to maintain high flow rates. The fracture pack or "frac-pack" completion process uses pressurized fluids, typically seawater, brine, or gelled brine, to create small fractures in the reservoir rock within a zone near the wellbore where the reservoir's permeability was damaged by the drilling process. Since formation "damage" caused by drilling operations does not extend for large distances away from the reservoir-borehole interface, the fracturing induced by the procedure is also designed to remain in close proximity to the borehole, extending distances of typically 15-30 m (49-98 ft) from the borehole (Ali et al. 2002; Sanchez and Tibbles 2007) to prevent the production of formation fines and sand.

Well Completion Fluids

Wells are drilled using a base fluid and a combination of other chemicals to aid in the drilling process. Fluids (drilling muds) present in the borehole can damage the geologic formation in the producing zone. Completion fluids are used to displace the drilling fluid and protect formation permeability. "Clear" fluids consist of brines made from seawater mixed with calcium chloride, calcium bromide, and/or zinc bromide. These salts can be adjusted to increase or decrease the density of the brine to hold back-pressure on the formation. Additives, such as defoamers and corrosion inhibitors, are used to reduce problems associated with the completion fluids. Recovered completion fluids can be recycled for reuse.

Additives used in fracture-pack operations are often similar, if not identical, to those used for shale or tight sand development in other regions and are used for similar purposes. The concentrations of some of these additives are typically different due to the very different geologic characteristics of the producing formations in the GOM. The most significant difference is that the GOM typically has much higher formation permeability and lower amounts of clay/shale in typical formations (American Petroleum Institute 2015c). Another factor that can substantially influence additive selection and use in offshore operations is the ability to discharge treated wastewaters that meet applicable regulatory requirements (American Petroleum Institute 2015c).

Boehm et al. (2001a) discusses completion, stimulation, and workover chemicals that are used in the Gulf of Mexico. These same chemicals are used for hydraulic fracturing, including "frac packs," gravel packs, and acidizing processes. Boehm et al. (2001a) lists and defines the types of chemicals used as well as providing examples for each category of chemical (Boehm et al. 2001a, Table 3). After the fluids used for fracturing have performed their desired function, they are disposed of in the same manner as completion fluids or may be combined with the produced water. If the fluids return topside as a part of the completion job, they are considered waste completion fluids and would be disposed of as such. After the completion job is finished, the fluid is removed from the tubing in the well in order to begin producing hydrocarbons; this fluid may be commingled with the produced water and discharged per the requirements for produced water.

Boehm et al. (2001a) notes 22 functional categories of additives and 2 categories of proppants used offshore in the GOM for fracturing activities.

- water-based polymers
- defoamers
- friction reducers
- oil gelling additives
- fluid loss additives
- biocides
- breakers
- acid-based gel systems

- emulsifiers
- water-based systems
- clay stabilizers
- cross-linked gel systems
- surfactants
- alcohol/water systems
- non-emulsifiers
- oil-based systems
- pH control additives
- polymer plugs
- crosslinkers
- continuous mix gel concentrates
- foamers
- resin-coated proppants
- gel stabilizers
- intermediate-to-high strength ceramic proppants

Each of these is described in greater detail in the Boehm et al. (2001a) study, along with other treatment and completion chemicals. The appendix to the study offers a chemical inventory with example products and Material Safety Data Sheets for those products. In general, discharges of any fluids, including those associated with well completion, are subject to the terms of NPDES permits issued by the USEPA under the Clean Water Act. These permits place limitations on the toxicity of selected effluents, as well as other requirements for monitoring and reporting. Wastes and discharges generated from produced water are discussed in **Chapter 2.2.1.3**.

During a “frac pack,” the pumping equipment, sand (proppant), and additives are carried, mixed, and pumped from a specialized stimulation and treatment vessel. BOEM considers these large special purpose vessels (supporting fracturing operations) as offshore supply/service vessels. The base fluid that is used for the “frac-pack” operation would typically be treated seawater, although other brines may be used if conditions dictate (American Petroleum Institute 2015c).

What is explained above is a general procedure for “frac-pack” operation, but every fracturing job is case specific. In general, the fracturing process remains the same but chemical formulations, fluid and proppant volumes, pump time, and pressure would vary based on the depth and engineering/geologic parameters for a particular well completion. After a production test determines the desired production rate to avoid damaging the reservoir, the well is ready to go online and produce.

A deepwater operations plan is required for all deepwater development projects in water depths ≥1,000 ft (305 m) and for all projects proposing subsea production technology. A deepwater operations plan is required initially and is usually followed by a development operations coordination document (DOCD). The DOCD is the chief planning document that lays out an operator’s specific intentions for development.

Well Treatment, Completion, and Workover Fluid Discharge

The USEPA Regions 4 and 6 allow the discharge of well-treatment, completion, and workover (WTCW) fluids if they meet the condition of the NPDES permits. These regions prohibit the discharge of well treatment, completion, and workover fluid with additives containing priority pollutants (e.g., benzene, toluene, lead, and mercury; the full list of priority pollutants can be found in Appendix A of 40 CFR part 423). Additives containing priority pollutants must be monitored. Discharge and monitoring records must be kept. The WTCW fluids commingled with produced waters have technology-based and water quality-based limits. The WTCW fluids not commingled with produced waters discharged have technology-based effluent limits.

As part of the 2017 NPDES general permit renewal process, USEPA Region 4 considered well WTCW fluids and concluded that the volume and constituents of the discharged material are not considered sufficient to pose a potential problem through bioaccumulation or persistence (USEPA 2017a). However, to confirm the USEPA's decision and as a precaution against any changes in operational practices that could change the USEPA's assumptions, the discharged volumes of WTCW fluids must be recorded monthly and reported once each year on the compliance monitoring report as a condition of the permit.

2.2.1.5 Production Solids and Equipment

As defined by the USEPA in the discharge guidelines (USEPA 1993), produced sands are slurried particles, which surface from hydraulic fracturing, and the accumulated formation sands and other particles including scale, which are generated during production. This waste stream also includes sludges generated in the produced-water treatment system, such as tank bottoms from oil/water separators and solids removed in filtration. The guidelines do not permit the discharge of produced sand, which must be transported to shore and disposed of as nonhazardous oil-field waste according to State regulations. Estimates of total produced sand expected from a platform are from 0 to 35 bbl/day according to the USEPA (1993). A variety of solid wastes are generated, including construction/demolition debris, garbage, and industrial solid waste. No equipment or solid waste from a facility may be disposed of in marine waters.

2.2.1.6 Bilge, Ballast, and Fire Water

Bilge, ballast, and fire water all constitute minor discharges generated by offshore oil and gas production activities, which are allowed to be discharged to the ocean, as long as the USEPA's guidelines are followed. Ballast water is untreated seawater that is taken on board a vessel to maintain stability. Ballast water contained in segregated ballast tanks never comes into contact with either cargo oil or fuel oil. Newly designed and constructed floating storage platforms use permanent ballast tanks, in which the ballast in those tanks rarely becomes contaminated. Bilge water is seawater that becomes contaminated with oil and grease and with solids such as rust when it collects at low points in the facility. Uncontaminated bilge and ballast water are included in the USEPA Regions 4 and 6 general permits, either as their own category or in the miscellaneous discharges category, depending on the region. With the right equipment on board, dirty bilge and ballast water can be processed in a way that separates most of the oil from the water before it is discharged into the sea (USEPA 1993). The discharge of any oil or oily mixtures is prohibited under 33 CFR § 151.10. The USEPA requires monitoring for visual sheen related to miscellaneous discharges, such as bilge and ballast water.

Offshore drilling rigs and the offshore production facilities used to process oil have special fire protection requirements. Fire water is defined in the USEPA general permits as excess seawater or freshwater that permits the continuous operation of fire control pumps, as well as water released during the training of personnel in fire protection. Fire control system test water is seawater, sometimes treated with a biocide that is used as test water for the fire control system on offshore platforms. This test water is discharged directly to the sea as a separate waste stream (USEPA 1993). As well, fire protection can also include a barrier of water that is sometimes used during flaring to provide protection between flaring systems and personnel, equipment, and facilities. The USEPA Regions 4 and 6 general permits allow for the discharge of fire water that meets their specified limitations. The requirements include regulations and monitoring for treatment chemicals, discharge rate, free oil, and toxicity.

2.2.1.7 Cooling Water

Cooling water is defined as water used for contact or noncontact cooling, including water used for equipment cooling, evaporative cooling tower makeup, and dilution of effluent heat content. Cooling water is typically discharged at the site in accordance with NPDES permit requirements and and any other requirements in accordance with Sections 301, 306, or 316(a) of the CWA. Seawater is drawn through an intake structure on the drilling rig, ship, or platform to cool power generators and other machinery, and produced oil or water. Drillship cooling water structures have been noted to intake 16-20 million gallons/day while semisubmersibles have been noted to intake 2 to over 10 million gallons/day from a water depth >400 ft (122 m) from the water's surface (USEPA 2006b). However, newer semisubmersible units were noted to have an intake capacity of 35 million gallons/day. Not all intake water is necessarily used as cooling water; some may be used for ballast water, cleaning, firewater, and testing. Organisms may be killed through impingement or entrainment. When fish and other aquatic life become trapped against the screen at the entrance to the cooling water intake structure through the force of the water being drawn through the intake structure, it is termed impingement. When eggs and larvae are sucked into the heat exchanger and eventually discharged from the facility, it is termed entrainment (CSA Ocean Sciences Inc. and LGL Ecological Research Associates Inc. 2014; LGL Ecological Research Associates Inc. 2009).

The Clean Water Act, Section 316(b) Phase III, established categorical regulations for offshore oil and gas cooling water intake structures. The 2017 NPDES permits for USEPA Regions 4 and 6 include cooling water intake structure requirements. The USEPA Regions 6 and 4 general permits began incorporating these requirements in 2007 and 2010, respectively, for new facilities that began construction after July 17, 2006, and that take in more than 2 million gallons/day of seawater, of which more than 25 percent is used for cooling (USEPA 2012b; 2017a). The requirements have several tracks depending on whether the facility is a fixed or non-fixed facility and whether it has a sea chest intake or not. Some of the requirements include cooling water intake structure design requirements to meet a velocity of <0.5 ft (0.2 m) per second, construction to minimize impingement and/or entrainment, entrainment monitoring, recordkeeping, and completion of a source water biological study.

2.2.1.8 Deck Drainage

Deck drainage includes all wastewater resulting from platform washings, deck washings, rainwater, and runoff from curbs, gutters, and drains, including drip pans and work areas on facilities engaged in field exploration, drilling, well production, and well treatment in the oil and gas industry. The USEPA's general guidelines for deck drainage require that no free oil be discharged, as determined by visual sheen. The quantities of deck drainage vary greatly depending on the size and location of the facility. An analysis of 950 GOM platforms during 1982-1983 determined that deck drainage averaged 50 bbl/day/platform (USEPA 1993). The deck drainage is collected, the oil is separated, and the water is discharged to the sea.

2.2.1.9 Treated Domestic and Sanitary Wastes

Domestic wastes originate from sinks, showers, laundries, and galleys. Sanitary wastes originate from toilets. For domestic waste, no solids or foam may be discharged. In addition, the discharge of all food waste within 12 nmi (14 mi; 22 km) from the nearest land is prohibited. In sanitary waste, floating solids are prohibited. Facilities with 10 or more people must meet the requirement of total residual chlorine >1 mg/L and must maintain as close to this concentration as possible. There is an exception in the general permits for the use of marine sanitation devices.

In general, a typical manned platform would discharge 35 gallons/person/day of treated sanitary wastes and 50-100 gallons/person/day of domestic wastes (USEPA 1993). It is assumed that these discharges are rapidly diluted and dispersed.

2.2.1.10 Minor/Miscellaneous Discharges

Minor and miscellaneous discharges include all other discharges not already discussed that may result during oil and gas operations. Minor or miscellaneous wastes may include desalination unit discharge, blowout preventer fluid, boiler blowdown, excess cement slurry, uncontaminated freshwater and saltwater, and miscellaneous discharges at the seafloor, such as subsea wellhead preservation and production control fluid, umbilical steel tube storage fluid, leak tracer fluid, and riser tensioner fluids. These discharges are regulated by the U.S. Environmental Protection Agency's NPDES permits, with some variation between regions. In all cases, no free oil shall be discharged with the waste. The discharge of freshwater or seawater that has been treated with chemicals is permitted providing that the prescribed discharge criteria are met. Under the USEPA Region 6 general permit, unmanned facilities may discharge uncontaminated water through an automatic purge system without monitoring for free oil.

2.2.1.11 Onshore Disposal of Wastes Generated from OCS Oil and Gas Facilities

Most wastes, other than produced water and water-based drilling muds and cuttings, are regulated by the USEPA and must be transported to shore or reinjected downhole. Additionally, wastes may be disposed of onshore if they do not meet permit requirements or because onshore disposal is economically advantageous. Wastes that are typically transported to shore include produced sand, aqueous fluids such as wash water from drilling and production operations, technologically enhanced naturally occurring radioactive materials such as tank bottoms and pipe scale, industrial wastes, municipal wastes, and other exploration and production wastes (Dismukes 2010). Most OBF muds and some SBF muds are recycled. If the physical and chemical properties of muds degrade, they may be disposed of or treated and reused for purposes other than drilling, instead of being recycled. Different reuses of treated muds include, among others, fill material, daily cover material at landfills, aggregate or filler in concrete, and brick or block manufacturing. The OBF cuttings are disposed of onshore or are injected onsite (USEPA 2000a). Both USEPA Regions 4 and 6 permit the discharge of SBF-wetted cuttings provided the cuttings meet the criteria with regard to percent of SBF retained, polycyclic aromatic hydrocarbon content, biodegradability, and sediment toxicity. The SBF is either recycled or transferred to shore for regeneration and reuse or disposal. For information on OBF or SBF, refer to **Chapter 2.2.1.2**. Drill cuttings contaminated with hydrocarbons from the reservoir fluid must be disposed of onshore or reinjected.

The USEPA allows treatment, workover, and completion fluids to be commingled with the produced-water stream if the combined produced-water/treatment, workover, and completion discharges pass the toxicity test requirements of the NPDES permit. Spent treatment, workover, and completion fluid is stored in tanks on tending workboats or is stored on platforms and later transported to shore on supply boats or workboats. Once onshore, the treatment, workover, and completion wastes are transferred to commercial waste-treatment facilities and disposed of in commercial disposal wells.

Operators are prohibited in the GOM from discharging any produced sands offshore. Cutting boxes (15- to 25-bbl capacities), 55-gallon steel drums, and cone-bottom portable tanks are used to transport the solids to shore via offshore service vessels. A general rule of thumb is that roughly 1 barrel of produced sand is generated for every 2,000 barrels of oil produced and approximately 1-55 barrels per completion or workover operation (USEPA 1993). Of 224 production facilities in the GOM surveyed by USEPA, 37 facilities reported generating produced sand, collectively averaging 74 barrels (USEPA 1996). Refer to **Chapter 2.2.1.3** for more information on produced sands. Both Texas and Louisiana have State oversight of exploration and production waste-management facilities (Veil 2015).

2.2.1.12 Onshore Disposal and Storage Facilities Supporting OCS-Generated Operational Wastes

Existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs. However, 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. The industry trend has been 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).

2.2.1.13 Discharges from Onshore Support Facilities

The Clean Water Act establishes conditions and permitting for discharges of pollutants into the waters of the United States under the NPDES and gives the USEPA the authority to implement pollution control programs such as setting wastewater standards for industry and setting water quality standards for all contaminants in surface waters. Accordingly, the USEPA regulates all waste streams generated from OCS oil- and gas-related activities through permits issued by the USEPA region that has jurisdictional oversight.

The primary onshore facilities needed to support offshore oil- and gas-related activities include service bases, helicopter hubs at local ports/service bases, construction facilities (i.e., platform fabrication yards, pipeyards, and shipyards), processing facilities (i.e., refineries, gas processing plants, and petrochemical plants), and terminals (i.e., pipeline shore facilities, barge terminals, and tanker port areas). Water discharges from these facilities are from either point sources, such as a pipe outfall, or nonpoint sources, such as rainfall run-off from paved surfaces. The USEPA or USEPA-authorized State program regulates point-source discharges as part of the NPDES. Facilities would be issued general or individual permits that limit discharges specific to the facility type and the waterbody receiving the discharge. Other wastes generated at these facilities would be handled by local municipal and solid-waste facilities, which are also regulated by the USEPA or a USEPA-authorized State program.

2.2.2 Non-OCS Oil- and Gas-Related Activities Causing Discharges and Wastes

2.2.2.1 Potentially Polluting Shipwrecks

There are thousands of shipwrecks in U.S. waters. Some of the vessels involved in those wrecks are likely to contain oil, as fuel and possibly cargo, and may eventually result in pollution to the marine environment. Warships and cargo vessels sunk in wartime may also contain munitions, including explosives and chemical warfare agents, which may pose a continued threat because of their chemical composition. The National Oceanic and Atmospheric Administration (NOAA) maintains a large database of shipwrecks, dumpsites, navigational obstructions, underwater archaeological sites, and other underwater cultural resources (NOAA 2013a). This internal database, Resources and Undersea Threats, includes approximately 20,000 shipwrecks in U.S. waters. Shipwrecks in the Resources and Undersea Threats database were ranked to identify the most ecologically and economically significant, potentially polluting wrecks in U.S. waters for inclusion in the Remediation of Underwater Legacy Environmental Threats Program (NOAA 2013a). Under this Program, wrecks are ranked based on age, size, hull material, type, location, historical information on the vessel, engineering analysis, archaeological site formation, whether they are currently leaking, and modeling of the trajectory, fate, and consequences of an oil release from a shipwreck. The NOAA identified 87 priority wrecks (13 in the Gulf of Mexico) on the 2012 Remediation of Underwater Legacy Environmental Threats Program (those with the highest probability of discharge). Of these, 53 sank during an act of war and 34 sank as a result of collision, fire, grounding, storms, or other causes.

Priority wrecks located in the Gulf of Mexico include *R.W. Gallagher*, which contains 80,855 bbl of Bunker C fuel oil, located about 40 mi (64 km) south of Terrebonne Parish, Louisiana, and *Joseph M. Cudahy*, which contains 77,444 bbl of crude and lubricating oil, located about 65 mi (105 km) northwest of Key West, Florida (**Figure 2.2.2-1**). The NOAA Wreck Oil Removal Program provides for the removal of oil from priority wrecks, where feasible.

Another shipwreck of note is *Tank Barge DBL 152*, which, on November 11, 2005, struck the submerged remains of a pipeline service platform in West Cameron Block 229 (about 50 mi [80 km] southeast of Sabine Pass, Texas). The platform had previously collapsed during Hurricane Rita. The barge was carrying a cargo of approximately 119,793 bbl of a blended mixture of low-API gravity oil (i.e., heavy oil, likely to sink). A portion of the oil was released at the point of impact, which sank to the seafloor. The barge was towed toward shallow water to facilitate salvage; however, it grounded and capsized approximately 12 mi (19 km) to the west-northwest, releasing additional oil to the seafloor. An estimated 45,846 bbl of oil were released during the incident, of which about 2,355 bbl were recovered by divers. In January 2006, recovery of additional oil was deemed infeasible and cleanup operations were discontinued, leaving approximately 43,491 bbl of oil unrecovered on the seafloor (NOAA 2013a).

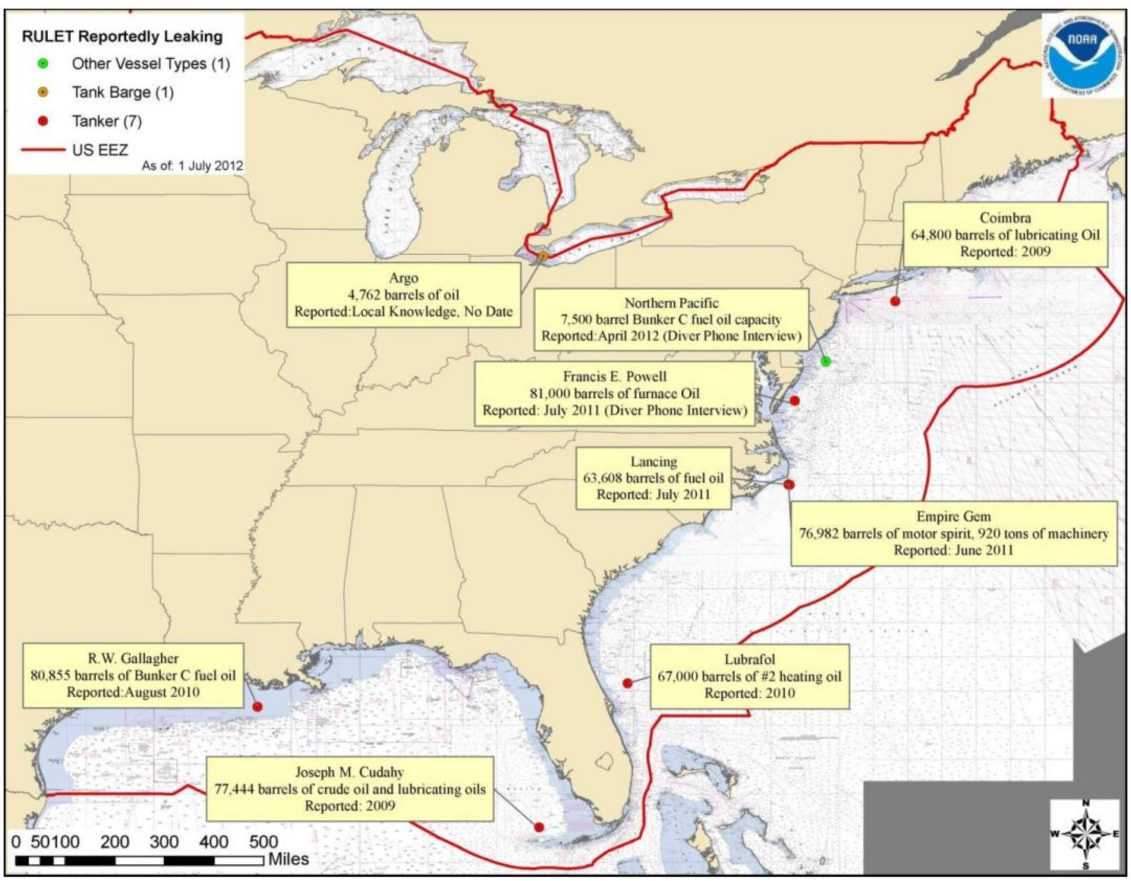


Figure 2.2.2-1. Shipwrecks in NOAA's Database along the Gulf of Mexico and Atlantic Coast That Reportedly are Leaking or Have Oil in the Overheads (EEZ = Exclusive Economic Zone) (NOAA 2013a).

2.2.2.2 Natural Seeps

A natural petroleum seep is a natural leak of crude oil and gas that migrates up through the seafloor and ocean depths. These seeps are very common in the GOM and are discussed further in **Chapter 3.3.3**.

2.2.2.3 Discharges Associated with Military Activities

The U.S. Department of Defense (DOD) conducts training, testing, and operations in offshore operating and warning areas, undersea warfare training ranges, and special use of restricted airspace on the OCS. The U.S. Navy uses the airspace, sea surface, subsurface, and seafloor of the OCS for events ranging from instrumented equipment testing to live-fire exercises. The U.S. Air Force conducts flight training and systems testing over extensive areas on the OCS. The U.S. Marine Corps' amphibious warfare training extends from offshore waters to the beach and inland. Military operations within military warning areas (MWAs) and Eglin Water Test Areas (EWTAs) vary in types of missions performed and their frequency of use. Such missions may include carrier maneuvers, missile testing, rocket firing, pilot training, air-to-air gunnery, air-to-surface gunnery, minesweeping operations, submarine operations, air combat maneuvers, aerobatic training, and instrument training.

Between the years of 1995 and 1999, Eglin Air Force Base in Florida conducted nearly 39,000 training flights per year in the eastern Gulf. Potential impacts from these activities are discussed in the *Eglin Gulf Test and Training Range, Final Programmatic Environmental Assessment* (Science Applications International Corporation 2002). These military activities may result in marine impacts from chaff, fuel releases, flares, chemical materials, and debris.

Chaff, which is composed of short, very fine aluminum fibers similar in appearance to human hair, metalized glass fiber, or plastic, is dispensed by military aircraft as a countermeasure to distract radar-guided missiles from their targets. Chaff could temporarily increase the turbidity of the ocean's surface when released during military training activities. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom at varying rates based on dispersion by currents and dilution rates. The U.S. Navy (2018), however, concluded that chemical alteration of water and sediment from decomposing chaff is not likely. Additionally, based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential (U.S. Navy 2018). The end-caps and pistons would sink; however, some may remain at or near the surface if it were to fall directly on a dense *Sargassum* mat. The expended material could also be transported long distances before becoming incorporated into the bottom sediments. Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment, principally flares and propellants for rockets, missiles, and torpedoes. Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment (U.S. Navy 2018).

During in-flight emergencies, fuel may be released in the air or a fuel tank may be jettisoned and impact the surface. Drones may also be shot down and release fuel upon surface impact. Fuel dumping by aircraft rarely occurs. Navy aircrews are prohibited from dumping fuel below 6,000 ft (1,828 m), except in an emergency situation. Above 6,000 ft (1,829 m), the fuel has enough time to completely vaporize and dissipate and would, therefore, have a negligible effect on the water below. A study performed by the Science Applications International Corporation (2002) indicated that 735 gallons of fuel released from an aircraft at a 5,000-ft (1,524-m) altitude resulted in approximately 99 percent evaporation before the fuel hit the surface. Additionally, jet fuel generally evaporates from the surface of water within 24 hours and, consequently, does not persist in the marine environment.

Flares may be ejected from aircraft to confuse and divert enemy heat-seeking or heat-sensitive missiles and may also be used to illuminate surface areas during nighttime operations. Solid flare and pyrotechnic residues may contain, depending on their purpose and color, aluminum, magnesium, zinc, strontium, barium, boron, chromium, cadmium, and nickel, as well as perchlorates. Hazardous constituents in pyrotechnic residues are typically present in small amounts or low concentrations and are bound in relatively insoluble compounds. Because flares are designed to burn completely, only a small amount of waste falls to the sea surface. The Air Force Air Armament Center characterizes the impact to water from flares to be less than the natural concentrations of magnesium found in the GOM (Science Applications International Corporation 2002, pages 4-20 and 4-21).

The Air Force Air Armament Center confirmed that chemical materials are introduced into the marine environment through drones, gun ammunition, missiles, chaff, flares, smokes, and obscurants but concluded that potential chemical contamination concentrations were extremely low and not likely to impact marine species (Science Applications International Corporation 2002).

Debris may be released into the GOM as a result of military activities, including ordnance and shrapnel deposits from bombs and missiles, drones, chaff and flare cartridges, and intact inert bombs. This debris generally falls into the major categories of aluminum, steel, plastic, concrete, and other components (i.e., copper and lead) and originates largely from inert bombs, missiles, and downed drones (Science Applications International Corporation 2002).

2.2.2.4 Historical Chemical Weapon Disposal

After World War I, chemical weapons were routinely disposed of in the world's oceans, including the GOM. Most of the activities occurred during World War II and continued until 1970. In some instances, conventional explosives and radiological wastes were dumped along with chemical weapons. The DOD published at least two reports on these activities, one in 2001 entitled *Off-shore Disposal of Chemical Agents and Weapons Conducted by the United States*, which was the basis of a 2007 Congressional Research Service Report entitled *U.S. Disposal of Chemical Weapons in the Ocean: Background and issues for Congress* (Bearden 2007). Chemical weapons disposed of contained hydrogen cyanide, arsenic trichloride, cyanogen chloride, lewisite, tabun, sarin, and venomous agent x (VX) nerve gas. The degree of risk from weapons leaking chemical agents into seawater depends on numerous factors. The extent to which an agent is diluted and the duration of exposure determine whether there is potential for harm. For example, most nerve agents are soluble and dissolve in water within several days. Less soluble agents still degrade over time as a result of hydrolysis. However, certain agents are less susceptible to hydrolysis, allowing them to remain in harmful forms for longer periods. For example, sulphur mustard in liquid or solid form turns into an encrusted gel when released in seawater. In this form, it can persist for many years before degrading (Bearden 2007). Refer to **Chapter 2.7.2.9**, “Ocean Dumping,” for more information on the known locations for munition disposal sites in the Gulf of Mexico.

Army records document several instances of mustard and phosgene bombs being disposed of in the Gulf of Mexico, originating from New Orleans, Louisiana, and Mobile, Alabama. Chemical weapons disposed of in other locations, and potentially in the Gulf of Mexico, contained hydrogen cyanide, arsenic trichloride, cyanogen chloride, lewisite, tabun, sarin, and VX, as reported in a Report to Congress (Bearden 2007). Six former explosives dumping areas are noted on NOAA’s chart of the Gulf of Mexico (NOAA 2015b) and likely contain disposed chemical weapons. These include two areas offshore Texas (about 65 nmi [75 mi; 120 km] southeast of Aransas Pass and about 100 nmi [115 mi; 185 km] south of Galveston); two areas offshore Louisiana (both about 35-40 nmi [42-46 mi; 65-74 km] south of the mouth of the Mississippi River); one area offshore Alabama (about 70 nmi [81 mi; 130 km] southeast of Mobile Bay); and one offshore Florida (about 130 nmi [150 mi; 241 km] west of Tampa Bay).

The Marine Protection, Research, and Sanctuaries Act of 1972, also known as the Ocean Dumping Act, was promulgated to regulate ocean dumping and to set aside certain areas as national marine sanctuaries. Section 101 of the Act (33 U.S.C. § 1411) prohibits ocean dumping, except as authorized by permit issued by the USEPA pursuant to Section 102 (33 U.S.C. § 1412). Section 102 specifically states that radiological, chemical, and biological warfare agents, high-level radioactive waste, and medical waste would not be permitted for ocean disposal after 1972.

2.2.2.5 Historical Industrial Waste Dumping

Prior to 1972, certain offshore locations of the United States were used for the disposal of various industrial wastes and low-level radioactive wastes. Although no complete records exist of the volumes and types of materials disposed in ocean waters in the United States prior to 1972, several reports indicate a vast magnitude of historic ocean dumping (USEPA 2020h). For example, a 1970 Report to the President from the Council on Environmental Quality on ocean dumping described that, in 1968, the following were dumped in the ocean in the United States: 38 million tons of dredged material (34% of which was polluted); 4.5 million tons of industrial wastes; 4.5 million tons of sewage sludge (significantly contaminated with heavy metals); and 0.5 million tons of construction and demolition debris. The USEPA records indicate that almost 34,000 containers of radioactive wastes were dumped at three ocean sites off the East Coast of the United States from 1951 to 1962.

In 1973, the USEPA permitted two interim industrial waste disposal sites in the Gulf of Mexico pursuant to Section 102 of the Marine Protection, Research, and Sanctuaries Act, the charting of which has been maintained by NOAA. Disposal Site A, located within the WPA, is situated on the upper part of the Texas-Louisiana continental shelf, about 125 nmi (144 mi; 232 km) south of Galveston, Texas. Disposal Site B is located in the CPA off the western side of the Mississippi Delta about 60 nmi (75 mi; 120 km) south of the mouth of the Mississippi River. The National Academy of Sciences' report, *Assessing Potential Ocean Pollutants* (National Research Council 1975), provides additional information about these sites.

Section 102 of the Ocean Dumping Act of 1972 (33 U.S.C. § 1412) authorizes the issuance of permits for ocean disposal of certain waste streams and requires that the USEPA determine that such dumping will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. The USEPA's Final Ocean Dumping Regulations and Criteria, published in January 1977, listed 14 interim municipal and industrial waste disposal sites which have since been phased out of use, with the last industrial dumper activity taking place in 1988 (USEPA 1991). Gulf of Mexico sites included the Galveston Site, the Mississippi River Site and the Gulf Incineration Site, amongst others. Questions remain about the potential short- and long-term effects of toxic compounds accumulating in deepwater sediments. With the Ocean Dumping Act of 1972 prohibiting new dumpers from commencing disposal of industrial waste, the ocean dumping of industrial waste in the GOM effectively ended in 1988 (USEPA 1991).

2.2.2.6 Dredged Material Disposal

Dredged material is described in 33 CFR part 324 as any material excavated or dredged from navigable waters of the United States. Materials from maintenance dredging are primarily disposed of offshore on existing dredged-material disposal areas and in ocean dredged-material disposal sites (ODMDSs). Additional dredged-material disposal areas for maintenance or new project dredging are developed as needed and must be evaluated and permitted by the U.S. Army Corps of Engineers (USACE) and relevant State agencies prior to construction. The ODMDSs are regulated by the USEPA under the Clean Water Act and Marine Protection, Research, and Sanctuaries Act (also called the Ocean Dumping Act).

There are two primary Federal environmental statutes governing dredged material disposal. The Ocean Dumping Act governs transportation for the purpose of disposal into ocean waters. Section 404 of the Clean Water Act governs the discharge of dredged or fill material into U.S. coastal and inland waters. The USEPA and USACE are jointly responsible for the management and monitoring of ocean disposal sites. The responsibilities are divided as follows: (1) the USACE issues permits under the Clean Water Act and Marine Protection, Research, and Sanctuaries Act; (2) the USEPA has lead for establishing environmental guidelines/criteria that must be met to receive a permit under either statute; (3) permits for ODMDS disposal are subject to USEPA review and concurrence; and (4) the USEPA is responsible for designating ODMDSs.

If funds are available, the USACE uses dredge materials beneficially for restoring and creating habitat, for beach nourishment projects, and for industrial and commercial development. The applicant would need funds to cover the excess cost over the least cost environmentally acceptable alternative. The material must also be suitable for the particular beneficial use. Virtually all ocean dumping that occurs today is maintenance dredging of sediments from the bottom of channels and bodies of water in order to maintain adequate channel depth for navigation and berthing.

The USACE maintains an Ocean Disposal Database website with the amount of dredged material deposited at each offshore site, with the largest site in the GOM identified as the New Orleans District. Based on data from 1996 through 2013, the New Orleans District dredges an average of 78 million cubic yards of material annually during maintenance dredging of Federal navigation channels. Excluding dredged material that is unsuitable for beneficial use (~17.7 million cubic yards) or too remote from coastal Louisiana (~19 million cubic yards), approximately 38 percent (15.8 million cubic yards) of the material dredged is used beneficially (USACE 2014). The remaining 62 percent of the total material dredged yearly by the USACE's New Orleans District is disposed of at placement areas regulated under Section 404 of the Clean Water Act, at ODMDSs, or is stored in temporary staging areas located inland (e.g., the Pass a Loutre Hopper Dredge Disposal Site at the head of the Mississippi River's main "birdfoot" distributary channel system).

Evaluation of dredged material for ocean disposal under the Marine Protection, Research, and Sanctuaries Act relies largely on biological (bioassay) tests. The ocean testing manual, commonly referred to as the Green Book (USEPA and USACE 1991), provides national guidance for determining the suitability of dredged material for ocean disposal. Benthic and water-column impacts of dredged material disposal are evaluated prior to disposal through analysis of representative samples of the material to be disposed, unless the sand source is previously characterized. Sample evaluation may include physical analysis (i.e., grain size, total solids, and specific gravity) and chemical analysis for priority pollutants (i.e., metals, semivolatile and volatile organic compounds, PCBs, and pesticides).

BOEM anticipates that, over the next 70 years, the amount of dredged material disposed of at ODMDSs will fluctuate generally within the trends established by the USACE's district offices. Between 2009 and 2018, the New Orleans District has averaged about 9.87 million cubic yards (yd^3) (7.55 million cubic meters [m^3]) of material dredged per year disposed of at ODMDSs, while the Mobile District has about one-quarter of that quantity, or 3.75 million yd^3 (2.87 million m^3) (USACE 2020c). Quantities disposed of at ODMDSs may decrease as more beneficial uses of dredged material onshore are identified and evaluated.

2.2.2.7 Land-Based Discharges and Nonpoint Source Pollution

Most aquatic pollutants result from agricultural or urban runoff or discrete point source wastewater discharges from industrial sites or sewage plants and are released to streams, rivers, bays, and estuaries. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and ground waters. Both discrete point sources and nonpoint sources make their way to the open ocean where they are prevalent stressors for marine life. Toxins directly harm the organisms that ingest them, but they can also have impacts further up the food chain through biomagnification, the process in which chemicals are passed to higher trophic levels through predation. Therefore, although filter-feeding benthic organisms may be the first to encounter toxic chemicals, these compounds can also contaminate predatory fish, marine mammals, and seabirds.

As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources on land that discharge pollutants into waters of the United States. Point sources are discrete conveyances (outfalls) such as pipes or manmade ditches that may contain process water flows and/or precipitation from impervious surfaces. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states (USEPA 2020j). An NPDES permit is typically a license for a facility to discharge a specified amount of a pollutant into a receiving water under certain conditions. Permits may also authorize facilities to process, incinerate, landfill, or beneficially use sewage sludge. These permits help regulate the amount of water pollution that is allowed to be discharged into the waters of the United States.

The Clean Water Act does not provide a detailed definition of nonpoint sources. Rather, they are defined by exclusion, i.e., nonpoint-source pollution refers to any source of water pollution that is not covered by the Clean Water Act's Section 502(14) definition of "point source." Typically nonpoint-source pollution comes from drainage, runoff, precipitation, seepage, atmospheric deposition, or hydrologic modification. There is no clearly discernible source, but rather, as stormwater runoff flows over and through the ground, it carries with it various pollutants (natural and manmade) and then is ultimately delivered to wetlands, ground waters, coastal waters, rivers, and lakes. Many sources have been identified by the USEPA; particularly relevant to OCS oil- and gas-related activities are oil, grease, and toxic chemicals from energy production. These types of pollutants can have negative effects on fisheries, wildlife, recreation, and water supplies. Nonpoint source pollution is recognized by many states as a major contributor to water quality problems, though specific effects can vary and be difficult to assess. Other types of nonpoint-source pollution unrelated to OCS oil- and gas-related activities include excess fertilizers, insecticides, and herbicides from residential areas and agricultural lands; bacteria and nutrients from livestock, faulty septic systems, and pet wastes; sediment from crops, forest lands, construction sites, and eroding streambanks; atmospheric deposition and hydromodification; and salt from irrigation practices and acid drainage from abandoned mines or other sources (USEPA, 2017c). Nutrients are elements that are essential to both plant and animal growth, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S) and silicon (Si). Excess nutrients can cause excessive algae growth, which can lead to hypoxia and indirect effects to fisheries, wildlife, recreation, and water supplies (refer to **Chapter 3.3.2**).

The NPDES program includes periodic characterization of outfall flow to limit pollutants entering surface water. The Mississippi River basin drains 41 percent of the 48 contiguous states of the United States. The basin covers more than 1,245,000 square miles (mi^2) (3,224,535 square kilograms [km^2]) and includes all or parts of 31 states and two Canadian provinces (USACE 2020b). Nonpoint-source contributions to the Mississippi River from erosion, uncontained runoff, and groundwater discharge are primary sources of freshwater, sediment, suspended solids, organic matter, and pollutants (including nutrients, heavy metals, pesticides, oil and grease, and pathogens).

As a result, water quality in coastal waters of the northern GOM is highly influenced by seasonal variation in river flow. The Mississippi River introduces approximately 3,680,938 bbl of oil and grease per year from land-based sources (National Research Council (2003c, Table I-9, page 242) into the waters of the Gulf of Mexico. Nutrients carried in waters of the Louisiana and Texas rivers contribute to seasonal formation of hypoxic zones (**Chapter 3.3.2**) on the Louisiana and Texas shelf. Additional information regarding water quality in the northern GOM can be found in **Chapter 4.2**.

Urban and Suburban Sources

The following overview of urban and suburban sources is summarized from the National Science and Technology Council and Committee on Environment and Natural Resources (2003), unless otherwise noted. Urban and suburban sources include point sources from municipal and industrial treatment plants and nonpoint sources from septic systems, storm sewers and combined sewer overflows, and lawn and landscape care. Municipal wastewater treatment plants are the primary point source discharge of nutrients to waterways in the United States, though industrial sources are also significant in some basins. In the 1990s, most sewage in the United States received secondary treatment, designed to lower the discharge of labile organic matter that contributes to "biological oxygen demand" (National Research Council 2000).

In some United States cities, sanitary wastes and stormwaters are served by the same combined sewer system while others have septic systems (i.e., onsite/decentralized wastewater treatment systems). Consequently, some nutrients entering sewage treatment plants originate from fossil fuel sources and lawn fertilizer washed off streets and lawns in rainstorms (National Research Council 2000). Most of the time, all of the combined sewage and stormwater goes to a sewage treatment plant, but heavy rains may cause pipes to fill and induce overflows and outfalls into coastal waters. The nutrient inputs from storm sewers and combined sewer overflows are not well quantified for any major urban area, but they are probably less than the input from sewage effluent (National Research Council 1993; 2000).

A well-designed and maintained septic system is effective for containing pathogens and phosphorus; however, they can be a significant source of nutrient inputs to coastal waters (National Research Council 2000). For example, the USEPA identified septic system leakage as a contributor to approximately 9 percent of Gulf Coast beach advisories for 2007 (USEPA 2012a). A variety of other activities by homeowners and urban residents can generate nutrient pollution. In particular, garden and lawn care activities can result in significant inputs of nutrients to area waterways by nonpoint-source pathways, such as runoff.

Agricultural Sources

The following overview of agricultural sources is summarized from the National Science and Technology Council and Committee on Environment and Natural Resources (2003), unless otherwise noted. Agricultural sources of nutrients come from leaching and runoff from agricultural lands and from animal agriculture. Agricultural fertilizer use in the United States grew rapidly from 1961 until

1980, declined somewhat after 1980, and has been rising steadily since 1985 (Howarth et al. 2002; National Research Council 2000).

Certain agricultural management practices, such as tile drainage, can accelerate the loss of nutrients, usually nitrogen, from agricultural lands to streams. This "short circuits" the flow of groundwater by draining the top of the water table into underground drainage tile lines and ditches. It also promotes the conversion of organic nitrogen and ammonia, which are relatively immobile forms of nitrogen, into nitrate, which is very mobile. The drained water, which may contain high concentrations of nitrate (Zucker et al. 1998), flows into nearby streams and rivers and may eventually empty into the GOM where it can contribute to eutrophication and hypoxia (refer to **Chapter 3.3.2**).

Animal wastes, particularly from large feeding operations, contribute significantly to the level of nutrients in coastal waters, and the production of animal protein continues to increase, in part driven by a steady increase in the per capita meat consumption of American (Howarth et al. 2002). Wastes from concentrated animal feeding operations tend to be handled in one of two ways: they are spread onto agricultural fields or they are held in lagoons. Some operations are also beginning to compost animal wastes (National Research Council 2000). Animal manure can be considered a fertilizer, and recycling of this organic waste to agricultural fields is seen as desirable. In practice, however, it is difficult to apply manure with uniformity over a field and also to ensure uniform delivery of nutrients appropriate to crop needs because of the variability of nutrient release from the applied manure (National Research Council 2000). Also, since most manure in the United States is transported less than 10 mi (16 km), it means fields near animal feeding operations can be over fertilized and cause associated groundwater and downstream aquatic ecosystem pollution (National Research Council 2000).

Atmospheric Sources

The following overview of atmospheric sources is summarized from the Committee on Environment and Natural Resources (National Science and Technology Council and Committee on Environment and Natural Resources 2003), unless otherwise noted. Air pollution is also discussed above in **Chapter 2.1**. Atmospheric nitrogen emissions come from two major sources: stationary (i.e., power plants) and mobile (i.e., cars, trucks, buses, and other internal combustion engines). It can deposit onto land or water surfaces during rain showers (i.e., wet deposition) and as dry deposition. The NO_x emissions are major contributors to acid rain, as well as significant contributors to nutrient pollution in coastal waters. The atmospheric deposition of nitrogen from fossil fuel combustion is a major input to virtually all of the coastal rivers and bays along the eastern seaboard and Gulf of Mexico (Paerl et al. 2002). Refer to **Chapter 2.1** for more information on NO_x emission amounts.

2.2.2.8 Trash and Debris

Marine debris originates from both land-based and ocean-based sources (USEPA 2017d). Some of the sources of land-based marine debris are beachgoers, storm-water runoff, landfills, solid waste, rivers, floating structures, and ill-maintained garbage bins. Land-based marine debris also comes from combined sewer overflows and typically includes medical waste, street litter, and sewage.

Ocean-based sources of marine debris include galley waste and other trash from ships, recreational boaters, fishermen, and offshore oil and gas exploration and production facilities. Commercial and recreational fishers produce trash and debris by discarding plastics (e.g., ropes, buoys, fishing line and nets, strapping bands, and sheeting), wood, and metal traps. Some trash items, such as glass, pieces of steel, and drums with chemical or chemical residues, can be a health threat to local water supplies and as a result to biological, physical, and socioeconomic resources, to beachfront residents, and to users of recreational beaches. Refer to **Chapter 2.9.1.7** for more information on the potential sources and effects from trash and debris resulting from other OCS activities not related to oil and gas development.

2.2.2.9 Recreational and Commercial Fishing, Boating, and Diving

Recreational and commercial fishing, boating, and diving are prevalent in the GOM. Fishing, boating, and diving can lead to discharges such as sewage, food waste, ground waste, metal traps, and plastics (e.g., ropes, buoys, fishing line and nets, strapping bands, and sheeting). However, various laws and regulations serve to limit waste discharges; the U.S. Coast Guard summarizes these requirements (USCG 2018). For example, there are limitations on where, and at what distances from shore, certain wastes can be discharged. Ocean Conservancy (2017) provides information regarding the impacts of discharges from recreational vessels, as well as information regarding best practices for recreational boaters.

2.2.2.10 Non-OCS Oil- and Gas-Related Hydrocarbon Spills

The National Research Council (2003c) computed petroleum hydrocarbon inputs into North American marine waters for several major categories. The results show that three activities – extraction, transportation, and consumption – are the main sources of anthropogenic petroleum hydrocarbon pollution in the sea.

Non-OCS oil- and gas-related spills include the loss of petroleum products as a result of the extraction-, transportation-, and refinery-related activities from State oil and gas leases offshore Louisiana and Texas. The major sources of petroleum hydrocarbon discharges into the marine waters by transportation activities, including non-OCS oil- and gas-related sources, are tank vessel spills, operational discharges from cargo washings, coastal facilities spills, and gross atmospheric deposition of VOC releases from tankers. Non-OCS oil- and gas-related offshore spills are possible during the extensive maritime barging and tankering operations that occur in offshore waters of the GOM. Spills from transportation activities include a wide variety of petroleum products (not just crude oil), each of which behaves differently in the environment and may contain different concentrations of toxic compounds.

Consumption-related sources of petroleum releases to the marine environment include land-based sources (i.e., river discharge and runoff), two-stroke vessel discharge, non-tank vessel spills, operational discharges, gross atmospheric deposition, and aircraft dumping. Releases that occur during the consumption of petroleum, whether by individual car and boat owners, non-tank vessels, or run-off from increasingly paved urban areas, contribute the vast majority of petroleum introduced to the environment through human activity. Nearly 85 percent of the 29 million gallons of petroleum that enter North American ocean waters each year as a result of human activities comes from land-based runoff, polluted rivers, and aircraft. Land runoff and two-stroke engines account for nearly three quarters of the petroleum introduced to North American waters from activities associated with petroleum consumption, activities almost exclusively restricted to coastal waters. Unlike other sources, inputs from consumption occur almost exclusively as slow chronic releases. The estimates for land-based sources of petroleum are the most poorly documented, and the uncertainty associated with the estimates range over several orders of magnitude. On occasion, aircraft carry more fuel than they can safely land with, so fuel is jettisoned into offshore marine waters. The amount of 1,120 bbl (160 tonnes) of jettisoned fuel per year was estimated for the GOM.

Tables 2.2.2-1 and 2-2.2-2 provide the National Research Council (2003c) estimates of hydrocarbon inputs into marine waters. In general, response activities to non-OCS oil- and gas-related spills would be similar to those described for an OCS oil- and gas-related spill (**Chapter 2.9.1**).

Table 2.2.2-1. Average Annual Inputs of Petroleum Hydrocarbons to Coastal Waters of the Gulf of Mexico, 1990-1999 (Source: National Research Council 2003c).

Inputs	Western Gulf of Mexico (tonnes)	Western Gulf of Mexico (bbl)	Eastern Gulf of Mexico (tonnes)	Eastern Gulf of Mexico (bbl)
Extraction of Petroleum Platform Spills	90	630	trace[1]	trace
Extraction of Petroleum Atmospheric Releases (VOCs)	trace	trace	trace	trace
Extraction of Petroleum Permitted Produced-Water Discharges	590	4,130	trace	trace
Extraction of Petroleum Sum of Extraction Inputs	680	4,760	trace	trace
Transportation of Petroleum Pipeline Spills	890	6,230	trace	trace
Transportation of Petroleum Tank Vessel Spills	770	5,390	140	980
Transportation of Petroleum Coastal Facilities Spills[2]	740	5,180	10	70
Transportation of Petroleum Atmospheric Releases (VOCs)[3]	trace	trace	trace	trace
Transportation of Petroleum Sum of Transportation Inputs[4]	2,400	16,800	160	1,120
Consumption of Petroleum Land-Based Sources[5]	11,000	77,000	1,600	11,200
Consumption of Petroleum Recreational Vessels	770	5,390	770	5,390
Consumption of Petroleum Vessel >100 GT (spills)	100	700	30	210

Inputs	Western Gulf of Mexico (tonnes)	Western Gulf of Mexico (bbl)	Eastern Gulf of Mexico (tonnes)	Eastern Gulf of Mexico (bbl)
Consumption of Petroleum Vessel >100 GT (operational discharges)	trace	trace	trace	trace
Consumption of Petroleum Vessel <100 GT (operational discharges)	trace	trace	trace	trace
Consumption of Petroleum Deposition of Atmospheric Releases (VOCs)	90	630	60	420
Consumption of Petroleum Aircraft Jettison of Fuel	N/A	N/A	N/A	N/A
Consumption of Petroleum Sum of Consumption	12,000	84,000	2,500	17,500

[1] Trace indicates <70 barrels (10 tonnes).

[2] Coastal facility spills do not include spills in coastal waters related to exploration and production spills or spills from vessels. The category "Coastal Facilities" includes aircraft, airport, refined product in coastal pipeline, industrial facilities, marinas, marine terminals, military facilities, municipal facilities, reception facilities, refineries, shipyards, and storage tanks.

[3] Volatization of light hydrocarbons during tank vessel loading, washing, and voyage.

[4] Sums may not match.

[5] Inputs from land-based sources during consumption of petroleum are the sum of diverse sources. Three categories of wastewater discharge are summed: municipal; industrial (not related to petroleum refining); and petroleum refinery wastewater. Urban runoff is included. It results from oil droplets from vehicles washing into waterways from parking lots and roads, and the improper disposal of oil-containing consumer products.

GT = gross tons; N/A = not available; VOCs = volatile organic compounds.

Table 2.2.2-2. Average Annual Inputs of Petroleum Hydrocarbons to Offshore Waters of the Gulf of Mexico, 1990-1999 (Source: National Research Council 2003b).

Inputs	Western Gulf of Mexico (tonnes)	Western Gulf of Mexico (bbl)	Eastern Gulf of Mexico (tonnes)	Eastern Gulf of Mexico (bbl)
Natural Sources Seeps	70,000	490,000	70,000	490,000
Extraction of Petroleum Platform Spills	50	350	trace[1]	trace
Extraction of Petroleum Atmospheric Releases (VOCs)	60	420	trace	trace
Extraction of Petroleum Permitted Produced-Water Discharges	1,700	11,900	trace	trace
Extraction of Petroleum Sum of Extraction	1,800	12,600	trace	trace
Transportation of Petroleum Pipeline Spills	60	420	trace	trace
Transportation of Petroleum Tank Vessels Spills	1,500	10,500	10	70

Inputs	Western Gulf of Mexico (tonnes)	Western Gulf of Mexico (bbl)	Eastern Gulf of Mexico (tonnes)	Eastern Gulf of Mexico (bbl)
Transportation of Petroleum Atmospheric Releases (VOCs)	trace	trace	trace	trace
Transportation of Petroleum Sum of Transportation	1,600	11,200	10	70
Consumption of Petroleum Land-Based Consumption[2]	N/A	N/A	N/A	N/A
Consumption of Petroleum Recreational Vessel Consumption[3]	N/A	N/A	N/A	N/A
Consumption of Petroleum Vessel >100 GT (spill)	120	840	70	490
Consumption of Petroleum Vessel >100 GT (operational discharges)	25	175	trace	trace
Consumption of Petroleum Vessel <100 GT (operational discharges)	trace	trace	trace	trace
Consumption of Petroleum Deposition of Atmospheric Releases (VOCs)	1,200	8,400	1,600	11,200
Consumption of Petroleum Aircraft Jettison of Fuel	80	560	80	560
Consumption of Petroleum Sum of Consumption[4]	1,400	9,800	1,800	12,600

[1] Trace indicates <70 barrels (10 tonnes).
[2] Limited to coastal zone.
[3] Limited to within 3 miles (5 kilometers) of the coast.
[4] Sums may not match.
GT = gross tons; N/A = not available; VOCs = volatile organic compounds.

2.3 Bottom Disturbance

2.3.1 OCS Oil- and Gas-Related Activities

Bottom disturbance can be caused by activities associated with offshore oil and gas exploration and production. The largest impact-producing factors include drilling, infrastructure and anchor emplacement, and infrastructure removals. Based on current industry practice and the application of lease stipulations, Notices to Lessees and Operators (NTLs), and other regulatory requirements, it is anticipated that wells would be drilled on soft seabed and that sensitive benthic features on hard bottoms or with topographic relief will be avoided.

2.3.1.1 Drilling

Drilling fluids (also known as drilling muds) and cuttings represent a large quantity of the discharge generated by drilling operations. Drilling an exploration well typically produces approximately 2,000 metric tons of combined drilling fluid and cuttings, though the total mass may vary widely for different wells (Neff 2005). The cuttings released when the initial borehole of a well is drilled splay onto the seafloor near the borehole and are typically found within 100 m (328 ft) of the wellsite (Continental Shelf Associates Inc. 2006). This is typically the thickest deposit of cuttings on the seafloor. Once the borehole is deep enough to insert a riser, rather than dispose of the cuttings at the seafloor, the cuttings are transported from the well, vertically through a riser, and up to a drilling rig. The way the cuttings are released from the drilling rig (surface release or bottom shunting) would result in substantial differences in the dispersal on the seafloor. Cuttings discharged at the sea surface tend to disperse in the water column and are distributed at low concentrations over a larger area of seafloor (Continental Shelf Associates Inc. 2004a). The portion of the water column in which the cuttings are released may experience increased turbidity during drilling activity. Refer to **Figure 2.3.1-1** for an example of surface cutting release and seafloor accumulation of cuttings. The majority of cuttings discharged at the sea surface are likely to be deposited within 820 ft (250 m) of the well, although deposits have been located several hundred meters to about a kilometer from a deepwater well (Continental Shelf Associates Inc. 2006). There are numerous studies about splays from various areas around the world (International Association of Oil and Gas Producers 2003; Neff et al. 2000; USEPA 2000b). The splay size and pattern on the seafloor differ from one location to the next and vary by well depth (which controls the total volume of cuttings available for disbursement), water depth, drilling fluid type (cuttings from oil-based or synthetic mud are taken to shore for disposal), and currents. A typical splay is not in a uniform circular shape but rather in the shape of a fan that is influenced by prevailing currents and the fall rate of drill cuttings. Cuttings typically settle to the seafloor in a patchy distribution (Continental Shelf Associates Inc. 2004b). Surface-released cuttings are usually not higher than about 1 ft [0.3 m] within a splay around a well and rarely accumulate to thicknesses of about 1 m (3 ft) immediately adjacent to the well (Zingula and Larson 1977).

On topographic feature lease blocks, lease stipuatlions require that cuttings be shunted to the seafloor through a structurally sound downpipe attached to a drill rig that terminates an appropriate distance, but no more than 10 m (33 ft) from the bottom (BOEM NTL No. 2009-G39) to focus the settlement and accumulation of cuttings away from sensitive benthic features with topographic relief (refer to **Chapter 5.10**). Cuttings must be shunted within the shunting zone (1,000 m, 1 mi, 3 mi, or 4 mi) surrounding the topographic feature so that cuttings do not settle on the topographic features within those lease blocks. The size of the shunting zone is dependent on the type of ecological community of the topographic feature that it surrounds. Cuttings shunted to the seafloor form piles concentrated within a smaller area than do sediments discharged at the sea surface and tend to be thicker than the deposition from surface released cuttings (Neff 2005). Changes to the substrate near a well may occur after drilling. Sediment grain size may be altered and enriched with sandy material (Kennicutt et al. 1996). Drilling muds that remain on the cuttings are broken down by bacteria and fungi, and can cause the sediment to become anoxic (lacking oxygen) (Neff et al. 2000).

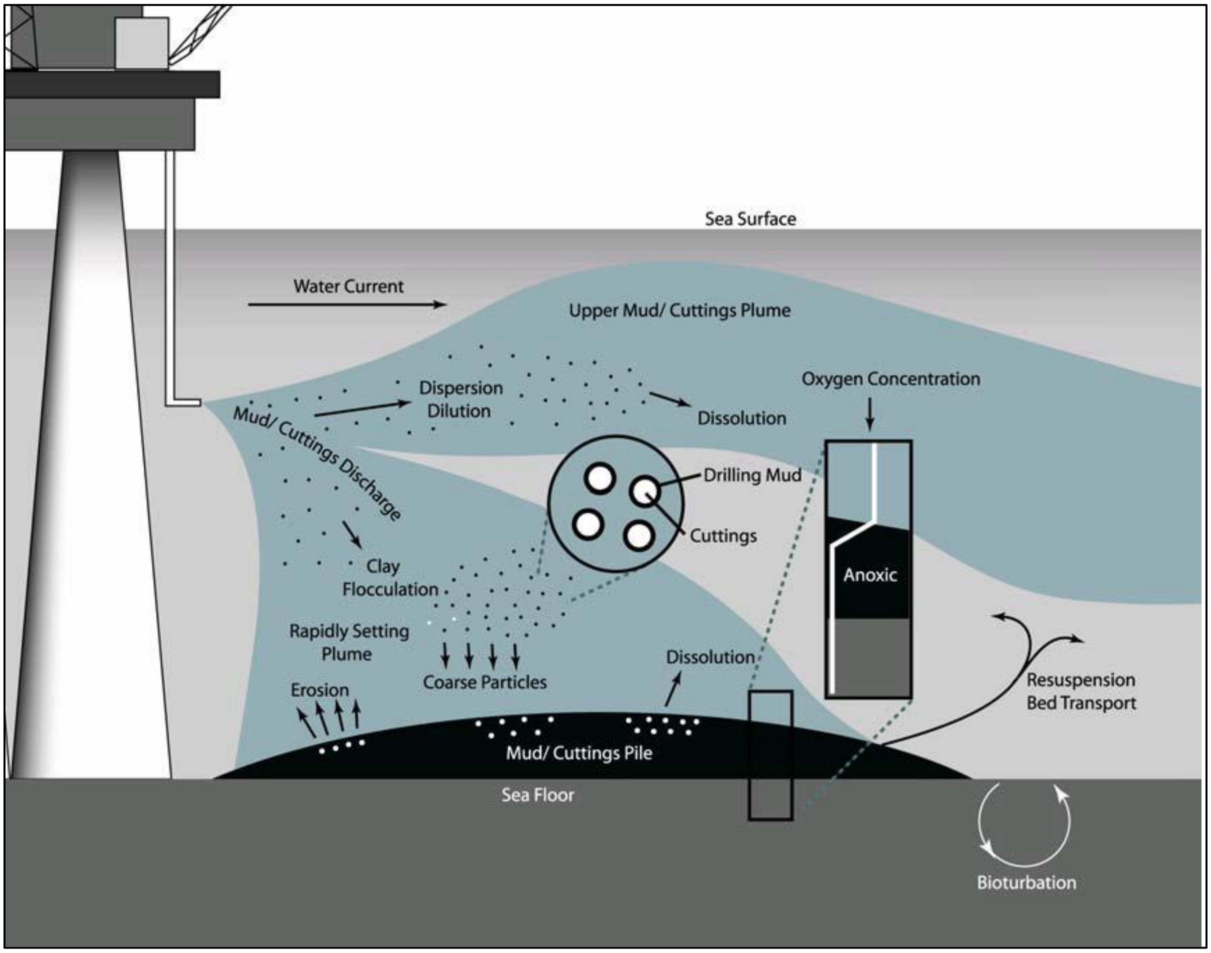
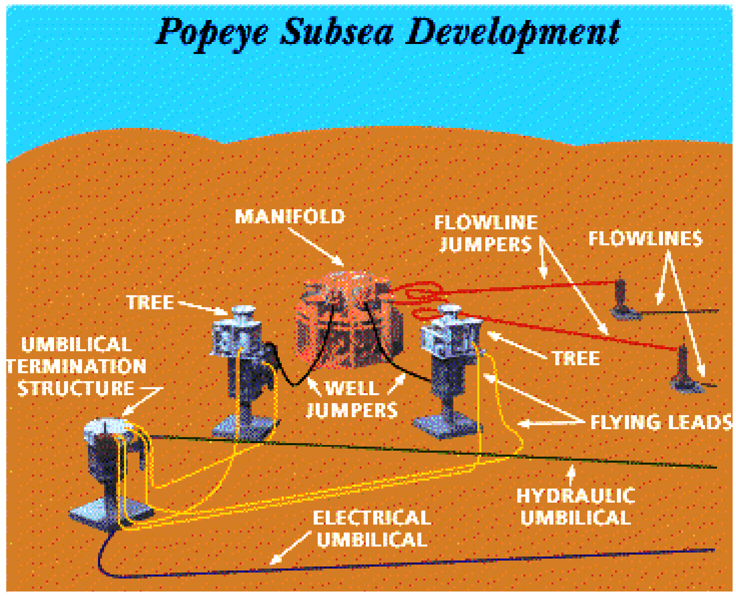


Figure 2.3.1-1. Example of Cuttings Being Discharged from a Platform (Continental Shelf Associates Inc. 2006).

The chemical content of drilling muds and cuttings (and, to a lesser extent, produced waters) may contain hydrocarbons and trace metals including heavy metals, elemental sulfur, and radionuclides (Kendall and Rainey 1990; Trefry et al. 1995). For more details on drilling muds, refer to **Chapter 2.2.1.1**.

2.3.1.2 Infrastructure, Anchor Emplacement, and Anchoring

Structures or vessels and their associated anchors that may facilitate oil and gas exploration and production include drilling rigs or MODUs (i.e., jack-ups, semisubmersibles, and drillships); pipelines; fixed surface, floating, and subsea production systems (i.e., manifolds and sleds); FPSOs (refer to **Chapter 1.3.3.4.1** for a discussion of these structures); barges; and service vessels. The emplacement of structures disturbs small areas of the sea bottom beneath or adjacent to the structure. The seafloor beneath a structure would endure direct physical contact within the footprint of the infrastructure. Impacts would vary in direct proportion to the surface area and mass of the specific equipment emplaced but would include crushing and compaction of substrate beneath the object and turbidity in the water column from object placement or pile driving. For example, the placement of a large bottom-founded platform would have a much greater area of impact than placement of a small umbilical cable. If mooring lines are anchored to the sea bottom, areas around the structure could also be directly affected by their emplacement and mooring line swing along the seafloor. The area of disruption on the seafloor would be within the swing arc, which is formed by anchor lines scraping across the bottom within the range of the anchoring system configuration.



Structures and equipment that can cause the largest impacts on the seafloor include rig and platform mooring systems, subsea production systems, pipelines, and anchors. The number and size of anchors and subsea equipment under floating production vessels, such as semisubmersibles and drillships (including dynamically positioned vessels), varies in size depending on the situation and location. A semisubmersible drilling rig can be anchored using twelve 65-m^2 (700 ft^2) anchors. The anchors typically measure about 25 ft x 28 ft (7.5 m x 8.5 m) (Regg et al. 2000). Typical subsea production systems, which are attached to the seafloor, include a subsea production tree (typically 12 ft x 12 ft x 12 ft [3.5m x 3.5m x 3.5m]), pipelines and flowlines (typically a 3- to 12-in [up to 36 in] outer diameter or a 7.5- to 30.5-cm [up to 91.5 cm] outer diameter), a subsea manifold (approximately 80 ft [24.5 m] per side), umbilicals (10 in [25.5 cm] in diameter), a termination unit (approximately 10 ft [3 m] on a side), production risers (3-12 in [7.5-30.5 cm] in diameter), a template (ranging from 10 to 150 ft long and 10 to 70 ft wide [or 3 to 45 m long and 3 to 21.5 m wide]), and jumpers (up to 20 in [51 cm] in diameter). Refer to **Figure 2.3.1-2** for an example of a subsea production system. This network can be spread over large areas of seafloor (Regg et al. 2000).

The mooring systems for rigs, platforms, and FPSOs vary depending on the type of structure (**Figure 1.3-6**). A fixed platform is connected to the seafloor by a jacket that consists of four, six, or eight tubulars, 7-14 ft (2-4.5 m) in diameter, which are welded together to form a stool-like structure on the seafloor. These tubulars are secured to the seafloor with 7-ft (2-m) diameter piles. Typical base dimensions for a fixed platform are 400 ft x 500 ft (122 m x 152.5 m), and the footprint is limited to the base of the jacket and the mooring systems of crane barges and workboats. Pipelines associated with fixed platforms are typically 4-36 in (10-91.5 cm) in diameter (Regg et al. 2000). A compliant tower is composed of a jacket with four-leg tubulars, 3-7 ft (1-2 m) in diameter, secured to the seafloor with 2- to 6-ft (0.5- to 2-m) diameter piles. Jacket dimensions can be up to 300 ft (91.5 m) per side. An additional mooring system, used with guyed-tower design, has as many as 20 piles, each 72 in (1.8 m) in diameter. Bottom disturbance from a compliant tower would include the jacket and mooring system, along with the associated pipelines (up to 36-in [91.5-cm] diameter), crane barge (12-point anchor layout), and the mooring systems of workboats and barges (Regg et al. 2000).

A spar is attached to the seafloor with 6-20 mooring lines that have an 7-ft (2.1-m) diameter pile. The length of the mooring lines can reach one-half mile or more in diameter measured from the center of the hull to anchor piles. Risers attached to the seafloor inside the mooring radius can have several types of footprints on the seafloor. A rectangular footprint is usually 100 ft long by 20 ft wide (30 m long x 6 m wide). A TLP is also held in place by a mooring system. A foundation is placed on the seafloor and serves as the base for which to attach tendon legs and production risers. As many as 16 tendons hold the TLP in place and are connected to the seafloor foundation with 10-ft (3-m) diameter piles, one pile per tendon. Sometimes large templates are also placed on the seafloor to show a pattern for well locations and foundations. The templates range in size, depending on use, and cover more seafloor than footprints of TLPs that only use foundations (Regg et al. 2000).

The area of bottom disturbed by an FPSO system would be a combination of a subsea production system and an anchor pattern. If an FPSO uses dynamic positioning, it would not have an anchor pattern. The product would be offloaded by pipeline, which would disrupt the seafloor within its footprint, or shuttle tanker.

Anchors disturb the seafloor and sediments in the area where they are dropped or emplaced. While a support vessel or barge anchor is being set and anchor chains are being winched taught, the anchor and chain could be dragged along the seabed for dozens of feet before the anchor flukes are set in the sediment (MMS 2005). Anchoring can cause physical crushing and compaction beneath the anchor and chains or lines, as well as resuspended sediment. Anchor chains can also disturb the seafloor and create turbidity in the area if an anchored rig or vessel swings while at anchor, resulting in the anchor chain sweeping across the seafloor. Anchors can also be dragged a distance across the seafloor during placement and recovery, or if the vessel loses footing.

Structures that are not fixed or anchored to the seafloor are held in place using dynamic positioning. Dynamic positioning uses four or more propeller jets to hold the vessel in place, reducing anchoring impact potential. Although not anchored, dynamic positioning uses transceivers mounted to the seafloor to hold the structure or vessel in place. A series of transceiver units send signals back and forth to the floating structure or vessel, enabling it to stay in place. The number and size of transceivers attached to the seafloor depend on the type of positioning employed. Although transceiver sizes can differ, the dimensions provided by one manufacturer for a transceiver were approximately 900 millimeter (mm) x 700 mm x 500 mm (2.95 ft x 2.3 ft x 1.64 ft), with a weight of about 72 kilograms (159 pounds) (Kongsberg Maritime 2016). Transceivers can cause crushing and sediment compaction of the seafloor within the direct footprint of the device.

Emplacement of pipelines can also disturb the seafloor. Pipelaying vessels operating in shallow water use anchors, weighing 30,000-50,000 pounds (13,608-22,680 kilograms) each, to pull them forward as they lay pipe behind the vessel. Anchors are continually moved as the pipelaying operation proceeds. Anchors crush and compact substrate beneath their footprint and create suspended sediment plumes around their footprint. In water depths <200 ft (61 m), BSEE requires pipelines to be buried to a depth of 3 ft (1 m). Burial is typically done by placing a pipeline into a water-jetted trench. High-pressure water jets on a jetting sled are pulled along the seafloor behind the lay vessel and create a trench that is only a few inches wider than the pipeline, which would be laid within. The trenching process disturbs the seafloor by forcing the sediment outside of the newly created trench and into the water column. As the trench is jetted, the pipeline is laid into the trench, behind the jetting sled (Cranswick 2001). Following the jetting process, sediment settles back to the seafloor, but over a distance farther than the trench itself. The area over which the sediment settles, and the thickness of the deposition, depends on bottom topography, sediment density, and currents. The typical cross section of a trench is about 3.77 m^2 (40.58 ft^2) for flowline bundles and 5.02 m^2 (54.03 ft^2) for export pipelines. Pipelines are buried deeper in fairways to avoid interaction with traveling vessels. The typical cross section of a trench across a fairway is about 12.83 m^2 (138.10 ft^2) for flowline bundles and 14.51 m^2 (156.18 ft^2) for export pipelines (Cranswick 2001). Pipelaying vessels operating in deep water (<200 ft [61 m]) rely on dynamic positioning rather than conventional anchors to maintain their position during operations. Pipelines laid in water deeper than 200 ft (61 m) do not require trenching; therefore, deepwater pipelaying is assumed to disturb less seafloor (about 0.32 hectares [ha]; 0.79 acres [ac]) per kilometer of pipeline installed than shallow-water operations, as the footprint of disturbance is limited to the pipeline itself (Cranswick 2001).

Most exploration drilling, platform, and pipeline emplacement operations on the OCS require anchors to hold the rig, topside structures, or support vessels and barges in place. Some vessels or barges require many anchors to hold them in place. For example, an average derrick barge may use 8-10 anchors for stability (MMS 2005). The relationship between water depth and lateral extent of the anchor pattern is not linear, and the typical radius of an anchor pattern for a semi-submersible drilling rig operating in a water depth of 100 m (328 ft) is 1,300-1,400 m (4,265-4,593 ft). Anchors are retrieved by anchor handler vessels by means of pennant wires that slide down the cable towards the anchor allowing a more or less vertical retrieval, facilitating anchor breakout from the seabed.

Mooring buoys may be placed near drilling rigs or platforms in water depths >150 m (492 ft) so that service vessels need not anchor, or for when they cannot anchor due to water depths that are too deep for anchoring. The temporarily installed anchors that hold these buoys in place would most likely be smaller and lighter than those used for vessel anchoring and, thus, would have less impact on the sea bottom. Moreover, installing one buoy would preclude the need for repeated individual vessel-anchoring events at the same location. Service-vessel anchoring is assumed not to occur in water depths >150 m (492 ft) and only occasionally in shallower waters (vessels typically tie up to a platform or buoy in water depths >150 m [492 ft]). Barges used during production are assumed to tie up to a production system rather than anchor. However, barges and other vessels that are used for both installing and removing structures (**Chapter 2.3.1.3**) may use anchors, but those anchors are placed far from the location of actual work so as to avoid other structures and pipelines.

2.3.1.3 Infrastructure Removal

Production Structures with Fixed Bases

Once production is complete, structures placed on the OCS must be decommissioned and removed. Routine structure-removal activities such as support vessel and barge anchoring, pre-severing operations (jetting around legs of the structure), severing operations (explosive and non-explosive severing of the structure), post-severing operations (standard or sectioned lift and load of structure), site clearance activities (trawling), and reefing of portions of the removed structure could contribute to localized bottom disturbance. Sediment disturbance would occur over a limited area of seafloor over a time period of less than a week to about a month for the most extensive removal projects (MMS 2005).

The anchors from support vessels and barges used in the structure-removal process may impact the seafloor. Vessel anchors and chains or the legs of a jack-up barge can crush and compact the substrate beneath their footprint. Anchors and anchor chains can drag over the seafloor while the vessel swings at anchor. The size of the affected area would depend on water depth, anchor and chain sizes, chain length, method of placement, wind, and current.

If a structure is completely removed, the base is typically cut at least 5 m (15 ft) below the mudline, using explosive or non-explosive severance methods. Non-explosive severing involves cutting tools operated by divers or remotely operated vehicles (ROVs) either inside or outside of the pile, and explosive severance devices involve explosive charges that are deployed inside the pile. Refer to **Chapter 1.3.3.5.2** for a more detailed description of severing tools and operations.

Pre-severance activities associated with non-explosive severance can cause sediment to be suspended and later deposited in the area surrounding the footprint of the structure being removed (MMS 2005). For non-explosive severance, in order to sever a platform below the mudline, excavation of sediment around the legs of the structure may be required (refer to **Figure 2.3.1-3**). In order to sever a pile externally, a trench around the pile could be excavated using water jets in order to gain access to the pile below the mudline. The trench could be up to 20 ft (6 m) deep and extend 20 ft (6 m) from the pile. If a pile is severed internally, mud within the pile must be removed to allow for severance below the mudline. Any mud within the piles is water jetted and the material is forced vertically up the pile until it splays out the top and into the water column. It would then settle to the seafloor. The physical removal of the sediment surrounding the pile or within the pile would result in turbidity and sediment accumulation in nearby locations (MMS 2005; National Research Council 1996). It is also possible that contaminants accumulated in the sediment during the life of the structure (i.e., hydrocarbons, metals, drilling muds, and cuttings) would be released to the water column when the area around the pile is excavated.

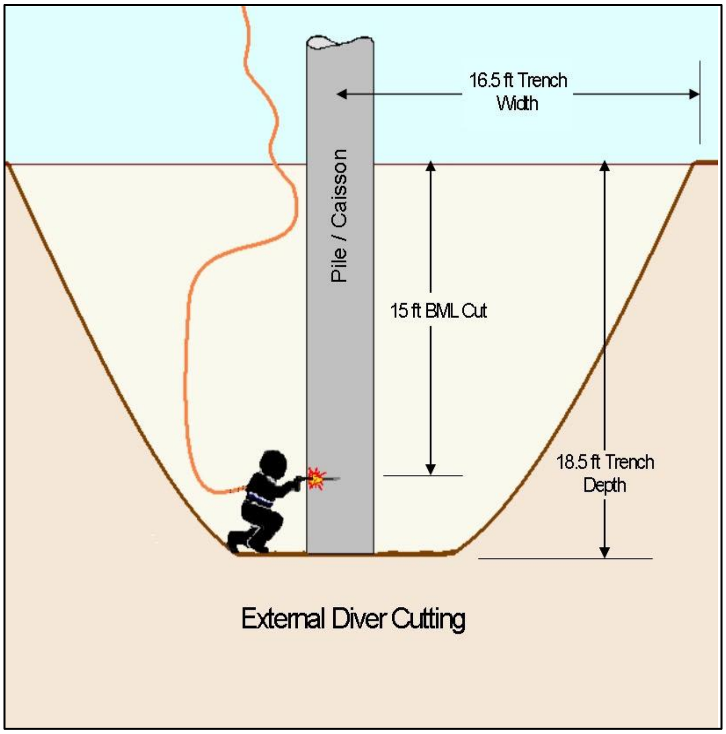


Figure 2.3.1-3. Seafloor Disturbance for Diver Assisted Severing Operations Below the Seafloor (MMS 2005a [adapted by MMS from NRC 1996]).

Explosive severance of fixed structures could cause disturbance in the immediate area of the structure. The explosive severing tools are typically deployed inside of the pile and are detonated both above the mudline for topside structure removal and below the mudline for complete structure removal (MMS 2005). Refer to **Chapter 1.3.3.5.2** for greater detail on explosive severing tools and techniques. Explosions above and below the mudline could produce explosive shock waves that radiate from the source. Charges detonated above and below the mudline could also result in localized turbidity and sedimentation. It is also possible that any contaminants in the sediment, such as hydrocarbons, metals, drilling muds, and cuttings, could be released to the water column with the sediments disrupted from an explosion.

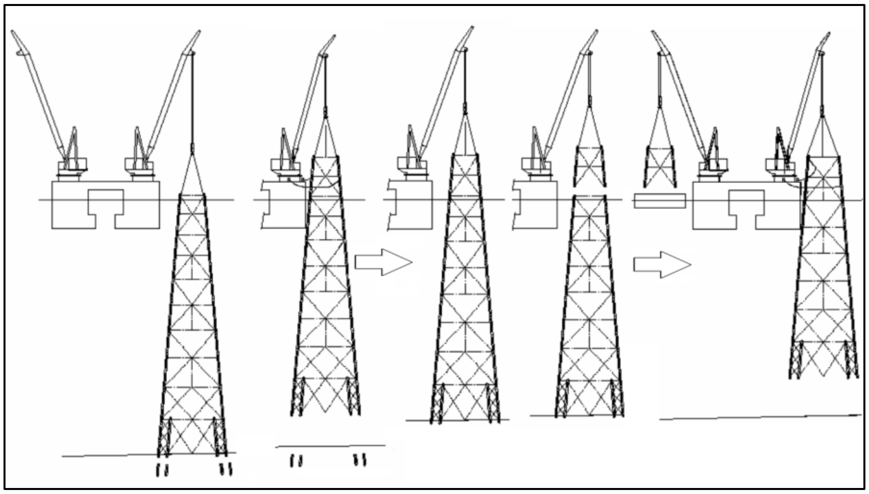


Figure 2.3.1-4. Progressive Transport or "Hopping" to Section a Large Jacket (MMS 2005a [adapted from Twachtman Snyder & Byrd, Inc 2000]).

Once a fixed structure is severed, it must be removed from the seabed. The structures are either lifted onto a barge or towed to their destination (shore or reef site). If a structure is completely loaded onto the transport vessel, there should be no further bottom disturbance as a result of structure transport. If the transport vessel does not have the capability of completely lifting the structure from the water, it is hoisted off the seafloor and towed in the water behind the vessel. The structure is lowered to the seafloor in a shallower, previously surveyed location, and the portion of the structure above the waterline is removed and both pieces are placed on the barge. This transport method is called "sectioned lift and load," "progressive transport," or "hopping" (MMS 2005; Twachtman Snyder & Byrd Inc. 2000) (**Figure 2.3.1-4**).

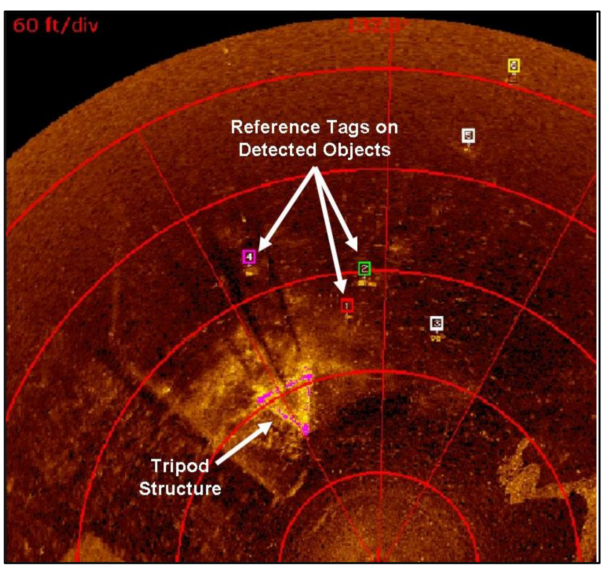


Figure 2.3.1-5. Example of a Site Clearance Survey (MMS 2005a).

Operators are required to perform site-clearance work once the structure is removed to ensure that the seafloor is returned to prelease conditions. The site may be cleared using trawls, diver surveys, sonar surveys, or ROV surveys to clear the area of objects lost at sea during the life of the structure. Refer to **Figure 2.3.1-5** for an example of a site-clearance survey. Trawl surveys use commercial trawl nets to survey a grid around the structure with a radius ranging from 91 to 402 m (300 to 1,320 ft), depending on the structure. Trawl passes may scour sediment in its path and cause turbidity as nets drag the seafloor, leaving trails of suspended sediment. Diver, sonar, or ROV surveys would cause less damage to the seafloor than trawling surveys. Disturbance of the seafloor would be limited to the area of seafloor obstruction that needed to be removed and the trawl sweep, if a trawl is used (MMS 2005).

Some decommissioned structures could be converted to artificial reefs. The structures may be partially removed, toppled in place, or fully removed and brought to a pre-approved reef site. Partially removed in place means the bottom portion of the platform would remain in place while the top portion (generally above 85-ft [26-m] water depth) would either be recycled or reefed. There would still be some seafloor impacts from support vessels, pre-severing operational impacts, severing impacts, and site clearance. If the platform is reefed at a predetermined reef site, the seafloor near the existing structure could endure support vessel impacts, pre-severing operational impacts, severing impacts, and site-clearance impacts. The structure would then be towed by a derrick barge to the predetermined reef site. The seafloor in the set down location would be physically disturbed, as well as areas that could encounter drag scars from jacket towing (MMS 2005).

Production Structures with Mooring Systems

Some of the mooring systems used in deepwater operations have quick-disconnect technology built into their designs. Using several varieties of exploding bolts, electromechanical couplings, and/or hydraulic-actuated connections, these release mechanisms can be controlled from a surface vessel and triggered on short notice. Following severance, ROVs fully recover the mooring system, including the lines, cables, and chains from the seafloor to return the seafloor to its original condition and prevent a future hazard to commercial fishing gear and navigation (MMS 2005). In addition, the moorings that hold the topsides in place need to be removed from the seafloor. Gravity-based structures may cause significant stress to lifting equipment during removal and may need to undergo excavation prior to lifting. If a small amount of excavation is needed, handheld diver or ROV-mounted suction or jetting tools may be used (Small 2016). If large-scale excavation is necessary, it may require mass-flow excavation or high-pressure water jetting. Suction caissons and anchors may be removed in the reverse way they were installed, using overpressure in place of suction. Additional excavation or explosive removal may be necessary as well. Piles are cut below the seabed and remain in place. Drag anchors, and their associated chains, can be removed with an anchor handling vessel by applying tension in the opposite direction than was used when the anchor was set (Small 2016). All of these techniques used in the removal of mooring equipment can cause seafloor crushing, turbidity, and resultant settling of sediment out of the water column. The amount of sediment suspended would be dependent on the amount of excavation, depth of excavation, type of excavation, amount of overpressure used, size of the drag anchor, and distance the drag anchor may have been pulled along the seafloor.

In situations where the mooring system disconnects were not employed or become disabled, structures may be removed using either explosive or non-explosive severance devices. Mechanical cutters such as wheel and guillotine saws, hydraulic shears, and diamond wire cutters can be deployed using ROVs, allowing the cuts to be performed as close to the anchors as possible. In much the same way, small explosive shaped-charge devices can be positioned onto the mooring targets by ROVs. These external cutters are generally designed with hydraulic/electric actuators and hinge systems that allow the shaped charge to be “clamped” over the target and then detonated after the ROV is removed to a safe distance. Together, these effective severing methods and the deep-diving capabilities of the ROVs allow for full recovery of the lines/cables/chains following severance (MMS 2005). The seafloor impacts associated with explosive severance are discussed in “Production Structures with Fixed Bases” above. The impacts from non-explosive severance would be limited in scope and only occur where the seafloor may have been touched or where sediment was disturbed as a result of the cutting activity.

Pipelines and Other Appurtenances

While production structures are generally removed, it is anticipated that pipelines and multiple appurtenances or types of equipment (e.g., subsea systems: pipeline end modules, subsea tie-in, pipeline end terminals, umbilical lines, etc.) would not be removed from the seafloor if they do not constitute a hazard (obstruction) to navigation and commercial fishing operations, unduly interfere with other uses of the OCS, or have adverse environmental effects, as allowed under certain conditions in 30 CFR § 250.1750. From 2009 to 2019, roughly 11,500 mi (18,507 km) of pipeline was decommissioned; approximately 98 percent of which was abandoned in place in accordance with the requirements at 30 CFR § 250.1006, while the other 2 percent was removed. **Figure 2.3.1-6** illustrates the general location of these decommissioned pipelines.

At the end of its useful life, or because of a catastrophic event such as a hurricane, an offshore pipeline may be decommissioned in place, which normally involves cleaning the line by pigging and flushing or flushing alone (with approval by BSEE’s Regional Field Operations Regional Supervisor), cutting the pipeline endpoints, and then plugging and burying each endpoint below the seabed or covering the endpoints with a concrete mattress. Verification of the pipeline cleaning would be based upon flush water quality checks that often rely on visual verification and the absence of hydrocarbon sheen. Measurements by instrumentation may also be used. Flush water is typically pumped down disposal wells at the platform if wells are available, processed for disposal, or shipped to an approved disposal site (Kaiser 2017).

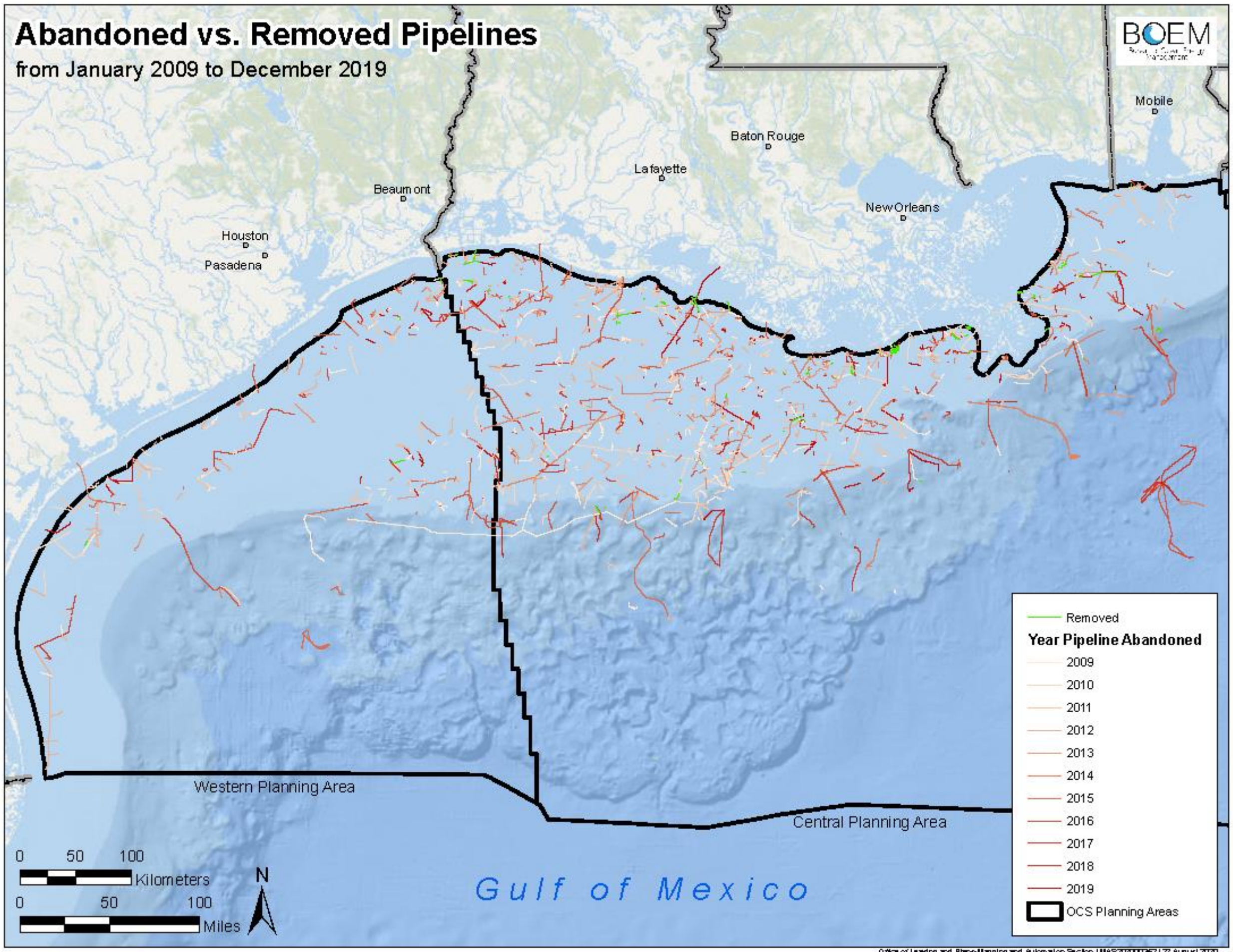


Figure 2.3.1-6. Pipelines Removed and Abandoned in Place from 2009 to 2019 (NOTE: Pipeline segments are magnified to improve visibility and are not to scale.).

Conventionally, a platform pipeline is typically cut near the base of the platform by divers or ROV using an arc oxygen torch or diamond-wire cutters, and a cap is installed on the end. This cut separates the riser portion of the pipeline, which connects to the platform, from the pipeline on the seabed. The end of the pipeline that remains on the seafloor is plugged and buried 3 ft (1 m) below the seabed, typically by diver- or ROV-operated jetting (Kaiser 2017) to prevent it from moving along the seafloor or being accidently entangled with fishing gear or other equipment. The pipeline end may alternatively be covered by a concrete mat that provides a cover for the pipeline and does not hinder a trawl net. Concrete mattresses can be used in deep water where it is not practical to bury the ends using divers. Concrete that experiences continuous immersion in seawater is not subject to deterioration and is considered stable (Mather 1965). The riser that extends from the seafloor up through the water column may be removed or left in place along with platform meters and associated equipment, depending on the agreement between the pipeline and platform owners. If removed, the riser may be partially or wholly removed. To partially remove a riser, it would be cut below the waterline and near the base of the platform, and the remaining section of the riser would be removed from the water column (Kaiser 2017). Localized turbidity and sedimentation could occur at the pipeline endpoints, where the pipeline is cut and buried, or covered with a mattress. Vessel anchors could compact the seafloor within their footprints.

Pipelines that make landfall may be removed through the surf zone and capped. The onshore pipeline may be removed completely, or some sections may be abandoned in place due to their transition through a sensitive environment. The pipeline end seaward of the surf zone is capped and jetted down 3 ft (1 m) below the mudline by divers. Pipeline crossings may be an obstacle to decommissioning, particularly if the pipeline to be decommissioned crosses under a live production pipeline. Localized seafloor disturbance (turbidity and sedimentation) could occur in the surf zone if the pipeline is fully removed or where the end is jetted below the seafloor.

The recovery of decommissioned and removed pipeline sections could be accomplished by rigging a winch wire to the pipeline and lifting it to the barge. A crane may be used in conjunction with the winch to hoist the pipeline onto the recovery vessel. Excavation may be required to remove the pipeline, or it may be recovered without excavation if enough lifting force can be applied. Localized seafloor turbidity, followed by sedimentation could occur in areas where the pipeline is dragged over the seafloor during removal or in the area of excavation. Compaction of the seafloor could occur within the footprint of anchors set by vessels removing the pipeline.

Before a pipeline is decommissioned (in-place or by removal), the operator is required to submit a removal application to BSEE, which includes the proposed decommissioning procedures, such as seafloor anchor patterns and radius, vessels to be used, length of pipeline to be removed or left in-place, transportation/disposal plans for removed pipeline, plans to protect archaeological and sensitive benthic features as well as an assessment of the environmental impacts and mitigations to minimize the impacts, and the projected schedule and duration of removal. In most cases the pipeline would also be required to be pigged (cleaning or clearing with a tool known as a “pig”) and flushed before removal (30 CFR § 250.1752) unless departures from pigging are approved by BSEE’s Regional Field Operations Regional Supervisor. If a pipeline is determined to be an obstruction (as decided by BSEE’s Regional Supervisor), under 30 CFR § 250.1700b, the pipeline is required to be removed rather than abandoned in place. Localized seafloor disturbance could occur within the direct footprint of any anchors used as well as where the pipeline was dragged along the seafloor during removal, if it was removed.

An abandoned pipeline may be removed from the seabed by reverse lay barge or reel recovery, J-lift recovery, tow recovery, or sectional recovery (John Brown Engineers and Constructors Ltd 1997; Scandpower Risk Management Inc. 2004). Pipelines are prepared for extraction by removing any sediment or rock cover under which it may be buried (if buried), removing pipeline anchors and crossing mats, and cutting the pipeline into sections, if necessary (Scandpower Risk Management Inc. 2004). For reverse lay recovery, the pipe is lifted with a winch onto a recovery vessel. For buried pipelines, a jet sled or other device would run approximately 300-400 ft (91-122 m) ahead of the recovery vessel and excavate the pipe, by liquefying and removing sediment from a trench in which the pipeline lays, before it is removed. The pipe is lifted, placed on the recovery vessel, cut, and removed in sections. The recovery vessel may either be dynamically positioned or use anchors to "crawl" along the seabed during the pipeline recovery. Anchors would be adjusted as the vessel moves along the seafloor. Reverse reel barge recovery is similar, except the pipe is wound onto a reel rather than cut into sections. Once the reel is full, the pipe is cut and allowed to rest on the seabed until the recovery vessel unloads the full reel and returns to recover the remainder of the pipeline (Scandpower Risk Management Inc. 2004). Localized seafloor disturbance would include crushing, turbidity, and sedimentation.

Pipelines are excavated for tow recovery as they are for reverse lay or reel recovery (**Figure 2.3.1-7**). Pipelines, usually in lengths of a few thousand feet long, are attached to buoys so they float and are towed to shore between the retrieval vessel and a tug boat. The sea state determines if the pipeline is towed near the seafloor, in the water column, or at the sea surface. Sectional recovery involves cutting the pipeline into smaller lengths for transportation to shore. The pipe may either be cut on the vessel after it is removed from the water (long-section barge recovery) or cut into short lengths on the seabed using an ROV, robot, or diver. Sections are then lifted onto the recovery vessel by crane (Scandpower Risk Management Inc. 2004). Localized seafloor disturbance would include crushing, turbidity, and sedimentation.

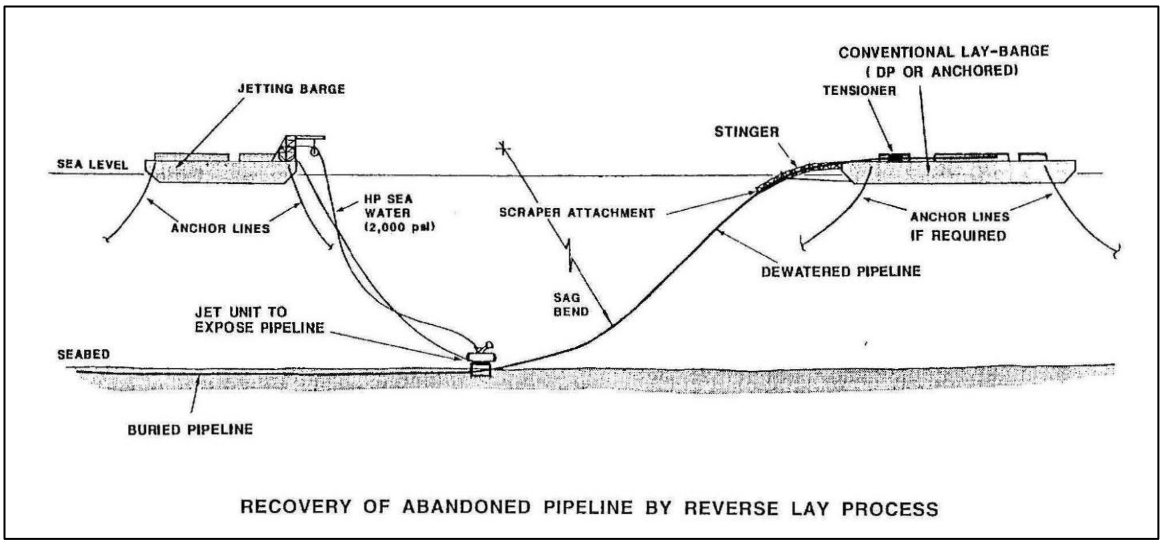
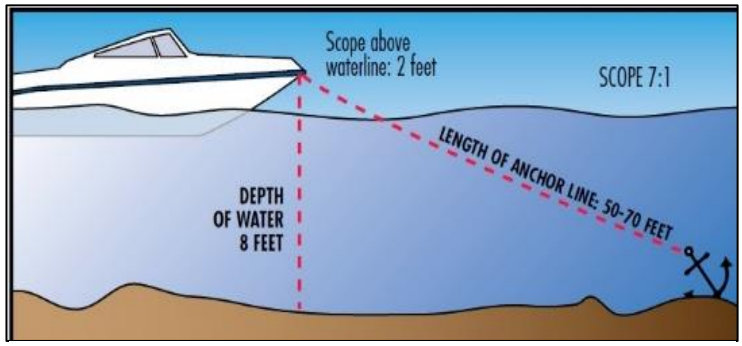


Figure 2.3.1-7. Example of Pipeline Recovery through the Reverse Lay Process (Scandpower Risk Management, Inc. 2004).

2.3.2 Non-OCS Oil- and Gas-Related Activities Causing Bottom Disturbance

Seafloor disturbance caused by activities that are not part of BOEM's oil and gas program can occur from anchoring, buoys, or moorings; military operations; State oil and gas activities; artificial reefs; dredging and trawling; renewable energy installations; and mass wasting events.

2.3.2.1 Anchoring, Buoys, and Moorings



Non OCS oil- and gas-related vessels (e.g., activity related to BOEM's marine minerals or renewable programs, military activity, pleasure vessels, recreational and commercial fishermen, and dive boats) frequently anchor to hold a vessel on location. Anchors "bite" into the seafloor in order to secure a vessel in place and work best in areas of soft seafloor sediment. Anchor chain lengths should be about seven times the water depth to hold the vessel securely, without the anchor slipping along the seafloor as the wind and waves move the vessel at the sea surface (**Figure 2.3.2-1**) (USCG 2010). Anchors do not grip well on hard substrates and tend to slide along the hard bottom substrate as a vessel drifts at the water's surface.

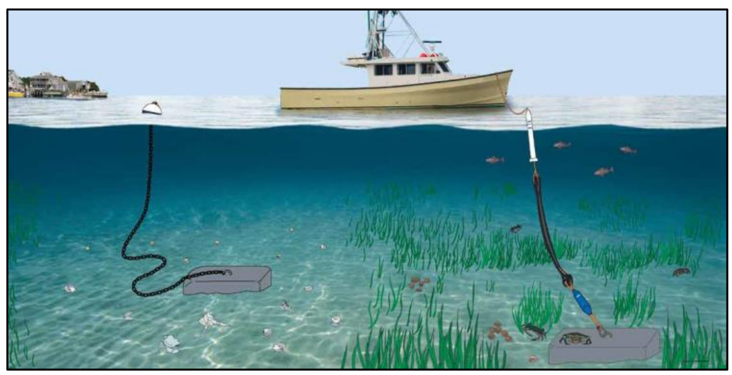


Figure 2.3.2-2. Example of Anchoring Buoys/Moorings on the Seafloor (NOAA et al. 2010).

Buoys or moorings are attached to the seafloor by permanent anchors. Vessels can secure to buoys or moorings to hold position (**Figure 2.3.2-2**) (Evans 2009; NOAA et al. 2009). Buoy or mooring fields can be found outside harbors for cargo ships to tie before heading into a port; in smaller ports or harbors for recreational vessels or small commercial vessels to moor; in locations that are marked for fishing, diving, or other recreation; or they may mark avoidance areas such as reefs, fishing nets, or scientific equipment. Buoys and moorings are typically found on soft seafloor rather than hard substrate because it is easier to attach or drive an anchor into soft sediment than rock.

The bottom disturbance caused by anchors, buoys, or moorings includes crushing and compaction of substrate beneath the vessel anchor or mooring foundation. The dropping of an anchor on the seafloor can cause turbidity in the water column. If an anchor does not grip the seafloor when it is set, the anchor could scour the seafloor if it is dragged by the motion of the attached vessel. Moorings can be attached to the seafloor by large seafloor foundations or buried piles or foundations. Piles and buried foundations could be jetted or pounded into the seafloor, which could cause suspended sediment and turbidity, followed by sediment deposition in the area of disturbance. In the small footprints where a mooring is attached to the seafloor, there is a permanent change in substrate from soft seabed to hard structure (**Figure 2.3.2-3**) (Morissey et al. 2018; Poppe et al. 2007). Although most anchoring occurs in soft sediment, where anchors grip best, severe damage can occur if anchors are placed over hard seafloor, such as coral habitat, where corals can be crushed or broken, or in submerged vegetation beds, where seagrasses could be torn and physically removed from the seabed.

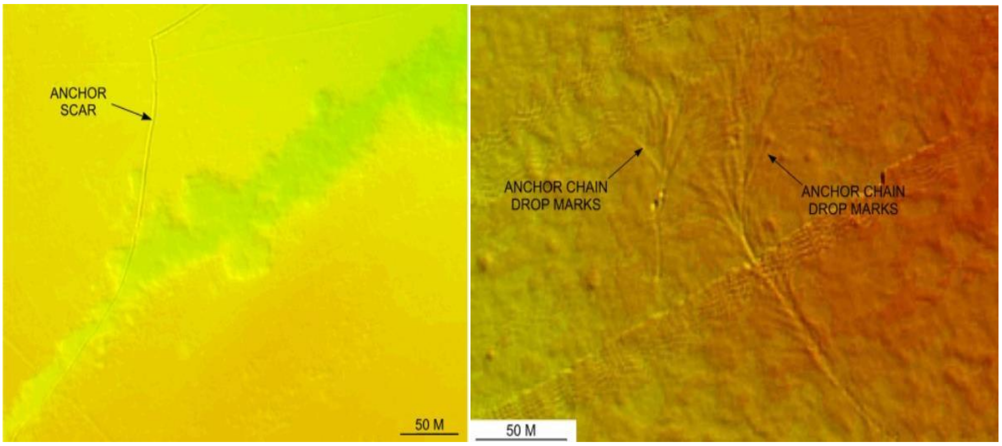


Figure 2.3.2-3. Examples of Chain and Anchor Scars on the Seafloor from Vessel Anchoring (Poppe et al. 2007).

The areas around the vessel anchors or bottom-founded mooring base could also be directly affected if anchor or mooring chains drag over the seafloor. Mooring chains need to be long enough to account for tidal differences as well as vessel movement, which can result in the chain scraping the seafloor at low tide or when a vessel swings. Chain scours may create a circular scar around the anchor due to tidal movement and wind direction. The size of the scar would depend on water depth and chain length. Areas with mooring fields are susceptible to seafloor erosion from repeated chain scour. Sediment grain size can change, and anoxia (lack of oxygen) can occur in sediments surrounding moorings as a result of chain sweep. Fine sediments that may have accumulated contaminants from moored vessels may be suspended in the water column as a result of chain sweep, can create turbidity in the water column, travel with currents, and distribute contaminants to other areas of seafloor as the sediment falls out of suspension (Morissey et al. 2018).

Large international cargo vessels often attach to commercial anchorage moorings outside of harbors or in rivers for safety reasons. There they can await a pilot familiar with local waters who can navigate the vessel to port or they can await a security boarding, vessel inspection, or maintenance. Anchorages may occur in State or Federal waters. Impacts from stationary moorings would be similar to those impacts described in the paragraphs above but would have a larger footprint of seafloor disturbance due to the larger moorings necessary to hold commercial ships in place. Sometimes areas of seafloor near ports are labeled on navigational charts as "anchorage areas" and are locations where large cargo vessels may drop their own anchor to hold location. The seafloor disturbance that would occur in these anchorage areas would include crushing and compaction of the seafloor beneath the anchors, as well as seafloor scour from anchor chain drag. Turbidity could also occur in the anchorage areas from anchor placement and chain scour. Refer to **Chapter 2.3.1.2** for more details on impacts associated with anchor placement.

2.3.2.2 Military Operations

The DOD conducts training, testing, and operations in offshore operating and warning areas, at undersea warfare training ranges, and in special use or restricted airspace on the OCS. The U.S. Navy utilizes the airspace, sea surface, subsurface, and seafloor of the OCS for events ranging from instrument and equipment testing to live-fire exercises. The U.S. Air Force conducts flight training and systems testing over extensive areas on the OCS. The U.S. Marine Corps may conduct amphibious warfare training extending from offshore waters to the beach and inland. For more information and the locations of military operations on the Gulf of Mexico OCS, refer to **Chapter 2.7.2.5**.

Many of the operations and training exercises conducted by the military can result in seafloor disturbance. Activities can include the following: live-fire testing and training; torpedo testing; weapons testing; live ordnance release and impact activities; live underwater ordnance detonation operations; mine neutralization operations; torpedo firing exercises; dynamic submarine, surface ship, and helicopter anti-submarine warfare exercises; anti-submarine warfare instrumented training on seabed; bomb dropping exercises; and mine warfare testing and training. The exercises can require underwater cables on the seafloor, permanently installed instruments and tracking devices on the seafloor, hydrophone arrays located on the seabed, and towed bodies that can be anywhere in the water column from surface to near the bottom in water depths of 100-1,000 ft (30-305 m). As a result of these exercises, there may be unexploded ordnances on the seafloor (DOD 2010).

Explosions on or near the seabed can result in large craters on the seafloor. The sediment forced from the crater could cause turbidity in the surrounding water column, followed by sediment deposition on the seafloor. The size of the crater and amount of displaced sediment would be dependent on the size of the blast. Instruments attached to the seafloor could crush or compact the sediment beneath their foundations. Any vessels that anchor during military operations could also crush or compact sediment beneath the anchor footprint. The area of impact would be directly related to the footprint of the instrumentation or anchor attached to the seafloor. For a description of impacts that could occur from instrument emplacement or anchoring, refer to the impacts discussed in **Chapter 2.3.2.1**.

2.3.2.3 State Oil and Gas

All of the five Gulf Coast States have had some historical oil and gas exploration activity and, with the exception of Florida and Mississippi, all currently allow production of oil and gas in State waters. The coastal infrastructure that supports the OCS Oil and Gas Program also supports State oil and gas activities.

State oil and gas infrastructure consists of the wells that extract hydrocarbon resources, facilities that produce and treat the raw product, pipelines that transport the product to refineries and gas plants for further processing, and additional pipelines that transport finished product to points of storage and final consumption. The type and size of infrastructure that supports production depends upon the size, type, and location of the producing field, the time of development, and the life cycle stage of operations. The seafloor impacts associated with State oil and gas production are the same as those that occur for offshore oil and gas production (refer to **Chapter 2.3.1**), and include localized crushing, turbidity, and sedimentation.

Texas

According to the Railroad Commission of Texas, since June 2015 cumulative total State offshore production of oil was reported at over 42.6 million bbl (Railroad Commission of Texas 2019a) and offshore gas production totals were reported at over 4.21 billion cubic feet (Bcf) (Railroad Commission of Texas 2019b). Texas was the leading crude-oil producing state in the Nation in 2013 and exceeded production levels even from the Federal offshore areas (Energy Information Administration 2014b).

The Lands and Minerals Division of the Texas General Land Office holds lease sales for oil and gas on State lands, and the Texas General Land Office manages Texas State resources for the benefit of public education. The Texas General Land Office generally holds lease sales every 4 months in January, April, July, and October. The Texas General Land Office's Mineral Leasing Division uses a sealed bid process for the leasing of State lands. BOEM expects that Texas would conduct regular oil and gas lease sales in State waters during the next 70 years, although the lease sales' regularity could differ from current practices.

Louisiana

Oil production in Louisiana began in 1902, with the first oil production in the coastal zone in 1926. Southern Louisiana produces mostly oil and northern Louisiana produces mostly gas. Over the last 60 years, Louisiana averaged around 27 MMbbl of oil and 12 trillion cubic feet of gas per year (Louisiana Department of Natural Resources 2015; 2016).

Louisiana's leasing procedure is carried out by the Petroleum Lands Division of the Office of Mineral Resources within the Louisiana Department of Natural Resources (Louisiana Mineral and Energy Board 2015). BOEM expects that Louisiana would conduct regular oil and gas lease sales in State waters during the next 70 years.

Mississippi

At present, Mississippi only has an onshore oil and gas leasing program; however, it is expected that the State would start issuing leases for offshore activity in State waters in the near future. In 2004, the Mississippi Legislature limited offshore natural oil and gas exploration to areas located predominantly south of the barrier islands. On December 19, 2011, the Mississippi Development Authority published draft regulations; the public comment period closed on January 20, 2012 (Mississippi Development Authority 2011). However, recent efforts to open Mississippi State waters for G&G and leasing activities have been challenged in court (Davis 2014).

Development of an offshore oil and gas leasing program in Mississippi State waters during the next 70 years is reasonably foreseeable.

Alabama

The State Oil and Gas Board of Alabama is the regulatory agency of the State of Alabama with statutory authority over oil and gas development. From 1990 to 2018, a total of 3,902,145,150 thousand cubic feet of gas and 756,890 bbl of oil/condensate was produced in State waters (Alabama Oil and Gas Board 2020). Alabama has no established schedule of lease sales. The limited number of blocks in State waters has resulted in the State not holding regularly scheduled lease sales. The last lease sale was held in 1997. BOEM does not expect Alabama to institute a lease sale program in the near future, although there is at least a possibility of a lease sale in State waters during the next 70 years.

Florida

The Florida Department of Environmental Protection's Mining Mitigation and Delineation Program is the permitting authority for the exploration and production of oil and gas in Florida.

A total of 19 wells were drilled in Florida State waters from 1947 to 1983 (Lloyd 1991). Offshore exploratory drilling in Federal waters of the EPA included six wells completed in 1988 and 1989; one of these was the discovery in the Destin Dome Area and was classified by the Federal Government as a producible field (Lloyd 1991). In July 1990, all offshore drilling activity in Florida State waters was prohibited and the State's policy on offshore oil and gas drilling changed. In 2006, the Gulf of Mexico Energy Security Act (GOMESA) enacted a moratorium on OCS oil- and gas-related activities off the western coast of Florida. Since 1989, the Florida State Legislature has prohibited new leasing off Florida in the EPA.

With current State policy and regulations prohibiting oil and gas exploration and development in State waters, BOEM does not expect Florida to institute a lease sale program in the near future. If State policy and regulations change and the moratorium is allowed to expire, the potential for a lease sale in State waters could be a possibility during the next 70 years.

State Pipeline Infrastructure

The existing pipeline network in the Gulf Coast States is the most extensive in the world and has unused capacity (Cranswick 2001). The network carries oil and gas onshore and inland to refineries and terminals, and a network of pipelines distributes finished products such as diesel fuel or gasoline to and between refineries and processing facilities onshore (Peele et al. 2002). Expansion of this network is projected to be primarily small-diameter pipelines to increase the interconnectivity of the existing network and a few major interstate pipeline expansions. However, there is spare capacity in the existing pipeline infrastructure to move oil and gas to market, and deepwater ports can serve onshore facilities, including intrastate as well as interstate pipelines. Refer to **Table 2.3.2-1** for a list of pipeline landfalls.

Table 2.3.2-1. OCS Pipeline Landfalls Installed from 1996 to 2014.

Segment Number	Year of Installation*	Product Type	Size (in)	Company	State
10631	1996	Oil	24	Equilon Pipeline Company LLC	LA
12470	1996	Oil	24	Manta Ray Gathering Company LLC	LA
11217	1997	Gas	30	Enbridge Offshore	LA
11496	1997	Oil	12	ExxonMobil Pipeline Company	LA
11952	2000	Oil	18-20	ExxonMobil Pipeline Company	TX
14470	2004	Oil	10	Chevron USA Inc.	LA
13972	2004	Oil	24	Manta Ray Gathering Company LLC	TX
13987	2004	Oil	24	Manta Ray Gathering Company LLC	TX
13534	2005	Oil	30	BP Pipelines (North America)	LA
13534	2005	Oil	30	Mardi Gras Endymion Oil Pipeline Co.	LA
17108	2007	Gas/Condensate	16	Stone Energy Corporation	LA
17691	2009	Gas/Oil	8	Stone Energy Corporation	LA

*Year when the initial hydrostatic test occurred.
Source: Smith, official communication 2015b.

2.3.2.4 Artificial Reefs

Use of artificial reefs to enhance fisheries along the U.S. coastline was documented as early as the mid-19th century (Christian et al. 1998; McGurrin et al. 1989; Stone 1974). For nearly 200 years, purpose-built structures (e.g., wooden huts, cinder block reefs, and concrete pyramids) and obsolete materials (e.g., decommissioned vessels and damaged concrete pipe) have been intentionally deposited in estuarine and marine environments to add bottom relief, attract fishes, and improve angler access and success. As a result of research into the potential benefits and adverse impacts resulting from specific artificial reef designs, materials, and siting, the National Artificial Reef Plan was developed and revised in 2007 to provide guidance to artificial reef coordinators, fisheries managers, and other parties on recommended siting, construction, management, and monitoring of artificial reefs. The Secretary of the Army, through the USACE, is responsible for the artificial reef permitting process and for coordination of the appropriate State and Federal agencies (NOAA 2007). The Wallop-Breaux Amendment provided increased Federal funding to State agencies for sport fish restoration, contributing to the National Fisheries Enhancement Act's objectives through support of habitat enhancement projects, research, and monitoring (Christian et al. 1998).

Offshore oil and gas platforms have been contributing hard substrate to the GOM since the 1930's, and fishermen quickly found fishing success was enhanced in the vicinity of OCS oil- and gas-related structures (LUCON Company 1999; Mississippi Department of Marine Resources 2019; Wilson et al. 1987). By the late-1970's some artificial reef advocates and recreational fishermen had begun viewing the decommissioning and removal of OCS oil- and gas-related structures as a lost opportunity. The increased interest and participation in fishing at offshore oil and gas platforms and national support for effective artificial reef development coincided with research and fisheries management efforts, which led to passage of the National Fishing Enhancement Act of 1984 and the development of the first National Artificial Reef Plan. In 1987, Louisiana published a State artificial reef plan that specifically addressed the need to support public interest through development of artificial reef planning areas and the addition of decommissioned OCS platforms as artificial reef substrate (Wilson et al. 1987). Texas' Artificial Reef Act of 1989 explicitly identified decommissioned platforms as the preferred substrate for the construction of artificial reefs (Stephan et al. 1990). Currently, all five Gulf Coast States have active artificial reef programs, which develop and manage artificial reefs on the Federal OCS. The seafloor impact associated with artificial reef creation is the physical crushing of the substrate below the objects used as reefs. Reefs, however, are not sited in sensitive habitat and seafloor locations where oil and gas platforms are to be used, as the habitat is investigated prior to placing the reef material to ensure that it does not harm sensitive habitat.

The OCSLA and implementing regulations establish decommissioning obligations for lessees, including the removal of platforms. The Rigs-to-Reefs Program provides a means by which lessees may request a waiver to the removal requirement. Since the first Rigs-to-Reefs conversion, approximately 11 percent of the platforms decommissioned from the Gulf of Mexico OCS have been redeployed within designated State artificial reefs. As of December 2021, 573 platforms previously installed on the OCS have been reefed in the Gulf of Mexico (BSEE 2023). Scientific and public interest in the ecology of offshore structures and the potential benefits of contributing hard substrate to a predominantly soft bottom environment have led to increased emphasis on the development of artificial reefs. The current paradigm posits oil and gas structures act as both fish-attracting and production-enhancing devices, depending upon the species (Carr and Hixon 1997; Dance et al. 2011; Gallaway et al. 2009; Shipp and Bortone 2009). However, determination of specific and cumulative impacts resulting from construction of artificial reefs within permitted areas is very difficult. As recommended by the National Artificial Reef Plan (NOAA 2007), well-defined objectives, clear management strategies, and long-term monitoring are critical elements of an artificial reef program and are necessary if managers intend to use artificial reefs as a fisheries management tool.

2.3.2.5 Dredging

OCS Sand Borrowing

BOEM's Marine Minerals Program identifies sediment resources mainly for coastal restoration. BOEM has issued leases and agreements for sand, sediment,and gravel projects along the Gulf Coast. Typically, the borrow areas are located in water depths of 9-18 m (30-60 ft) in close proximity to the coast (approximately 3-8 nmi), but current technology can reach 30 m (98 ft).

The most common type of dredge used offshore for beach restoration is the trailing suction hopper dredge (**Figure 2.3.2-4**) (Michel et al. 2013). Trailing suction hopper dredges are self-propelled and are therefore able to traverse an expansive area within a borrow site. Dredge cut depths are approximately 2 ft (0.6 m). This type of dredge uses suction to obtain seafloor sediment and stores the material in the hull of the ship. The sediment is agitated into a water and sediment slurry via water jets and/or "teeth" located on the underside of the draghead, which is secured to the vessel with a dragarm. Sediment is hydraulically excavated from the seafloor via the draghead and pumped through the dragarm into the ship's hull or "hopper." Coarse sediment settles to the bottom of the hopper, and a water and fine sediment slurry is released into the water column via "overflow." Turbidity in the water column can result from the overflowing process as well as sediment disturbance near the draghead. The suspended sediment eventually falls out of the water column and settles on the seafloor. Once the hull is full, the vessel either dumps the sediment in a previously authorized site through doors in the bottom of the hull, pumps the sediment through a pipeline onto the beach, or disperses the sand through the air onto the beach (CSA International Inc. et al. 2009; Michel et al. 2013).

Figure 2.3.2-4. Seafloor Disturbance from a Trailing Suction Hopper Dredge (TSHD). (The TSHD components include a draghead (1), on the end of a large suction pipe (2) through which large centrifugal pumps transport the dredged material as a slurry to the hopper (3) from where it is later discharged either through bottom doors (4) or pumped (5) through a pipeline from the bow) (Michel et al. 2013).

A cutterhead suction dredge (**Figure 2.3.2-5**) (Frabotta 2012) excavates material from the seafloor by creating a slurry that is pumped into a pipeline and transported to the disposal site. The cutterhead swings in an arc and creates a slurry as it scours the seafloor and a suction mouth vacuums the slurry off the seafloor. Cutterhead dredge operations are not mobile and, therefore, excavate deeper cuts into the seafloor than the trailing suction hopper dredge, resulting in a smaller, but deeper, overall footprint of seafloor impact. This type of dredge operation can result in high turbidity levels in the area because a large percentage of the slurry may not be suctioned by the

Figure 2.3.2-5. Example of a Cutter Suction Dredge (Frabotta 2012).

dredge. The disturbed sediment can eventually fall out of suspension and settle to the seafloor in uneven rows or piles (Michel et al. 2013). Additional turbidity is created when the dredge stops pumping, and the slurry can backflow out of the suction mouth (CSA International Inc. et al. 2009). The cutterhead suction dredges use side anchors and spuds, which are frequently repositioned, to allow the dredge to be repositioned (Michel et al. 2013). The placement of anchors and spuds can disturb, compact, and crush the seafloor beneath their footprint, and chains and wires that drag along the seafloor as the dredge moves can create turbidity. Because dredging occurs in soft sediment, impacts from the dredge would not be expected for sensitive hard bottom benthic communities. In addition, surveys conducted before dredging activity occurs would ensure that anchors or spuds are not placed on sensitive hard bottoms.

Dredging results in the direct removal of the seafloor sediment in a localized area. When the sediment is removed, the seabed topography is temporarily altered. The dredged footprint may refill at rates depending on site-specific conditions, normally with a slow deposition of fine particulates due to reduced current velocity at the bottom of the pit (CSA International Inc. et al. 2009). Turbidity can occur from the cutting of the seafloor, anchor and spud placement, chains dragging on the seafloor, backflow and inefficiency of dredges, and overflow of hulls used to store sediment. Turbidity can also occur when the sediments are transferred to the beach or intermediate transfer equipment. Because sediment sources used for beach nourishment are sandy material, the sand grains tend to settle out of the water column fairly rapidly after disruption (CSA International Inc. et al. 2009). The distance sediment travels in the water column before it settles will depend on local currents and sediment grain size. The resultant grain size profile of the borrow area and nourished beach area may be different from the pre-dredge and nourishment profiles as finer grained sediments may be washed out of the area through the dredging and nourishing process (Smith et al. 2019). BOEM applies a range of best management practices and mitigating measures to minimize environmental impacts; the particular suite of measures depends on each project, its setting, and the nearshore area.

Prior to dredging, geophysical and geological seafloor surveys are conducted to identify suitable borrow sites. Borrow sites are located on sandy seafloor and restrictions are put in place to avoid hard bottom habitat. The greatest seafloor disturbance would be from bottom sampling and sediment coring. A core or grab sample is estimated to disturb up to 1-9 ft^2 (0.009-0.84 m^2) of seafloor, (BOEM 2014). Sediment would be physically removed from the seafloor as well as temporarily suspended in the water column as a result of the bottom sampling. Anchors of sampling vessels could also compact sediment in the area, although dynamically positioned vessels may also be used. Suspended sediment could extend beyond the sampling area and settle out of the water column nearby.

U.S. Army Corps of Engineer Navigation Channel Dredging

In accordance with the Rivers and Harbors Act of 1899, USACE is responsible for the regulation of activities involving dredging, the disposal of dredged materials, and the modification of navigable waterways (Latham et al. 2017). Dredging is a permitted activity. Compensatory mitigations (i.e., on-site enhancement, off-site enhancement, restoration, and/or preservation credits for unavoidable resource impacts), operational controls, regulations, and best management practices are regularly used for dredging associated with port modifications (Whitney III et al. 2016).

Channels are kept deep and wide enough through dredging for safe movement of ships from deep ocean waters to the more than 200 deepwater harbors where imports are unloaded and exports loaded. Dredging, performed primarily by the Corps of Engineers at navigation channels and by Port Authorities at harbors, takes place in five major areas, and the materials removed differ in consistency and placement options:

- main approaches (approach channel in ocean) – dredged material is composed primarily of sand;
- bar channels (sandbars at inlets) – dredged material is composed primarily of coarse-grained sand;
- entrance channels (to harbors) – dredged material is composed primarily of sand to fine-grained silt and clay;
- berthing areas (harbors/ports) – dredged material is composed primarily of silt and some sand; and
- inland waterways (intracoastal waterways and river channels) – dredged material is composed primarily of silt and sand.

The operation and expansion of ports can result in increased dredging (Whitney III et al. 2016). Dredging may be needed for channel access and/or quayside improvements related to potential port modifications (Whitney III et al. 2016). Port operations and growth depend on channel depth, which determines the ship size able to safely transit through a port (Dismukes 2014). Channel depth also affects the breadth of turning basins and terminal-side water depths (Dismukes 2014). Some ports need to be dredged to allow cargo to transit in the most safe, cost-effective, and efficient manner (Dismukes 2014). Periodic and annual dredging removes several hundred million cubic yards of silt, sand, and gravel (Dismukes 2014). Overall, about 10-15 percent of dredged material requires special handling, while the remaining 85 percent is available for beneficial use (USACE 2020a). Of this available sediment, approximately 30-35 percent is currently used beneficially to deliver environmental, economic, and social benefits (USACE 2020a).

Maintenance dredging on Federal navigation channels is performed on an as-needed basis. Typically, the USACE schedules surveys every 2 years on each navigation channel under its responsibility to determine the need for maintenance dredging. Dredging cycles may be from 1 to as many as 11 years from channel to channel and from channel segment to channel segment. The USACE is charged with maintaining all larger navigation channels in the GOM region. The USACE dredges millions of cubic meters of material per year in the cumulative activities area. Some shallower port-access channels may be deepened over the next 10 years to accommodate deeper draft vessels. Construction and maintenance dredging of rivers and navigation channels can furnish sediment for a beneficial purpose, a practice the USACE calls beneficial use of dredge materials program. In recent years, dredged materials have been sidecast to form new wetlands using the beneficial use of dredge materials program. Dredging from the USACE uses similar vessels and methods as described for "OCS Sand Borrowing" above. Impact-producing factors associated with the dredging of navigation channels include decrease in sediment deposition on downdrift landforms because the sediment supply is physically removed, bottom sediment disturbance via turbidity, the resuspension of pollutants, and sediment deposition. Impacts from navigation channel dredging related to coastal disturbance are described in **Chapter 2.5.2.4**.

2.3.2.6 Commercial Fishing

Commercial fish trawling and shellfish dredge operations typically take place in nearshore waters and are limited to depths in which their gear can reach, typically less than 200 m (656 ft). Typically trawl and dredge fishing occur over sandy and muddy seafloor in order to prevent damage to commercial fishing gear. Because these gears are mobile, their impacts can cover large areas of seafloor. The major seafloor impacts associated with these fishing gears include seafloor scouring, turbidity, and sedimentation.

Commercial fishing dredges are made up of a steel frame box or bag-shaped device used to target benthic sessile species such as bivalve mollusks (i.e., clams, oysters, scallops, and mussels). Oyster dredges are pulled behind or alongside fishing vessels over an oyster reef (**Figure 2.3.2-6**). They typically measure about 3 ft (1 m) wide and weigh about 120 lbs (54 kilograms) (VanderKooy 2012). Oyster dredges consist of a metal frame with teeth that scrape the oyster reef to dislodge oysters, and a bag behind the metal frame to catch the oysters that are dislodged (**Figure 2.3.2-6**). The dredge is deployed, towed until it is filled with oysters, retrieved, and redeployed for another catch. Oyster dredges typically navigate in a circular pattern over the oyster reefs while they fish (VanderKooy 2012). Oyster dredge operation primarily causes bottom scouring, suspended sediment and turbidity, and sediment accumulation as the sediment falls out of suspension. Oysters can also be harvested using hand tongs or rakes (**Figure 2.3.2-6**). Tonging is done in shallow water, as the handles of the tongs are only 14-16 ft (4-5 m) long (VanderKooy 2012). Tonging is less destructive of the oyster reefs and seafloor than dredging.

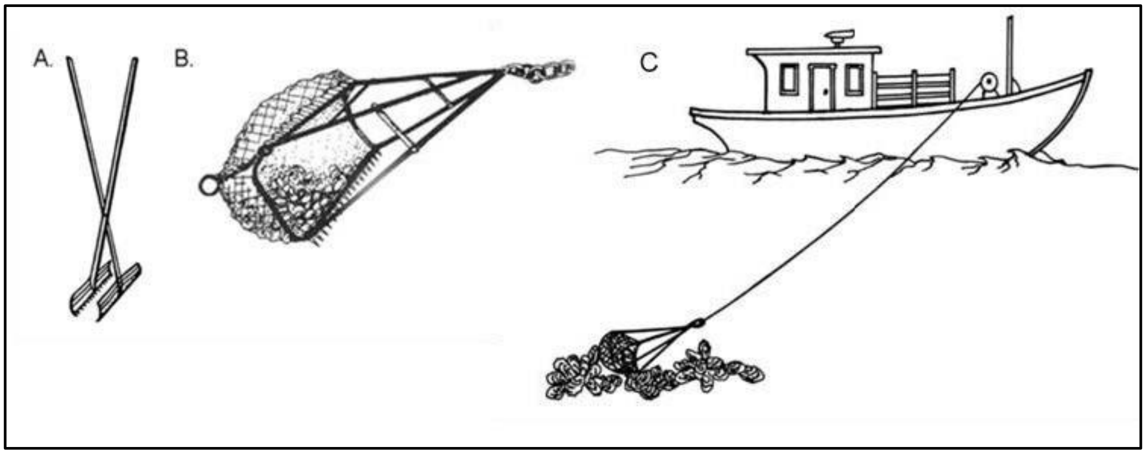


Figure 2.3.2-6. Examples of Oyster Fishing in the Gulf of Mexico. Oysters can be harvested using tongs (A) or with a dredge (B) that is towed behind a vessel (C) (VanderKooy 2012).

Trawls are large bag-shape nets constructed with natural fibers or synthetic materials that are rectangular or polygon in shape (mouth openings). Trawls are towed at specific water depths (surface, mid-water, or bottom) depending on the target species. Trawls are classified by their function, bag construction, or method of maintaining the mouth opening (Stevenson et al. 2004). Trawls that cause the greatest environmental effects are the bottom trawls because they disturb the seafloor.

Bottom trawls are designed to be towed along the seafloor to catch a variety of demersal fish and invertebrate species (in the Gulf of Mexico, shrimp are the primary target for trawl fisheries but a few bycatch species have commercial value as well, i.e., Gulf and southern flounder, and butterfish). A funnel-shaped net is towed over the seafloor and large “doors” on either side of the trawl hold the net open as the trawl “fishes” (Churchill 1989). The net and doors drag along the seafloor, scouring the seafloor and creating turbidity as it fishes. Some trawls use rollers or “tickle chains” that drag on the seafloor and chase fish into the net (Churchill 1989). Refer to **Figure 2.3.2-7** for an example of a bottom otter trawl.

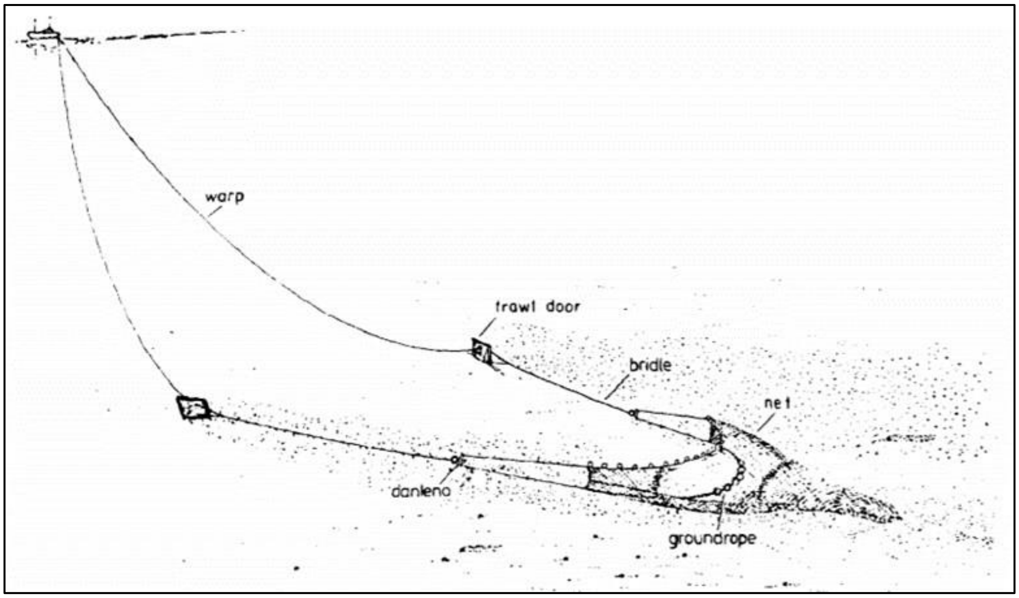


Figure 2.3.2-7. Example of a Bottom Otter Trawl (Churchill 1989).

Bottom trawlers target areas of soft seafloor sediment in order to prevent snagging nets on hard bottoms and features elevated from the seafloor. Any accidental trawling on hard bottoms could result in snagged nets, overturned boulders, and the physical removal of benthic organisms associated with the hard bottom habitat. Because trawling generally takes place on soft sediment, this fishing activity can result in seafloor scouring and temporarily high levels of turbidity as a net passes. Trawling experiments showed suspended sediment plumes from trawls to reach 3.0-3.5 m (9.8-11.5 ft) in height and 4.5-6.0 m (14.8-19.9 ft) in width at a distance 50 m (164 ft) astern of the trawl doors (Churchill 1989). The suspended sediment is temporary and will fall out of suspension after the disturbance has stopped. The sediment may travel some distance, depending on surrounding currents.

Trawling and dredging from commercial fishing and other activities can repeatedly and regularly affect the water column, seabed, and associated communities. Commercial fishing can potentially occur anywhere in favored areas where it is not temporarily or permanently excluded (i.e., in areas where there are no surface or bottom obstructions). Virtually all commercial trawl fishing is performed in water depths less than 200 m (656 ft). Churchill (1989) has measured near-bottom total suspended solids to be up to 1,500 milligrams/liter as a result of trawling operations. Seafloor conditions found in some areas may result in re-suspension of upwards of a cubic yard of sediment into the water column for every foot of trawling.

2.3.2.7 Renewable Energy Installations

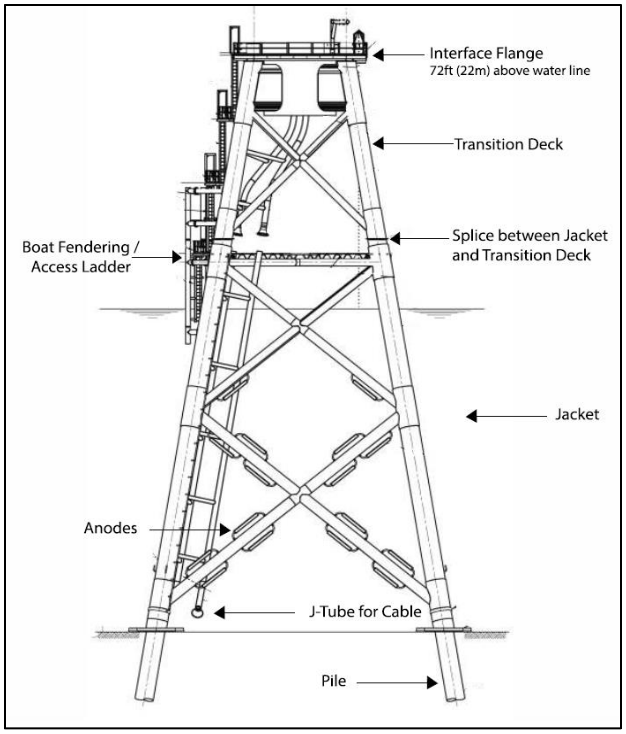


Figure 2.3.2-8. Example of a Jacket Foundation for an Offshore Wind Turbine (Amaral et al. 2018).

Offshore renewable energy installations, particularly offshore wind turbines, can cause seafloor disturbance. For more detailed information on offshore construction activities related to renewable energy, refer to BOEM's report, *Effects Matrix for Evaluating Potential Impacts of Offshore Wind Energy Development on U.S. Atlantic Coastal Habitats* (Latham et al. 2017). The following is a description of how renewable construction activities can cause bottom disturbance. The type of foundation used for offshore wind turbines depends on the water depth and sediment characteristics of the seafloor. Monopiles driven into the seafloor are frequently used, although large gravity foundations, jackets with piles installed at the corners, and floating turbines attached to the seafloor with anchors are all possible foundations (**Figure 2.3.2-8**). Wind turbines with monopile foundations use hollow piles 33.8 ft (10.3 m) in diameter. These monopiles are driven 147.6 ft (45 m) into a sandy or muddy seabed (BOEM 2018). Driving monopiles into the seabed may result in temporary suspended sediment and sediment deposition on the nearby seafloor. It is anticipated that minimal sediment disturbance would result from pile-driving activities, as the piles are hollow and will self-contain much of the disturbed sediment (MMS 2009). Larger jackets or tripods made of steel are typically used for turbines that are 5 megawatts or greater (Latham et al. 2017). Steel jacket bases typically have four hollow legs through which piles are driven to hold them in place. A typical base is 80 ft x 80 ft (24 m x 24 m) and the piles are 1.4-1.7 m (4.6-5.6 ft) in diameter (Amaral et al. 2018). As with monopiles, the steel foundation will permanently displace the soft sediment seafloor that was present before construction with hard substrate. The area lost will be dependent on the area of the foundation and the number of foundations in the installation. In addition, the presence of foundations may increase localized erosion of seafloor sediments near the structures. Scour protection (e.g., boulders, cement bags) may be placed around the foundations to reduce scour. Scour protection would replace soft sediment habitat with hard substrate, but it would also reduce turbidity in the area (BOEM 2018). For more information on the presence of renewable energy in the GOM, as well as space-use conflicts, refer to **Chapter 2.7.2.8**.

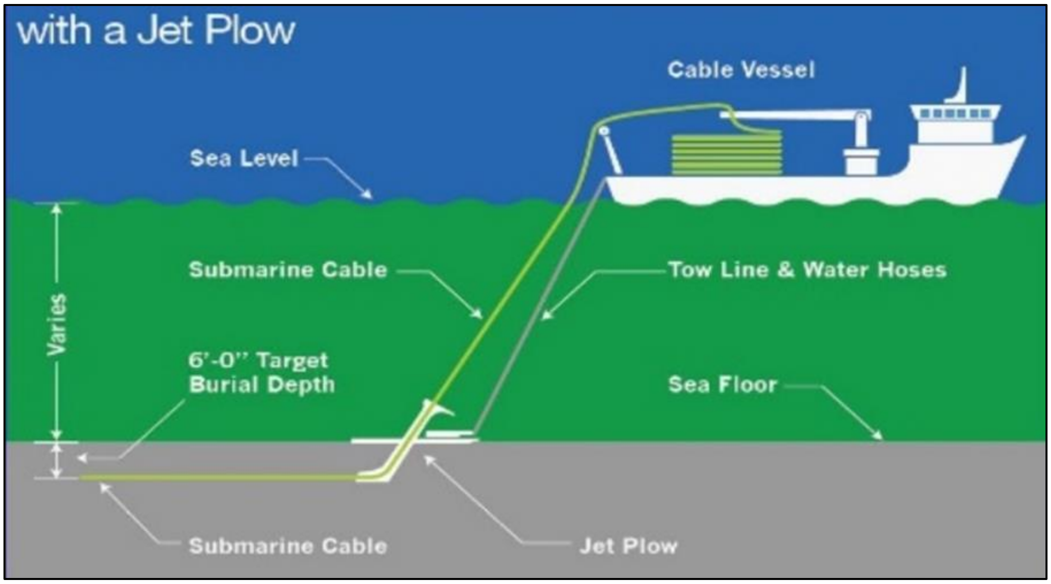


Figure 2.3.2-9. Example of Installing a Submarine Cable with a Jet Plow (Elliot et al. 2017).

Cables in the inner-array between wind turbines and the transmission line to shore are buried in the seafloor. Jet plows use high-pressure water jets to fluidize the seabed, creating a trench, into which a cable is laid (**Figure 2.3.2-9**). Cable trenches for offshore wind projects are estimated to be 4-6 ft (1-2 m) wide and a depth of 6-8 ft (2-2.5 m) below the seafloor (BOEM 2018; Elliot et al. 2017). It is estimated that, for each linear foot of cable, at least 3 ft^2 (0.3 m^2) of the seafloor will be disturbed (BOEM 2018). Refer to **Figure 2.3.2-10** for an example of a cable trench (Latham et al. 2017). A majority of the fluidized sediment is expected to remain within the trench, although some may escape the trench and fall out of suspension on the nearby seafloor. Overspill levees on either side of the trench have been measured from 1.5 to 7 m (5 to 23 ft) beyond the trench. Levees were measured to have an average thickness of 7 cm (3 in) but have been measured as thick as 25 cm (10 in) near the trench with decreased thickness away from the trench (Elliot et al. 2017). Suspended sediment should return to the seafloor within a few hours after jet plowing has ceased (BOEM 2018).

Figure 2.3.2-10. Example of a Cable Trench (Latham et al. 2017).

The cable laying activity uses a barge that is connected to a tug boat through a pulley system. Anchors are laid and repositioned to move the jet plowing vessel forward using the cable and pulley system. The anchors may leave scars in the seafloor and the cables may leave sweep marks. Much of the sediment that could suction to the anchor while being pulled from the seafloor is expected to return to the anchor footprint once the anchor is retrieved, reducing the depth of the anchor scar (BOEM

2018). The impact of the cables sweeping along the seabed can be minimized by attaching mid-line buoys to hold the cables off the bottom and preventing sweep scours (BOEM 2018).

The seafloor may also be impacted by the jack-up barges or other construction vessels that are used to install the wind turbines. Jack-up barges have six spuds with feet that each measure 10 ft x 20 ft (3 m x 6 m) across. Additional spud barges that are working in the area may have 2-4 spuds each, with diameters of 2-4 ft (0.6-1.2 m). Other construction vessels may use anchors in the area. Each of the platform feet or anchors may leave an impression on the seafloor, cause sediment to be suspend with the deployment and retrieval of anchors, and result in the deposition of sediment nearby (**Figure 2.3.2-11**) (Amaral et al. 2018; MMS 2009).

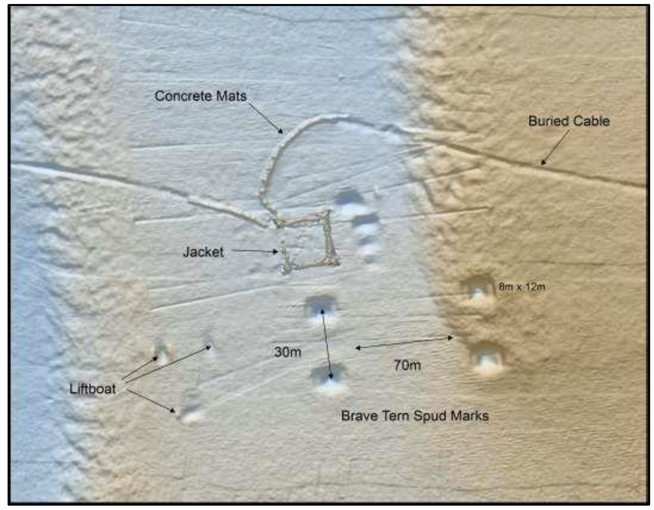


Figure 2.3.2-11. Examples of Bottom Disturbance Impressions from Offshore Wind Installations (Amaral et al. 2018).

2.3.2.8 Mass Wasting Events (Mudslides)

Mass wasting events are downslope movements of seafloor material, or underwater landslides. They can occur as a result of gravity, an earthquake, or waves produced during a hurricane. Some can travel hundreds of kilometers downslope and move large volumes of sediment, powerful enough to break undersea communication cables and destroy offshore oil and gas platforms; however, most are not this intense. Mass movement can occur in a range of forms, from solid block movement (material moves downslope in a solid mass) to turbulent flow (material moves downslope in a fluidlike mass), depending on the amount of water in the sediment. Submarine landslides occur most often on seafloors where there are thick accumulations of soft sediment, slopes are steep, and environmental loads are high. In the Gulf of Mexico, the type of environment supportive of submarine landslides is active river deltas on the continental shelf, submarine canyons and deep-sea fan systems, and the continental slope (Schwab et al. 1993). Slope failures in the eastern Gulf of Mexico have left large scarps along the West Florida Slope, resulting in areas of instability, which are particularly dangerous for OCS oil and gas development (Schwab et al. 1993). The carbonate sediments in this area can become unstable along gentle gradients. Farther west in the Gulf of Mexico, where rapid sedimentation has occurred as a result of the outflow of the Mississippi River, and below which salt domes have been deformed by the weight of the overlying sediment, mass wasting and submarine landslides have occurred. A major submarine landslide occurred in the East Breaks Area in the northwestern GOM. The landslide covers an area of 2,250 km^2 (869 mi^2), beginning in 200 m (656 ft) of water at the shelf edge and flowing downhill in two lobes. One lobe extends 70 km (43 mi) downslope to a depth of 1,350 m (4,429 ft), while the other lobe extends 110 km (68 mi) downslope to a depth of 1,300 m (4,265 ft). Both lobes continue downslope in finger-like projections to a depth of 1,600 m (5,249 ft) (Schwab et al. 1993).

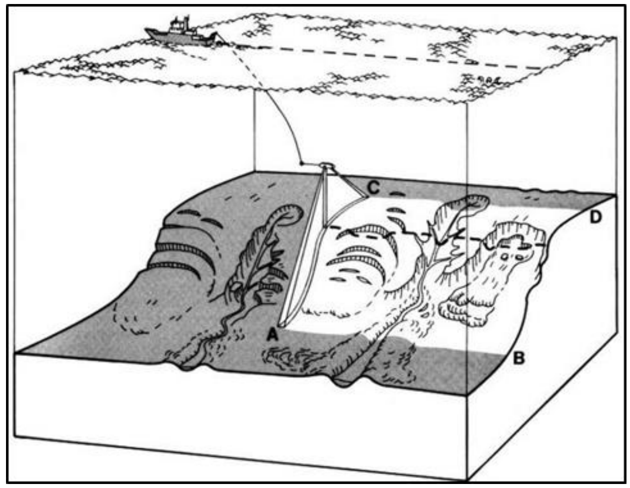


Figure 2.3.2-12. Example of Different Mass Wasting Events on the Seafloor (Schwab et al. 1993).

A mass wasting event in a submarine canyon would begin following a triggering event with the sediment accumulated at the head of a canyon moving downslope as a coherent block and incorporating water as it moves downslope. As more water is incorporated, a diluted cloud of sediment, called a turbidity current, is created and can flow for long distances at high velocities. The deposition of the mass movement results in a deep-sea fan of sediments. Mass wasting events that occur on the open continental slope are most likely a result of seismic activity, as the gradient on the continental slope is not very steep (Schwab et al. 1993) (**Figure 2.3.2-12**). Submarine landslides typically travel 2-4 km (1.2-2.5 mi) (although they have traveled up to 380 km [2,361 mi]), are typically 1-2 km (0.6-1.2 mi) wide (but have reached 50 km [31 mi] wide), and can have a thickness of sediment from 10-650 m (33-2,133 ft) (Schwab et al. 1993).

2.4 Noise

"Noise" is considered unwanted sound that can disturb routine behavioral patterns and life functions (e.g., communication, feeding), cause annoyance, or physical injury.

Acoustic sources can be described by their sound characteristics. For the regulatory process, they are generally divided into two categories: (1) impulsive (e.g., lightning strikes, explosives, airguns, and impact pile drivers) and (2) non-impulsive (e.g., sonars and vibratory pile drivers). Currently, there is no universally accepted definition for what constitutes an impulsive sound, but they are generally understood to be powerful sounds with relatively short durations, broadband frequency content, and rapid rise times to peak levels. In general, these sound characteristics have been observed to be more physiologically damaging to marine mammals than non-impulse sounds with equivalent pressures and energies (Southall et al. 2007), and therefore, are examined with a different and more protective set of acoustic threshold criteria.

Configuration of an acoustic source also directly affects how that source will transfer energy into the marine environment. Impulsive and non-impulsive sound sources can also be characterized as controlled or non-controlled. Sound produced by controlled anthropogenic sources (e.g., hydrophones, airguns, and speakers) take their basic sound-producing characteristics from these individual components, but beam patterns (e.g., large-scale 3D patterns of projected acoustic energy) are restrained by configuration of the source array itself. (The equivalent in the visual environment is that a lightbulb defines the color and brightness of the light produced, but reflectors and lenses in a flashlight determine how the light is broadcast outward.) Under a controlled source, adjustments to timing and amplitudes of the signal produced by each individual source element can refine and steer the beam pattern within the constraint dictated by the array configuration. Another type of source, called non-controlled (e.g., radiation pattern of sound from a driven pile as the shock wave travels down its length), also may exhibit some beam-forming and steering, but most unintended sound sources (e.g., cavitation and vessel thrusters) radiate in an approximately omnidirectional fashion.

One final consideration, especially for controlled anthropogenic sources, is the difference between point and distributed sources. Some sources that are physically smaller (i.e., completely contained within a sphere with a 1-m [3-ft] diameter) can be considered point sources. However, most other sources (e.g., an airgun array, which may be tens of meters in width and length) are distributed sources. For a distributed source, a receiver must be some distance away from the source in order to perceive it acoustically as a single, or point, source. (Closer to the source, a receiver gathers many signals from all separate components of the source. The receiver is then considered in the "near-field.") Once a receiver is beyond this range, and can interpret the signal as a point source, it is considered in the source's "far-field."

This distinction between near-field and far-field is a particularly important one for distributed sources such as airgun arrays. This is because the most severe potential impacts to animals generally occur near the source, and a correct understanding and assessment of these impacts requires a correct understanding of the sound field in the near-field. If a receiver (i.e., animal) is in the near-field of an airgun array, then it would receive energy from all individual sources (e.g., individual airguns) in that array. But the closest individual source would tend to be the dominant source, with other individual sources in the array making smaller contributions to the overall received sound level. Because these additional contributions would be delayed in time (due to the physical geometry and the time differences required for sound travel from individual sources to the receiver) and may not be in phase (i.e., peak pressures may not arrive simultaneously or "in-phase"), these contributions would seldom sum to the maximum energy of the overall signal and may actually result in diminishing some of the signal. In this way, near-field sound of the real array would always be less than that modeled for a theoretical point source. In effect, estimating the near-field sound field around an assumed point source is conservative because it would always be greater than the actual values in the near-field.

Propagation

Once a sound source is characterized (i.e., sound levels at very close proximity to the source are understood), the next step is to consider how acoustic energy emitted from the source propagates (or spreads). How sound from a particular source propagates is a function of the characteristics of the source and properties of the medium through which it travels (in this case, water). There are four basic physical processes that affect sound propagation.

- **Spreading:** The average energy on the surface of an acoustic wavefront decreases as the wavefront expands over time.

- **Absorption:** Loss of acoustic energy to heat energy as sound propagates through the ocean. The rate of this energy loss is related directly to the distance sound has traveled and its frequency: absorption increases with distance and frequency.
- **Refraction:** Bending of a sound wave as it changes speed in the ocean. Sound speed changes in water as a function of variations in temperature, salinity, and hydrostatic pressure. In general, sound speed increases with increasing temperature, salinity, hydrostatic pressure, and/or water depth. Sound velocity can also change horizontally in the ocean due to the presence of different water masses, currents, and eddies. For example, the Gulf Stream is usually much warmer than waters that it is passing through, and sound speed in the Gulf Stream varies accordingly. Sound will bend towards areas promoting lower sound speeds.
- **Reflection:** Sound is deflected off the interface between two media having differing sound speed properties. This happens at the air/sea and water/sediment interfaces of the ocean. It can also occur when discrete objects (like air bubbles or fish air bladders) occur in the water column or the biota inhabiting the water column.

Given these variables, predicting the exact propagation of sound in the oceans is nearly impossible without detailed knowledge of the acoustic environment parameters (i.e., all local conditions that influence acoustic propagation and ambient noise conditions). However, the acoustic community has worked for many decades to understand and quantify these parameters. Today, many important parameters required to predict propagation have been identified and have been mapped well enough to support representative propagation modeling in most U.S. waters.

Reverberation

Reverberation is another standard acoustic analysis term with a precise meaning and definition that is not always used accurately in the policy realm. Standard technical usage of the term revolves around the scattering of sound from an acoustic source from numerous scatterers throughout the water column and at the ocean’s surface and bottom. The combined return from these scatterers is called reverberation.

2.4.1 OCS Oil- and Gas-Related Activities

2.4.1.1 Geological and Geophysical Surveys

A variety of G&G surveys are conducted in support of oil- and gas-related activities to (1) obtain data for exploration and production, (2) aid in siting offshore structures (e.g., production platform), (3) identify possible seafloor or shallow depth geologic hazards, and (4) locate potential archaeological resources and potential hard bottom habitats for avoidance. Such data are also used to ensure the proper use and conservation of OCS energy resources and the receipt of fair market value for the leasing of public lands. In general, routine noise-generating activities include the following:

- deep-penetration seismic airgun surveys (2D, 3D, 4D, ocean-bottom nodal, and azimuth multi-vessel surveys);
- airgun HRG surveys that are used to investigate the shallow subsurface for geohazards (also known as shallow hazard surveys) and that are used during initial site evaluation, drilling rig emplacement, and platform or pipeline design and emplacement;
- electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods;
- non-airgun HRG surveys (electromechanical) used to detect and monitor geohazards, archaeological resources, and benthic communities; and
- geological and geotechnical seafloor sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, and cables).

BOEM's Resource Evaluation Program oversees G&G data acquisition and permitting activities pursuant to regulations at 30 CFR parts 550 and 551. The G&G activities for oil and gas exploration are authorized on the basis of whether or not the proposed activities occur

- before leasing takes place (prelease), which can occur over leased and unleased blocks for areawide data acquisition; or
- on an existing lease (postlease or ancillary activity) authorized by OCS plan approvals, plan revisions, or by a requirement for notification of BOEM before certain onlease activities are undertaken. Ancillary G&G activities are most commonly used to assess well and reservoir productivity (refer to **Chapter 1.3.3.1** for a description of ancillary activities).

Further detailed information on each of the specific G&G survey types and descriptions can be found in Appendix F of the *Gulf of Mexico OCS Proposed Geological and Geophysical Activities: Western, Central, and Eastern Planning Areas; Final Programmatic Environmental Impact Statement* (BOEM 2017c) and are summarized below.

Seismic Surveys

Deep seismic surveying penetrates more deeply into the crust layers than other survey types, can be high energy and low frequency (2D, 3D, 4D or wide azimuth), and may also be done on leased blocks for more accurate identification of potential reservoirs, thereby aiding in the identification of additional reservoirs in "known" fields. Three-dimensional technology can be used in developed areas to identify bypassed hydrocarbon-bearing zones in currently producing formations and new productive horizons near or below currently producing formations. It can also be used in developed areas for reservoir monitoring and field management. Four-dimensional seismic surveying is predominantly used for on-lease reservoir monitoring and management. Through time-lapse surveys, the movement of oil, gas, and water in reservoirs can be observed over time, and that information is used to adjust production techniques and decisions, leading to more efficient production of the reservoir and the ultimate recovery of a greater portion of the original oil and gas in place. Surveying may occur periodically throughout the productive life of a lease, as frequently as every 6 months.

2D Surveys

For 2D seismic surveys, a single streamer is towed behind the survey vessel, together with a single source or airgun array. Seismic vessels generally follow a systematic pattern during a survey, typically a simple grid pattern for 2D work, with lines typically no closer than half a kilometer. In simplified terms, 3D surveys collect a very large number of 2D slices, with minimum line separations of only 25-30 m (82-98 ft). A 3D survey may take many months to complete (e.g., 3-18 months) and involves a precise definition of the survey area and transects, including multiple passes to cover a given survey area. For seismic surveys, 3D methods represent a substantial improvement in resolution and useful information relative to 2D methods. Consequently, most areas in the Gulf of Mexico that were surveyed using 2D have been re-surveyed using 3D methods.

3D Surveys

The 3D seismic surveying provides the opportunity to create higher resolution subsurface images and to resolve imaging challenges, thereby enabling a more accurate assessment of potential hydrocarbon reservoirs. As a result, the oil and gas industry is able to optimally locate and successfully develop wells, while minimizing the number of exploratory wells required. Highly technical computer mapping systems can handle much denser data coverage than the older 2D seismic surveys. Multiple-source and multiple-streamer technologies are used for 3D seismic surveys. A typical 3D survey might employ a dual array of 18 air guns per array. At 10 m (33 ft) from the source, the resultant pressure is approximately ambient pressure plus one atmosphere. The streamer array might consist of 6-8 parallel cables, each 3,000-12,000 m (9,843-39,370 ft) long, spaced 25-100 m (82-328 ft) apart. An 8-streamer array used for deepwater surveys is typically 700 m (2,297 ft) wide.

Narrow Azimuth (NAZ)

In a typical 3D marine seismic survey the vessel traverses the surface in a predetermined direction above the subsurface target. Since most of the recorded seismic signals travel nearly parallel to the sail line, at small azimuth, the survey is called a narrow azimuth or NAZ survey. Azimuth is the angle at the source location between the sail line and the direction to a given receiver. The target essentially is illuminated from one direction in NAZ surveys.

Full Azimuth (FAZ)

An FAZ towed streamer coil survey is an advanced method of acquiring ultra-long offset marine seismic data using numerous vessels (typically 4 survey, 2 chase, and 1 supply) following a circular path. The technique delivers higher seismic images than are achieved with the narrow-azimuth acquisition techniques that have been the norm for the last few decades. This acquisition provides target illumination in challenging environments by enabling greater azimuthal coverage and a higher signal-to-noise ratio. The FAZ seismic acquisition concept of coil shooting was introduced around 2008.

Wide Azimuth

Wide-azimuth, towed-streamer acquisition has emerged in the last few years as a change in marine acquisition technology in the Gulf of Mexico. This technology came about because the risky exploration and development of deepwater subsalt reservoirs required seismic data to have better illumination, higher signal-to-noise ratio, and improved resolution. Wide-azimuth acquisition configurations involve multiple vessels operating concurrently in a variety of source-vessel to acquisition-vessel geometries. Several source vessels (usually 3-5) are used in coordination with single or dual receiver vessels either in a parallel or rectangular arrangement with a typical 1,200-m (3,937-ft) vessel spacing to maximize the azimuthal quality of data acquired. It is not uncommon to have sources also deployed from the receiver vessels in addition to source-only vessels. This improves the signal-to-noise ratio and helps to better define the salt and subsalt structures in the deep waters of the GOM.

Ocean-Bottom Airgun Surveys

Ocean-bottom surveys can use either cables or nodes. Ocean-bottom cable (OBC) surveys were originally designed to enable seismic surveys in congested areas (e.g., producing fields) with their many platforms and producing facilities (**Figure 2.4.1-1**). Ocean-bottom node (OBN) surveys are deployed and retrieved by either cable or ROVs that are now used as an alternative to cables. The OBC surveys have been found to be useful for obtaining multi-component (i.e., seismic pressure, vertical, and the two horizontal motions of the water bottom, or seafloor) information. The OBC/OBN surveys require the use of multiple ships (usually two ships for cable or node layout/pickup, one ship for recording (OBC), one to two ships for shooting, and two utility boats) (**Figure 2.4.1-2**). Operations are conducted “around the clock” and begin by dropping the cables off the back of the layout boat or by deployment of the nodal receivers by ROVs. Cable length or the number of nodes depend upon the survey demands; cable length is typically 4.2 km (2.6 mi) but can be up to 12 km (7.5 mi).

Depending on spacing and survey size, hundreds of nodes can be deployed and re-deployed over the span of the survey. Groups of seismic detectors, usually hydrophones and vertical motion geophones, are attached to the cable in intervals of 25-50 m (82-164 ft). Multiple cables/nodes are laid parallel to each other using this layout method with a 50-m (164-ft) interval between cables/nodes. Typically, dual airgun arrays are used on a single-source vessel. When the cable/node is in place, a ship towing an airgun array (which is the same airgun array used for streamer work) passes between the cables/nodes, firing every 25 m (82 ft). Sometimes a faster source ship speed of 6 kn (7 mph), instead of the normal 4.5-kn (5.2-mph) speed, is used with a decrease in time between gun firings. After a source line is shot, the source ship takes about 10-15 minutes to turn around and pass down between the next two cables or line of nodes. When a cable/node is no longer needed to record seismic data, it is picked up by the cable pickup ship and is moved over to the next position where it is needed. The nodes are retrieved by an ROV.

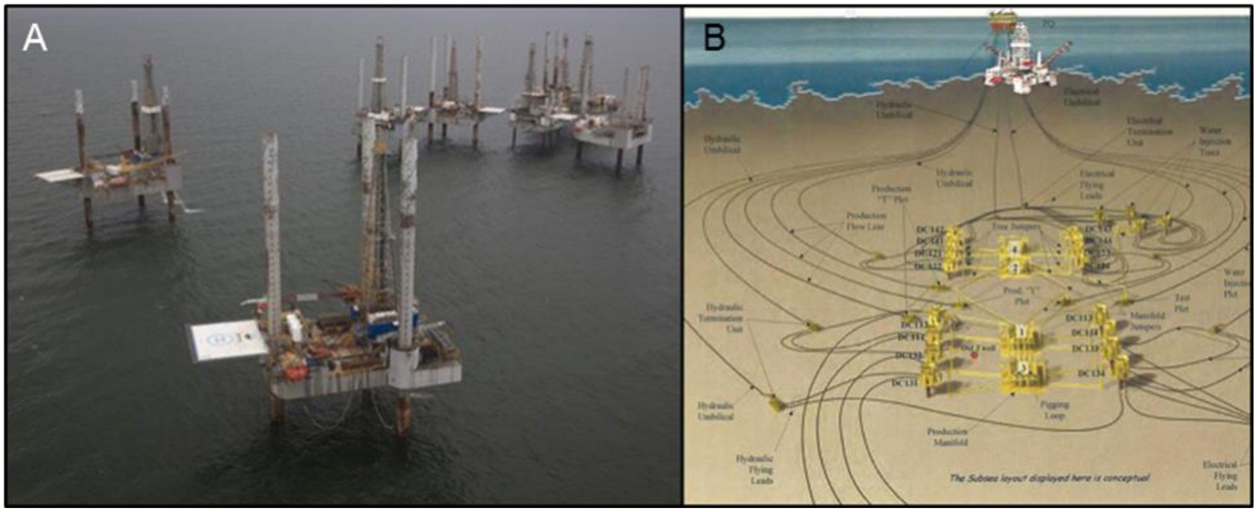


Figure 2.4.1-1. Example of an Area Where 3D Ocean-Bottom Seismic Surveys Would Occur in the Gulf of Mexico (From: Caldwell 2015). (Panel A shows drilling rigs and platforms in the GOM in a configuration that makes a towed-streamer seismic survey impossible to conduct; OBC/OBN would be required to acquire 3D seismic data in such an obstructed area. Panel B provides a schematic of one possible deployment of subsea structures at the Atlantis Field in the Gulf of Mexico; the acquisition of 3D seismic data in such a situation might best be handled using an ocean-bottom node system.)

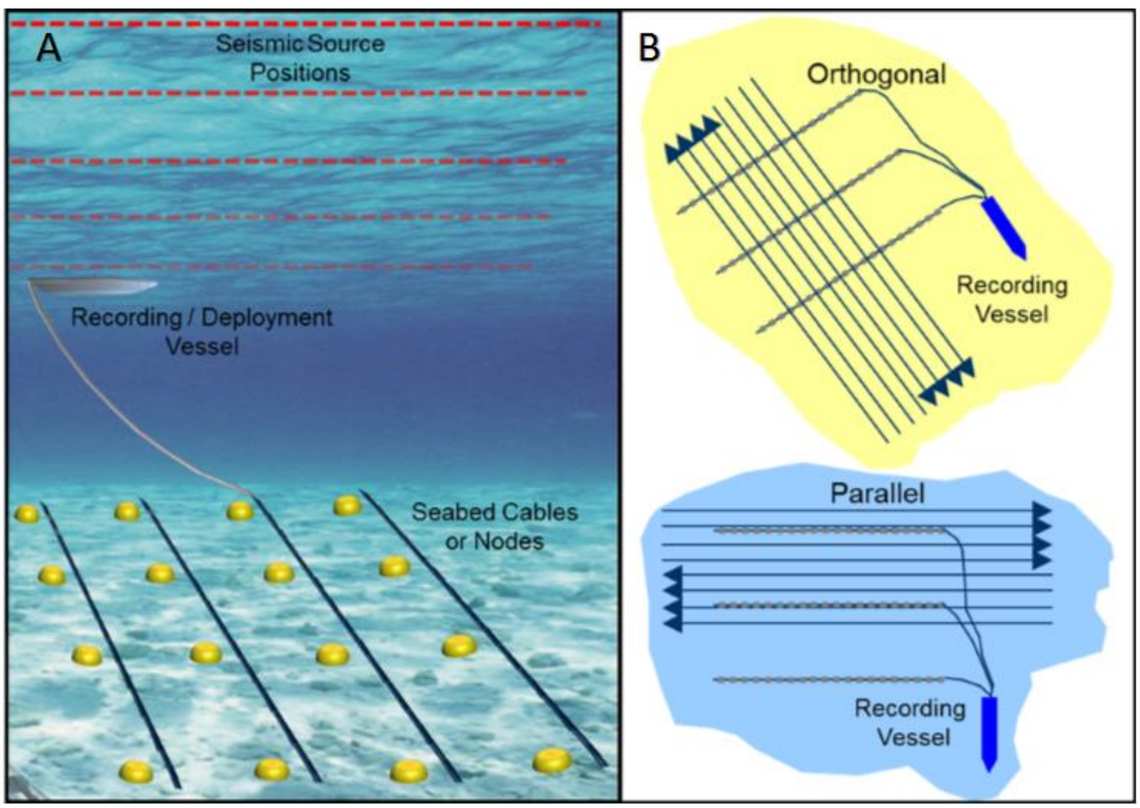


Figure 2.4.1-2. Placement of an Ocean-Bottom Node or Ocean-Bottom Cable System in a 3D Seismic Survey. (Panel A illustrates the layout pattern of an ocean-bottom node or ocean-bottom cable system. Panel B shows cable systems attached to recording vessels and indicates the various arrangements of track lines relative to the receiving array.)

A particular cable/node can lay on the bottom anywhere from 2 hours to several days, depending upon operation conditions. Normally, a cable will be left in place about 7-10 days. However, nodes may remain in place until the survey is completed or recovered and then re-deployed by an ROV. Location of the cables/nodes on the bottom is done by acoustic pingers located at the detector groups and by using the time of first arrival of the seismic pulse at the detector group. Acoustic pingers use frequencies in the 9- to 13-kilohertz (kHz) range. A detector group is a node or group of nodes that enable the seismic ship to accurately determine node location. To obtain more accurate first arrival times, the seismic data are recorded with less electronic filtering than is normally used. This detailed location is combined with normal navigational data collected on the source ship. In deep water, the process of accurately locating bottom cables/nodes is more difficult because of the effects of irregular water bottoms and of the thermal layers, which affect travel times and travel paths, thus potentially causing positioning errors.

4D Surveys

Another type of seismic surveying that can be conducted onlease are time-lapse (4D) surveys, which are 3D surveys that are repeated one or more times after the original survey to monitor reservoirs. The usefulness and value of 4D surveys is well-established, and such surveys have become common. The particular acquisition technique chosen (towed-streamer, temporary OBC or OBNs, or permanently emplaced systems on the seafloor) depends on the objectives of the survey, the particular geology being addressed, the physical facilities in a given field, and the nature of the geophysical response to changes such as reservoir saturation and pressure. The seismic sensors used for 4D surveys have been almost exclusively nodal. The seismic survey equipment and procedures used for 4D surveys are the same as those described in previous sections. However, because these surveys are conducted over producing fields, the survey area is smaller and the survey time shorter than needed for most other 3D towed-streamer and 3D OBC or OBN surveys. The time lapse between a baseline survey and 4D survey has been as short as 3 months and as long as 10 years. Many 4D surveys are repeated every 1-2 years. When permanently emplaced receiver systems are used, the repeat time generally is on the order of several months because a relatively small and inexpensive seismic source vessel is all that is required to conduct additional monitoring surveys.

The purpose of 4D surveys in the hydrocarbon industry has been to monitor changes in oil and gas reservoirs to better manage them. However, in addition to that purpose, 4D surveys are now being used to monitor changes for environmental and safety reasons. Examples of this include monitoring for oil leaks in the seafloor above reservoirs not only for health, safety, security, and environment purposes but also for carbon capture and storage. The 4D surveys use the same seismic source size and depth, as well as the same receiver systems, and attempt to duplicate as much as possible all other details of the original survey. A series of 3D surveys collected over time (commonly referred to as four-dimensional or 4D seismic surveying) is used for reservoir monitoring and management (the movement of oil, gas, and water in reservoirs can be observed over time). Increasingly, the data collected in a 3D seismic survey can be processed to provide near surface images adequate for many of the needs previously met by high-resolution surveys.

Pressure Monitoring Transponders (PMTs) and Pressure Inverted Echo Sounders (PIESs)

Pressure monitoring transponders (PMTs) and pressure inverted echo sounders (PIESs) are utilized for continued subsidence monitoring. Both PMTs and PIESs are deployed by ROVs at predetermined locations on the seabed. They log data at a specific interval for a period of time, depending on their respective battery life (5-12 years). The PMT readings are logged internally and then uploaded to the surface (~20 minutes per year) by means of acoustic telemetry equipment (18-36 kHz/202 decibels referenced 1 microPascal [dB re 1µPa]) installed on a vessel at sea surface, whereas PIESs transmit an acoustic pulse (14-20 kHz/202 dB re 1µPa) that is reflected off the sea surface and detected by PIESs on the seabed. The PMT and PIES operate in water depths up to 19,685 ft (6,000 m) and are recovered via an ROV or retrieved at the sea surface. The PIESs are utilized in 4D seismic surveys and also in long-term seafloor subsidence studies, which aid in determining reservoir depletion in oil and gas development projects.

Borehole Seismic Surveys

While deep-penetration speculative seismic surveys most often occur offlease (i.e., on unleased blocks), there are also some instances when a speculative seismic survey is acquired over leased and unleased blocks for survey continuity. Vertical seismic profiling (VSP) is the typical standard survey type used for ancillary activities and includes varying methods such as 2D VSP techniques (e.g., zero-offset, offset, deviated-well, and walkaway), 3D VSP surveys, and checkshot surveys (**Figure 2.4.1-3**). The VSP surveys provide information about geologic structure, lithology, and fluids that is intermediate between that obtained from sea-surface seismic surveys and the well-log scale of information. The VSP surveys may be conducted during all stages of oil and gas industry activity (i.e., exploration, development, and production), but most VSP surveys are conducted during the exploration and development stages.

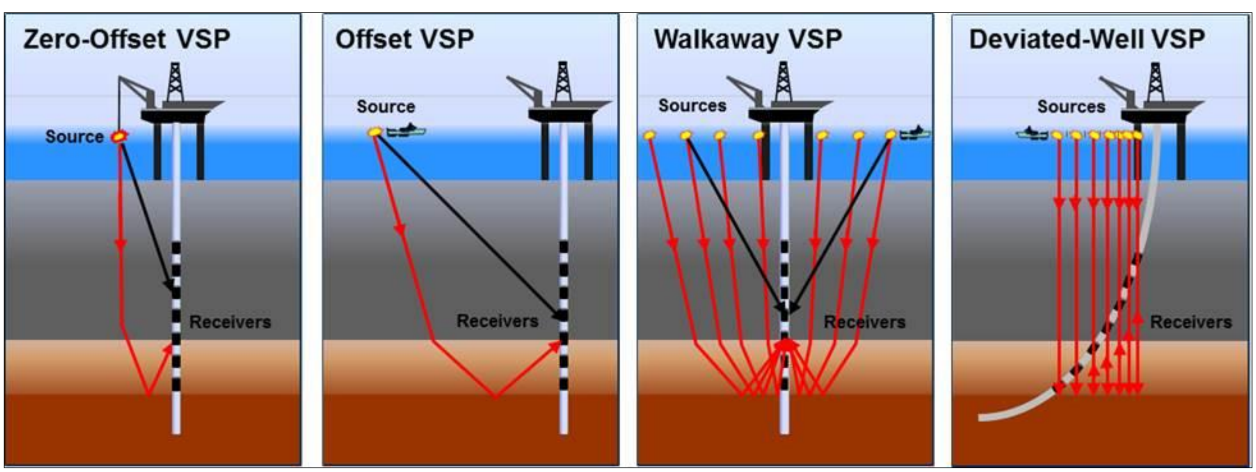


Figure 2.4.1-3. Geometries of the Four Basic Types of 2D Vertical Seismic Profiles (From: Caldwell 2015).

The airguns used for VSPs may be the same or similar to those used for 2D and 3D towed-streamer surveys. Normally, the number of airguns and the total volume of airguns used are less than those used for towed-streamer surveys (**Figure 2.4.1-4**). Less sound energy is required for

VSP surveys because the seismic sensors are in a borehole, which is a much quieter environment than that for sensors in a towed streamer, and because the VSP sensors are located nearer to the targeted reflecting horizons. The total round-trip path for sound from the seismic source to reflector and back to a sensor in a VSP is one-half to two-thirds as long as those for seismic surveys where the source and seismic sensor are located near the sea surface. The VSP survey duration mostly depends on the equipment used for the survey, but it also depends partially on survey type and objectives. Some VSP surveys take less than a day, and most are completed in a few days.

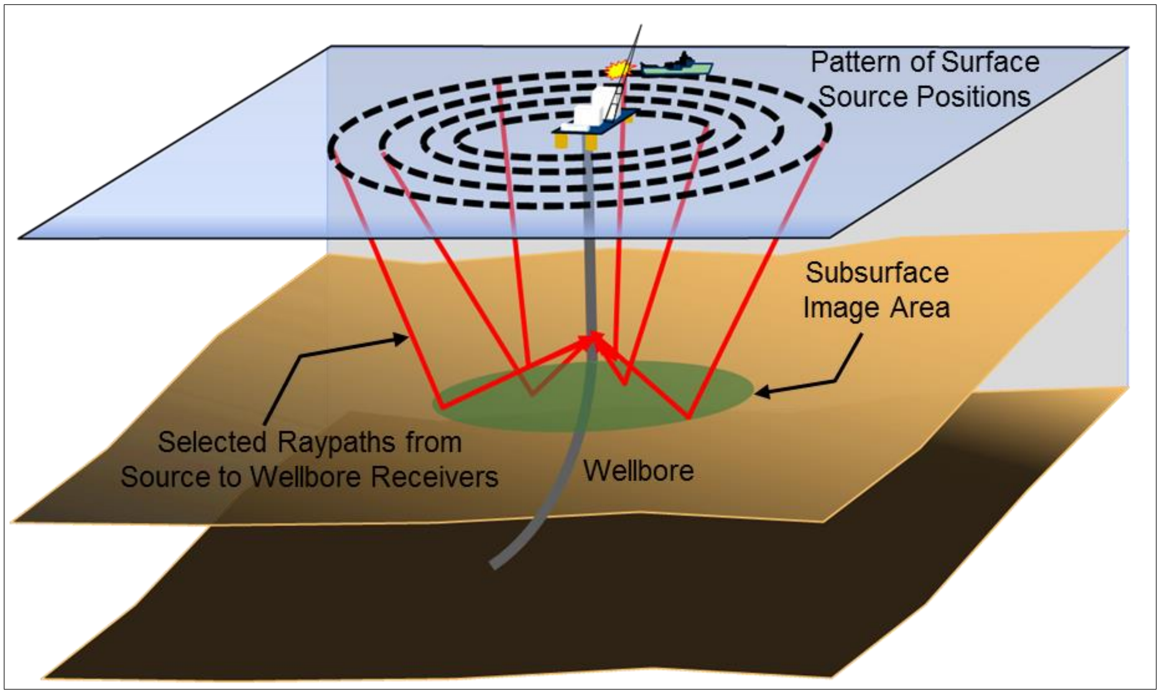


Figure 2.4.1-4. Geometry of a 3D Vertical Seismic Profile Survey (From: Caldwell 2015).

Checkshot surveys are similar to zero-offset VSP but (1) are less complex and require less time to conduct, (2) produce less information, (3) are cheaper, (4) use a less sophisticated borehole seismic sensor, and (5) acquire shorter data records at fewer depths. Because checkshot surveys are much less expensive and do not use the wellbore and the drilling rig as long, they are much more common than other VSP surveys. During a checkshot survey, a seismic sensor is sequentially placed at a few depths (<20 m; 66 ft) in a well, and a seismic source (almost always an airgun) is hung from the side of the well platform. The purpose of a checkshot survey is to estimate the velocity of sound in rocks penetrated by the well. Typically, the depths at which the sensors are placed are at, or near, the boundaries of prominent lithologic features. In most checkshot surveys, the seismic source is hung from the platform in a fixed location within the water column; therefore, a surface vessel is not needed. Because reflection energy does not need to be acquired, the seismic source usually is smaller than those used for other VSP surveys.

Airgun HRG Surveys

Airgun HRG surveys are conducted to investigate the shallow subsurface for geohazards and soil conditions over specific locations in one or more OCS lease blocks. In general, these surveys use smaller sounds sources, are shorter in duration, and have a smaller geographic extent than the deep-penetration seismic airgun 2D, 3D, 4D, ocean bottom nodal, and azimuth multi-vessel surveys discussed above. Identification of geohazards is necessary to avoid drilling and facilities emplacement problems. Geohazards include shallow gas, over-pressured zones, shallow water flows, shallow buried channels, gas hydrates, incompetent sediments, and mass transport complexes. These surveys also are used to identify potential benthic biological communities (or habitats) and archaeological resources. Survey data are used for initial site evaluation, drilling rig emplacement, platform or pipeline design and emplacement, and renewable energy structure emplacement.

Airgun HRG surveys are used to image shallow depths (typically 1,000 m [3,280 ft] or less below the seafloor) and to produce high-resolution images. The airgun sources used (typically one or two airguns) are smaller (typically 40-400 cubic inches [in^3]), the streamers are shorter and towed shallower, the streamer-separation distances are smaller (150-300 m [492-984 ft]), and the firing times between airgun shotpoints are shorter than for deep-penetration seismic airgun surveys (2D, 3D, 4D, ocean bottom nodal, and azimuth multi-vessel surveys). Typical surveys cover one OCS lease block, which is usually 4.8 km (3 mi) on a side. The presence of historic archaeological resources (e.g., shipwrecks), shallow hazards, or live bottom features can require surveys using a maximum line spacing of 300 m (984 ft). Including vessel turns at the end of lines, the time required to survey (transect all lines) one OCS lease block is approximately 36 hours. Other activities and factors before and after the time spent actively acquiring seismic data, such as streamer and airgun deployment, weather delays, and other factors, add to the total survey time. In addition, weather can create conditions that degrade the performance of streamer arrays and prevent acquisition of useful data, especially in shallow water where streamers are towed close to the sea surface. Also, in some instances, the time required to conduct a survey is affected by needs for tighter line spacing to accomplish survey objectives and data quality (**Figure 2.4.1-5**).

The 3D high-resolution airgun seismic surveys using ships towing multiple streamer cables have become more common. Again, these surveys generally use smaller sounds sources, are shorter in duration, and have a smaller geographic extent than deep-penetration 3D seismic airgun surveys. These surveys include (1) dual-source acquisition that incorporates better source and streamer positioning accuracies (derived from global positioning system [GPS]) that allow for advanced processing techniques (pre stack time migration), (2) single-source multi-streamer (up to 6 streamers maximum in most cases), (3) dual-source multi-streamer, and (4) P-Cable acquisition. All of these 3D survey types, except P-Cable acquisition, have the same surveying practices as high-resolution 2D surveying, including shorter streamers (typically 100-1,200 m [328-3,937 ft]); shallower streamer tow depths; more closely spaced shots, often as close as 12.5 m (41 ft); smaller airgun arrays (typically 40-400 in^3); and more closely spaced track lines (generally 25-100 m [82-328 ft]).

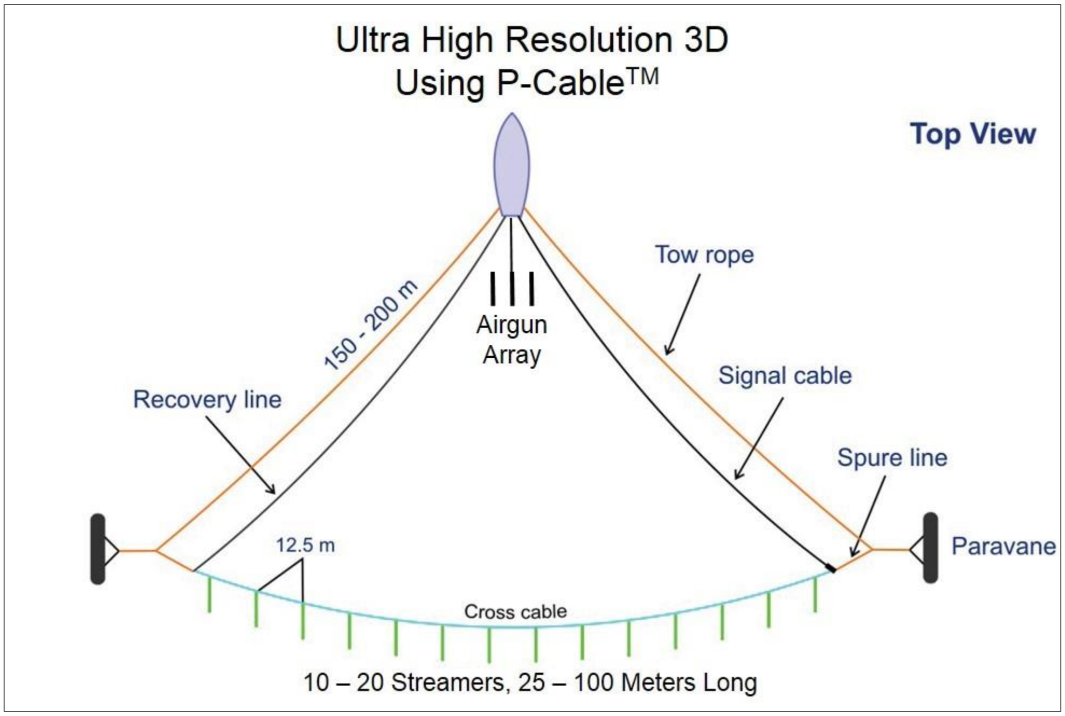


Figure 2.4.1-5. Equipment Layout for a P-Cable Acquisition Survey (From: Caldwell 2015).

Non-Airgun HRG Surveys

Non-airgun HRG surveys are routinely conducted onlease and along pipeline routes to evaluate the potential for geohazards, archaeological resources, and certain types of benthic communities. In most cases, conventional 2D and 3D deep-penetration seismic surveys do not have the resolution to provide the required information. Consequently, in addition to high-resolution, shallow-penetration airgun 2D or 3D seismic surveys, non-airgun acoustic surveys are conducted (often from the seismic vessel but sometimes from a vessel dedicated to such surveys). Common non-airgun HRG sources include CHIRP subbottom profilers, side-scan sonars, and multi-beam echosounders as described by survey type below in the “Active Acoustic Sound Sources” section below.

Geotechnical Surveys

Finally, geotechnical sampling is conducted to assess seafloor conditions with respect to siting facilities such as platforms and pipelines. The principal objectives of geotechnical surveys are (1) to assess the suitability of shallow foundation soils to support energy structures and associated infrastructure (i.e., transmission cables, pipelines, etc.) under any extreme operational and environmental conditions that might be encountered and (2) to obtain information about soil characteristics needed for design and installation of energy structures, support infrastructure, and assessment of sediment resources and minerals for non-energy projects. Geotechnical survey data describe the stratigraphic and geoengineering properties of sediment that may affect the design of foundations and anchoring systems. Geotechnical surveys typically are conducted using a barge or ship approximately 20-100 m (65-328 ft) in length.

A NEPA review is part of the approval process for all oil and gas G&G permit authorization and OCS plans for exploration, development, or production under the OCS Oil and Gas Program. The review includes a proposed action at a specific location with specific types of tools and intensity of G&G activity, and it may include an EA. Currently, BOEM prepares an EA for any G&G activity proposing the use of airguns or that could have the potential to impact benthic or archaeological resources. The noise-related, impact-producing factors associated with G&G activities include

- active acoustic sound sources (see below);
- vessel and equipment noise (**Chapter 2.4.1.2**); and
- aircraft noise (**Chapter 2.4.1.3**).

Active Acoustic Sound Sources

Active acoustic sound sources include airguns and non-airgun HRG sources such as CHIRP subbottom profilers, side-scan sonars, and multi-beam echosounders.

Airguns

Airguns would be used as seismic sources during deep-penetration seismic surveys and ancillary surveys (i.e., VSP and HRG). An airgun is a stainless steel cylinder filled with high-pressure air. The airgun releases a high-pressure bubble of air underwater as a source of energy to generate the acoustic/pressure waves that are used in seismic reflection surveys. During seismic surveys, seismic pulses are typically emitted at intervals of 5-30 seconds, and occasionally at shorter or longer intervals dependent upon data acquisition target or goals.

Airguns produce an intense but highly localized sound energy that propagates throughout the water column. Individual airguns are available in a wide range of chamber volumes, from <5 in^3 to more than 2,000 in^3, depending on survey requirements. The airgun array volume is the sum of the volumes of each individual airgun used. The volume of airgun arrays used for seismic surveys can vary from approximately 45 to 8,460 in^3. Airgun sources can range from a single airgun (for some HRG surveys) to a large array of airguns (for deep-penetration seismic surveys). Airgun arrays are broadband sound sources that project energy over a wide range of frequencies, from <10 Hertz (Hz) to >2,000 Hz (2 kHz). Most of the usable energy, however, is concentrated in the frequency range below 200 Hz. The energy level produced by an airgun array depends primarily on three factors:

- the firing pressure in pounds per square inch of the guns (2,000 pounds per square inch for most of the surveys currently being conducted);
- the number of airguns in the array (generally between 20 and 80); and
- the total volume in cubic inches of the array (generally between 1,500 and 8,640 in^3).

Airgun surveys are conducted by towing airguns and streamers behind the vessel(s). There are several different configurations/methods of performing airgun surveys dependent upon the data needs (**Figure 2.4.1-6**). Shallow-penetration airgun (HRG airgun) seismic surveys image shallow depths, typically 1,000 m (3,280 ft) or less below the seafloor to produce high-resolution images. Because the intent of HRG airgun surveys is to image shallow depths and to produce higher resolution images, the airgun sources used (typically 1 or 2) are smaller volume (typically 40-400 in^3) than deep-penetration seismic sources. Also, the streamers are shorter, towed more shallowly and closer together, and the airgun shots are fired at shorter intervals than for larger, deep-penetration seismic surveys. These shallow hazard surveys in general cover a smaller area (1 to several OCS blocks) and usually take about 5 days to complete following streamer and airgun deployment.

Deep-penetration airgun seismic surveys are conducted to obtain data on geological formations as deep as 40,000 ft (12,192 m) below the seafloor (BOEM 2017c). Data acquisition generally takes place day and night and, depending on the size of the survey area, may continue for days, weeks, or months. A typical deep-penetration seismic airgun survey may experience approximately 20-30 percent of non-operational downtime due to a variety of factors, including technical or mechanical problems, standby for weather or other interferences, and performance of mitigating measures (e.g., ramp-up, pre-survey visual observation periods, and shutdowns).

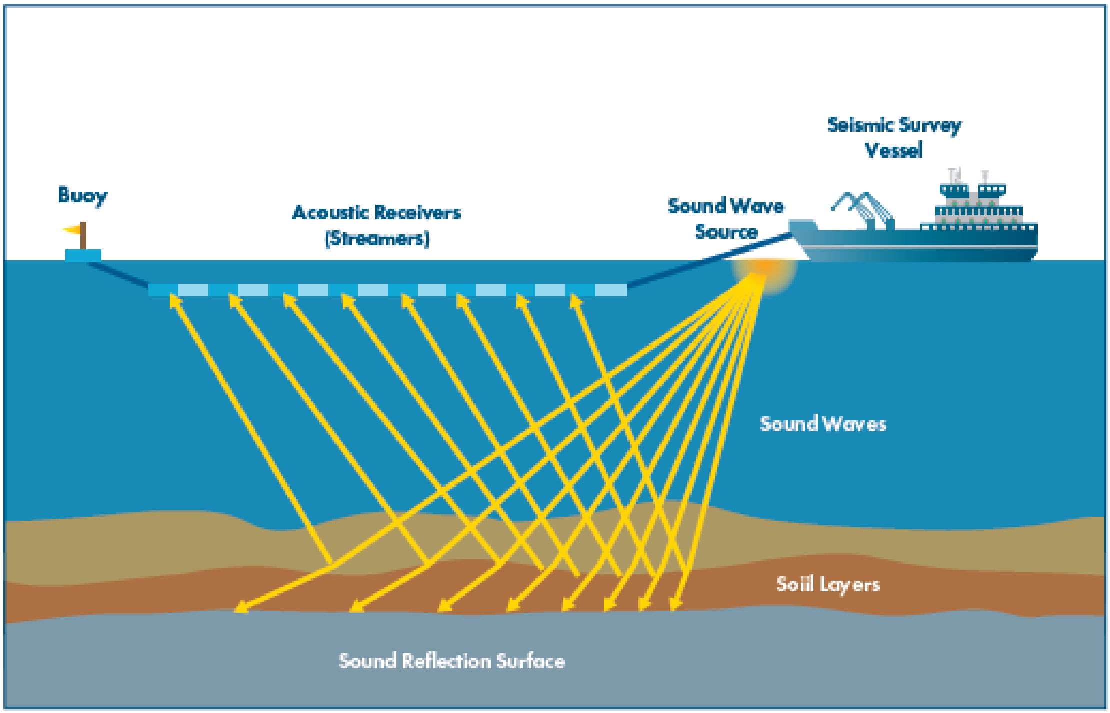


Figure 2.4.1-6. Basic Seismic Survey Configuration (individual surveys would vary depending on data needs).

Electromechanical/Non-Airgun HRG Sources

Electromechanical (also referred to as non-airgun HRG) surveys use sound waves that are reflected off subsea structures to collect data on conditions both at the seafloor and shallow subsurface (**Figure 2.4.1-7**). Typical non-airgun HRG surveys may involve one or more types of high-frequency acoustic sources, such as those listed in the **Table 2.4.1-1** (BOEM 2017c).

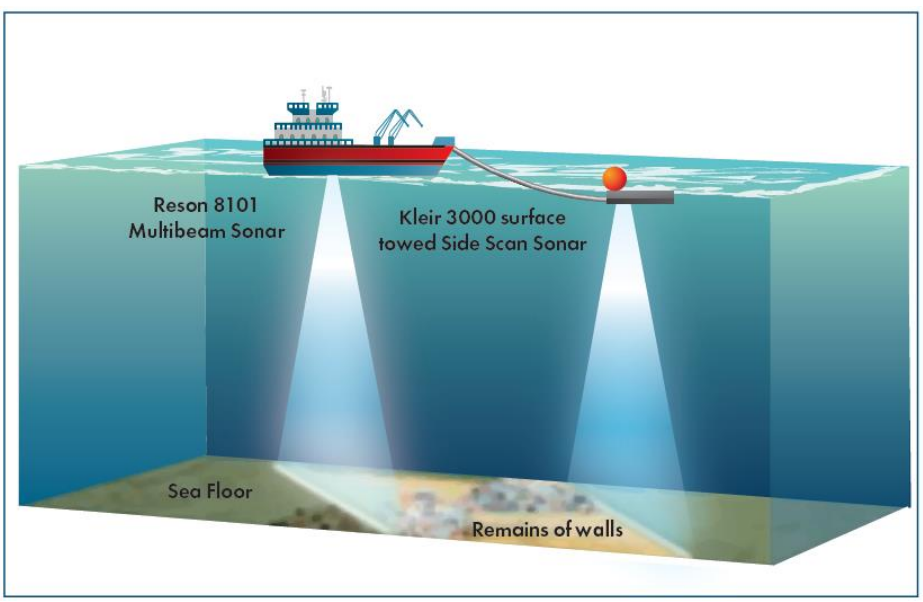


Figure 2.4.1-7. Representative High-Resolution Geophysical Surveys.

Table 2.4.1-1. Common HRG Sources and Associated Frequency Ranges.

High-Frequency Acoustic Source	Sound Frequency
Subbottom/Sediment Profilers	2.5-7 kHz
Compressed High-Intensity Radar Pulse (CHIRP) Subbottom Profilers	0.5-24 kHz
Side-Scan Sonar	Usually 16-1,500 kHz
Single-Beam Echosounders	12-240 kHz
Multibeam Echosounders	50-400 kHz
Pingers	2,000 Hz
Sparkers	50-4,000 Hz
Boomers	300-3,000 Hz

Hz = Hertz; kHz = kilohertz.

In general, any combination of these techniques, which are employed for both hazard and archaeological surveys, may be conducted during a single deployment from the same vessel. High-resolution geophysical systems usually use higher frequencies than those used in seismic airgun surveys and image smaller structures with a higher level of detail. The survey equipment is either mounted to the ship or ROV, conducted using an autonomous underwater vehicle, or towed behind a survey vessel. The sound source and receiver can be located in a single piece of equipment, or the sound source is collected by towed hydrophones.

There are several different types of HRG non-airgun (electromechanical) equipment used to meet the data needs and different sound levels (frequencies) used for different mapping resolutions. The specific frequency used would depend on the manufacturer, water depth, purpose of the survey, and seabed characteristics in the Area of Interest. For onlease engineering studies involving the placement of production facilities and pipelines in deep water, HRG surveys are often conducted with autonomous underwater vehicles equipped with a multibeam depth sounder, side-scan sonar, and a chirp subbottom profiler (**Figure 2.4.1-8**). Geophysical contractors have been using autonomous underwater vehicles since about 2000 to make detailed maps of the seafloor before they start building subsea infrastructure.

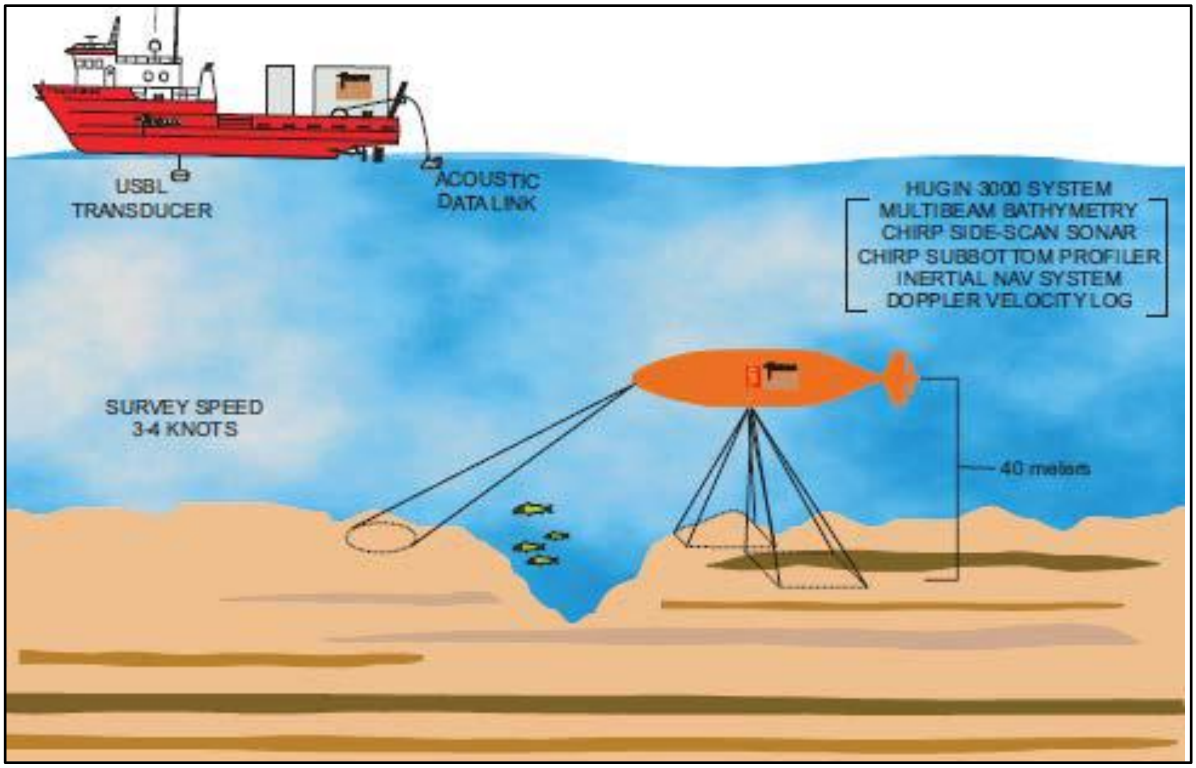


Figure 2.4.1-8. Common High-Resolution Geophysical Survey Configuration in the Gulf of Mexico.

2.4.1.2 Vessel Noise

Vessel noise is a combination of narrow-band (tonal) sounds, usually in frequency bands <500 Hz, and some broadband sound. 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 vessel's wake (Richardson et al. 1995). Large vessels produce sounds; vessels that use dynamic positioning for station keeping employ thrusters to maintain position and produce higher sound levels. Representative source levels for dynamically positioned vessels range from 184 to 190 dB re 1 µPa at 1 m, with a primary amplitude frequency <600 Hz (Blackwell and Greene Jr. 2003; Kyhn et al. 2011; McKenna et al. 2012).

Nearly all G&G activities would be conducted from ships. The G&G survey vessels would contribute to overall noise by transmitting noise through air and water. Vessel noise is a combination of narrow-band (tonal) and broadband sound (Richardson et al. 1995). Tones typically dominate up to approximately 50 Hz. The majority of broadband sound energy is restricted to frequencies below 100-200 Hz, but broadband sounds may include sound energy at frequencies as high as 100 kHz.

The primary sources of vessel noise are the propeller and machinery. Ship-generated noise at frequencies <50 Hz is dominated by sound produced by propeller cavitation, which results from high thrust loading and non-uniform inflow of water into a propeller (Wright 2008). Some propellers may produce a high-pitched noise, often referred to as propeller singing, within the practical frequency range of approximately 10-1,200 Hz. The audible range of singing, however, can be as high as 12,000 Hz (HydroComp Inc. 2003).

Primary sources of machinery noise include diesel-powered propulsion engines and ship service engines (Wright 2008). Other sources of noise include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al. 1995). Propeller cavitation usually is the dominant noise source. The intensity of noise from support vessels is approximately 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 unladen vessels. For a given vessel, relative noise tends to increase with speed. Ship noise radiates asymmetrically, with stern aspect noise levels higher than bow aspect levels by 5-10 decibels (dB) (McKenna et al. 2012). Broadband source levels for most small ships (a category that would include seismic survey vessels and support vessels used when drilling continental offshore strategic test wells or shallow test wells) are anticipated to be in the range of 170-180 dB re 1 μPa at 1 m (Richardson et al. 1995).

The drilling of continental offshore strategic test and shallow test wells would introduce additional underwater noise into the Area of Interest from engines, generators, dynamic positioning systems, and other drilling rig equipment. Jack-up rigs typically are used in water depths less than 100 m (328 ft). Semisubmersibles are floating rigs that are used in depths ranging from 100 to 3,000 ft (328 to 9,843 ft) and can be either anchored/moored or dynamically positioned. Drillships are used in water depths greater than about 600 m (1,968 ft) and can also be anchored/moored or dynamically positioned (usually the latter).

Noise levels vary with the type of drilling rig and water depth. Drillships produce the highest levels of underwater noise because the hull containing the rig generators and drilling machinery has a large surface area in contact with the water. In addition, dynamically positioned drillships use thrusters to maintain position and are constantly emitting engine and propeller noise. Jack-up rigs are at the other end of the spectrum because they are supported by metal legs with only a small surface area in contact with the water, the drilling machinery is located on decks well above the water, and there is no propulsion noise. Semisubmersibles are intermediate in noise level because the machinery is located well above the water but the pontoons supporting the structure have a large surface area in contact with the water. Richardson et al. (1995) Broadband source levels for semisubmersible rigs have been reported to be about 154 dB re 1 μPa. Source levels for drillships have been reported to be as high as 191 dB re 1 μPa during drilling.

Drilling operations and G&G survey vessels would be supported by crew boats, supply vessels, and/or helicopters traveling between the drilling rig and vessels and the onshore support bases, as needed. For drilling, support vessels usually make a few round trips per week, and helicopters typically make one round-trip daily. The characteristics of aircraft noise are discussed below.

Noise levels from project-related survey and survey support vessel traffic would be spatially restricted to discrete survey areas or OCS lease blocks and of relatively short-term duration. BOEM predicts that additional vessel traffic would contribute to elevated local ambient noise levels during surveys; however, these levels would likely dissipate quickly with distance from the source.

2.4.1.3 Aircraft Noise

Helicopters and fixed-wing aircraft generate noise from their engines, airframe, and propellers. The dominant tones for both types of aircraft generally are below 500 Hz (Richardson et al. 1995). Richardson et al. (1995) reported that received sound pressure levels (in water) from aircraft flying at altitudes of 152 m (499 ft) were 109 dB re 1 µPa for a Bell 212 helicopter and 101 dB re 1 µPa for a small fixed-wing aircraft. Helicopters are approximately 10 dB louder than fixed-wing aircraft of similar size (Richardson et al. 1995). Penetration of aircraft noise into the water is greatest directly below the aircraft with much of the sound being reflected and not penetrating the water (Richardson et al. 1995). The duration of underwater sound from passing aircraft is much shorter in water than air; for example, a helicopter passing at an altitude of 152 m (499 ft) that is audible in the air for 4 minutes may be detectable underwater for only 38 seconds at 3-m (10-ft) depth and for 11 seconds at 18-m (59-ft) depth (Richardson et al. 1995).

The Federal Aviation Administration regulates helicopter flight patterns. Because of noise concerns, Federal Aviation Administration Circular 91-36C encourages pilots to maintain higher than minimum altitudes near noise sensitive areas. The Helicopter Safety Advisory Conference recommended practice states that helicopters should maintain a minimum altitude of 750 ft (229 m) while in transit offshore and a maximum of 500 ft (152 m) while working between platforms and drilling rigs (Helicopter Safety Advisory Conference 2010). When flying over land, the specified minimum altitude is 1,000 ft (305 m) over unpopulated areas and coastlines, and 2,000 ft (610 m) over populated areas and sensitive areas including national parks, recreational seashores, and wildlife refuges. In addition, guidelines and regulations issued by NMFS under the authority of the Marine Mammal Protection Act include provisions specifying helicopter pilots to maintain an altitude of 1,000 ft (305 m) within 100 yd (91 m) of marine mammals.

Helicopters are a potential source of aircraft noise during the drilling of continental offshore strategic test and shallow test wells. It is expected that well drilling activities would be supported by a helicopter making one round trip daily between the drilling rig and onshore support base. The Helicopter Safety Advisory Conference recommended practice states that helicopters should maintain a minimum altitude of 750 ft (229 m) while in transit offshore and a maximum of 500 ft (152 m) while working between platforms and drilling rigs (Helicopter Safety Advisory Conference 2010). These helicopters also follow the Federal Aviation Administration's minimum of 360 ft (110 m) altitude over "coastal game reserves" (bird strike issues), cruising altitudes for easterly and westerly headings, and altitude restrictions over certain offshore fields, and the operators' contractual guidelines. Helicopters would likely be expected to follow these recommendations and restrictions as applicable, weather permitting. Helicopters could also be used for transporting supplies and/or crew changes.

While rare, sometimes airborne magnetic and airborne gravity surveys are conducted by fixed-wing aircraft and look for deep crustal structure, salt-related structure, and intra-sedimentary anomalies. Aeromagnetic surveys are typically done as a supplement to deep-penetration seismic surveys. A typical aeromagnetic survey would require 1-3 months to complete. Recent surveys done in the GOM have been flown at altitudes of 60 to 300 m (197 to 984 ft), at speeds of 110 kn (126.6 mph), and with flight line spacing of 0.5 to 2 km (0.3 to 1.2 mi) (BOEM 2017c). Based on the scale of past aeromagnetic surveys that have been conducted in the northern GOM, an individual survey would likely cover <10 percent of the Area of Analysis.

2.4.1.4 Drilling and Production Noise

Noise from drilling and production operations includes strong tonal components at low frequencies (<500 Hz), including infrasonic frequencies in at least some cases (Richardson et al. 1995). Machinery noise can be continuous or transient and can be variable in intensity. Noise levels vary with the type of drilling rig and water depth. Drillships produce the highest levels of underwater noise because the hull containing the rig generators and drilling machinery is well coupled to the water. In addition, dynamically positioned drillships use thrusters to maintain position and are constantly emitting engine and propeller noise. Jack-up rigs are at the other end of the spectrum because they are supported by metal legs with only a small surface area in contact with the water, the drilling machinery is located on decks well above the water, and there is no propulsion noise. Semisubmersibles are intermediate in noise level because the machinery is located well above the water but the pontoons supporting the structure have a large surface area in contact with the water. Sound source levels vary, depending upon the drilling structure: drilling from islands and caissons generates sound source levels of 140-160 dB re 1 µPa-m, with frequencies of 20-1,000 Hz; drilling from bottom-founded platforms generates received sound levels of 119-12,760 dB re 1 µPa-m, with frequencies of 5-1,200 Hz; and drilling from vessels generates sound source levels of 154-191 dB re 1 µPa-m, with frequencies of 10-10,000 Hz.

2.4.1.5 Decommissioning Noise

Noise would be generated during explosive and non-explosive structure removal. Vessel and helicopter traffic would also occur in the vicinity of the platform undergoing decommissioning. Which severing tool the operators and contractors use takes into consideration the target size and type, water depth, economics, environmental concerns, tool availability, and weather conditions. A summary of the different severing tools available in the GOM can be found in *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf* (MMS 2005).

2.4.2 Non-OCS Oil- and Gas-Related Activities Causing Noise

Noise in the ocean is the result of both natural and anthropogenic sources. Natural sources of noise include sounds produced by animals and processes such as wind-driven waves, rainfall, and storms.

Human-generated (anthropogenic) contributions to the ocean's soundscape have steadily increased in the past several decades. This increase is largely driven by a worldwide increase in oil and gas exploration and the amount of vessel traffic using the GOM, including sources not related to oil and gas operations such as tourism, commercial shipping, naval operations (e.g., military sonars, communications, and explosions, fishing (e.g., pingers used in fisheries to prevent animals getting caught in nets), research (e.g., air-guns, sonars, telemetry, communication, and navigation), and other activities such as construction (e.g., pile driving) and recreational boating (**Table 2.4.2-1**; Hildebrand 2009). Anthropogenic sources, such as vessel noise, are a chronic contribution to local and global soundscapes. Other anthropogenic sources affect marine life on a more restricted temporal and spatial scale, but often produce high sound energies and may pose immediate health risks to marine wildlife. Many anthropogenic sounds are produced intentionally as part of active data gathering effort using sonar, depth sounding, and seismic surveys. Though not oil- and gas-related, BOEM permits ancillary G&G activities related to (1) OCS sand, gravel, and shell resource development; (2) leasing and operation in the OCS for minerals other than oil, gas, and sulfur; and (3) renewable energy development and operation. All of these activities are subject to plan and NEPA review by BOEM based on the activity being proposed as described in **Table 2.4.2-2**. Though BOEM does not have the authority to regulate other non-OCS oil- and gas-related noise sources, some do occur on the OCS (**Table 2.4.2-2**). Refer to **Chapter 2.4.1** for information on OCS oil- and gas-related sources of noise in the GOM.

Table 2.4.2-1. Typical Sources of Anthropogenic Noise.

Sound Source	Activity Description	Source Level (dB re 1 µPa at 1 m)	Bandwidth Δ = 10 dB (Hz)	Pulse Duration(s)
Ship Shock Trial (10,000-lb explosive)	Military test to determine the strength of a ship using live explosives near the ship	304	0.5-50	2
Torpedo MK-46 (98-lb explosive)	Military test of live ammunition	289	10-200	0.1
Air-gun Array	Used during seismic surveys (refer to **Chapter 2.1.2.2.1**)	260	5-300	0.03
53C ASW Sonar	Used for military surveillance	235	2,000-8,000	2
SURTASS LFA Sonar	Used for military surveillance	235	100-500	6-100
Pile-driving 1,000 kJ Hammer	Used in the construction of structures offshore	237	100-1,000	0.05
Multibeam Sonar Deepwater EM 122	Sonar and imagers used by civilians and commercial ships	245	11,500-12,500	0.01
Multibeam Sonar Shallow EM 710	Sonar and imagers used by civilians and commercial ships	232	70,000-100,000	0.002
Sub-bottom Profiler SBP 120	Sonar and imagers used by civilians and commercial ships	230	3,000-7,000	0.1
Seal Bombs (2.3-g charge)	Small explosive charges detonated by fishermen to deter seals and sea lions from competing for fish	205	15-100	0.03
Acoustic Harassment Device	Used to keep marine mammals away from fishing gear or aquaculture facilities	205	8,000-30,000	0.15-0.5

Sound Source	Activity Description	Source Level (dB re 1 µPa at 1 m)	Bandwidth Δ = 10 dB (Hz)	Pulse Duration(s)
Acoustic Deterrent Device	Used to keep marine mammals away from fishing gear or aquaculture facilities	150	5,000-160,000	0.2-0.3
Cargo Vessel (173-m length, 16 kn)	Noise from the engines of commercial shipping vessels	192	40-100	Continuous
Acoustic Telemetry SIMRAD HTL 300	Used for underwater communications, remote vehicle command and control, diver communications, underwater monitoring and data logging, trawl net monitoring, and other applications requiring underwater wireless communications	190	25,000-26,500	Continuous
Small Boat Outboard Engine (20 kn)	Noise from recreational vessels or possibly oil- and gas-related service vessels	160	1,000-5,000	Continuous
Operating Windmill Turbine	Noise from renewable resources, such as turbines	151	60-300	Continuous

Source: Hildebrand 2009.

Table 2.4.2-2. Non-Oil- and Gas-Related G&G Activity, Permitting Authority, and Typical NEPA Action.

G&G Activity in Support of	On Lease	Off Lease and/or Third Party	Permitting Authority	Approved by OCS Plan	Approved by Permit Application	Typical NEPA Action
Renewable Energy - Site Assessment	X	-	30 CFR part 585	Site Assessment Plan		EA or EIS
Renewable Energy Facility Development	X	-	30 CFR part 585	Construction and Operation Plan		EA or EIS
Renewable Energy - Other Activities	X	-	30 CFR part 585	General Activities Plan		EA or EIS
Marine Minerals - OCS Sands, Gravel, and Shell Resources (non-competitive)		X	OCSLA Section 8(k) 30 CFR part 583		Permit Authorization or Notification	EA or EIS
Marine Minerals - Research and Prospecting		X	OCSLA Section 11 30 CFR part 580	None	Permit Authorization or Notification	EA or EIS
Marine Minerals - Leasing Related	X		OCSLA Section 8(k) 30 CFR parts 581-582	Delineation, Testing, or Mining Plan		EA or EIS

[1]Renewable energy is discussed in more detail in **Chapters 2.3.2.7 and 2.7.2.8**.
[2]Sand resources are discussed in more detail in **Chapter 2.7.2.7**.

2.5 COASTAL LAND USE/MODIFICATION

Land use encompasses six general categories: transportation, recreation, agriculture, residential, commercial, or industrial uses. Coastal infrastructure, for the purposes of BOEM's analysis, refers specifically to onshore oil- and gas-related infrastructure that provides support for offshore OCS oil- and gas-related activities. As opposed to land use, this type of coastal infrastructure serves as both an impact-producing factor *for* other resources and also as a resource (refer to **Chapter 4.4.1**, Land Use and Coastal Infrastructure) that is impacted by OCS oil- and gas-related activities and non-OCS oil- and gas-related activities because coastal infrastructure supports other interests that are unrelated to OCS oil- and gas-related activities, such as State oil and gas activities, commercial entities, and recreational uses.

The following sections discuss oil- and gas-related and other human-induced activities that can affect existing land-use patterns and/or physically alter coastal habitats or shorelines. 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 Economic Impact Areas (EIAs) based on economic and demographic similarities among counties/parishes (Varnado and Fannin 2018). **Figure 2.5.1-1** depicts a map of these EIAs. Much of the analysis below focuses on these EIAs since many of the issues related to OCS oil and gas leasing in the Gulf of Mexico would be concentrated in these EIAs. These EIAs also serve as consistent units for which to present economic and demographic data.

2.5.1 OCS Oil- and Gas-Related Activities

Future oil and gas leasing could create the potential need for new facility construction and/or expansions at existing facilities. A detailed description of the existing land use and coastal infrastructure in the GOM can be found in **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Oil and gas exploration, production, and development activities on the OCS are supported by an expansive onshore infrastructure industry that includes large and small companies providing an array of services from construction facilities, service bases, and waste disposal facilities to crew, supply, and product transportation, as well as processing facilities. It is an extensive and mature system providing support for both offshore and onshore oil and gas activities in the GOM region (**Figure 2.5.1-2**). The extensive presence of this coastal infrastructure is not subject to rapid fluctuations and results from long-term industry trends. Existing oil and gas infrastructure is expected to be sufficient to handle development associated with a proposed action. Should there be some expansion at current facilities, the land in the analysis area is sufficient to handle such development.

Activities and factors associated with coastal infrastructure include service bases, gas processing plants, pipeline landfalls, navigation channels, and waste disposal facilities. **Chapter 2.2.1.11** addresses onshore waste disposal. While no single proposed lease sale is projected to substantially change existing OCS-related service bases or require any additional service bases, it could contribute to the use of existing service bases. Sufficient land exists to construct a new gas processing plant but, given that spare capacity at existing facilities is sufficient to satisfy new gas production, the need to construct a new facility would possibly materialize only toward the end of the lifecycle of a future lease sale (approximately 50 years based on historical trends). While a lease sale and subsequent oil and gas activitity would contribute to the continued need for maintenance dredging of existing navigation channels, a mature network of navigation channels already exists in the analysis area; therefore, new navigation channel construction as a direct result of a future lease sale is not likely (Dismukes 2011).

BOEM continuously collects new data and monitors changes in infrastructure demands in order to support scenario projections that reflect current and future industry conditions. The scenario projections outlined below reflect the already well-established industrial infrastructure network in the GOM region and fluctuations in OCS oil- and gas-related activity levels. To prevent underestimating potential effects, BOEM makes conservative infrastructure scenario estimates; therefore, a projection of between 0 and 1 is more likely to be 0 than 1. The following sections provide the current trends, or outlook scenario projections, for the varied infrastructure categories. The primary sources for the information on coastal infrastructure and activities presented here are BOEM's New Orleans Office's fact books: (1) *OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (The Louis Berger Group Inc. 2004); (2) *Fact Book: Offshore Oil and Gas Industry Support Sectors* (Dismukes 2010); and (3) *OCS-Related Infrastructure Fact Book; Volume I: Post-Hurricane Impact Assessment* and *Volume II: Communities in the Gulf of Mexico* (Dismukes 2011).

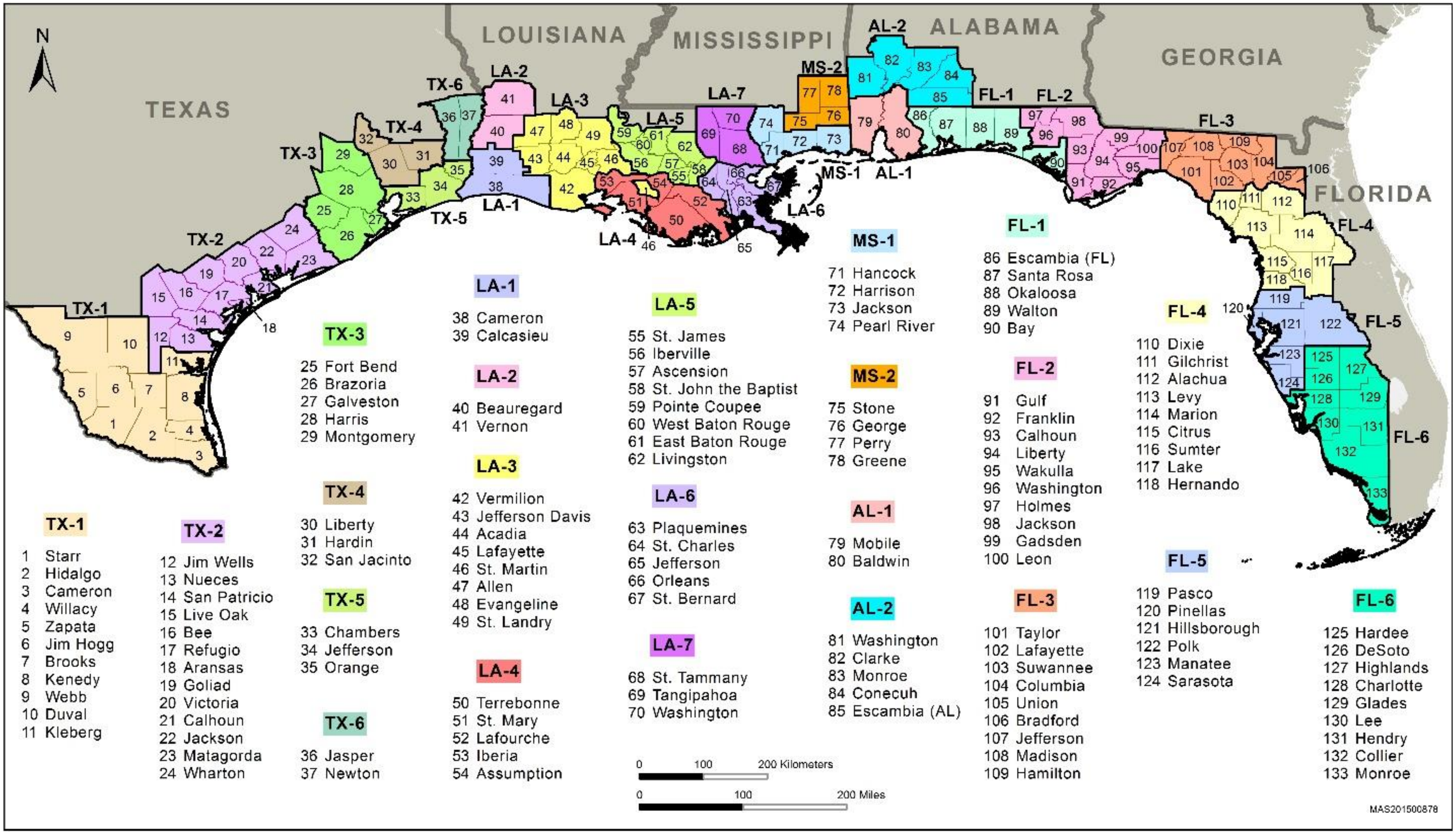


Figure 2.5.1-1. Economic Impact Areas in the Gulf of Mexico Region.

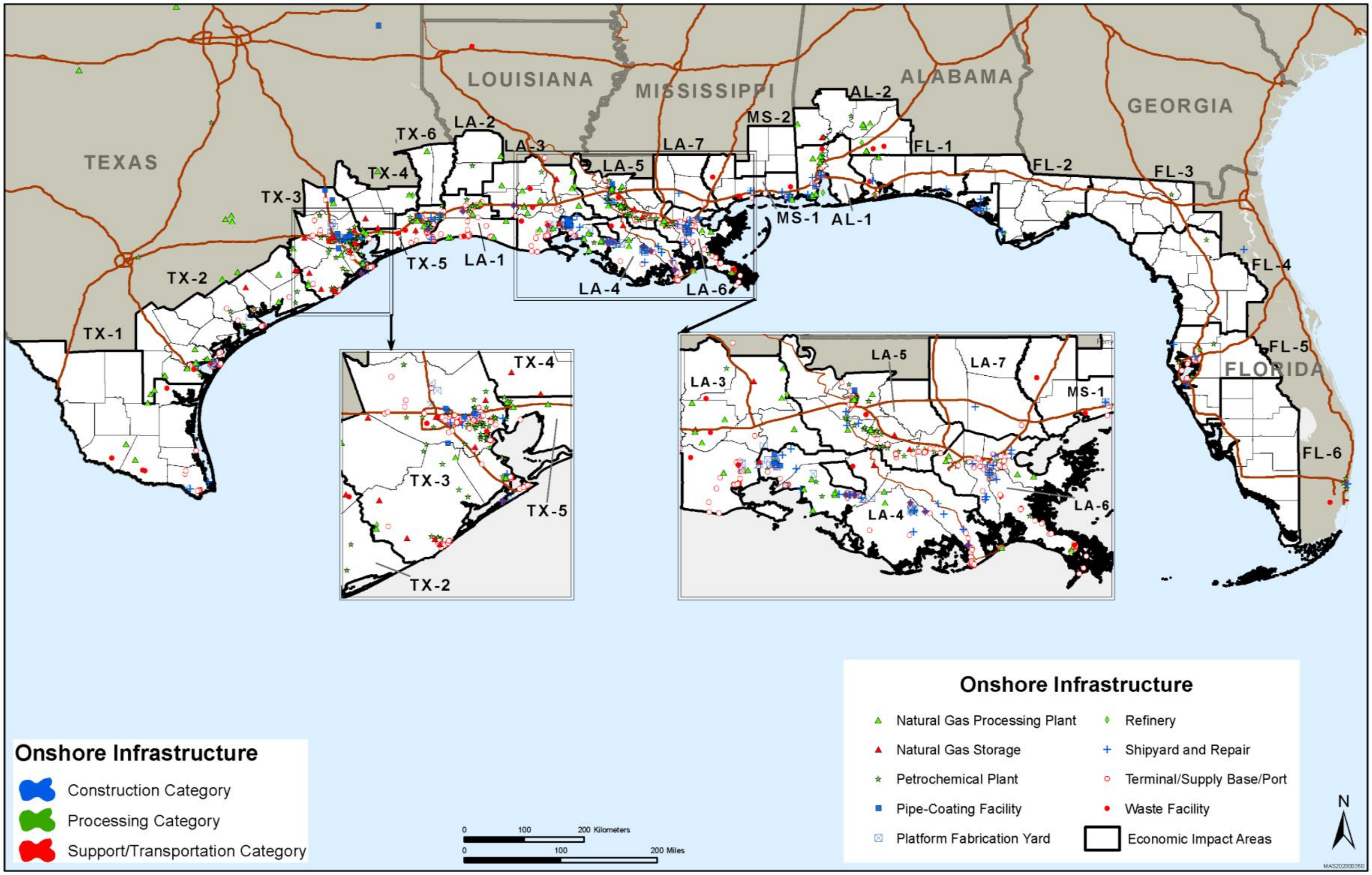


Figure 2.5.1-2. Onshore Infrastructure (Sources: Dismukes 2010; 2011).

2.5.1.1 Construction Facilities

Platform Fabrication Yards

Facilities where platforms (and drilling rigs) are fabricated are called platform fabrication yards. Most platforms are fabricated onshore and then towed to an offshore location for installation. When an oil and/or gas discovery occurs, an exploratory drilling rig would be either replaced with, or converted to, a production platform assembled at the site using a barge equipped with heavy lift cranes. As oil prices fluctuate, platform fabrication yards adjust accordingly. When oil prices are low, they diversify their operations into other marine-related activities or scale back on the overall scope of their operations. The variety of diversification strategies may include drilling rig maintenance and re-builds, barge or vessel fabrication, dry-docking, or equipment survey.

The existing fabrication yards do not operate as "stand alone" businesses; rather, they rely heavily on a dense network of suppliers of products and services. Also, since a vast network of existing fabrication yards has been historically evolving in the GOM region for many decades, the emergence of new fabrication yards is relatively low compared to region with less existing infrastructure. There are 52 platform fabrication yards in the analysis area, with the highest concentration in Louisiana at 37, followed by Texas at 13. Given the large size of offshore platforms, fabrication yards necessarily span several hundred acres. The location of platform fabrication yards is tied to the availability of a navigable channel sufficiently large enough to allow the towing of bulky and long structures, such as offshore drilling and production platforms. Thus, platform fabrication yards are located either directly along the Gulf Coast or inland along large navigable channels, such as the Intracoastal Waterway. For more detail on platform fabrication yards as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Shipbuilding and Shipyards

There are several kinds of shipyards throughout the Gulf Coast region that build and repair all manner of vessels, many of which are not related to OCS oil- and gas-related activities. These marine vessels are perhaps the most important means of transporting equipment and personnel from onshore bases and ports to offshore drilling and production structures. The shipbuilding and repair industry has struggled over the last few decades. Since the mid-1990s, there has been some industry stabilization, but the outlook for shipbuilding and shipyards is uncertain. The industry is overly dependent on military contracts and faces numerous economic challenges, such as the lack of international competitiveness, workforce development challenges, availability of capital, and the lack of research and development funding. In the GOM region, there is a direct correlation between OCS oil- and gas-related activities and the demand or opportunities for expanding shipbuilding and offshore support vessels. There are many shipyards located within the analysis areas. For more detail on shipbuilding and shipyards yards as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Pipe-Coating Facilities and Yards

Pipe-coating plants generally receive manufactured pipe by rail or water at either their plant or pipe yard depending on their inventory capabilities. At the plant, pipes that transport oil and gas are coated on the interior and exterior to protect from corrosion and abrasion. There are 18 pipe-coating plants in the analysis areas. Pipe-coating facilities receive manufactured pipe, which they then coat the surfaces of with metallic, inorganic, and organic materials to protect from corrosion and abrasion and to add weight to counteract the water's buoyancy. Two to four sections of pipe are then welded at the plant into 40-ft (12-m) segments. The coated pipe is stored (stacked) at the pipe yard until it is needed offshore.

To meet deepwater demand, pipe-coating companies were expanding capacity or building new plants before the *Deepwater Horizon* explosion, oil spill, and response; afterwards, activity levels dropped temporarily, then rebounded until the oil price drop and economic downturn of late 2014/early 2015, resulting in a decrease in OCS activity levels and less demand for pipe-coating services. Demand for pipe-coating recovered after 2015 but has taken a downturn as commodity prices have dropped in 2020 and the industry has contracted across the Gulf Coast. As activity levels fluctuate in the GOM, the demands for pipe-coating services fluctuate accordingly. For more detail on pipe-coating facilities and yards as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

2.5.1.2 Support Facilities and Transportation

Service Bases and Ports

A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel needed at offshore work sites. A service base may also be referred to as a supply base or terminal and may be associated with a port. Although a service base may primarily serve the adjacent OCS planning area and EIAs in which it is located, it may also provide substantial services for the other OCS planning areas and EIAs. **Table 2.5.1-1** shows services bases organized by EIA, and **Figure 2.5.1-3** shows the geographic location of the service bases.

Table 2.5.1-1. OCS Oil- and Gas-Related Service Bases.

State	EIA	County/Parish	
Texas	TX-1	Port Isabel (Cameron)	Port Mansfield (Willacy)
Texas	TX-2	Aransas Pass (Nueces) Corpus Christi (Nueces) Ingleside (San Patricio) Port O'Connor (Calhoun)	Bayside (Aransas) Harbor Island (Nueces) Port Aransas (Nueces) Rockport (Aransas)
Texas	TX-3	Freeport (Brazoria) Pelican Island (Galveston)	Galveston (Galveston) Surfside (Harris)
Texas	TX-5	Port Arthur (Jefferson)	Sabine Pass (Jefferson)
Louisiana	LA-1	Cameron (Cameron) Lake Charles (Calcasieu)	Grand Chenier (Cameron)

State	EIA	County/Parish	
Louisiana	LA-3	Amelia (St. Mary) Berwick (St. Mary)	Bayou Boeuf (St Mary) Cocodrie (Terrebonne)
Louisiana	LA-4	Dulac (Terrebonne) Gibson (Terrebonne) Leeville (Lafourche) Morgan City (St. Mary) Patterson (St. Mary) Weeks Island (Iberia)	Fourchon (Lafourche) Houma (Terrebonne) Louisa (St. Mary) New Iberia (Iberia) Theriot (Terrebonne)
Louisiana	LA-6	Empire (Plaquemines) Harvey (Jefferson) Paradis (St. Charles)	Grand Isle (Jefferson) Hopedale (St. Bernard) Venice (Plaquemines)
Mississippi	MS-1	Pascagoula (Jackson)	
Alabama	AL-1	Bayou LaBatre (Mobile) Theodore (Mobile)	Mobile (Mobile)
Florida	FL-1	Panama City (Bay)	

EIA = Economic Impact Area.

As the OCS oil and gas industry continues to evolve, so do the requirements of the onshore support network. With advancements in technology, the shore-side supply network would continue to be challenged to meet the industry's needs and requirements. The intermodal nature of oil and gas operations gives ports (which traditionally have water, rail, and highway access) a natural advantage as ideal locations for onshore activities and intermodal transfers (**Figure 2.5.1-3**). Therefore, ports would continue to be a vital factor in the total process and must incorporate the needs of the offshore oil and gas industry into their planning and development efforts, particularly with regard to determining their future investment needs. In this manner, both technical and economic determinants influence the dynamics of port development.

Expansion of some existing service bases is expected to occur to capture and accommodate the current and future oil and gas business that is generated by development on the OCS. Some channels in and around the service bases would need to be deepened and expanded in support of deeper draft vessels and other port activities, some of which would be OCS-related. Channel depths at most major U.S. ports typically range from 35 to 45 ft (11 to 14 m). The current generation of new large ships that service the offshore industry requires channels from 45 to 53 ft (14 to 16 m). For more detail on service bases and ports as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

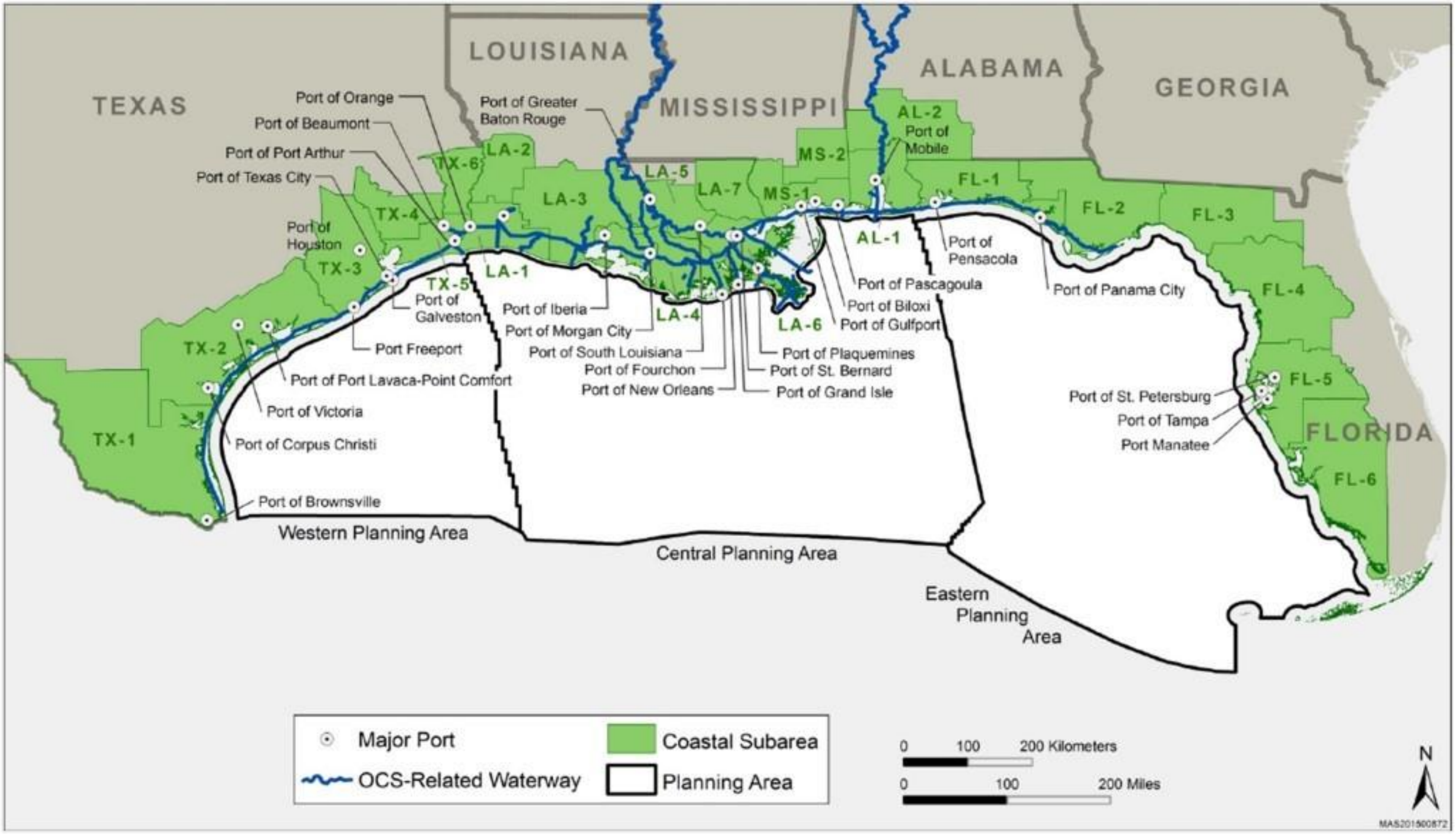


Figure 2.5.1-3. Ports and Waterways in the Gulf of Mexico.

Helicopter Hubs

There are numerous heliports within the GOM region that support OCS oil- and gas-related activities. Dozens are located in Texas and Louisiana and a handful in Mississippi and Alabama. There are no OCS-related heliport hubs located in Florida. For more detail on helicopter hubs as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Tanker Port Areas

The transport of OCS-produced oil from FPSO operations to onshore facilities would be accomplished with shuttle tankers rather than oil pipelines. The following tanker ports were identified as destinations for shuttle tankers transporting crude oil from FPSO operations in the GOM: Houston or the Louisiana Offshore Oil Port are most likely candidates, followed by possibly Corpus Christi, Freeport, and Port Arthur/Beaumont, Texas, although it would be most likely for oil to be transported to Port Arthur/Beaumont via pipeline (Dismukes 2011). Tankers may also offload in the other following areas: Nederland, Texas; Pascagoula, Mississippi; Mobile, Alabama; Garyville, Louisiana; Lake Charles, Louisiana; Saint Rose, Louisiana; Galveston Bar, Texas; Texas City, Texas; Baton Rouge, Louisiana; and Yabucoa, Puerto Rico. For more detail on tankers as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Barge Terminals

The OCS oil barged from offshore platforms to onshore barge terminals represents a small portion of the total amount of oil barged in coastal waters. While there is a tremendous amount of barging that occurs in the coastal State waters of the GOM, no estimates exist of the volume of this barging that is directly attributable to the OCS industry. Secondary barging of OCS oil often occurs between terminals or from terminals to refineries. Oil that is piped to shore facilities and terminals is often subsequently transported by barge up rivers, through the Gulf Intracoastal Waterway, or along the coast. For more detail on barge terminals as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Pipeline Shore Facilities

The term “pipeline shore facility” is a broad term describing the onshore facilities where the first stage of processing occurs for OCS pipelines carrying different combinations of oil, condensate, gas, and produced water. Some processing may occur offshore at the platform; only onshore facilities are addressed in this discussion. Pipelines carrying only dry gas do not require pipeline shore facilities; the dry gas is piped directly to the gas processing plant. Therefore, new pipeline shore facilities are projected to only result from oil pipeline landfalls. A pipeline shore facility may support one or several pipelines; therefore, new pipeline shore facilities are projected to only result from larger pipelines (>12 in; 30 cm). Although older facilities may be located in wetlands, current permitting programs prohibit or discourage companies from constructing any new facilities in wetlands. Also, it is more cost effective for companies to tie into the existing offshore pipeline network. For more detail on pipeline shore factlities as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Waste Disposal Facilities

A variety of different types of wastes are generated by offshore oil and gas exploration and production activities along the GOM. Some wastes are common to any manufacturing or industrial operation (e.g., garbage, sanitary waste [toilets], and domestic waste [sinks and showers]) while others are unique to the oil and gas industry (e.g., drill fluids and produced water). Most waste must be transported to shore-based facilities for storage and disposal. In the analysis area, there are 13 waste disposal facilities in Texas, 29 in Louisiana, 3 each in Mississippi and Alabama, and 1 in Florida. For more detail on waste disposal facilities as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Natural Gas Storage Facilities

Most of the natural gas storage facilities in the GOM region are salt caverns. The overwhelming majority of all salt cavern storage facilities operating in the U.S. are located along the Gulf Coast. Gulf Coast salt caverns account for only 1 percent of total U.S. working gas capacity. In the GOM, Texas has 16 salt cavern sites with 168 billion cubic feet per day (Bcf/day) of working gas capacity, Louisiana has 11 sites with 156 Bcf/day of working gas capacity, Mississippi has 6 sites with 135 Bcf/day of working gas capacity, and Alabama has 1 site with 22 Bcf/day of working gas capacity (Dismukes 2020b). Not all of these facilities are located within the BOEM-defined EIAs. More specifically, there are 22 underground natural gas storage facilities in the BOEM-defined EIAs. These facilities total 165 Bcf/day of working gas capacity. For more detail on natural gas storage facilities as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

2.5.1.3 Processing Facilities

The sections below discuss various processing facilities, i.e., gas processing facilities, refineries, onshore liquefied natural gas (LNG) facilities, and petrochemical plants. These are included as the final endpoint for OCS oil and gas; however, at the time that OCS product reaches these facilities, it has already been joined with non-OCS product from State waters and onshore activities. The percentage of oil and gas product processed by these facilities that originates from Federal OCS waters has not been determined previously and would not likely given the numerous factors unrelated to the delivery of OCS product, such as downstream demand. Therefore, in contrast to most other infrastructure types, scenario projections for processing facilities are inherently limited with no direct correlation to OCS oil- and gas-related activities.

Gas Processing Plants

All natural gas is processed in some manner to remove unwanted water vapor, solids, and/or other contaminants that would interfere with pipeline transportation or marketing of the gas. After processing, gas is then moved into a pipeline system for transportation to an area where it is sold.

Much of the natural gas processing plant capacity in the U.S. is located along the Gulf Coast and is available for supporting Federal offshore production. While natural gas production on the OCS shelf (shallow water) has been declining, deepwater gas production has been increasing, but not at the same pace. Overall, the combined trends of increasing onshore shale gas development, declining offshore gas production, and increasing efficiency and capacity of existing gas processing facilities have lowered demands for new gas processing facilities along the Gulf Coast. Spare capacity at existing facilities should be sufficient to satisfy new gas production for many years, although there remains a slim chance that a new gas processing facility may be needed by the end of the 50-year life of a proposed lease sale. Expectations for new gas processing facilities being built during the analysis period are dependent on long-term market trends that are not easily predicable over the next 50 years (Dismukes 2011). For more detail on gas processing plants as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Refineries

The U.S. Department of Energy's Energy Information Administration updates national energy projections annually, including refinery capacity. Most of the GOM region's refineries are located in Texas and Louisiana. Texas contains 30 operable refineries, with an operating capacity of over 6.2 MMbbl/day, which is over 30 percent of the total U.S. capacity. Louisiana contains 17 operable refineries, with an operational capacity of over 3.5 MMbbl/day, which is over 17 percent of the total U.S. capacity (Energy Information Administration 2020e). There has been a trend toward constructing simple refineries instead of complex refineries. In the United States, the last complex refinery started operating in 1977 in Garyville, Louisiana. In the GOM analysis area, a new simple refinery was constructed in 2017 in Channelview, Texas (Energy Information Administration 2020b). For more detail on refineries as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Onshore Liquefied Natural Gas Facilities

The wide variety of pipeline systems and delivery markets makes the GOM attractive for LNG developers. Onshore natural gas production has increased to the extent that LNG facilities along the GOM are seeking and receiving approval to export natural gas to foreign countries. There are 10 existing LNG import/export terminals in the GOM region – 4 in Texas, 5 in Louisiana, and 1 in Mississippi (FERC 2020f; 2020g). There are 16 proposed LNG export terminals in the GOM region – 2 under construction in Texas and 4 under construction in Louisiana (FERC 2020e). There are 19 facilities with export approval that are not yet built – 9 in Texas, 9 in Louisiana, and 1 in Mississippi (FERC 2020a). For more detail on onshore liquefied natural gas facilities as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Petrochemical Plants

Petrochemical plants are usually located in areas with close proximity to the raw material supply (petroleum-based) and multiple transportation routes, including rail, road, and water. Texas, New Jersey, Louisiana, North Carolina, and Illinois are the top domestic chemical producing states.

However, most of the basic chemical production is concentrated along the Gulf Coast where petroleum and natural gas feedstock are available from refineries. Many of the Nation's top production complexes are located in Texas and Louisiana.

Along the Gulf Coast, the petrochemical industry is heavily concentrated in coastal Texas and south Louisiana and in various counties along the Alabama, Mississippi, and Florida coasts. The vast majority of petrochemical plants in the Gulf of Mexico region are located along coastal Texas and south Louisiana. **Figure 2.5.1-2** illustrates the geographical distribution of petrochemical facilities across the 133 GOM counties and parishes within the analysis area. For more detail on petrochemical plants as they relate to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

2.5.2 Non-OCS Oil- and Gas-Related Activities Causing Coastal Land Use/Modification

2.5.2.1 Sea-Level Rise and Subsidence

Although absolute sea-level rise is a contributor to the total amount of sea-level rise along the Gulf Coast, subsidence is the most important contributor to the total.

Some areas of the Gulf Coast have experienced higher local rates of sea-level rise than the global average (U.S. Global Change Research Program 2018). This coupled with coastal subsidence will likely increase the risks to and extent of impacts from storm surges (U.S. Global Change Research Program 2018). There are two aspects of sea-level rise: absolute sea-level rise and relative sea-level rise. Absolute sea-level rise refers to a net increase in the volume of water in the world's oceans. Absolute sea-level rise is caused primarily by (1) change in the volume of ocean water based on temperature; and (2) change in the amount of ice locked in glaciers, mountain ice caps, and the polar ice sheets. Relative sea-level rise refers to the appearance of or observed sea-level rise when factoring in other circumstances such as subsidence of the land is taking place at the same time that an absolute sea-level change may be occurring. Geologists tend to consider all sea-level rises as relative because the influence of one or the other is difficult to separate over geologic timeframes.

The Intergovernmental Panel on Climate Change (IPCC) reported that, since 1961, global average sea level (mean sea level) has risen at an average rate of 1.8 mm/yr (0.07 in/yr) and, since 1993, at 3.1 mm/yr (0.12 in/yr) (Bindoff et al. 2007). With updated satellite data to 2010, Church and White (2011) show that satellite-measured sea levels continue to rise at a rate close to that of the upper range of the IPCC projections (IPCC 2012). It is unclear whether the faster rate for 1993-2010 reflects decadal variability or an increase in the longer-term trend. In the structured context used by the IPCC, there is high confidence that the observed sea-level rise rate increased from the 19th to the 20th century. Over the period 1901 to 2010, global mean sea level rose by 0.19 m (0.62 ft) (with a range of 0.17-0.21 m [56-69 ft]). The rate of sea-level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (IPCC 2014). In 2018, the U.S. Global Change Research Program (2018) reported that, over the last 50 years, sea level has risen up to 8 in (203 mm) along parts of the Atlantic and Gulf Coasts, which included Louisiana and Texas, and that global sea level is currently rising at an increasing rate.

Results from the National Assessment of Coastal Vulnerability to Sea Level Rise estimate the rate of sea-level rise in the GOM, in particular the areas around Eugene Island, Louisiana, to be the highest (9.65 mm/yr; 3.17 ft/century) in the United States (NOAA 2020g). This classification is based upon variables such as coastal geomorphology, regional coastal slope, rate of sea-level rise, wave and tide characteristics, and historical shoreline change rates. As much as 88 percent of the northern GOM falls within the high vulnerability category. Areas ranked as the very low vulnerability category still have some sea-level rise. The lowest rate of rise is found in Panama City, Florida, with a rate of 1.6 mm/yr or 0.53 ft/century. Given this range, BOEM anticipates that, over the next 50 years, the northern GOM would likely experience a minimum relative sea-level rise of 80.7 mm (3.18 in) and a maximum relative sea-level rise of 482.6 mm (19.0 in). Sea-level rise and subsidence together have the potential to affect many important areas, including the OCS oil and gas industry, waterborne commerce, commercial fishery landings, and important habitat for biological resources (Coastal Protection and Restoration Authority of Louisiana 2012). Programmatic aspects of climate change relative to the environmental baseline for the GOM are discussed in **Chapter 3.4**. For more detail on coastal land loss as it relates to coastal infrastructure as a resource, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Formation Extraction and Subsidence

Extracting fluids and gas from geologic formations can lead to localized subsidence at the surface. The Texas coast is experiencing high (5-11 mm/yr) (0.19-0.43 in) rates of relative sea-level rise that are the sum of subsidence and eustatic sea-level rise (Sharp and Hill 1995). Even higher rates are associated with areas of groundwater pumping from confined aquifers. Berman (2005, Figure 3) reported that 2 m (6 ft) of subsidence had occurred in the vicinity of the Houston Ship Channel by the mid-1970s as a result of groundwater withdrawal.

Morton et al. (2005) examined localized areas or “hot spots” corresponding to fields in the Louisiana coastal area (LCA) where oil, gas, and brine were extracted at known rates. Morton et al. (2005, Figure 26) shows measured subsidence along transects across these fields that range from 18 to 4 mm/yr (0.7 to 0.15 in), with the greatest rates tending to coincide with the surface footprints of oil or gas fields. Mallman and Zoback (2007) interpreted downhole pressure data in several Louisiana oil fields in Terrebonne Parish and found localized subsidence over the fields; however, they could not link these localized rates to the subsidence measured and observed on a regional scale.

Down-to-the-basin faulting, also called listric or growth faulting, is a long recognized fault style along deltaic coastlines, and the Mississippi Delta is no exception (Dokka 2006; Dokka et al. 2006; Gagliano 2005c). There is currently disagreement in the literature regarding the primary cause of modern fault movement in the Mississippi Delta region, and the degree to which it is driven by fluid withdrawal or sediment compaction resulting from the sedimentary pile pressing down on soft, unconsolidated sediments that causes downward and toward the basin movement along surfaces of detachment in the shallow and deep subsurface. Berman (2005) discussed the conclusions of Morton et al. (2005) and believed that they failed to make the case that hydrocarbon extraction caused substantial subsidence over the broader area of coastal Louisiana, a conclusion also reached by Gagliano (2005a; 2005b), and Chan and Zoback (2007).

Oil production on the LCA peaked at 513 MMbbl in 1970 and gas production peaked at 7.8 million cubic feet in 1969 (Ko and Day 2004). Between 2003 and 2012, oil production from Federal Gulf of Mexico waters continued to decline (Energy Information Administration 2014a). From the peak, the level of production activity is slowly decreasing. The magnitude of subsidence caused by formation extraction is a function of how pervasive the activity is across the LCA. The oil and gas field maps in Turner and Cahoon (1988a; 1988b; 1988c, Figure 4) and Ko and Day (2004) seem an adequate basis to estimate the LCA's oil- and gas-field footprint at ~20 percent of the land area. The amount of subsidence from formation extraction is also occurring on a delta platform that is experiencing natural subsidence and sea-level rise. Fluid and gas extraction may lead to high local subsidence on the scale of individual oil and gas fields but not as a pervasive contributor to regional subsidence across the LCA.

2.5.2.2 Erosion

Thatcher et al. (2011) estimates that the average canal is widening at a rate of 0.99 m/yr (3.25 ft/yr). Because OCS Oil and Gas Program-related vessel traffic constitutes such a small percentage (<1%) of the contributing factors to erosion in navigation canals and other waterways, most of this land loss can be attributed to non-OCS oil- and gas-related activities.

Net landloss 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. BOEM anticipates that, over the next 40 years, if current trends in the beneficial use of dredged sand and sediment are projected based on past land additions (USACE 2009), approximately 50,000 ac (20,234 ha) may be created or protected in the LCA through dredged materials programs.

2.5.2.3 Saltwater Intrusion

Saltwater intrusion is one of many factors that impact coastal environments, contributing to coastal land loss. Such impacts can be natural, as when storm surge brings GOM water inland, or anthropogenic, as when navigation or pipeline canals allow tides to introduce high salinity water to interior marshes. In addition, produced water from oil wells in the coastal zones can be a source of water of extreme high salinity, well over 100 parts per thousand. Produced water, which is regulated, often contains pollutants such as heavy metals and hydrocarbons, as well.

Marsh plants are exposed to salinity stress when higher salinity GOM waters reach interior marshes, exposing plants to salinities above their tolerance levels. This can result in decreased plant growth and/or mortality depending on the tolerance of the plant species and the amount, rate, and duration of salinity increase (Mendelssohn and McKee 1987). Plant dieback can be followed by subsequent erosion of the marsh substrate and eventual land loss (Boesch et al. 1994; Ko and Day 2004).

The freshwater-adapted habitats (i.e., fresh or intermediate marsh and forested wetlands) are more sensitive to saltwater intrusion than the other more salt-tolerant habitats, such as brackish and saline marsh. Saltwater intrusion can result in conversion of freshwater to saline habitats or can simply kill fresh or intermediate marshes, thus converting them to open water (Johnston et al. 2009).

The leveeing of the Mississippi River and the construction of numerous water control structures are generally thought to have accelerated coastal land loss by isolating coastal wetlands from the freshwater, sediment, and nutrients of the Mississippi River, which previously served to nourish and sustain these wetlands. Among other impacts, this isolation effect results in the loss or reduction in freshwater flow, and thus a greater marine influence on the coastal wetlands, which in turn results in saltwater intrusion (Johnston et al. 2009).

Saltwater intrusion into coastal environments can also impact estuarine species distribution, shifting patterns of habitat usage. Marine species penetrate farther inland when salinities are within their tolerance, and less salt-tolerant species are restricted to the fresher areas. This can also lead to a shift in the pattern of availability of preferred fish species to fishermen.

2.5.2.4 Dredging and Navigation Canals

The Gulf Intracoastal Waterway (GIWW) is a Federal, shallow-draft navigation channel constructed to provide a domestic connection between GOM ports after the discovery of oil in East Texas in the early 1900s, as well as to provide a pathway to support the growing need for interstate transport of steel and other manufacturing materials in the early 20th century. It extends approximately 1,400 mi (2,253 km) along the Gulf Coast from St. Marks in northwestern Florida to Brownsville, Texas, with the Louisiana part reported to be 994 mi (1,600 km) in length (Louisiana Department of Natural Resources 1995). With the exception of the east-west GIWW in Louisiana, Federal channels are approximately north-south in orientation, making them vulnerable to saltwater intrusion during storms.

Along the Texas Coast there are eight federally maintained navigation channels in addition to the GIWW. Most of the dredged materials from the Texas channels have high concentrations of silt and clay. Beneficial uses of dredged material include beach nourishment for the more sandy materials and storm reduction projects or ocean disposal for much of the finer-gained material.

There are 10 Federal navigation channels in the LCA, ranging in depth from 4 to 14 m (12 to 45 ft) and in width from 38 to 300 m (125 to 1,000 ft), that were constructed as public works projects beginning in the 1800s (Louisiana Department of Natural Resources 1995, Table 1). The combined length of the Federal channels in Good et al. was reported as 2,575 mi (1,600 km), with three canals considered deep-draft and seven considered shallow (Louisiana Department of Natural Resources 1995, page 9). The Federal navigation channels in Louisiana identified by (Louisiana Department of Natural Resources 1995, Table 1) are as follows: (1) GIWW East of Mississippi River; (2) Mississippi

River Gulf Outlet; (3) GIWW between the Atchafalaya and Mississippi Rivers; (4) GIWW West of Atchafalaya River; (5) Barataria Bay Waterway; (6) Bayou Lafourche; (7) Houma Navigation Canal; (8) Mermentau Navigation Channel; (9) Freshwater Bayou; and (10) Calcasieu River Ship Channel. The Mississippi River Gulf Outlet has been decommissioned and sealed with a rock barrier as of July 2009 (Shaffer et al. 2009, page 218).

Impacts include the displacement of wetlands by original channel excavation and disposal of the dredged material. Turner and Cahoon (1988b) (Table 4-5) estimated that immediate land loss impacts from the construction of navigation channels were between 58,000 and 96,000 ac (23,472 and 38,850 ha). Separating the causes of coastal land loss is difficult, but Turner and Cahoon (1988b) estimated that the total of direct and indirect impacts from OCS oil- and gas-related activities from 1955 to 1978 accounted for 8-17 percent of Louisiana's total wetland loss.

Indirect cumulative land losses resulted from hydrologic modifications, saltwater intrusion, or bank erosion from vessel wakes (Wang 1988). Once cut, navigation canals tend to widen as banks erode and subside, depending on the amount of traffic using the channel. Louisiana Department of Natural Resources (1995, Table 1) estimated indirect impacts on wetland loss from bank erosion at 35,000 ac (14,164 ha).

Federal channels and canals are maintained throughout the relevant onshore area by the USACE, State, county, commercial, and private interests. The USACE is charged with maintaining all larger navigation channels in the area of interest. The USACE dredges millions of cubic meters of material per year in the area of interest, most of which is under the responsibility of the New Orleans District. Proposals for new and maintenance dredging projects are reviewed by Federal, State, and local agencies as well as by private and commercial interests to identify and mitigate adverse impacts upon social, economic, and environmental resources.

The USACE reported that the New Orleans District has the largest channel maintenance dredging program in the U.S., with an annual average of 78 million yd^3 (53.5 million m^3) of material dredged (USACE 2014). Maintenance dredging activity for Federal channels by USACE's Galveston District, New Orleans District, and Mobile District are reported in the USACE's Ocean Disposal Database, which can be found on the USACE website at https://odd.el.erdc.dren.mil/. Between 2009 and 2018, the New Orleans District has averaged about 9.87 million yd^3 (7.55 million m^3) of material dredged per year disposed of at ODMDSs, while the Mobile District has about one-quarter of that quantity, or 3.75 million yd^3 (2.87 million m^3) (USACE 2020c). BOEM anticipates that, over the next 70 years, the amount of dredged material disposed of at ODMDSs will fluctuate generally within the trends established by the USACE's district offices.

Maintenance dredging is performed on an as-needed basis. Typically, the USACE schedules surveys every 2 years on each navigation channel under its responsibility to determine the need for maintenance dredging. Dredging cycles may be from 1 to as many as 11 years from channel to channel and from channel segment to channel segment. Some shallower port-access channels may be deepened over the next 10 years to accommodate deeper draft vessels. Vessels that support deepwater OCS oil- and gas-related activities may include those with drafts to about 7 m (23 ft).

Construction and maintenance dredging of rivers and navigation channels can furnish sediment for a beneficial purpose, a practice the USACE calls "beneficial uses of dredged material." Drilling, production activity, and maintenance at most coastal well sites in Louisiana require service access canals that undergo some degree of periodic maintenance dredging to maintain channel depth, although oil and gas production on State lands peaked in 1969-1970 (Ko and Day 2004). In recent years, dredged materials have been sidecast to form new wetlands using the beneficial uses of dredged material program. Potential areas suited for beneficial uses of dredged material are considered most feasible within a 10-mi (16-km) boundary around authorized navigation channels in the New Orleans District, but the potential for future long-distance pipelines for disposal of dredged material could increase the potential area available for the beneficial use of dredge materials program considerably (USACE 2009, page 27).

As discussed in **Chapter 2.3.2.5**, the New Orleans District dredges an average of 78 million cubic yards of material annually during maintenance dredging of Federal navigation channels, with approximately 38 percent of that average used for the beneficial use of the dredge materials program (USACE 2020a). The USACE reported in 2013, that over a 20 year period, approximately 12,545 ha (31,000 ac) of wetlands were created with dredged materials, most of which are located on the LCA delta plain (USACE 2013).

2.5.2.5 Coastal Restoration Programs

The Marine Minerals Program (MMP) partners with communities to address serious erosion along the Nation's coastal beaches, dunes, barrier islands, and wetlands. Erosion affects natural resources, energy, defense, public infrastructure, and tourism. To help address this problem, the MMP leases sand, gravel, and/or shell resources from Federal waters on the OCS for shore protection, beach nourishment, and wetlands restoration with vigorous safety and environmental oversight. The OCSLA provides the authority to manage minerals on the OCS and the requirement to provide environmental oversight. Additional information on MMP coastal restoration efforts can be found in **Chapter 2.7.2.7**.

In the GOM region, one of the major coastal features is the Mississippi River Delta. 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 (USACE 2004a; 2004b) experiences relatively high rates of subsidence relative to more stable coastal areas eastward and westward. Coastal Louisiana wetlands make up the seventh largest delta on Earth and undergo about 90 percent of the total coastal wetland loss in the continental United States. In fact, from 1932 to 2010, coastal Louisiana has undergone a net change in land area of about 1.2 million ac (0.48 million ha). Trend analyses conducted from 1985 to 2010 show that the coastal Louisiana wetland loss rate is 16.57 mi^2 (42.92 km^2) per year. If this loss were to occur at a constant rate, it would equate to Louisiana losing an area the size of one football field per hour (Couvillion et al. 2011).

In recognition of these ongoing impacts, several programs have been established for the conservation, protection, and preservation of coastal areas, including wetlands along the Gulf Coast. In recent years, Louisiana has received over $1 billion in offshore 8(g) revenues, over half a billion dollars in Coastal Impact Assistance Program funds, and stands to receive many more billions in offshore revenue shares in coming years. These programs are described below.

Coastal Wetlands Planning, Protection and Restoration Act

The first systematic program authorized for coastal restoration in the LCA was established by the Federal 1990 Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), otherwise known as the “Breaux Act.” Individual CWPPRA projects are designed to protect and restore between 10 and 10,000 ac (4 and 4,047 ha), require an average of 5 years to transition from approval to construction, and are funded to operate for 20 years (GAO 2007), which is a typical expectation for project effectiveness (Campbell et al. 2005).

The 1990 CWPPRA introduced an ongoing program of relatively small projects to partially restore the coastal ecosystem. As the magnitude of Louisiana’s coastal land losses and ecosystem degradation became more apparent, it was identified that a more systematic approach to integrate smaller projects with larger projects to restore natural geomorphic structures and processes was needed. Projects have ranged from small demonstration projects to projects that cost over $50 million. The Coast 2050 report combined previous restoration planning efforts with new initiatives from private citizens, local governments, State and Federal agency personnel, and the scientific community to converge on a shared vision to sustain the coastal ecosystem. The LCA Ecosystem Restoration Study (USACE 2004a; 2004b) built upon the Coast 2050 Report. The LCA’s restoration strategies generally fell into one of the following categories: (1) freshwater diversion; (2) marsh management; (3) hydrologic restoration; (4) sediment diversion; (5) vegetative planting; (6) beneficial use of dredge material; (7) barrier island restoration; (8) sediment/nutrient trapping; and (9) shoreline protection, as well as other types of projects (USACE 2004a).

As of September 2016, 210 authorized CWPPRA projects were approved, 108 of which have been constructed. Over 100,000 “anticipated total acres” have been projected from completed projects, and 102 projects that were not yet completed as of mid-2016 are reported to result in greater than 54,000 anticipated total acres (USGS National Wetlands Research Center 2020). Of the 108 completed projects listed on the U.S. Geological Survey’s (USGS’) National Wetlands Research

Center (2020), more than half were one of three categories types: shoreline protection projects (30 projects); hydrologic restoration projects (24 projects); and marsh creation projects (22 projects).

Following Hurricanes Katrina and Rita in 2005, an earlier emphasis on coastal or ecosystem restoration of the LCA was reordered to add an equal emphasis on hurricane flood protection. The Department of Defense Appropriations Act of 2006 required Louisiana to create a State organization to sponsor the hurricane protection and restoration projects that resulted. The State legislature established the Coastal Protection and Restoration Authority (CPRA) and charged it with coordinating the efforts of local, State, and Federal agencies to achieve long-term, integrated flood control and wetland restoration. The CPRA has since produced comprehensive master plans for a sustainable coast (Coastal Protection and Restoration Authority of Louisiana 2007; 2012; 2017; and drafting 2023) as its vision of an integrated program that identified 109 high-performing projects that could substantially increase flood protection for communities and create a sustainable coast through recreating the natural processes of the system, providing coastal habitat to support commercial and recreational activities, sustaining the unique cultural heritage of coastal Louisiana, and promoting a viable working coast (Louisiana Coastal Protection and Restoration Authority 2013).

Anticipating which projects are undertaken for the USACE’s comprehensive range of flood control, coastal restoration, and hurricane protection measures for the LCA would feed into the CPRA’s Annual Plan for authorization, and which ones would ultimately be completed, is challenging. Past completed projects have the potential of protecting up to 100,000 ac (40,469 ha) of Louisiana’s wetlands (Coastal Protection and Restoration Authority of Louisiana 2017). Because CWPPRA projects compete for annual Federal appropriations, there is no simple way to establish projections for land added or preserved over the lifecycle of OCS oil- and gas-related activities resulting from an OCS oil and gas lease sale and the potential protection those projects would provide. Nor is there a way to anticipate which projects under the protection of the State’s CPRA are admitted to its Annual Plan and completed.

Louisiana Coastal Master Plan

From 2007 to 2017, the CPRA completed or funded for construction a total of 135 projects, resulting in over 36,000 ac (14,569 ha) of land benefited, 282 mi (454 km) of levee improvements, and over 60 mi (96 km) of barrier islands and berms constructed or under construction (Coastal Protection and Restoration Authority of Louisiana 2017). The projects included in the Louisiana Coastal Master Plan have the potential to build between 580 and 800 mi^2 (1,502 and 2,072 km^2) of land over the next 50 years, depending on future conditions.

The 2017 Coastal Master Plan builds on the commitment and knowledge gained from the 2007 and 2012 master plans, recommending diverse projects to build land and reduce flood risk in order to balance short-term needs with long-term goals. It identifies and prioritizes high-performance projects for implementation over the next 10 years, while planning out another 50 years. The plan recommends 124 projects that build or maintain more than 800 mi^2 (2,072 km^2) of land and reduce expected damage by $8.3 billion annually by year 50, which equates to more than $150 billion over the next 50 years

(Coastal Protection and Restoration Authority of Louisiana 2017). The goal is to not only provide coastal restoration and reduce flood risks but also boost economic development opportunities in Louisiana and its communities.

The CPRA publishes an Annual Plan that inventories projects and presents schedules for these projects. In addition, it identifies funding schedules and budgets. In order to keep track of progress, the Annual Plan also provides updates on the State's efforts to protect and restore its coast and identify results that citizens can expect to see as progress is made towards a sustainable coast.

Coastal Impact Assistance Program

The Coastal Impact Assistance Program (CIAP) provides Federal grant funds derived from Federal offshore lease revenues to oil-producing states for conservation, protection, or restoration of coastal areas. The funds can be directed to a number of different projects, including restoration of wetlands; mitigation of damage to fish, wildlife, or natural resources; planning assistance and payment of the administrative costs of complying with these objectives; implementation of a federally approved marine, coastal, or comprehensive conservation management plan; and mitigation of the impacts of OCS oil- and gas-related activities through the funding of onshore infrastructure projects and public service needs.

The Energy Policy Act of 2005 was signed into law by President George W. Bush on August 8, 2005. Section 384 of Energy Policy Act amended Section 31 of the OCSLA (43 U.S.C. § 1356(a)) to establish the CIAP. The authority and responsibility for the management of CIAP is vested in the Secretary of the Interior; the Secretary delegated this authority and responsibility to BOEM until September 30, 2011. On October 1, 2011, the U.S. Fish and Wildlife Service (FWS) took over administration of CIAP as directed by the Secretary because the program aligned with FWS's conservation mission and similar grant programs run by FWS. The eligibility requirements for States, coastal political subdivisions, and fundable projects remained largely the same after the transfer (**Table 2.5.2-1**). Under Section 384, Congress directed the Secretary to disburse $250 million for each of the fiscal years 2007 through 2010 to eligible OCS oil- and gas-producing States and coastal political subdivisions. At this time, CIAP is closed to new applications and is not currently funded (Texas General Land Office 2020).

Table 2.5.2-1. Eligible CIAP States and Coastal Political Subdivisions.

Eligible CIAP States	Eligible CIAP Coastal Political Subdivisions
Alabama	Baldwin and Mobile Counties
Alaska	Municipality of Anchorage and Bristol Bay, Kenai Peninsula, Kodiak Island, Lake and Peninsula, Matanuska-Susitna, North Slope, and Northwest Arctic Boroughs
California	Alameda, Contra Costa, Los Angeles, Marin, Monterey, Napa, Orange, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, and Ventura Counties

Eligible CIAP States	Eligible CIAP Coastal Political Subdivisions
Louisiana	Assumption, Calcasieu, Cameron, Iberia, Jefferson, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Martin, St. Mary, St. Tammany, Tangipahoa, Terrebonne, and Vermilion Parishes
Mississippi	Hancock, Harrison, and Jackson Counties
Texas	Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Harris, Jackson, Jefferson, Kennedy, Kleberg, Matagorda, Nueces, Orange, Refugio, San Patricio, Victoria, and Willacy Counties

CIAP = Coastal Impact Assistance Program.

Natural Resource Damage Assessment

The Oil Pollution Act of 1990, as provided in 33 U.S.C. § 2706, allowed the designation of the Natural Resource Damage Assessment Trustee Council (Trustee Council), which included certain Federal agencies, States, and federally recognized Indian Tribes. Executive Order 13554, which was signed on October 5, 2010, recognized the role of the Trustee Council under the Oil Pollution Act and "designated trustees as provided in 33 U.S.C. § 2706, with trusteeship over those natural resources injured, lost, or destroyed as a result of the *Deepwater Horizon* oil spill." Specifically, Executive Order 13554 recognized the importance of carefully coordinating the work of the Gulf Coast Ecosystem Task Force with the Trustee Council, "whose members have statutory responsibility to assess natural resource damages from the *Deepwater Horizon* oil spill, to restore trust resources, and seek compensation for lost use of those trust resources" (The White House 2012). The Task Force, on the other hand, was charged with creating a plan to improve the overall health of the Gulf of Mexico area and has focused on a number of stressors to the Gulf Coast ecosystem beyond those caused by the *Deepwater Horizon* explosion, oil spill, and response. While the work of the Task Force has been independent from the work of the Trustees, the valuable information gathered by the Task Force is useful to the Trustees in their restoration planning efforts (NOAA 2015a).

The Natural Ressource Damage Assessment activities for the *Deepwater Horizon* oil spill have been divided into the categories below and focus on specific species, habitats, or uses (Deepwater Horizon Natural Resource Damage Assessment Trustees 2020).

- marine mammals and sea turtles;
- fish and shellfish;
- birds;
- deepwater habitat (e.g., deepwater coral);
- intertidal and nearshore habitats (including seagrasses, mud flats, and coral reefs);
- shoreline habitats (including salt marsh, beaches, and mangroves); and
- public uses of natural resources (including recreational fishing, boating, beach closures).

In the 10 years since the 2010 oil spill, approximately 200 projects have been approved to restore injured Gulf of Mexico resources. The combined estimated cost of these projects is $1.4 billion.

Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act

In July 2012, in response to the *Deepwater Horizon* explosion, oil spill, and response and other environmental challenges in the Gulf Coast region, Congress passed the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act or the RESTORE Act. In September 2012, an Executive Order was released affirming the Federal Government's Gulf Coast ecosystem restoration efforts in light of the recent passage of the RESTORE Act, which created a Gulf Coast Restoration Trust Fund (Trust Fund), outlined a structure for allocating the Trust Fund, and established the Gulf Coast Ecosystem Restoration Council (Council) (The White House 2012). The Council is comprised of governors from the five affected Gulf Coast States and the Secretaries of the U.S. Departments of the Interior, Commerce, Agriculture, and Homeland Security, as well as the Secretary of the Army and the Administrator of the U.S. Environmental Protection Agency.

As an independent entity, the Council has responsibilities with respect to 60 percent of the funds made available from a Gulf Coast Restoration Trust Fund and was charged with developing a comprehensive plan for ecosystem restoration on the Gulf Coast (Comprehensive Plan), as well as any future revisions to the Comprehensive Plan (Gulf Coast Ecosystem Restoration Council 2020). Among its other duties, the Council is tasked with establishing additional advisory committees as may be necessary to assist the Council, including a scientific advisory committee and a committee to advise the Council on public policy issues; gathering information relevant to Gulf Coast restoration, including thorough research, modeling, and monitoring; and providing an annual report to Congress on implementation progress (The White House 2012).

Under the Council-Selected Restoration Component of the RESTORE Act, 30 percent of available funding will be administered for Gulfwide ecosystem restoration and protection according to a 2016 Comprehensive Plan developed by the Council. Another 30 percent is allocated to the States under the Spill Impact Component according to a formula established by the Council through a regulation and is spent according to individual State Expenditure Plans to contribute to the overall economic and ecological recovery of the GOM (Gulf Coast Ecosystem Restoration Council 2020).

The Council has adopted five strategic goals in the 2013 Comprehensive Plan, recommitting to them (with the addition of *Water Quantity* to Goal 2) in the 2016 Comprehensive Plan Update: (1) restore and conserve habitat; (2) restore water quality; (3) replenish and protect living coastal and marine resources; (4) enhance community resilience; and (5) restore and revitalize the GOM economy (Gulf Coast Ecosystem Restoration Council 2020).

National Fish and Wildlife Foundation: Gulf Environmental Benefit Fund

In early 2013, a U.S. District Court approved two plea agreements resolving certain criminal cases against BP and Transocean, cases which arose from the 2010 *Deepwater Horizon* explosion, oil spill, and response. The agreements direct a total of $2.544 billion to the National Fish and Wildlife Foundation's Gulf Environmental Benefit Fund to fund projects benefiting the natural resources of the Gulf Coast that were impacted by the spill. Funding priorities include projects that

- restore and maintain the ecological functions of landscape-scale coastal habitats, including barrier islands, beaches, and coastal marshes, and ensure their viability and resilience against existing and future threats, such as sea-level rise;
- restore and maintain the ecological integrity of priority coastal bays and estuaries; and
- replenish and protect living resources including oysters, red snapper and other reef fish, Gulf Coast bird populations, sea turtles, and marine mammals.

From 2013 to 2019, the Gulf Environmental Benefit Fund has supported 169 projects worth more than $1.4 billion. These projects leverage or compliment other conservation investments worth more than $675 million, creating a total impact of nearly $2.1 billion (National Fish and Wildlife Foundation 2020).

2.5.2.6 Tourism Infrastructure

Tourism infrastructure enables humans to spend time away from home in pursuit of recreation, leisure, and other endeavors. Counties and parishes along the Gulf of Mexico are home to various resources and infrastructure that support recreation and tourism. Publicly owned and administered areas (such as national seashores, parks, beaches, and wildlife lands), as well as specially designated preservation areas (such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, and scenic rivers), attract residents and visitors throughout the year. Each of these sites has varying amounts and types of accompanying infrastructure that range from service roads and boat ramps to visitor centers and maintained trails or walking paths. Commercial and private recreational facilities and establishments (such as resorts, casinos, marinas, golf courses, amusement parks, hotels, restaurants, and ornamental gardens) also serve as primary interest areas and support services for people who seek enjoyment from the recreational resources near the Gulf of Mexico. There are many Gulf Coast tourism infrastructure projects resulting from the 2010 *Deepwater Horizon* oil spill. According to the (Deepwater Horizon Project Tracker 2020), as of December 4, 2020, there are 84 recreational use projects with over $377 million in funding, which include infrastructure projects ranging from trail and boat ramp improvements to new boardwalk construction. The overall scales of recreation and tourism, which utilize tourism infrastructure, are discussed in more detail in **Chapter 4.4.4**. The recreation and tourism industries are sizable in many areas along the Gulf Coast and make up a significant portion of local coastal economies.

Coastal land use/modification stemming from tourism infrastructure include coastal environment destruction, fragmentation, and degradation. For instance, habitat alteration or loss can occur from the construction of coastal infrastructure and resulting land use changes (Michel 2013). In addition, an increase in associated nonpoint-source pollution, such as runoff, can impair habitat and water quality (Michel 2013). Coastal developments can also change coastal hydrology and sediment transport (Michel 2013). For example, associated runoff can cause an increase in nutrient fluxes (Michel 2013). Further, the natural path of sediment transport can be obstructed (Michel 2013). For more information on potential offshore habitat modification/space-use associated with tourism, refer to **Chapter 2.7.2**.

2.6 LIGHTING AND VISUAL IMPACTS

This IPF broadly addresses the extent to which activities (both oil- and gas-related and other factors) produce infrastructure presence and light emissions that (1) create annoyance or interfere with activities; (2) contrast with, or detract from, the visual resources and/or the visual character of the existing environment; or (3) provide safety and security by illuminating dark areas. Visual effects can be difficult to define and assess because they involve subjectivity. The aesthetic qualities of visible industrialized infrastructure are subjective but are generally regarded as negative, particularly in landscape/seascape settings such as National Parks or National Marine Sanctuaries, where the purpose of designation is often associated with an area's defining natural features. Lighting of areas such as fishing piers or parks for safety or enjoyment during the nighttime hours, however, can provide positive experiences to some user groups.

2.6.1 OCS Oil- and Gas-Related Activities

The placement or removal of infrastructure, both offshore and onshore, could alter the existing landscapes and seascapes. Depending on the location of offshore blocks leased and whether or not those blocks are successfully explored and developed, nearby coastal areas could experience the introduction of new infrastructure and increased activity both offshore and onshore that could alter the visual aesthetics of the existing coastal landscapes and seascapes. Many of these potential impacts arise from new structures and activities visible during the day, but there are also potential impacts that could arise from the lighting used on platforms, service vessels, and coastal infrastructure, including night sky disturbances for visitors at parks (refer to **Chapter 4.4.5.2**). It is important to note, however, that the GOM has an extensive history of oil and gas development. Since the first offshore drilling began in 1942, over 6,000 oil and gas structures have been installed in the Gulf of Mexico, making lighting and visible infrastructure presence from past and ongoing oil- and gas-related activities a well known aspect of coastal viewsheds along the WPA and CPA for decades.

Using general guidelines for estimating distance to horizon based on the natural curvature of the Earth, a 60-ft (18-m) tall structure greater than 12 mi (19 km) from shore would likely not be visible to a person at sea level on the shoreline (NOAA 2020c). A structure 250 ft (76 m) above sea level, such as an oil platform, would not be visible to 6-ft tall beachgoers if it is >24 mi (38 km) from shore (NOAA 2020c). Federal OCS waters are 9 nmi (10.35 mi; 16.66 km) from the Texas and Florida shores and 3 nmi (3.45 mi; 5.6 km) from the Louisiana, Mississippi, and Alabama shores. Additionally, BOEM has included the Blocks South of Baldwin County, Alabama Stipulation (refer to **Chapter 7.11**) in previous OCS oil and gas lease sales, which further reduced the likelihood of oil and gas infrastructure and lighting being visible from Alabama and Florida shorelines. Lighting and visual effects to Alabama and Florida shorelines could likely be reduced or avoided from future OCS oil and gas leasing by applying this stipulation as well.

In a study conducted by the Geological Survey of Alabama and State Oil and Gas Board of Alabama in 1998, several facets of the visibility of offshore structures were analyzed. The Geological Survey of Alabama earth scientists found that visibility is dictated not only by size and location of the structures and curvature of the Earth but also by atmospheric conditions. Atmosphere refers to conditions of weather, air quality, and the presence or absence of fog, rain, smog, and/or winds. Social scientists added factors, such as the viewer's elevation (e.g., ground level, in a 2-story house, or in a 30-story condominium) and the viewer's expectations and perceptions. The height of the viewer affects their ability to see and distinguish objects several miles away. Perceptions often dictate what people expect to see and, hence, what they do see.

In order to more fully comprehend these concepts of size, distance, and visibility, the State Oil and Gas Board, with the assistance of the Offshore Operators Committee, collected and studied photographs of existing offshore structures. The Geological Survey of Alabama and State Oil and Gas Board of Alabama (1998) found that the tallest and widest structures off the Alabama coast at that time (up to 120 ft by 205 ft [36.6 m by 62.5 m] and 60-70 ft [18.3-21.3 m] high), i.e., those showing the most surface in the viewscape, were visible at up to 7 mi (11.3 km) from shore. The shorter and the smaller the structure, the less visible at 5 mi (8 km); the smallest could barely be seen at 3 mi (5 km) from shore. According to this study, no structure located more than 10 mi (16 km) offshore would be visible from the shoreline (Geological Survey of Alabama and State Oil and Gas Board of Alabama 1998).

Structure Lighting

The OCS oil- and gas-related structures in the GOM are illuminated from incandescent lights and from the glow of burning or flaring natural gas that cannot be stored or transported to shore. The USCG regulates workplace health and safety and maritime safety items, including lights illuminating working environments and navigational warning lights, on OCS platforms according to 33 CFR § 143.15. To assist in nighttime operations and aid navigation, manned platforms are generally well illuminated by exterior floodlights. All vessels operating between dusk and dawn are required to have navigation lights turned on as well. Platforms generally have two varieties of floodlights: high-pressure sodium or mercury vapor. High-pressure sodium lights emit yellow-orange light, whereas mercury vapor lights emit a perceptually blue-white light. Some initiative has been taken to move toward downward facing lighting and green light. Although there are differences between platforms, floodlights located between 20 and 40 m (66 and 132 ft) above the water surface illuminate the structure and the surrounding water to a depth of at least 100-200 m (328-656 ft) and can often be observed several miles away from the platform (Keenan et al. 2007). Unmanned structures usually have minimal aid-to-navigation lights.

In addition to offshore lighting, coastal support infrastructure is also illuminated. Coastal infrastructure lighting may be specifically designed to emit horizontal or vertical light. Horizontal and near-horizontal light emittance increases the visibility of light sources from a distance and significantly increases the illuminated area, but it can also cause the encroachment of light into adjacent unlit areas. Light emitted horizontally or near-horizontally produces more sky glow than that emitted upward, and much more than light emitted downward (Gaston et al. 2012). A number of factors can affect light transmission, both in air and water. In air, the transmission of light can be affected by atmospheric moisture levels, cloud cover, and the type and orientation of lights. In water, turbidity levels and waves, as well as the type of light, can affect transmission distance and intensity.

2.6.2 Non-OCS Oil- and Gas-Related Activities Causing Lighting and Visual Impacts

There are many stakeholders that use the ocean environment in addition to the OCS Oil and Gas Program including tourism and recreation, commercial and recreational fishing, marine transportation, subsea cables, military activities, deepwater ports, OCS sand borrowing, renewable energy development, and ocean dumping (**Chapter 2.7.2**). Each of these uses has the potential to alter or disrupt the existing visual and aesthetic environment. For example, the Gulf Coast region contains some of the world's busiest ports, with shipping fairways that funnel thousands of cargo vessels, cruise ships, and other non-oil- and gas-related vessels annually (**Chapter 2.7.2.3**). Spills, marine debris (e.g., derelict fishing gear), structure presence, and light emissions from these activities could have similar visual impacts as those from oil- and gas-related sources. Should renewable energy projects be built in the GOM, turbines would have lighting to assist with navigation and for safety. Some lighting may provide user groups safety and security in the dark. For example, lighting in parks and on fishing piers provides user groups a safe environment for recreation at night. These types of effects are discussed more in **Chapter 4.4**, Social Factors.

2.7 OFFSHORE HABITAT MODIFICATION/SPACE USE

Habitats and other specific areas of the OCS offer environmental, recreational, economic, historical, cultural, and/or social values in the same geographic area. Modification and/or use of these areas can be divided based on which space or habitat is being used, i.e., the space above the water or the airspace, the water column, and the seafloor.

2.7.1 OCS Oil- and Gas-Related Activities

Production platforms have historically been and would likely continue to be less than 1 percent of the total surface area available in the GOM.

Leasing on the OCS results in operations that occupy OCS space for dedicated uses both temporary and long term. Likewise, the placement or removal of infrastructure can create long-term alterations to the existing land- and seascapes (i.e., the physical habitat) including seabed, water column, and/or sea surface habitats. The OCS oil- and gas-related operations that can potentially create, remove, modify, or occupy space or habitat(s) include G&G surveys, bottom surveys, and the installation of surface or subsurface bottom-founded production structures with anchor cables and safety zones. These activities can create potential space-use conflicts with other OCS uses such as tourism and recreation, commercial and recreational fishing, marine transportation, undersea cables, military operations, deepwater ports, OCS sand borrowing, renewable energy, and ocean dumping, but these activities can also have positive or negative effects to biological communities that rely on the presence of absence of these habitats (**Chapter 4.3.4**, Fish and Inertebrates; **Chapter 4.3.5**, Birds; **Chapter 4.3.6**, Marine Mammals; and **Chapter 4.3.7**, Sea Turtles).

The G&G surveys can occur in both shallow and deepwater areas. Usually, fishermen are precluded from a very small area for several days during active G&G surveying. Exploratory drilling rigs spend approximately 40-150 days onsite and are a short-term interference to commercial fishing. A major bottom-founded production platform in water depths less than 450 m (1,476 ft), with a surrounding 100-m (328-ft) navigational safety zone, requires approximately 6 ha (15 ac) of space. A bunkhouse structure needs about 4 ha (9 ac) and a satellite structure needs about 1.5 ha (3.7 ac) of space.

In water depths greater than 450 m (1,476 ft), production platforms would be compliant towers, floating production structures (such as TLPs and spars), and FPSOs. Even though production structures in deeper water are larger and individually would take up more space, there would be fewer of them compared with the great numbers of bottom-founded platforms in shallower water depths. Factoring in various configurations of navigational safety zones, deepwater facilities may require up to a 500-m (1,640-ft) radius safety zone or 78 ha (193 ac) of space per 33 CFR § 147.15. Production structures in all water depths have a life expectancy of 20-30 years.

2.7.1.1 Sea Surface and Airspace

The sea surface and airspace consideration includes any activity that would occur skywards of the sea surface. Routine oil and gas activities that could contribute to airspace conflicts or modification include the physical presence of a platform or other production structure that extends above the water surface. Each deck of a platform is on average 25 ft (8 m) tall, and platforms, based on platform size in the GOM, can range in height from 1-7 decks (Regg et al. 2000). A summary of platform types can be found in **Chapter 1.3.3.4**. Service-vessel and helicopter traffic in support of OCS oil and gas development would also occupy space above the water surface. For more information on helicopters and service-vessel traffic, refer to **Chapter 2.5.1.2**.

2.7.1.2 Water Column

The water column consideration includes any activity that would occur between the sea surface and the seafloor. Routine OCS oil- and gas-related activities that can contribute to water-column space use or modification include the platform hull, jackets, and tethers used to anchor platforms and other structures to the seafloor, and pipes and risers.

Deep-sea platforms typically consist of a hull that is tethered to the seafloor. Spars and TLPs are examples of structures that have hulls. The hull is constructed using normal marine and shipyard fabrication methods. The number of wells, surface wellhead spacing, and facilities weight determine the size of the centerwell and the diameter of the hull. Approximate hull diameter for a typical GOM spar is 130 ft (40 m), with an overall height, once deployed, of approximately 700 ft (213 m) (with 90% of the hull in the water column). The hull of a TLP has four air-filled columns supported by pontoons.

A jacket is a tubular supporting structure for an offshore platform consisting of four, six, or eight 7- to 14-ft (2.1 to 4.3-m) diameter tubulars welded together with pipe braces to form a stool-like structure. Jackets for a compliant tower can be seen in **Figure 1.3.3-4**. The jacket is secured to the seafloor by weight and 7-ft (2.1-m) diameter piles that penetrate several hundreds of feet beneath the mudline. More information can be found in Regg et al. (2000).

Mooring lines are used for a variety of platform types and are a combination of spiral strand wire and chain. For a spar, the moorings can vary in number up to 20 lines and contain 3,700 ft (1,128 m) of chain and wire. Starting at the seafloor, a typical mooring leg may consist of approximately 200-ft (61-m) long, 84-in (213-cm) diameter piles; 200 ft (61-m) of 4.75-in (12-cm) bottom chain; 2,500 ft (762 m) of 4.75-in (12-cm) spiral strand wire; and 1,000 ft (305 m) of 4.75-in (12-cm) platform chain. Tendons for a TLP are typically steel tubes with dimensions of 2-3 ft (0.6-0.9 m) in diameter with up to 3 in (7.6 cm) of wall thickness, the length depending on water depth. A typical TLP would be installed with as many as 16 tendons.

Risers and pipes are separated into three types. Vertical access production risers are top tensioned with a buoyant cylinder assembly through which one or two strings of well casing are tied back and the well completed. This arrangement allows for surface trees and a surface BOP for workover. Drilling risers also have a top-tensioned casing with a surface drilling BOP, which allows a platform-type rig to be used. Export/import risers can be flexible or top-tensioned steel pipe or steel catenaries.

2.7.1.3 Seafloor

Routine OCS oil- and gas-related activities that can contribute to seafloor habitat modification and/or space-use conflicts include emplacement or removal of pipelines, infrastructure footprints including anchors and tethers, and subsea systems as described in **Chapters 2.3.1.2 and 2.3.1.3**. Geologic coring and G&G surveys that deploy bottom nodes can also alter the seafloor or create space-use conflicts. In addition, wells could conflict with any other mining operation interested in other resources below the seafloor (i.e., sand, sulfur, etc).

2.7.2 Non-OCS Oil- and Gas-Related Activities Causing Offshore Habitat Modification or Space-Use Conflicts

There are many stakeholders that use the ocean environment. Some of these stakeholders' needs for space to carry out their activities overlap. In addition to the OCS Oil and Gas Program, other activities on the Gulf of Mexico OCS include tourism and recreation, commercial and recreational fishing, marine transportation, subsea cables, the military, deepwater ports, OCS sand borrowing, renewable energy development, and ocean dumping. Each of these uses for the Gulf of Mexico OCS requires some amount of space to operate and must be taken into account when planning to hold oil and gas lease sales that would potentially make areas of the Gulf of Mexico OCS unavailable for other uses (**Table 2.7.2-1**). This chapter describes the space-use needs for those other uses for the Gulf of Mexico OCS.

Table 2.7.2-1. Areas of Marine Space Use by Industries Other Than Oil and Gas.

Industry	Coastal	Sea Surface/ Airspace	Water Column	Seafloor
Recreation	X	X	X	X
Commercial and Recreational Fishing	X	X	X	X
Ports, Navigation Lanes, and Shipping	X	X	X	-
Undersea Cables	-	X	-	X
Military	X	X	X	X
Deepwater Ports	-	X	X	X
OCS Sand Borrowing	-	X	-	X
Coastal Restoration	X	-	-	X
Renewable Energy	X	X	X	X
Ocean Dumping	-	-	-	X

The Multipurpose Marine Cadastre, a web-based tool developed by BOEM, NOAA's Coastal Services Center, and other partners, was used for identifying uses of the Gulf of Mexico. The Multipurpose Marine Cadastre is an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system (GIS) framework. This tool is used by Federal regulatory agencies and others who are screening renewable energy sites and other offshore activities, as well as people working on regional and State marine planning efforts. At its core, this data viewer contains the official U.S. marine cadastre, and it is the only place where users can see all of the official U.S. boundaries on one map. Similar to the Nation's land-based parcel system, a marine cadastre describes the spatial extent, rights, restrictions, and responsibilities of U.S. waters. All data come from the appropriate authoritative source; these organizations are responsible for data upkeep. In addition, data from BOEM's Marine Minerals Information System (a separate online, GIS-based data portal for offshore mineral resources), BOEM, and the Naval Facilities Engineering Command were used for the discussions of other uses within the Area of Analysis.

2.7.2.1 Recreation

Recreational activities occur in coastal areas, at the sea surface, throughout the water column, and at the seafloor. People are attracted to the Gulf Coast by a diverse range of marine and coastal habitats, including sandy beaches and barrier islands, estuarine bays and sounds, inland waterbodies, maritime forests, and marshlands. Some of these recreational activities occur in large areas (i.e., beach going), but many occur in small, localized areas (i.e., offshore diving). **Table 2.7.2-2** shows the types of recreational activities by habitat type. **Table 2.7.2-2** does not present every type of recreational activity but it lists the main types of activities that occur in a given locale. Recreational fishing is described in more detail in **Chapter 4.4.2.2**.

Table 2.7.2-2. Types of Recreational Activities by Location in the Gulf of Mexico.

Location	Recreational Activities	Space Use
Offshore Waters (depths >30 m [98 ft])	Fishing Diving (very limited; e.g., Flower Garden Banks National Marine Sanctuary) Wildlife viewing (e.g., whale watching, pelagic birdwatching)	Sea Surface Water Column Seafloor
Nearshore Waters (depths <30 m [98 ft])	Fishing Boating Diving (artificial reefs and wrecks) Wildlife Viewing (e.g., whale watching and pelagic birdwatching)	Sea Surface Water Column Seafloor
Beaches	Swimming, snorkeling, surfing Sunbathing Fishing Boating Wildlife viewing Camping (e.g., State parks and national seashores)	Coastal Sea Surface Water Column Seafloor
Lagoons and Embayments	Swimming Fishing Boating Wildlife viewing Camping	Coastal Sea Surface Water Column Seafloor
Other Coastal Areas	Sightseeing Golf Bicycling Hiking Hunting	Coastal

The amount of space-use impact on the OCS by ocean-based tourism varies by activity and location. Some types of recreational activities, such as boating, fishing, and wildlife viewing, may occur over large areas of the OCS depending on the targeted species or vessel characteristics. Diving mostly occurs in small, localized locations on the OCS associated with some type of natural or modified habitat such as artificial bottom structure or wreckage. These known seafloor obstructions, including shipwrecks, are identified in NOAA's Automated Wreck and Obstruction Information System database. Shipwrecks are discussed in detail in **Chapter 2.2.2.1**. Artificial reefs are a form of habitat modification resulting from various fabricated materials, natural rock, decommissioned oil and gas platforms, or vessels that can attract or aid the proliferation of live bottom communities.

Offshore Texas there are 91 artificial reefs and covering greater than 4,000 ac (1,619 ha) (Texas Parks and Wildlife Department 2020a; 2020c). In Louisiana, there are 83 artificial reef sites in coastal and offshore waters covering more than 19,000 ac (7,689 ha) for reef habitat (Louisiana Department of Wildlife & Fisheries 2020d). Mississippi has 90 artificial reef sites spread over the coastal and offshore zones encompassing more than 16,000 ac (6,475 ha) (Mississippi Department of Marine Resources 2019). The State of Alabama has one of the largest artificial reef programs in terms of area permitted in the United States with 14 permit areas covering 678,400 ac (274,579 ha)

(Alabama Department of Conservation and Natural Resources 2020a). Florida has over 2,500 individual reef sites in the Gulf of Mexico that are occur in waters along the entire Gulf Coast of Florida in waters ranging from 4 to 458 ft (1.2 to 139.6 m) in depth (Florida Fish and Wildlife Conservation Commission 2020e). In addition, NOAA's Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks on the United States OCS. At present on the Gulf Coast, there is one National Marine Sanctuary (Flower Garden Banks) that interacts with offshore oil and gas operations (**Figure 2.7.2-1**). The Flower Garden Banks National Marine Sanctuary serves as a popular site for recreational diving in the Gulf of Mexico. This sanctuary is made up of Stetson Bank, West Flower Garden Bank, East Flower Garden Bank, and 14 additional reefs and banks. Together, these areas represent about 160 mi^2 (415 km^2) of protected marine habitat (Office of National Marine Sanctuaries 2021). Despite the numerous opportunities for recreational use of artificial reefs or the national marine sanctuary, the tourism activities occurring at seafloor obstructions represent only a small and temporary use of the OCS and most commonly occur in nearshore waters, beaches, lagoons, and embayments.

Shore-based tourism activities also represent a significant use of coastal space. The Gulf of Mexico coastal region contains numerous national wildlife refuges, national parks, and national seashores, as well as many State parks and recreational areas where the public engages in various recreational activities (i.e., sunbathing, swimming, and camping; **Figure 2.7.2-1**). For example, on the Gulf Coast, there are 13 coastal national wildlife refuges over 20,000 ac (8,094 ha) and 26 under 20,000 ac (8,094 ha) (FWS 2020b), 5 national parks covering about 2,568 shoreline miles and 549,159 marine acres, and 2 national seashores covering approximately 645 shoreline miles and 184,360 marine acres (NPS 2018). These public recreational areas represent thousands of acres or shoreline miles that would be unavailable to any future Gulf of Mexico OCS oil and gas infrastructure needs.

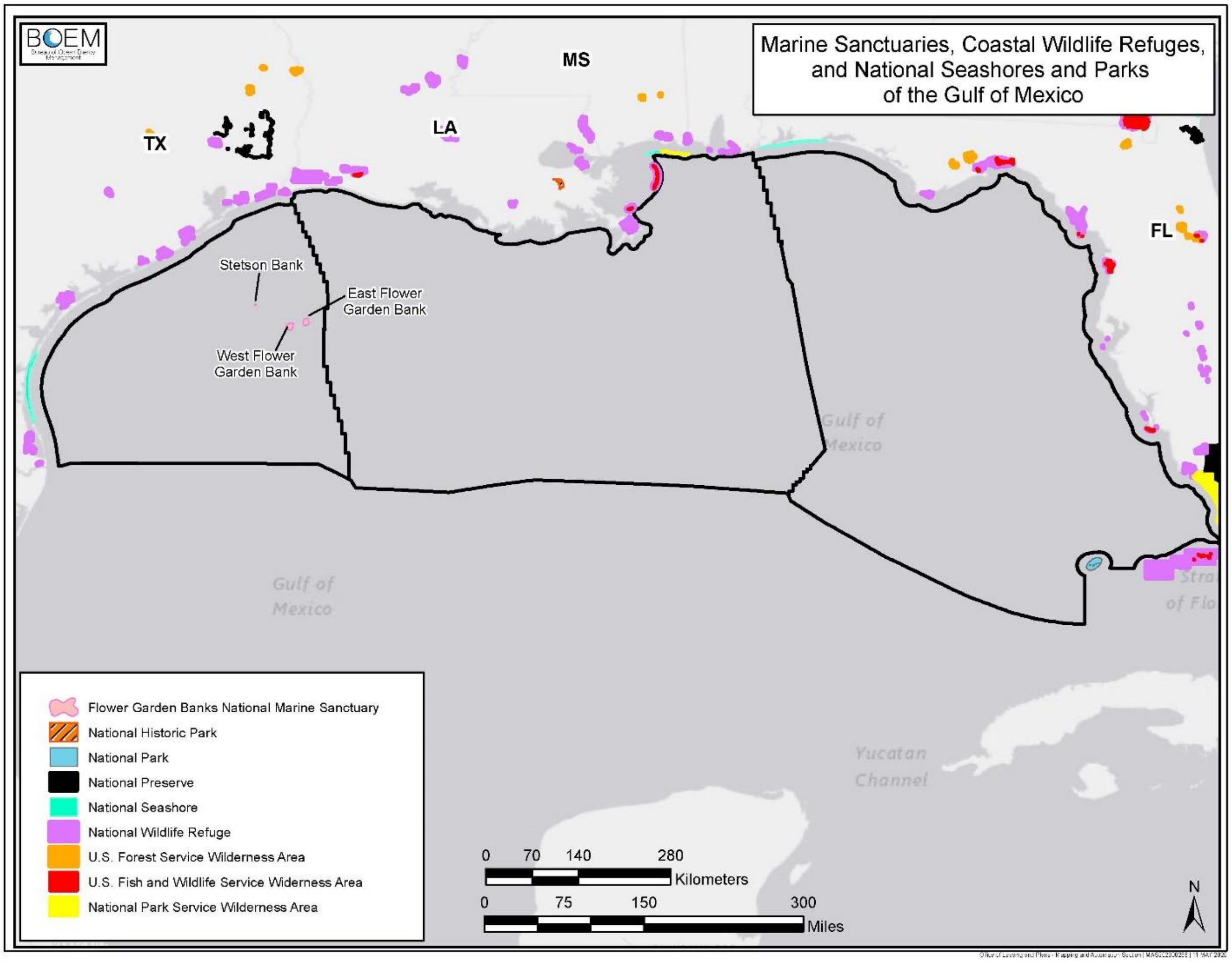


Figure 2.7.2-1. Marine Sanctuaries, Coastal Wildlife Refuges, and National Seashores and Parks of the Gulf of Mexico.

2.7.2.2 Commercial and Recreational Fishing

Commercial and recreational fishing takes place in coastal and offshore areas, at the sea surface, throughout the water column, and at the seafloor. The U.S. Gulf Coast supports regionally and nationally important commercial fisheries as well as a socially and economically important recreational fishing industry. In 2018, the GOM commercial fishing industry represented approximately 26 percent of landings and 19 percent of value for the Nation, and the GOM has three of the top 10 ports for fishery landings in the Nation (NMFS 2020g). Recreational fisheries in the GOM had the highest percentage of trips in the Nation at 28 percent and 37 percent of catch in 2018 (NMFS 2020k). Both of these valuable industries represent significant uses of the OCS and must be considered in future OCS planning.

In areas of dense fishing effort, or where gear is spread over a large area, commercial fishing has the potential to cause semi-permanent, standoff-distance conflicts on the OCS. Marine standoff-distance conflicts are already an issue between many competing fisheries in some portions of the OCS (e.g., pelagic longline fisheries and deepwater crab fisheries). On a space-use basis, commercial fishing can occur anywhere in favored areas where it is not temporarily or permanently excluded (i.e., in areas where it is not prohibited and where there are no surface or bottom obstructions).

Most recreational fishing in the GOM planning areas takes place within State waters. Approximately 95 percent of the total GOM recreational catch came on saltwater trips that fished primarily in the State territorial seas and about 51 percent came on trips that fished primarily in inland waters (NMFS 2020k). However, for those few trips that do take place on the Federal OCS, they represent a short-term and localized use of the OCS.

2.7.2.3 Ports, Navigation Lanes, and Shipping

Ports, navigation lanes, and shipping use space on the coast, the sea surface, and to some degree the water column. Maritime shipping is one of the most important industries on the Gulf Coast. As such, there is a large existing infrastructure presence in the GOM to support the industry, including ports and navigation lanes. The USACE annually designates the top 150 ports in the country in terms of tonnage as principal ports. In 2017, the GOM coastal region was home to 25 principal ports (**Figure 2.7.2-2**). At that time, these principal ports handled 1,256,697,800 tons of cargo for the Nation (USACE 2017a). In order to service these ports, several navigation lanes, fairways, and zones have been designated in the Gulf of Mexico. The USCG determines the fairways to keep ships and the ocean's inhabitants out of harm's way. Different types of lanes and zones exist for straight traveling, turning, and avoiding collisions. Staying within these routing measures often means steering clear of endangered species, wrecks, coral reefs, and other areas (NOAA 2015c; 2019c). Because these areas are designated for safety, they are areas off limits for installing fixed structures. Many of these areas extend out onto the OCS, some beyond 100 nmi (115 mi; 185 km) offshore (**Figure 2.7.2-2**). The maritime shipping industry represents a major use of GOM coastal space both for onshore infrastructure needs such as port facilities and for offshore needs such as safe navigation.

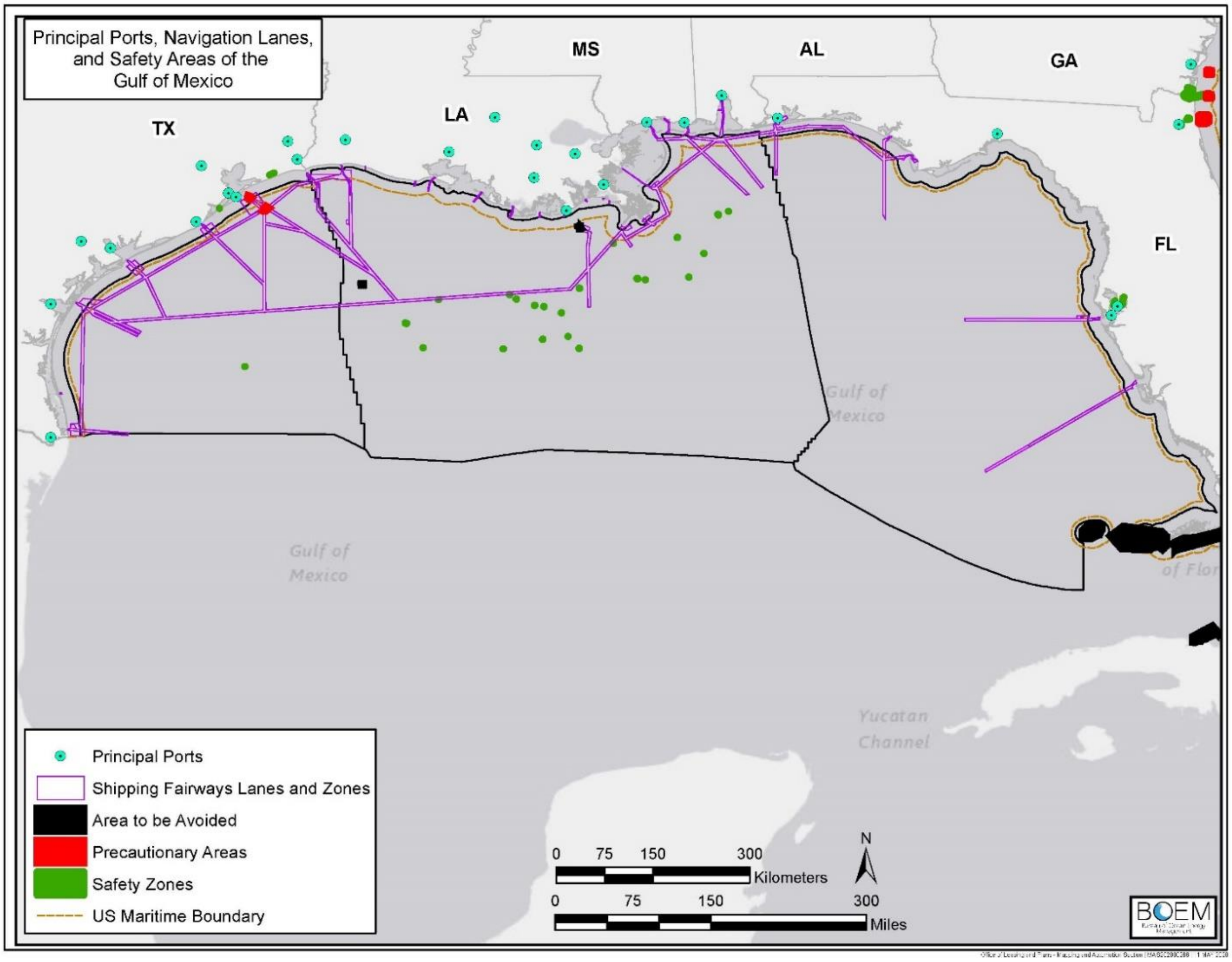


Figure 2.7.2-2. Principal Ports, Navigation Lanes, and Safety Areas of the Gulf of Mexico.

2.7.2.4 Undersea Cables

Undersea cables use space at the sea surface during laying and the seafloor while in use. The GOM contains undersea cable infrastructure mostly related to the offshore oil and gas industry. The NOAA has identified two large cable networks that utilize the Federal OCS in the Gulf of Mexico (NOAA 2018c). The larger, Gulf of Mexico Fiber Optic Network, is primarily used by the oil and gas industry, and it is reasonably foreseeable that other users like telecommunication companies or the military might utilize these networks as well (BP America 2020). There is also a single telecommunications submarine cable the crosses part of the EPA. The AURORA cable system connects the U.S. (Sarasota, Florida) with Central (Mexico, Guatemala, and Panama) and South America (Colombia and Ecuador) (Fiber Prime Telecommunications 2020). While there is currently no activity in the Gulf of Mexico, the renewable energy industry relies on submarine cables to transmit generated electricity back to shore. These cables are critical infrastructure for telecommunications or power transmission and represent an important use of the OCS.

The space-use requirements for undersea cables are dependent on the requirements for the specific project and are typically determined on a case-by-case basis. However, several guidelines exist that inform separation distances between cables and burial depths. The International Cable Protection Committee recommends that undersea cables in shallow waters be spaced 500 m (1,640 ft) from each other; in deeper waters, the cables should be spaced at the lesser of three times the depth of the water column or 9 km (6 mi) (International Cable Protection Committee, 2015). BOEM's requirements for renewable energy transmission cables are that the cable be placed in a 200-ft (61-m) wide corridor from the center of the cable per 30 CFR § 585.301. In addition to seafloor areal extent needs, undersea cables have sea surface needs for cable laying and maintenance operations. The vessels required are large and need space in which to maneuver during the often complex processes of cable laying and burial, or repair work. These issues are further compounded during times of inclement weather (North American Submarine Cable Association 2012). Because the space-use requirements may be large and depend on project specifics, coordination with other OCS users and operators is essential.

2.7.2.5 Military Space Use of the Gulf of Mexico OCS

The U.S. military uses coastal regional space, airspace, the sea surface, the water column, and the seafloor. The DOD conducts training, testing, and operations in offshore operating areas (OPAREAs), MWAs, at warfare training ranges, and in special use or restricted airspace on the OCS. Some of the most extensive offshore areas used by DOD include U.S. Navy at-sea training areas. Training and testing occurs throughout U.S. Gulf of Mexico OCS waters but is concentrated in OPAREAs and testing ranges (**Figure 2.7.2-3**). The Gulf of Mexico Range Complex contains four separate OPAREAs: Panama City and Pensacola, Florida; New Orleans, Louisiana; and Corpus Christi, Texas. The OPAREAs within the Gulf of Mexico Range Complex are not contiguous but are scattered throughout the GOM. The Gulf of Mexico Range Complex includes special-use airspace with associated warning areas and restricted airspace, and surface and subsurface sea space of the four OPAREAs. The air space over the GOM is used by the DOD for conducting various military operations such as air combat training using Air Combat Maneuvering Instrumentation Systems. The Gulf of Mexico air combat maneuvering range is a virtual combat zone, tracking dozens of aircraft in realistic, high-intensity training exercises. The latest systems include the capability to monitor and score air-to-air and air-to-ground weapons deliveries, as well as include ground-based threat systems and simulators (Panarisi 2001). Military operations within MWAs and water test areas (e.g., EWTAs) vary in types of missions performed and their frequency of use. Twelve MWAs and six EWTAs are located within the GOM. Missions may include carrier maneuvers, missile testing, rocket firing, pilot training, air-to-air gunnery, air-to-surface gunnery, minesweeping operations, submarine operations, air combat maneuvers, aerobatic training, and instrument training. These activities are critical to military readiness and national security.

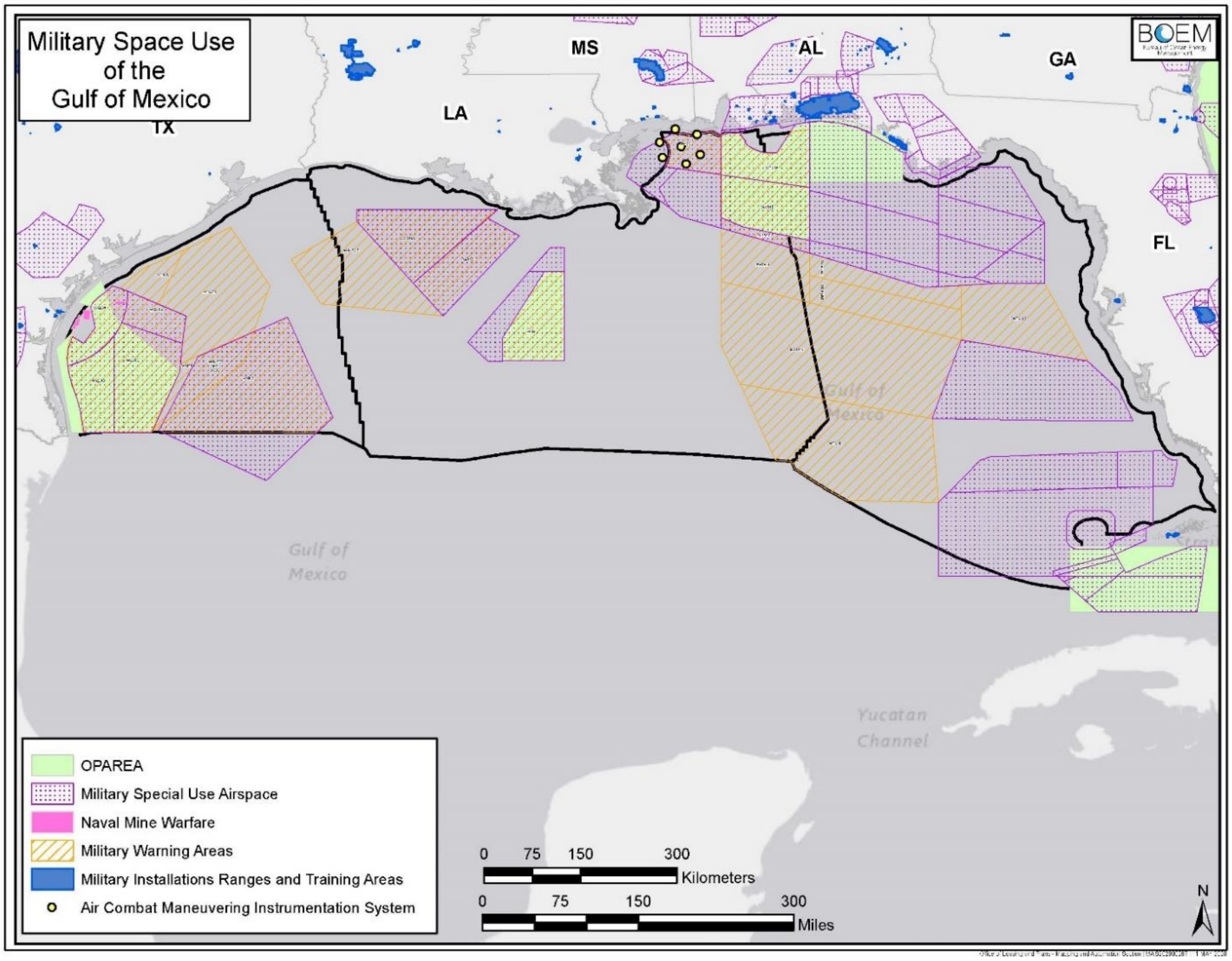


Figure 2.7.2-3. Military Space Use of the Gulf of Mexico.

The OPAREAs, MWAs, and EWTAs are multiple-use areas where military operations and oil and gas development have coexisted without conflict for many years. Several military stipulations may be applied for leases issued within identified military areas. To eliminate potential impacts from multiple-use conflicts on the aforementioned area and on blocks that the Navy has identified as needed for testing equipment and for training mine warfare personnel, a Military Areas Stipulation has routinely been applied to all GOM leases. In addition, BOEM's New Orleans Office issued BOEM NTL No. 2014-G04, which provides links to the addresses and telephone numbers of the individual command headquarters for the military warning and water test areas in the GOM. BOEM's NTLs can be found on BOEM's website at https://www.boem.gov/guidance. The DOD and DOI will continue to coordinate extensively under the 1983 Memorandum of Agreement, which states that the two parties shall reach mutually acceptable solutions when the requirements for mineral exploration and development, and defense-related activities conflict.

2.7.2.6 Deepwater Ports

Deepwater ports use space at the sea surface, in the water column, and at the seafloor. These ports are installations on the OCS that service the importing and exporting of natural gas products like

LNG and crude oil. The LNG is a form of natural gas that is used mainly for transport to markets, where the liquid is regasified and distributed via pipeline networks. Deepwater ports are under the jurisdiction of USCG and the U.S. Department of Transportation's Maritime Administration (MARAD). There is one licensed, operational deepwater port in the Gulf of Mexico (**Figure 2.7.2-4**). The LOOP is located about 18 nmi (21 mi; 33 km) off the coast of Louisiana in about 115 ft (35 m) of water (LADOTD 2020; LOOP LLC 2020). The major fixed components of the LOOP deepwater port are the unloading buoy system, three single-point moorings consisting of wire rope and chain connecting to anchor points on the seabed, a control platform and a pumping platform, approximately 1.5 mi (2.4 km) of 56-in (142-cm) diameter pipeline to bring crude to the pumping platform, and approximately 18 nmi (21 mi; 33 km) of 48-in (122-cm) pipeline to connect to LOOP's onshore infrastructure (LADOTD 2020). While there is currently only the LOOP in the Gulf of Mexico, several additional deepwater ports have been proposed and are in the licensing and permitting process. Four oil export facilities and one gas export facility have pending license applications with MARAD, and one LNG project has been approved and is pending license issuance. These projects are proposed to be built off the coasts of Texas and Louisiana from 10.5 to 40.8 nmi (12.1 to 47.0 mi; 19.4 to 75.6 km) in water depths from 57 to 115 ft (17.4 to 35 m) (MARAD 2016; 2020a; 2020b).

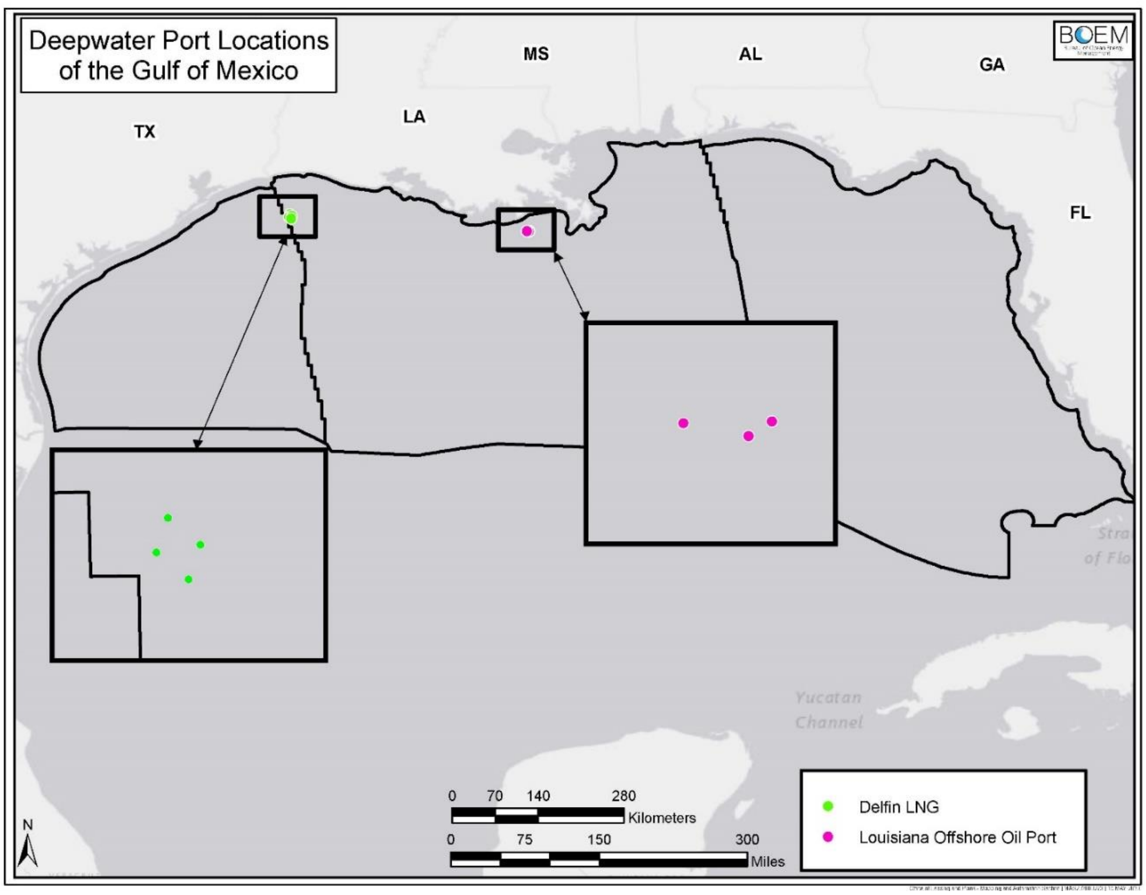


Figure 2.7.2-4. Deepwater Port Locations of the Gulf of Mexico.

2.7.2.7 OCS Sand Borrowing and Coastal Restoration

Sand borrowing and coastal restoration uses space in coastal regions from the sea surface to the seafloor. Loss of sand from the Nation's beaches, dunes, and barrier islands is a serious problem that affects the coastal environment, storm damage, and the economy. Sand, gravel, and other mineral resources from the OCS are often used in beach nourishment, wetlands restoration, and other coastal restoration projects to address erosion issues. BOEM has conveyed rights to millions of cubic yards of OCS sand for coastal restoration projects along the Gulf Coast through leases (in the form of negotiated noncompetitive agreements for sand and gravel projects). W.F. Baird & Associates Ltd (2018) summarize a forecast of activities that could require OCS sand resources along the Gulf Coast through 2028.

BOEM recently launched the Marine Minerals Information System (MMIS) accessible at https://mmis.doi.gov/BOEMMMIS. Through the MMIS, users can find information about marine minerals lease areas, core sample information derived from multiple sources, and identified sand sources. The MMIS also provides citations for BOEM's environmental study reports and environmental assessments through the Environmental Studies Program (https://www.boem.gov/ESPIS/) or through the MMP in your State (https://www.boem.gov/marine-minerals/mmp-your-state) and includes topics such as sea turtle behavior or habitat and fish use of shoal habitat in specific offshore areas. The MMIS is the result of coordination through our partnerships with other Federal agencies and State and local governments, particularly research conducted through our cooperative agreements with the States.

While drilling for oil and gas may not be prescribed in the 3- to 8-nmi (3- to 9-mi; 6- to 15-km) zone currently typical of OCS borrow areas, the pipelines that could bring these resources onshore could impact both known and unidentified sediment resources. Borrow areas are typically located in water depths of 30-60 ft (9-18 m) (not more than 120-ft [37-m] depth), in close proximity to the coast (within 3-12 nmi; 3-14 mi; 6-22 km), and cover less than 32 mi^2 (83 km^2) per lease. These projects have resulted in the restoration of hundreds of miles of the Nation's coastline, protecting billions of dollars of infrastructure, as well as protecting, creating, and enhancing important ecological habitat.

BOEM published a "Final Environmental Assessment and Finding of No Significant Impacts for Sand Survey Activities" in support of BOEM's Marine Minerals Program (BOEM 2019), concluding that potential effects from sand-related surveys are expected to be negligible to minor, localized, and short lived. The EA identifies mitigation, monitoring, and reporting requirements necessary to avoid, minimize, and/or reduce and track any adverse impacts that could result from sand survey activities. Any future connected actions, such as dredging, conveyance, and placement of OCS sand resources would be considered separately in subsequent environmental reviews.

BOEM/USACE Memorandum of Understanding

BOEM and the USACE often work together on projects involving the use of OCS sand. In order to solidify this collaborative relationship, BOEM and the USACE signed a Memorandum of Understanding on February 24, 2017, to coordinate on the use of sand, gravel, and shell resources from the OCS. The Memorandum of Understanding establishes a framework for early and sustained coordination and cooperation between BOEM and the USACE. Items covered in the Memorandum of Understanding include consistency in environmental compliance, project scheduling, and negotiated agreement requirements for all projects proposing to use OCS sand, gravel, and shell resources, for which there has been a growing demand.

In order to anticipate and coordinate future OCS sand needs, BOEM participates in many marine planning bodies. BOEM facilitates regional Sand Management Working Group meetings in order to provide a forum for exchange of information between BOEM and other agencies and local stakeholders in the region. These meetings are intended to foster communication and collaboration, understand stakeholder interests, communicate current projects and research efforts, deconflict multiuse areas, and understand local priorities. BOEM's Marine Minerals Program participates on the Federal Communications Commission Interagency Submarine Cable Coordination meetings to monitor the location of proposed submarine cables as they traverse the sea bottom and have the potential to cross sediment resources. BOEM solicits and directs field work and studies designed to identify and characterize sediment resources on the OCS through cooperative agreements with our partners at State and local governments, universities, or private contractors, such as the BOEM-funded study by Baird (2018) that forecasted potential future use of OCS sediment through 2028, a 10-year horizon.

2.7.2.8 Renewable Energy Development

Renewable energy development uses coastal regions, airspace, sea surface, water column, and seafloor space. The majority of interest in U.S. offshore renewable energy development has occurred on the Atlantic OCS, and BOEM is determining the potential for renewable energy operations that might occur in the Gulf of Mexico. In preparation, BOEM's New Orleans Office funded two renewable energy studies to analyze which types of renewable energy technologies are feasible in the Gulf of Mexico and what types of economic impacts could be expected (Musial et al. 2020a; Musial et al. 2020b). The renewable energy resources evaluated included wind, wave, tidal, current, solar, deepwater source cooling, and hydrogen. Offshore wind showed the greatest resource potential when applied to the Gulf of Mexico and is the most mature technology of those analyzed for the region. Once offshore wind was identified as the leading technology for Gulf of Mexico application, BOEM and the National Renewable Energy Laboratory further analyzed the economic feasibility of offshore wind for selected sites in the Gulf of Mexico. In the *Offshore Wind in the U.S. Gulf of Mexico: Regional Economic Modeling & Site-Specific Analyses* (Musial et al. 2020a), site-specific economic analysis indicated that a single offshore wind project could support approximately 4,470 jobs and $445 million in gross domestic product during construction and an ongoing 150 jobs and $14 million annually from operation and maintenance labor, materials, and services. Results are based on a 600-megawatt project at a reference site with a commercial operation date of 2030. The results of these studies will inform Federal, State, and local strategic renewable energy planning over the next decade.

In 2022, NOAA's National Centers for Coastal Ocean Science, in partnership with BOEM, built a spatial model to identify optimum locations for offshore wind energy in the Gulf of Mexico (NCCOS

2022). These options recently underwent public review, which will further refine the areas that will be offered for auction. As renewable energy planning begins in the Gulf of Mexico, the identification of future leasing areas could cause certain areas of the OCS to be unavailable for oil and gas development and must be taken into account when planning for future oil and gas lease sales.

Determining the actual area needed for renewable energy production offshore is difficult to predict in the early planning stages. Each renewable energy project is custom engineered for the specific purpose of the project. Therefore, the area required, and subsequently unavailable for oil and gas exploration, would vary depending on the needs of the project and the involved state(s). Once renewable energy development interest is established, BOEM would engage with Federal-State Intergovernmental Task Forces to address stakeholder issues and public input to determine appropriate sizes for renewable energy areas. Space use between renewable and conventional energy development will be an important issue moving forward.

2.7.2.9 Ocean Dumping

Ocean dumping uses space at the seafloor. Prior to 1972, no complete records exist of the volumes and types of materials disposed in ocean waters in the United States. Some of the types of wastes disposed of in the oceans were chemical and industrial wastes, radioactive wastes, trash, munitions, sewage sludge, and contaminated dredged material. In October 1972, Congress enacted the Marine Protection, Research and Sanctuaries Act, sometimes referred to as the Ocean Dumping Act, declaring that it is the policy of the United States to regulate the dumping of all materials, which would adversely affect human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities. The USEPA is responsible for issuing ocean dumping permits for materials other than dredged material. In the case of dredged material, the USACE is responsible for issuing ocean dumping permits using USEPA's environmental criteria. Permits for ocean dumping of dredged material are subject to USEPA review and written concurrence (USEPA 2020h). Designated ocean disposal sites for dredged materials are selected to minimize the risk of potentially adverse impacts of the disposed material on human health and the marine environment. The USEPA is responsible for designating and managing ocean dumping sites under the Marine Protection, Research and Sanctuaries Act. Ocean disposal of dredged material requires use of a USEPA-designated ODMDS to the greatest extent feasible (USEPA 2019c). As of March 2020, there were 31 active ocean-dredged material disposal sites in the GOM (USACE 2020c) (**Table 2.7.2-3** and **Figure 2.7.2-5**).

Table 2.7.2-3. Ocean Dredge-Material Disposal Sites (ODMDS) of the Gulf of Mexico.

ODMDS	USACE Region	Last Used	Cumulative Disposal	Disposal Events
Atchafalaya River, Bayous Chene, Boeuf, Black (East)	LA	2002	213,968,086	30
Atchafalaya River, Bayous Chene, Boeuf, Black (West)	LA	2017	111,195,977	21
Barataria Bay Waterway	LA	1988	3,480,353	5
Brazos Island Harbor	TX	2018	7,294,846	18
Brazos Island Harbor – 42-ft project	TX	1992	575,100	1
Calcasieu Dredged Material Site 1	LA	2008	61,133,265	13
Calcasieu Dredged Material Site 2	LA	2018	114,872,477	33
Calcasieu Dredged Material Site 3	LA	2018	5,946,564	11
Corpus Christi New Work	TX	-	no disposal	-
Corpus Christi Ship Channel	TX	2017	8,883,176	14
Freeport Harbor – maintenance, 45-ft project	TX	2018	57,603,306	39
Freeport Harbor – new work, 45-ft project	TX	2015	6,015,690	4
Galveston	TX	2018	64,435,511	34
Gulfport – Eastern Site	MS	2005	13,717,677	9
Gulfport – Western Site	MS	2018	20,589,246	20
Matagorda Ship Channel	TX	2017	3,619,304	8
Mississippi River Southwest Pass	LA	2018	200,750,270	57
Mobile	AL	2018	133,286,271	95
Pascagoula	MS	2018	28,855,405	30
Pensacola – Nearshore Site	FL	1987	1,834,997	4
Pensacola – Offshore Site	FL	2014	4,938,817	4
Port Mansfield	TX	2002	590,524	4
Sabine-Neches – Material Site 1	TX	2017	16,222,341	15
Sabine-Neches – Material Site 2	TX	2018	20,454,959	15
Sabine-Neches – Material Site 3	TX	2018	24,044,782	17
Sabine-Neches – Material Site 4	TX	2018	57,373,415	25
Sabine-Neches – Material Site A	TX	-	no disposal	-
Sabine-Neches – Material Site B	TX	-	no disposal	-
Sabine-Neches – Material Site C	TX	-	no disposal	-
Sabine-Neches – Material Site D	TX	-	no disposal	-
Tampa	FL	1997	12,713,519	16

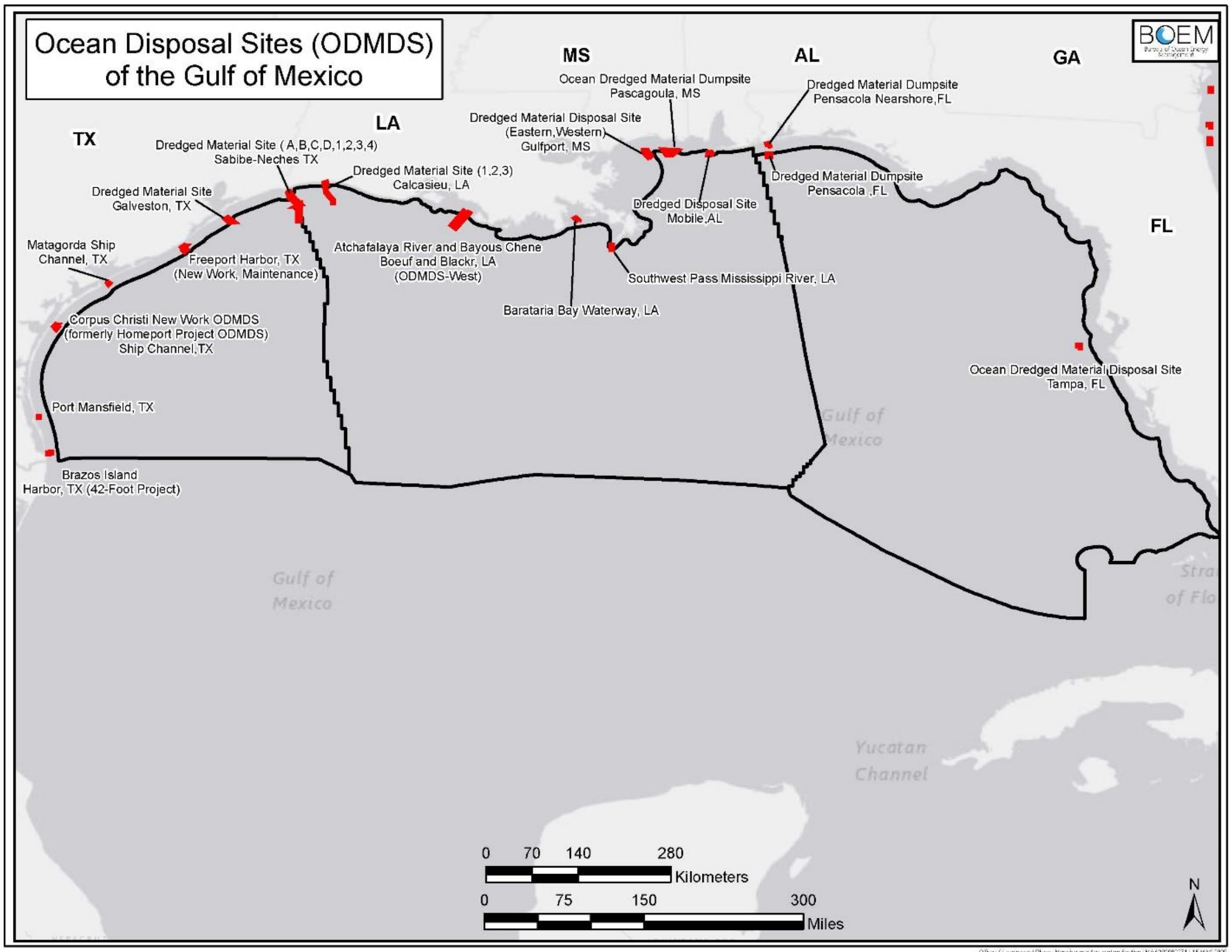


Figure 2.7.2-5. Ocean Dredged-Material Disposal Sites (ODMDSs) of the Gulf of Mexico.

The USEPA Region 4 and the USACE's Mobile and Jacksonville Districts classify ODMDSs that have not been used within 5 years and are not expected to be used within the next 5 years (e.g., Pensacola-Nearshore site) as "Inactive." The Pensacola-Nearshore site, however, remains part of the ocean site list at 40 CFR § 228.15 and, therefore, can still technically be made available for disposal of dredged sediment should the "inactive" status be removed by the USEPA/USACE (Wilkens 2020, official communication). The frequency of use of active disposal sites and the amount of dredged material disposed will continue to fluctuate; however, the USACE must obtain USEPA concurrence and use the USEPA's dumping criteria and sites to the extent practicable to minimize potential effects.

As previously described in **Chapter 2.2.2.4**, from World War I through 1970, the U.S. Armed Forces disposed of weapons in ocean waters. Unfortunately, the precise locations of many of these dumping sites are unknown. Some sites have rough coordinates while others are only identified by the body of water or a distance offshore. Through a coordinated effort between the DOD and NOAA, seven dumping sites were identified in the Gulf of Mexico. Identified sites ranged from <1 nmi to 80 nmi (1 mi to 92 mi; 2 km to 148 km) from shore and in water depths of >30 ft to >5,500 ft (9 m to 1,676 m) (**Figure 2.7.2-6**).

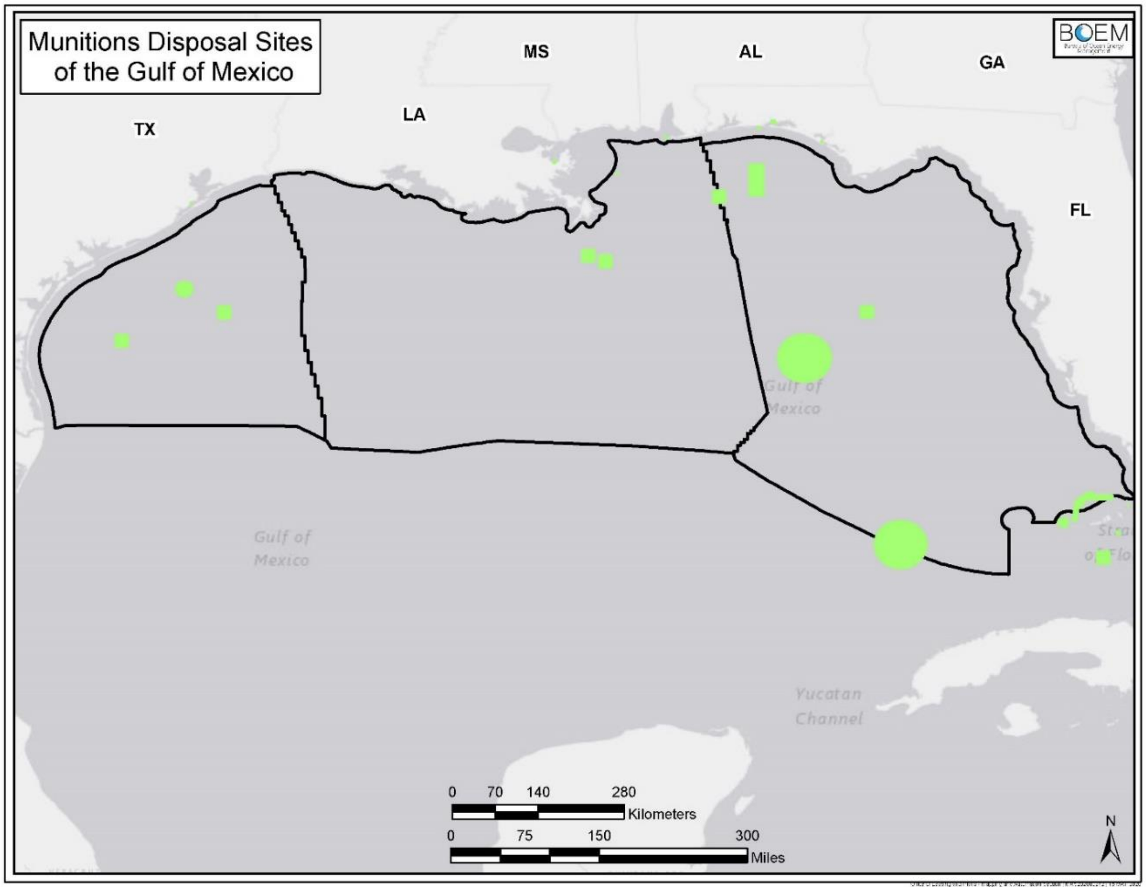


Figure 2.7.2-6. Munitions Disposal Sites of the Gulf of Mexico.

2.7.2.10 Aquaculture

Offshore aquaculture is the rearing of aquatic animals in controlled environments (e.g., cages or net pens) in Federal waters. In the Gulf of Mexico, marine aquaculture focuses on stock enhancement (i.e., the release of juvenile fishes to supplement wild populations), food production, research, and restoration efforts (NMFS 2020a). Species cultured in the region include oysters, clams, shrimp, red drum, almaco jack, spotted seatrout, summer flounder, snook, pompano, black seabass, and algae. More information on NOAA's role in marine aquaculture can be found on NOAA's website at https://www.fisheries.noaa.gov/topic/aquaculture.

Due to a 2018 court ruling, NOAA is not currently issuing permits for aquaculture in Federal waters of the Gulf of Mexico; however, NOAA continues to support the development of offshore aquaculture through early engagement and participation in other Federal agency permitting processes. The Department of Justice, on behalf of the United States, has appealed the Court decision and the outcome of that appeal is pending. An interagency group led by NOAA has been established and is working on the permitting process for future proposed aquaculture activities. This group consists of the three permitting agencies, i.e., NOAA, USEPA, and USACE, and other agencies with an interest or expertise on the OCS, including the USCG, FWS, BOEM, and BSEE. *A Guide to the Permitting and Authorization Process for Aquaculture in U.S. Federal Waters of the Gulf of Mexico*

(2019) provides information on the Federal permitting and authorization requirements to establish an aquaculture operation in U.S. Federal waters of the Gulf of Mexico (NOAA et al. 2019). The operator of an offshore aquaculture facility must obtain all required Federal permits and authorizations prior to beginning operations, e.g., placing any structures or animals in OCS waters. The type of permit(s) required will vary depending on the type of aquaculture operation, e.g., finfish versus macroalgae.

2.8 SOCIOECONOMIC CHANGES AND DRIVERS

This IPF broadly addresses the extent to which activities (both OCS oil- and gas-related and non-OCS oil- and gas-related factors) produce socioeconomic changes. Because humans plan for, instigate, avoid, and react to changes in myriad ways, socioeconomic considerations are also drivers of change in the offshore oil and gas industry and elsewhere in society, changes which, in turn, beget additional changes with their own impacts. These impacts are often interpreted subjectively and can be perceived as positive, negative, or neutral, often simultaneously, for multiple reasons or by multiple groups of people.

The oil and gas industry is one element in the socioeconomic landscape of the GOM. It exists in and is supported by other elements of the landscape, including communities, governments, industries, and individuals. This landscape is tied into global networks, markets, and forces, making the region both responsive to and an instigator of changes across the world. For example, the offshore oil and gas industry was developed in the GOM in the early 20th century and is now a driver of change across the globe. Conversely, the oil and gas price crash following the spread of the novel coronavirus (COVID-19) in early 2020 instigated widespread slowdowns in the offshore oil and gas industry, including the shut-ins of some GOM facilities. While the full impacts of COVID-19 are not yet known, it illustrates the impact of outside forces on the offshore oil and gas industry in the GOM.

The GOM's socioeconomic landscape is rich and varied, representing diverse peoples, cultures, ways of life, and industries. There are six economic sectors that depend on the ocean, including living resources (e.g., seafood), marine construction, marine transportation, offshore mineral extraction (mostly comprised of offshore oil and gas activities), ship and boat building, and recreation and tourism. The combination of these sectors is called the ocean economy. Overall, in 2016, the ocean economy accounted for 598,000 employees and $104 billion in gross domestic product in the GOM region and, since 2007, employment in the ocean economy has grown almost 10 percent faster than the U.S. economy (NOAA and Office for Coastal Management 2019b). Marine and coastal resources play a significant role in generating income and employment through fishing, recreation, and tourism. These resources may be particularly crucial to the wellbeing of vulnerable coastal communities but are also significant to the sense of place and culture of communities across the GOM.

Offshore oil- and gas-related activities may affect 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 counties and parishes from the five Gulf Coast States into 23 EIAs based on economic and demographic similarities among counties and parishes. Much of BOEM's socioeconomic analyses focus on these EIAs since many of the positive and negative effects related to OCS oil and gas leasing in the Gulf of Mexico are concentrated in these EIAs. These EIAs also serve as consistent units for which to present economic and demographic data.

2.8.1 Population Shifts

As one of the leading industries in the GOM, decisions made by oil and gas companies about development, including facility siting and staffing, contribute to population shifts in the GOM region. As companies are founded, merge, go out of business, or relocate, they alter the landscape of available employment. As companies moved their headquarters or regional offices out of southern Louisiana to New Orleans and then Houston, they altered the availability of employment in both the cities and towns they left and the cities to which they moved. Since, as discussed above, offshore oil and gas employment can be more lucrative than other available options, this may have substantial impacts on the sustainability and character of these areas, particularly smaller areas where other options may be more limited.

2.8.2 OCS Oil- and Gas-Related Activities

Many people, both nationally and internationally, rely on coastal and marine resources such as food, tourism, and industry. Offshore oil and gas activity in the GOM contributes significantly to regional employment and income arising from industry expenditures, government revenues, corporate profits, and other market impacts. The GOM ocean economy is dominated by offshore mineral extraction, which puts this region at the top in terms of gross domestic product (NOAA and Office for Coastal Management 2019b). Likewise, the GOM ocean economy has above-average wages, which is largely due to the high wages found in the offshore mineral extraction sector (NOAA Office for Coastal Management 2019b). The heavy presence of the oil and gas industry can also contribute to the culture and sense of place in many parts of the GOM region, many of which would be concentrated along the immediately adjacent coasts.

2.8.2.1 Employment Conditions

From 2010 to 2014, employment growth was slightly greater in the coastal areas of the GOM (2.43%) as compared to the total for coastal states as whole (2.29%) (Kildow et al. 2016). Offshore oil and gas contributes to this employment growth.

The offshore oil and gas industry generally follows an employment pattern on offshore oil and gas projects. Direct employment levels for a single project typically increase shortly after a lease sale during the data acquisition and analysis phase (typically years 2 to 5 after a lease sale) and increase rapidly during exploration and development. Employment peaks during design, fabrication, and installation, but these levels are short term, only lasting several years. Employment then declines and flattens out during long-term production, which may last 15-35 years, depending on the size of the oil and gas reserves. Employment then initially increases before tapering off during the decommissioning phase. The timing of the different development phases varies by individual project, with the pre-production phases likely to be shorter in mature areas and longer in frontier areas. Increases in employment do not necessarily represent the creation of new jobs, but the maintenance of current job levels in mature areas and migration of skilled workers from other regions to frontier areas.

In established basins, such as the WPA and CPA, multiple projects in a lease sale area tend to be staggered, resulting in smoother employment patterns over time.

Theeoretically, direct changes in employment, income, and expenditures resulting from the project would initiate subsequent rounds of income generation, spending, and re-spending. Third-party contractors, vendors, and manufacturers receiving payment for goods and services required by the project would, in turn, be able to pay others who support their businesses. In addition, persons directly and indirectly employed because of the project would generate additional jobs and income in the economy as they purchase goods and services. These indirect and induced effects are sometimes referred to as "multiplier effects." Shifts in offshore oil and gas employment would therefore have impacts on local spending and associated industries, such as recreation and tourism. They would also impact the overall local economy.

Offshore oil and gas development requires an extensive network of onshore support facilities and services that generate many of the indirect and induced employment opportunities. Port facilities, fabrication facilities, oil and gas processing facilities, pipelines, and waste management facilities are among those that provide support to offshore oil and gas projects. These facilities are described above in **Chapters 2.2 and 2.5**. Transportation, lodging, food, legal, architectural, and other services also employ many workers that provide project-related support.

The nature of offshore and onshore support activities allows for regional employment impacts to vary considerably. Offshore worker schedules (e.g., 2 weeks on and 2 weeks off) allow for very long-distance commuting. The schedules allow employees to participate in a range of economic, subsistence, and cultural activities that may not be as possible, lucrative, or pleasurable on an alternative schedule. Employees who work in company offices or in support industries often work business hours, shift work, or other alternative schedules. These schedules may be more desirable for many but reduce the reasonable commuting area unless employees can work remotely. Continued leasing in the GOM is likely to help maintain the current levels of offshore-related employment in the adjacent states (as workers cycle from one project to the next) rather than create significant levels of new employment.

In the GOM, offshore oil and gas workers typically earn higher-than-average incomes. Wages of employees in support industries vary greatly, as does the availability of overtime, bonuses, and benefits, which contribute to an employee's total compensation and factor into decisions of where to seek or accept employment. Contractors are also a significant source of labor in the offshore oil and gas and support industries. Employment opportunities associated with offshore oil and gas and support industries, therefore, range from highly paid, skilled full-time, permanent employees who work directly for companies to employees of contract companies to minimum wage employees to part-time and temporary contract workers. Depending on the industry, benefits and job stability vary. The shipbuilding and fabrication industry illustrates this diversity. In some commuting areas, shipbuilding and fabrication, along with oil and gas (including offshore and petrochemical plants) are among the highest paid jobs for skilled labor (McGuire et al. 2014). Despite that, workers for some companies may count on the availability of overtime in their livelihood strategies and suffer when that overtime is not available. Companies who cannot afford to pay the same wages as larger or better-funded shipyards can instead find skilled employees who find other factors significant in their employment decisions, including flexibility in schedule, additional overtime, shorter commute, lack of a union, and availability of training (McGuire et al. 2014). Contractors have become an increasingly important feature in the hiring decisions in the industry, where again wages and benefits vary, from some who are full-time employees of contract companies with generous benefits to others who work temporary positions and accept additional pay in exchange for benefits and job security.

2.8.2.2 Industry Spending

In addition to spending on employment, industry has expenditures on various goods and services. For example, offshore oil and gas activity directly affects firms that drill wells, manufacture equipment, construct pipelines, and service OCS oil- and gas-related activities. The OCS oil- and gas-related activities also impact the suppliers to those firms, as well as firms that depend on consumer spending of oil and gas industry workers, as discussed above.

Industry spending is also tied to development of coastal and submerged lands, either directly by offshore oil and gas or by associated industries. Associated IPFs are discussed in **Chapters 2.3 and 2.5**. Increases in spending and subsequent development can also be linked to increased air emissions, discharges and wastes, noise, and visual impacts, as discussed in **Chapters 2.1**, **2.2**, **2.4, and 2.6**.

2.8.2.3 Government Revenues

The Federal Government collects revenues from the production of oil and natural gas on the OCS through bonus bids, royalties, and rents from lessees. Federal revenues reported for all OCS oil and gas leases totaled over $6 billion in Fiscal Year 2019 (ONRR 2020b). A large portion of OCS revenues are retained by the U.S. Department of the Treasury, others are deposited into the Historic Preservation Fund and the Land and Water Conservation Fund, shared with states through the Section 8(g) provision of the OCSLA, as amended, or shared with states and coastal political subdivisions through GOMESA revenue sharing.

Section 8(g) of OCSLA, as amended, requires that 27 percent of the revenues for Federal lease blocks within 3 nmi (3.5 mi; 5.6 km) of a State's seaward boundary be shared with the state to compensate for oil and gas reservoirs that might be underlying both OCS and submerged State tidelands. Revenue sharing authorized under GOMESA in 2006 shares specific percentages of OCS revenues with GOM producing states (i.e., Texas, Louisiana, Mississippi, and Alabama) and their coastal political subdivisions, and provides additional revenue to the Land and Water Conservation Fund. The GOMESA revenue sharing program was designed to compensate for potential negative impacts of OCS activities. Beginning in Fiscal Year 2007, and thereafter, the GOM producing states and their coastal political subdivisions received 37.5 percent and the Land and Water Conservation

Fund received 12.5 percent,of the qualified OCS revenue from new leases, including bonus bids, rentals, and production royalties issued in the 181 Area in the EPA and in the 181 South Area. The second phase of GOMESA revenue sharing started in Fiscal Year 2017, which expanded the areas that qualify for revenue sharing. Phase II also imposes revenue-sharing caps on States and the Land and Water Conservation Fund. Overall, State revenue-sharing caps under Phase II are $375 million for Fiscal Years 2017-2019, $487.5 million for Fiscal Years 2020 and 2021, and $375 million for Fiscal Years 2022-2055. The cap will be lifted beginning in Fiscal Year 2056. Governments also receive revenues from offshore oil and gas activities in the form of property taxes related to onshore support infrastructure and corporate income taxes. The impacts generated by these revenues depend on where and how the revenues are used.

2.8.2.4 Profit

In addition to contributing to local and regional spending and government revenues, Gulf of Mexico OCS activity contributes to corporate 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 the GOM. Similarly, it is difficult to trace specific spending by firms to increases in corporate profits, although these impacts are also likely to be widespread.

2.8.2.5 Energy Supply and Prices

Gulf of Mexico OCS oil- and gas-related activity is intended to add to the Nation's energy supply. This contributes to U.S. policy goals of energy independence and security. Increased energy supply resulting from Gulf of Mexico OCS oil- and gas-related activity would put downward pressure on energy prices, although the small scale of a proposed lease sale(s) relative to the overall energy market would make these price effects minimal. Both can have additional impacts on energy markets.

2.8.2.6 Fluctuations in the Oil and Gas Industry

The global oil and gas industry is notoriously volatile. When prices rise or fall, activity levels follow, though due to the size of expenditures and the length of development needed before a return on investment can be realized with offshore oil and gas, activity is insulated from some of the short-term impacts of this volatility. When activity shifts, this causes swings in spending and employment.

2.8.2.7 Public Perceptions

Nothing exists in a vacuum and activities and patterns of activity are noticed, remarked upon, and influence future choices. As public perception changes, activities or situations that were perceived as normal or acceptable at one time may no longer be tolerated. For example, offshore oil and gas workers who survived the bust of the 1980s and industry fluctuations of the 1990s and 2000s may encourage their children to seek employment that offers more stability elsewhere (also refer to Austin et al. 2002b). Others who left during a downturn refuse to return because they see any increase in wages or benefits as short-term and not worth the risk of future volatility. Support industries experience similar shifts in perception, and employment can rise and fall in popularity, especially as compared to other available options in the community (McGuire et al. 2014).

2.8.3 Other Activities Causing Socioeconomic Changes

2.8.3.1 Economic Strength and Outlook

Changes to the local, State, national, and global economy and economic outlook can have far-reaching impacts on human activity. As these economies strengthen or weaken, and as outlooks for the future improve or worsen, government, industry, and consumers respond in myriad ways. Consumers and industries can increase spending to take advantage of low prices or interest rates, or due to confidence in continued economic growth. This spending can serve to increase employment, government revenue, and profits, as discussed above. It can also serve to increase competition, raise prices, and therefore decrease activity. Alternatively, a poor economic outlook or high prices may generally serve to limit spending, decreasing those subsequent impacts. Planners and decisionmakers may take different approaches, so responses to a shift in trends or a shock are likely to vary. Development, itself, may be controversial, i.e., viewed by some stakeholders as positive for the myriad benefits associated with growth, or a negative, particularly when it threatens to change areas or resources considered central to sense of place or local identity.

Commodity prices also vary with the state of the economy, market forces, and other factors, including international trade flows, geopolitical developments, and widespread shifts in human behavior, including that due to a pandemic or other social disruption. This includes oil and gas, as discussed above. Price fluctuations can have positive or negative impacts on industries, sectors, and communities, depending on their relationship with that commodity (e.g., buyer or seller, immediate or long-term need, etc.).

2.8.3.2 Ocean Economy

The six economic sectors that depend on the ocean include living resources (e.g., seafood), marine construction, marine transportation, offshore mineral extraction (mostly comprised of offshore oil and gas activities), ship and boat building, and recreation and tourism. They are all important to the regional economies of the Gulf of Mexico, which contributed the highest percentage of gross domestic product in the entire U.S. ocean economy (NOAA and Office for Coastal Management 2019b). As of 2016, ocean economy employment declined by 0.4 percent overall, largely due to decreased employment in the offshore mineral extraction sector (NOAA and Office for Coastal Management 2019b). The tourism and recreational sector was the largest employer with 56.6 percent, and it also experienced the highest absolute gains in employment (NOAA and Office for Coastal Management 2019b).

2.8.3.3 Laws, Regulations, and Governmental Priorities

Government at all levels is both responsive to and instigates change through its legal and regulatory action and administrative priorities. This includes, but is not limited to, infrastructure, education and workforce development, environmental and land management (including zoning, development planning, conservation, resource management), taxes and financial management, emergency planning, military, public health, and social services. Collectively, the impacts are widespread and touch on every aspect of human life. Government actions and decisions are based on myriad types of input, including public opinions and election results.

2.8.3.4 Population and Workforce

In 2010, 39 percent of the U.S. population (or 123.3 million people) lived in coastal shoreline counties (Crossett et al. 2013). From 2010 to 2014, employment growth was slightly greater in the coastal areas of the GOM States (2.43%) as compared to the total for GOM states as a whole (2.29%) (Kildow et al. 2016). Population growth has also been slightly greater (1.45%) in the coastal areas as compared to the total Gulf Coast States as a whole (1.30%) (Kildow et al. 2016). It is anticipated that as areas feel the impacts of climate change and sea-level rise, however, these trends will reverse and coastal areas will see losses of population (Hauer 2017; Robinson et al. 2020), as is already evident in areas of coastal Louisiana.

Areas with larger populations have more diverse economies, offer more services, and provide more varied employment opportunities. The availability of employees in all labor categories, including skilled and unskilled labor and technical expertise and the facilities to train workers, influences industry siting and development plans, just as the availability of employment influences migration decisions. Additional factors that influence the constitution of the labor force include the mix of industries, presence and quality of educational and training facilities, availability and strength of unions, and the content of labor laws and regulations.

2.8.3.5 Culture

Culture is a socialized pattern of behavior and understanding (Center for Advanced Research on Language Acquisition 2014), which can help define a "sense of place." It is also "the set of attitudes, values, beliefs, and behaviors shared by a group of people, but different for each individual, communicated from one generation to the next." While all Gulf Coast States participate in American culture, they, and their regions, cities, and ethnic, religious, and linguistic communites all have their unique cultures. Culture creates shared understandings that allow for social function. For example, how business is conducted varies from one place to another, i.e., does a handshake create a binding contract or is written documentation required? Individuals and communities may also choose to value certain livelihoods or lifestyles because of their cultural importance. Those choices may not be easily understandable to people who do not share their culture. These differences can lead to conflict, particularly around questions of development and resource use, where decisions are, or can be perceived as, mutually exclusive or as impacting the identity or sense of place of a group. Culture changes over time and things that were once normal may no longer be accepted, or the once strange may become commonplace.

2.9 Accidental OCS Oil- and Gas-Related Events

Impacts associated with accidental events are considered in terms of accidental events that occur with enough frequency that such events are statistically expected to occur. Events that are statistically unexpected to occur but would still be possible, such as a catastrophic discharge event, are not discussed in this document. For more information on a catastrophic discharge event, refer to BOEM's *Gulf of Mexico Catastrophic Spill Event Analysis: High-Volume, Extended-Duration Oil Spill Resulting from Loss of Well Control on Gulf of Mexico Outer Continental Shelf* (BOEM 2021d). BOEM does not regulate accidental events from non-OCS oil- and gas-related activities and therefore did not analyze them in detail in this chapter.

Categories of impact-producing factors associated with reasonably foreseeable accidental events include the following:

- releases into the environment, which includes oil spills, chemical spills, pipeline failures, losses of well control, accidental air emissions, hydrogen sulfide and sulfurous petroleum releases, and trash and debris;
- vessel collisions as a result of vessels colliding with platforms or other vessels; and
- spill response associated with the activity that might occur in response to an oil spill.

2.9.1 Unintended Releases into the Environment

2.9.1.1 Oil Spills

As a consequence of activities related to the exploration, development, production, and transportation of oil and gas, historical trends in the GOM region demonstrate that the possibility for accidental releases exists. Input through public scoping meetings, Federal and State agency consultation and coordination, and industry and nongovernmental organizations' comments indicate that stakeholders have concerns about oil spills and the resulting consequences they pose to the environment. Although oil spill occurrence cannot be predicted, its likelihood can be estimated using spill rates derived from historical data and projected volumes of oil production and transportation. The following sections discuss aspects of oil spills relevant to potential oil and gas exploration and development activities in OCS planning areas along the Gulf Coast.

Fairly soon after oil is spilled in an ocean environment, physical and chemical processes (i.e., weathering) begin affecting and modifying the oil. Some oil compounds will weather by evaporation, dispersion into water, or bacterial degredation, while others will not, such as polycyclic aromatic hydrocarbons. Different crude oils have different chemical compositions that are governed primarily by the geologic conditions under which they were formed, migrated, and accumulated. These conditions can result in oil from a given location or geologic formation having a unique chemical composition, including specific compounds that help experts distinguish one crude oil from another. Collectively, the physical and chemical changes determine the transport and fate of an oil spill. Transport denotes the processes that move the oil from place to place either horizontally or vertically and is strongly affected by the currents and winds. The horizontal movement is accomplished by advection, spreading, dispersion, and entrainment. Vertical motion is mainly accomplished through dispersion, entrainment, and vortex-type currents, sinking, overwashing, partitioning, and sedimentation.

The fate and transport of oil and gas after a spill differs. Oils may sink, become entrained in the water column, or surface. The chemical nature of the oil also changes over the course of a spill from evaporation, emulsion, dissolution, and oxidation. The moment oil reaches the surface, it begins to evaporate as the aromatic compounds and the remaining heavier compounds react to other environmental conditions (i.e., sun, wind, waves, and currents). Natural gas may remain submerged and be degraded by bacteria prior to reaching the surface, depending on the depth of the spill. The same bacteria produce mucus that may attach to oil droplets and cause marine oil snow that then settles to the seafloor (NOAA 2016b).

Trends in OCS Spills

A summary of reported spill incidents is available from the USCG in a report entitled *Polluting Incidents In and Around U.S. Waters, A Spill/Release Compendium: 1969-2011* (USCG 2012). The data include reports of all releases involving oil and hazardous substances from various sources, including barges, tanks, pipelines, and waterfront facilities. A review of the information shows that the majority of spills are ≤1 bbl. While all spills must be reported to the USCG through the National Response Center, BSEE's regulations require that for all OCS spills ≥1 bbl from an operator's facility, the operator must also notify the Regional Supervisor, Field Operations per 30 CFR § 254.46. In addition, all spills ≥50 bbl have additional reporting requirements and in some cases are followed up by incident investigations. A report prepared by ABS Consulting Inc (2016) examined the occurrence rates for offshore oil spills and gathered data from a variety of sources including BSEE, the USCG, and the U.S. Department of Transportation's (DOT's) Pipeline and Hazardous Material Safety Administration. The report focused on all spills ≥1 bbl from offshore platforms, offshore pipelines, tankers, and barges. **Figure 2.9.1-1** shows the number of oil spills ≥1 bbl that have occurred in the GOM, and **Figure 2.9.1-2** shows the total volume (bbl) of oil spilled for spills ≥1 bbl in the GOM for the period 2001 through 2015.

The ABS Consulting Inc study examined a number of causal factors including equipment failure, human error, weather/natural causes, and other/external factors. Spills from offshore production platforms and drilling rigs revealed two notable trends. First, hurricanes have had a substantial impact on the total number and volume of spills, as can be seen in **Figures 2.9.1-1 and 2.9.1-2**. In 2005, for example, the integrated tug-barge unit comprised of the tugboat *Rebel* and the double-hull tank barge *DBL 152* struck the submerged remains of a pipeline service platform that previously collapsed during Hurricane Rita, releasing an estimated 45,846 bbl (1,925,532 gallons) of oil. The second notable trend is that the dominant driver of reduced spill rates is likely a reduction in equipment failures as the number of events has steadily decreased since 1975. This suggests that technology advancements have played a large role in improving spill rates. The analysis also examined additional causal factors related to pipeline spills, including corrosion and vessel/anchor/trawl damage. The analysis reveals that, like platform spills, hurricanes have had a substantial impact on pipeline spill frequency and spill volume. The results also showed that the number of operational spills per year appears to follow a downward trend as the majority of pipeline spills in the last 15 years were caused by hurricanes (ABS Consulting Inc 2016). **Figures 2.9.1-3 and 2.9.1-4** show the relative contribution from offshore platforms versus offshore pipelines.

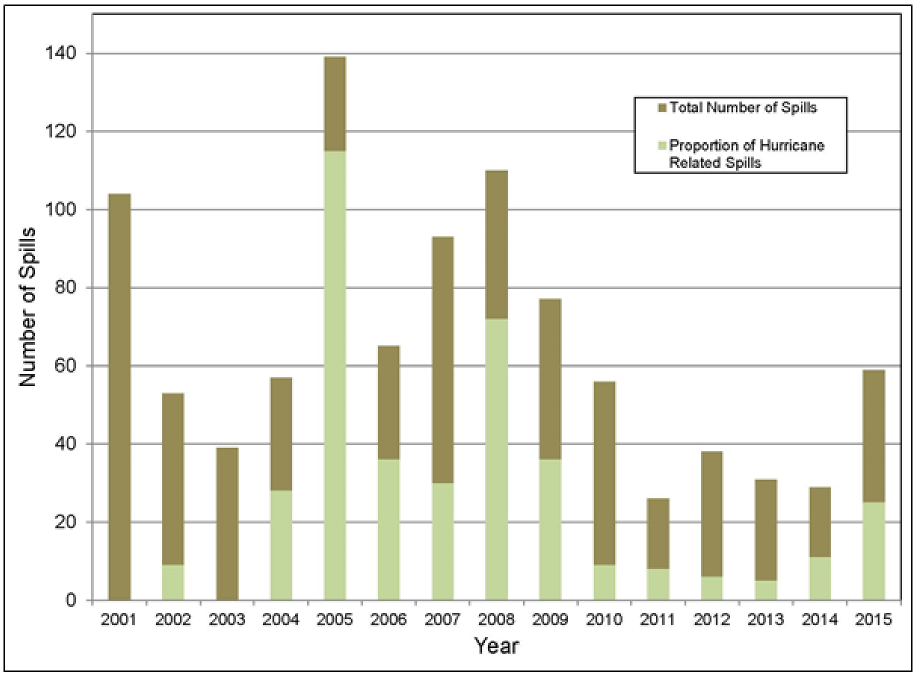


Figure 2.9.1-1. Number of Oil Spills ≥1 bbl That Have Occurred in the Gulf of Mexico for the Period 2001 through 2015.

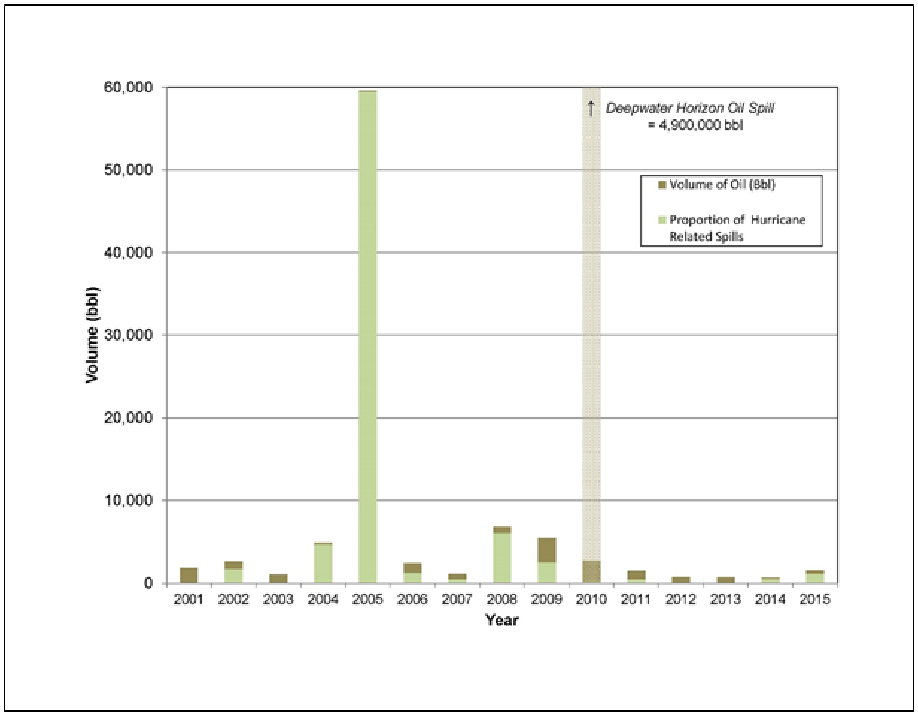


Figure 2.9.1-2. Total Volume (bbl) of Oil Spilled in Gulf of Mexico Waters for Spills ≥1 bbl for the Period 2001 through 2015. (Notes: In 2005, the integrated tug-barge unit DBL 152 *struck the submerged remains of a pipeline service platform that collapsed during Hurricane Rita. The* Deepwater Horizon *explosion and oil spill occurred in 2010.)*

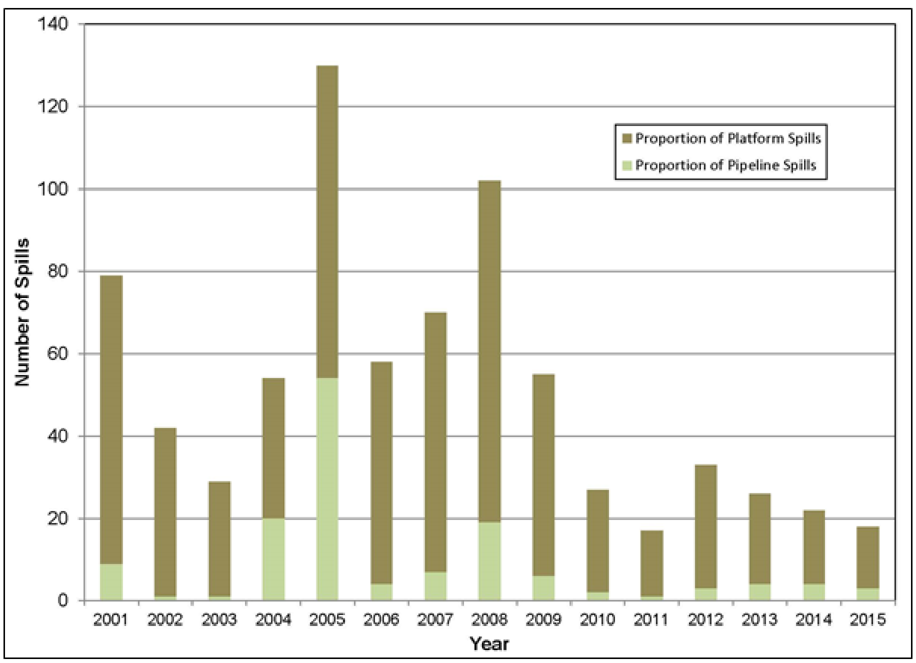


Figure 2.9.1-3. Number of Platform- and Pipeline-Related Oil Spills ≥1 bbl That Have Occurred in the Gulf of Mexico for the Period 2001 through 2015.

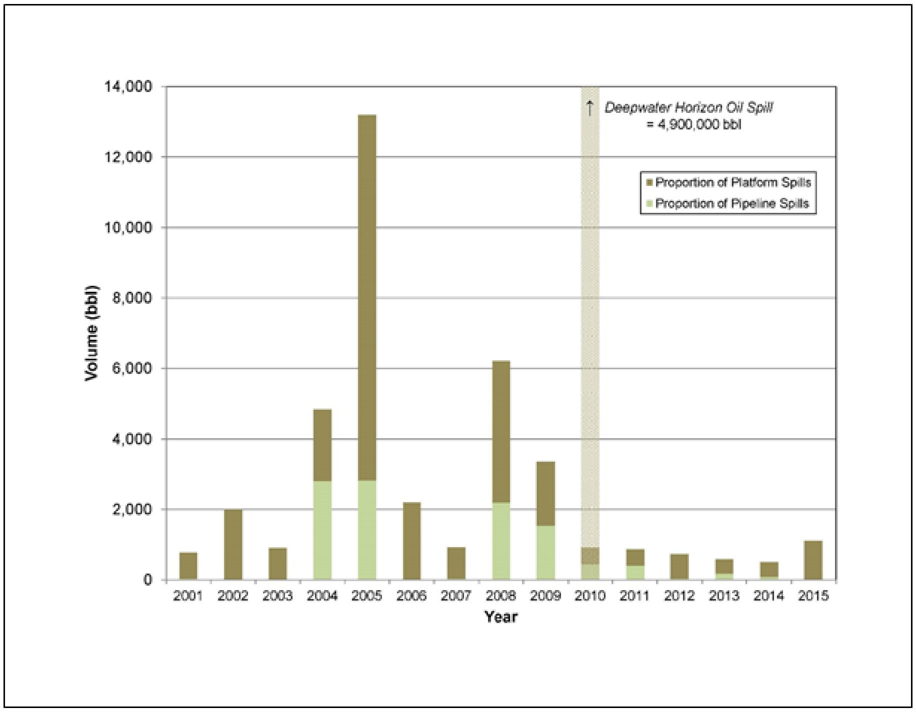


Figure 2.9.1-4. Total Volume of Spilled Oil for Platform- and Pipeline-Related Oil Spills ≥1 bbl That Have Occurred in the Gulf of Mexico for the Period 2001 through 2015.

In response to the damages sustained to oil and gas infrastructure as a result of hurricanes, the MMS (BOEM and BSEE's predecessor) imposed more stringent design and assessment criteria for both new and existing structures in the GOM. The rule incorporates three API bulletins to help increase survivability during hurricane conditions and reduce the number of damaged platforms, including (1) guidance for design and operation of MODU mooring systems; (2) recommendations to siting jackup MODUs and to recommend certain operational procedures to enhance jackup survivability and stationkeeping during drilling, workover, and while stacked (idled) at a non-sheltered location; and (3) guidance to improve tie-down performance.

Oil-Spill Occurrence Rates

Anderson et al. (2012) utilized United States' OCS platform and pipeline spill data from 1964 through 2010 to provide updated estimates of oil-spill occurrence rates expressed and normalized in terms of the number of spills per volume of crude oil handled. Platform and pipeline spills included both crude oil and condensate, but platform spills may also include refined products such as diesel fuel. The report utilized the spill record from 1964 through 2010 but also examined shorter intervals to identify trends and also to show how the *Deepwater Horizon* explosion, oil spill, and response influenced the spill statistics. The report notes several additional factors that have influenced spill rates, including six highly destructive hurricanes between 2002 and 2008 that destroyed or extensively damaged 305 platforms, 76 drilling rigs, and over 1,200 pipeline segments, and the inclusion of "passive spills" or petroleum missing based on pre-storm platform inventories.

Recently, BSEE contracted ABS Consulting Inc (2016) to update the occurrence rates for offshore oil spills based on the previous work by Anderson et al. (2012) (**Table 2.9.1-1**). The report uses the most recent available data since the prior report to calculate rates consistent with current trends. When comparing the most recent 15 years of data (2001 through 2015) to the 1996 through 2010 rates in Anderson et al. (2012), platform spill rates remained at 0.25 spills per billion barrel (Bbbl) for spills ≥1,000 bbl and 0.13 spills per Bbbl for spills ≥10,000 bbl. Spill rates for OCS pipelines dropped from 0.88 to 0.38 spills per Bbbl for spills ≥1,000 bbl and from 0.18 to 0.07 spills per Bbbl for spills ≥10,000 bbl.

Table 2.9.1-1. Spill Rates for Petroleum Spills ≥1,000 Barrels from OCS Platforms and Pipelines, 1964 through 2010.

Spill Size and Source	Previous Rate, 1964-2010[1] Volume Handled (Bbbl)	Previous Rate, 1964-2010[1] Number of Spills	Previous Rate, 1964-2010[1] Spill Rate	Revised Rate, 1996-2010[1] Volume Handled (Bbbl)	Revised Rate, 1996-2010[1] Number of Spills	Revised Rate, 1996-2010[1] Spill Rate	Current Rate, 2001-2015[2] Volume Handled (Bbbl)	Current Rate, 2001-2015[2] Number of Spills	Current Rate, 2001-2015[2] Spill Rate
Platforms ≥1,000 bbl	15.8 of 18.1	5 of 13	0.32	8.0	2	0.25	8.0	2	0.25
Pipelines ≥1,000 bbl	9.6 of 18.1	9 of 20	0.94	8.0	7	0.88	8.0	3	0.38
Platforms ≥10,000 bbl	15.8 of 18.1	1 of 5	0.06	8.0	1	0.13	8.0	1	0.13
Pipelines ≥10,000 bbl	9.6 of 18.1	–	0.19	8.0	–	0.18	8.0	–	0.07

Bbbl = billion barrels.
[1]Anderson et al. 2012.
[2]ABS Consulting Inc. 2016.

Coastal Spills

Coastal spills are defined here as spills in State offshore waters from barges and pipelines carrying OCS-produced oil. These spills may occur at shoreline storage, processing, and transport facilities supporting the OCS oil and gas industry and could be spills of crude oil or spills of fuel oil used in vessels. Many reports of spills cannot be traced back to the source or type of oil and are recorded as unknown. Similarly, for these small spills (i.e., <1,000 bbl) of unknown oil, the volume is also likely to be an estimate. Records of spills in coastal waters or State offshore waters are maintained by the USCG (USCG 2015). The source may be recorded, for example, as an offshore pipeline, but the database does not identify the source of the oil in the pipeline (OCS versus non-OCS domestic). A pipeline carrying oil from a shore base to a refinery may be carrying oil from both State and OCS production; imported oil might also be commingled in the pipeline. The USCG also records the type of oil spilled and whether it is crude oil, a refined product such diesel fuel or heavy fuel oil, or a type of commodity in transport, such as vegetable oil. The USCG data have some shortcomings that should be noted. For spills of unknown source, the caller may guess as to what type of oil, crude, or fuel was released. The database includes a latitude and longitude GPS (global positioning system) position for each spill, as well as a verbal description of location. The verbal description may not match the position. For example, the verbal description could be Mississippi Sound, but the GPS position is actually on the OCS. For this report, the GPS position was used, not the verbal description of the location.

BOEM pays special attention to spills related to exploration and production that occur on Federal leases in OCS waters, i.e., the submerged lands, subsoil, and seabed lying between the seaward extent of the State's jurisdiction and the seaward extent of Federal jurisdiction. BOEM does not maintain comprehensive data on spills that have occurred in the State's jurisdiction. Although BSEE has occasionally collected information on State pollution incidents, there is no database available that contains only past spills that have occurred in State offshore or coastal waters solely and directly as a result of OCS oil and gas development.

Therefore, coastal spill data from all potential spillage sources were searched using USCG's database for the most recent 13 years, January 2002-April 2015 (USCG 2015) in order to obtain information on spills that have occurred in State offshore or coastal waters, most probably as a result of oil and gas development. In order to search the data, USCG's data were examined using the latitude and longitude provided in the spill report, which resulted in some of the reported locations that fell inland or outside of the GOM being omitted. Some broad assumptions were made in the use of these data. State offshore waters and coastal waters are defined here as the portion of the GOM under State jurisdiction that begins at the coastline and ends at the Federal/State boundary 9 nmi (10.36 mi; 16.67 km) offshore Texas; 3 nmi (3.5 mi; 5.6 km) offshore Louisiana, Mississippi, and Alabama; and 9 nmi (10.36 mi; 16.67 km) offshore Florida. The number of GOM coastal spills from five sources associated with State or Federal offshore production and international importation was determined from the data (**Table 2.9.1-2**). Louisiana and Texas have extensive oil and gas activity occurring in their territorial seas, as well as in Federal waters on the OCS. The sources that were counted are fixed platforms, MODUs, OSVs, offshore pipelines, and tank ships or barges. Although counts for tank ships and barges are shown as sources, the amount of barged and tankered GOM oil production is limited; therefore, these numbers are conservatively high as they include all of the oil tankered or barged. BOEM shows that 96 percent of OCS oil- and gas-related activity spills are <1 bbl, with an average size of 0.05 bbl, and that 4 percent of OCS oil- and gas-related activity spills are <999 bbl, with an average size of 77 bbl (Anderson et al. 2012). Furthermore, ABS Consulting Inc. (2016) updated the 2012 oil spill occurrence rates and, when comparing trends, determined that spill rates decreased in all categories, with substantial decreases in tanker spill rates. When comparing the most recent 15-years of data (2001 through 2015 data) to the 1996 through 2010 rates in Anderson et al. (2012), spill rates remained at 0.25 spills per Bbbl for spills ≥1,000 bbl and 0.13 spills per Bbbl for spills ≥10,000 bbl; however, increased volumes of oil handled led to decreases in the overall spill rates (ABS Consulting Inc 2016).

Table 2.9.1-2. Historic Spill Source, Location, and Characteristics of a Maximum Spill for Coastal Waters[1] (data extracted from USCG records, January 2002-July 2015) (USCG 2015)[2].

Source	Total Number of Spill Events	Number of Spills (<1,000 bbl)	Number of Spills (≥1,000 bbl)	Maximum Volume of a Single Incident Volume (bbl) of Maximum Spill from the Source	Maximum Volume of a Single Incident Maximum Spill Amount Product/Year
Western Planning Area (WPA)[2] Fixed Platform	147	147	0	7.62	Crude/2005
Western Planning Area (WPA)[2] Pipeline	0	0	0	N/A	N/A
Western Planning Area (WPA)[2] MODU	2	2	0	4	Crude/2002
Western Planning Area (WPA)[2] OSV	1	1	0	0.05	Crude/2014
Western Planning Area (WPA)[2] Tank Ship or Barge	5	5	0	23.8	Crude/2009
Western Planning Area (WPA)[2] Total	155	155	0	–	–
Central Planning Area (CPA)[2] Fixed Platform	2,398	2,398	0	300	Crude/2004
Central Planning Area (CPA)[2] Pipeline	4	4	0	5	Crude/2002
Central Planning Area (CPA)[2] MODU	28	27	1	4,928,100	Crude/2010
Central Planning Area (CPA)[2] OSV	7	7	0	0.07	Crude 2014
Central Planning Area (CPA)[2] Tank Ship or Barge	6	6	0	2	Crude/2013
Central Planning Area (CPA)[2] Total	2,443	2,442	1	–	–
Eastern Planning Area (EPA)[2] Fixed Platform	0	0	0	N/A	N/A
Eastern Planning Area (EPA)[2] Pipeline	0	0	0	N/A	N/A
Eastern Planning Area (EPA)[2] MODU	0	0	0	N/A	N/A

Source	Total Number of Spill Events	Number of Spills (<1,000 bbl)	Number of Spills (≥1,000 bbl)	Maximum Volume of a Single Incident Volume (bbl) of Maximum Spill from the Source	Maximum Volume of a Single Incident Maximum Spill Amount Product/Year
Eastern Planning Area (EPA)[2] OSV	0	0	0	N/A	N/A
Eastern Planning Area (EPA)[2] Tank Ship or Barge	0	0	0	N/A	N/A
Eastern Planning Area (EPA)[2] Total	0	0	0	–	–
Coastal Waters: Texas Fixed Platform	67	67	0	20	Crude/2002
Coastal Waters: Texas Pipeline	14	14	0	10	Crude/2005
Coastal Waters: Texas MODU	5	5	0	0.48	Crude/2002
Coastal Waters: Texas OSV	2	2	0	0.05	Crude/2003
Coastal Waters: Texas Tank Ship or Barge	3	3	0	0.36	Crude/2009
Coastal Waters: Texas Total	91	91	0	–	–
Coastal Waters: Louisiana Fixed Platform	2,022	2,021	1	1,200	Crude/2008
Coastal Waters: Louisiana Pipeline	98	97	1	7,000	Crude/2008
Coastal Waters: Louisiana MODU	4	4	0	0.24	Crude/ 2013
Coastal Waters: Louisiana OSV	17	17	0	3	Crude/2013
Coastal Waters: Louisiana Tank Ship or Barge	2	2	0	50	Crude/2002
Coastal Waters: Louisiana Total	2,143	2,141	2	–	–
Coastal Waters: Mississippi Fixed Platform	1	1	0	0.001	Crude/2008
Coastal Waters: Mississippi Pipeline	0	0	0	N/A	NA
Coastal Waters: Mississippi MODU	0	0	0	N/A	N/A
Coastal Waters: Mississippi OSV	0	0	0	N/A	N/A
Coastal Waters: Mississippi Tank Ship or Barge	1	1	0	0.05	Crude/2002

Source	Total Number of Spill Events	Number of Spills (<1,000 bbl)	Number of Spills (≥1,000 bbl)	Maximum Volume of a Single Incident Volume (bbl) of Maximum Spill from the Source	Maximum Volume of a Single Incident Maximum Spill Amount Product/Year
Coastal Waters: Mississippi Total	2	2	0	–	–
Coastal Waters: Alabama Fixed Platform	2	2	0	0.024	Crude/2007
Coastal Waters: Alabama Pipeline	0	0	0	N/A	N/A
Coastal Waters: Alabama MODU	0	0	0	N/A	N/A
Coastal Waters: Alabama OSV	0	0	0	N/A	N/A
Coastal Waters: Alabama Tank Ship or Barge	0	0	0	N/A	N/A
Coastal Waters: Alabama Total	2	2	0	–	–
Coastal Waters: Florida Fixed Platform	0	0	0	N/A	N/A
Coastal Waters: Florida Pipeline	0	0	0	N/A	N/A
Coastal Waters: Florida MODU	0	0	0	N/A	N/A
Coastal Waters: Florida OSV	0	0	0	N/A	N/A
Coastal Waters: Florida Tank Ship or Barge	0	0	0	N/A	N/A
Coastal Waters: Florida Total	0	0	0	–	–

bbl = barrel; km = kilometer; mi = mile; MODU = mobile offshore drilling unit; N/A = not applicable; nmi = nautical mile; OSV = offshore support vessel; USCG = U.S. Coast Guard.

Note: The reader should note that the spills are reported to the USCG by responsible parties, other private parties, and government personnel. The USCG does not verify the source or volume of every report.

[1] Coastal Waters – The portion of the Gulf of Mexico under State jurisdiction that begins at the coastline and ends at the Federal/State boundary 9 nmi (10.36 mi; 16.67 km) offshore Texas; 3 nmi (3.5 mi; 5.6 km) offshore Louisiana, Mississippi, and Alabama; and 9 nmi (10.36 mi; 16.67 km) offshore Florida.

[2] The data included represent spill events from January 2002 until July 2015.

Offshore Spills

Petroleum spills from OCS oil- and gas-related activities include crude oil, condensate, and refined products such as diesel, hydraulic oil, lube oil, and mineral oil. For spills of synthetic oil products, drilling muds, or chemicals, refer to **Chapter 2.9.1.2**. Spills from facilities include spills from drilling rigs, drillships, and storage, processing, or production platforms that occurred during OCS drilling, development, and production operations. Spills from pipeline operations are those that have occurred on the OCS and are directly attributable to the transportation of OCS oil. Oil-spill information comes from a variety of sources. The BSEE requires operators to report any spill ≥1 bbl occurring on the OCS and maintains a database for all reported incidents. Not included in BSEE's data records are spills <1 bbl. Spills of any size and composition are required to be reported to the USCG's National

Response Center and are further documented in the USCG's Marine Information for Safety and Law Enforcement (2001-present) database and its predecessors. Also not included in BSEE's database are spills that have occurred in Federal waters from OCS barging operations and from other service vessels that support the OCS oil and gas industry. These data are included in the USCG's record of all spills; however, the USCG's database does not include the source of oil (OCS versus non-OCS) or in the case of spills from vessels, the type of vessel operations; such information is needed to determine if a particular spill occurred as a result of OCS operations. Spills from vessels are provided for tankers in worldwide waters and for tankers and barges in U.S. coastal and offshore waters. The latter is a subset of the spills included in the worldwide tanker spill data. These data identify whether the spill occurred "at sea" or "in port' as they can occur due to mishaps during loading, unloading, and taking on fuel oil, and from groundings, hull failures, and explosions. As mentioned previously, a recent report prepared by ABS Consulting Inc (2016) examined the occurrence rates for offshore oil spills gathering data from a variety of sources, including BSEE, the USCG, and the DOT's Pipeline and Hazardous Material Safety Administration. **Tables 2.9.1-3 and 2.9.1-4** provide information on OCS spills ≥1,000 bbl that have occurred offshore in the GOM for the period from 1964 through July 2016.

Table 2.9.1-3. Petroleum[1] Spills ≥1,000 Barrels from United States OCS[2] Platforms, 1964-July 2016.

Date	Leasing Area[3] and Block Number	Water Depth (ft)	Distance to Shore (mi)	Volume Spilled (bbl)	Operator	Facility or Structure and Cause of Spill
4/08/1964	EI 208	94	48	2,559	Continental Oil	Freighter struck Platform A: fire, platform, and freighter damaged
10/03/1964	Hurricane Hilda			11,869[4]	Event Total	5 platforms destroyed during Hurricane Hilda
10/03/1964	EI 208	94	48	5,180	Continental Oil	Platforms A, C, and D destroyed: blowouts (several days)
10/03/1964	SS 149	55	33	5,100	Signal O & G	Platform B destroyed: blowout (17 days)
10/03/1964	SS 199	102	44	1,589	Tenneco Oil	Platform A destroyed: lost storage tank
7/19/1965	SS 29	15	7	1,688[5]	PanAmerican	Well #7 drilling: blowout (8 days), minimal damage
1/28/1969	6B 5165 Santa Barbara Channel, California	190	6	80,000	Union Oil	Well A-21 drilling: blowout (10 days); 50,000 bbl during blowout phase; subsequent seepage of 30,000 bbl (over decades); 4,000 birds killed; considerable oil on beaches; platform destroyed
3/16/1969	SS 72	30	6	2,500	Mobil Oil	Submersible rig *Rimtide* drilling in heavy seas bumped by supply vessel
2/10/1970	MP 41	39	14	65,000[6]	Chevron Oil	Platform C: rig shifted and sheared wellhead, blowout (3-4 days), fire of unknown origin, blowout 12 wells (49 days), lost platform, minor amounts of oil on beaches
12/1/1970	ST 26	60	8	53,000	Shell Oil	Platform B: wireline work, gas explosion, fire, blowout (138 days), lost platform and 2 drilling rigs, 4 fatalities, 36 injuries, minor amounts of oil on beaches

Date	Leasing Area[3] and Block Number	Water Depth (ft)	Distance to Shore (mi)	Volume Spilled (bbl)	Operator	Facility or Structure and Cause of Spill
1/09/1973	WD 79	110	17	9,935	Signal O & G	Platform A: oil storage tank structural failure
1/26/1973	PL 23	61	15	7,000	Chevron Oil	Platform CA: storage barge sank in heavy seas
11/23/1979	MP 151	280	10	1,500[7]	Texoma Production	MODU Pacesetter III: diesel tank holed, workboat contact in heavy seas
11/14/1980	HI 206	60	27	1,456	Texaco Oil	Platform A: storage tank overflow during Hurricane Jeanne evacuation
9/16/2004	MC 20	475	9	Ongoing Event[8] *Possibly* >175,000	Taylor Energy Company	Platform A toppled by undersea mudslide that was triggered by Hurricane Ivan; facility had 25 unabandoned wells.
9/24/2005	Hurricane Rita			5,066[9]	Event Total	1 platform and 2 rigs destroyed by Hurricane Rita
9/24/2005	EI 314	230	78	2,000[5]	Forest Oil	Platform J: destroyed, lost oil on board and in riser
9/24/2005	SM 146	238	78	1,494[10]	Hunt Petroleum	Jack-up Rig Rowan Fort Worth: swept away, never found
9/24/2005	SS 250	182	69	1,572[10]	Remington O & G	Jack-up Rig Rowan Odessa: legs collapsed
04/20/2010	MC 252	4,992	53	4.9 million[11]	BP E & P	*Deepwater Horizon* Rig: gas explosion, blowout (86 days to cap well), fire, drilling rig sank, 11 fatalities, multiple injuries, considerable oil on beaches, wildlife affected, temporary closure of area fisheries

Notes: barrel (bbl) = 42 gallons, billion = 10^9, MODU = mobile offshore drilling unit

Between 1964 and 2009, over 17.5 billion bbl of oil and 176.1 million cubic feet of natural gas were produced on the OCS.

[1]Crude oil release unless otherwise noted; no spill contacts to land unless otherwise noted.

[2]Outer Continental Shelf (OCS) – submerged lands, subsoil, and seabed administered by the U.S. Federal Government (http://www.boem.gov/Governing-Statutes/).

[3]Gulf of Mexico leasing area unless otherwise noted (official protraction diagrams, http://www.boem.gov/Official-Protraction-Diagrams/l): EI = Eugene Island, HI = High Island, MC = Mississippi Canyon, MP = Main Pass, PL = South Pelto, SS = Ship Shoal, SM = South Marsh Island, ST = South Timbalier, and WD = West Delta.

[4]Hurricane Hilda, 10/3/1964: platform spills ≥1,000 bbl at 3 facilities totaled 11,869 bbl; treated as 1 spill event.

[5]Condensate – a liquid product of natural gas production.

[6]Spill volume estimate between 30,000 and 65,000 bbl, previously reported as 30,000 bbl.

[7]Diesel fuel.

[8]The MC 20 oil spill/pollution event is ongoing with sheening observed at the site near daily since September 2004. Current government response efforts and spill containment program has resulted in oil recovery rates averaging from 25 to 30 bbl per day; equating to potential oil spill volumes up to 10,950 bbl each year. Not considering fluctuations in release rates and the current collection system inefficiencies (i.e., sheening continues at the site despite containment efforts), the MC 20 spill may have released over 175,000 bbl, and rising, since the platform's toppling.

[9]Hurricane Rita, 9/24/2010: platform and 2 rig losses ≥1,000 bbl at 3 locations totaled to 5,066 bbl; treated as 1 spill event. The 5,066-bbl spill was a "passive" spill based on unrecovered pre-storm inventories from the platform and 2 rigs; no spill observed; no response required.

[10]Diesel fuel and other refined petroleum products stored on rig.

[11]The Federal Interagency Solutions Group 2010.

Sources: ABS Consulting Inc 2016; Anderson et al. 2012.

Table 2.9.1-4. Petroleum[1] Spills ≥1,000 Barrels from United States OCS[2] Pipelines, 1964-July 2016.

Date	Leasing Area[3] and Block Number	Water Depth (ft)	Distance to Shore (mi)	Volume Spilled (bbl)	Operator	Pipeline Segment (pipeline authority[4]) Cause/Consequences of Spill
10/15/1967	WD 73	168	22	160,638	Humble Pipeline	12" oil pipeline, Segment #7791 (DOT): anchor kinked, corrosion, leak
3/12/1968	ST 131	160	28	6,000	Gulf Oil	18" oil pipeline, Segment #3573 (DOT): barge anchor damage
2/11/1969	MP 299	210	17	7,532	Chevron Oil	4" gas pipeline, Segment #3469 (DOT): anchor damage
5/12/1973	WD 73	168	22	5,000	Exxon Pipeline	16" gas & oil pipeline, Segment #807 (DOT): internal corrosion, leak
4/17/1974	EI 317	240	75	19,833	Pennzoil	14" oil Bonita pipeline, Segment #1128 (DOI): anchor damage
9/11/1974	MP 73	141	9	3,500	Shell Oil	8" oil pipeline, Segment #36 (DOI): Hurricane Carmen broke tie-in to 12" pipeline, minor contacts to shoreline, brief cleanup response in Chandeleur Area
12/18/1976	EI 297	210	17	4,000	Placid Oil	10" oil pipeline, Segment #1184 (DOI): trawl damage to tie-in to 14" pipeline
12/11/1981	SP 60	190	4	5,100	Atlantic Richfield	8" oil pipeline, Segment #4715 (DOT): workboat anchor damage
2/07/1988	GA A002	75	34	15,576	Amoco Pipeline	14" oil pipeline, Segment #4879 (DOT): damage from illegally anchored vessel
1/24/1990	SS 281	197	60	14,423[5]	Shell Offshore	4" condensate pipeline, Segment #8324 (DOI): anchor damage to subsea tie-in
5/06/1990	EI 314	230	78	4,569	Exxon	8" oil pipeline, Segment #4030 (DOI): trawl damage
8/31/1992	PL 8	30	6	2,000	Texaco	20" oil pipeline, Segment #4006 (DOT): Hurricane Andrew, loose rig Treasure 75, anchor damage, minor contacts to shoreline, brief cleanup response
11/16/1994	SS 281	197	60	4,533[5]	Shell Offshore	4" condensate pipeline, Segment #8324 (DOI): trawl damage to subsea tie-in
1/26/1998	EC 334	264	105	1,211[5]	Pennzoil E & P	16" gas & condensate pipeline, Segment #11007 (DOT): anchor damage to tie-in to 30" pipeline, anchor dragged by vessel in man-overboard response
9/29/1998	SP 38	108	6	8,212	Chevron Pipe Line	10" gas & oil pipeline, Segment #5625 (DOT): Hurricane Georges, mudslide damage, small amount of oil contacted shoreline
7/23/1999	SS 241	133	50	3,200	Seashell Pipeline	12" oil pipeline, Segment #6462 & Segment #6463 (DOT): "Loop Davis" jack-up rig, barge crushed pipeline when sat down on it
1/21/2000	SS 332	435	75	2,240	Equilon Pipeline	24" oil pipeline, Segment #10903 (DOT): anchor damage from MODU under tow
9/15/2004	MC 20	479	9	1,720[6]	Taylor Energy	6" oil pipeline, Segment #7296 (DOI): Hurricane Ivan, mudslide damage
9/13/2008	HI A264	150	73	1,316[7]	HI Offshore System	42" gas pipeline, Segment #7364 (DOT): Hurricane Ike, anchor damage parted line

Date	Leasing Area[3] and Block Number	Water Depth (ft)	Distance to Shore (mi)	Volume Spilled (bbl)	Operator	Pipeline Segment (pipeline authority[4]) Cause/Consequences of Spill
7/25/2009	SS 142	60	30	1,500	Shell Pipe Line	20" oil pipeline, Segment #4006 (DOT): micro-fractures from chronic contacts at pipeline crossing caused failure (separators between pipelines missing)
5/11/2016[8]	GC 248	3,500	97	2,100	Shell Offshore	6" oil pipeline, Segment #14371 (DOI): cracked collar on jumper line connecting well head to pipeline network

Notes: barrel (bbl) = 42 gallons, billion = 10^9, MODU = mobile offshore drilling unit.

Between 1964 and 2009, over 17.5 billion bbl of oil and 176.1 thousand cubic feet of natural gas were produced on the OCS.

[1] Crude oil release unless otherwise noted; no spill contacts to land unless otherwise noted.

[2] Outer Continental Shelf (OCS) – submerged lands, subsoil, and seabed administered by the U.S. Federal Government (http://www.boem.gov/Governing-Statutes/).

[3] Gulf of Mexico leasing area unless otherwise noted (official protraction diagrams, http://www.boem.gov/Official-Protraction-Diagrams/l): EC = East Cameron, EI = Eugene Island, GA = Galveston, HI = High Island, MC = Mississippi Canyon, MP = Main Pass, PL = South Pelto, SS = Ship Shoal, SP = South Pass, ST = South Timbalier, and WD = West Delta.

[4] Pipeline authority: DOI = U.S. Department of the Interior, Bureau of Ocean Energy Management (formerly Bureau of Ocean Energy Management, Regulation and Enforcement; and Minerals Management Service) ; DOT = U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration.

[5] Condensate – a liquid product of natural gas production.

[6] The 1,720-bbl spill based on unrecovered pre-storm inventory within the segment prior to the undersea mudslide.

[7] The 1,316-bbl spill was a “passive” spill based on unrecovered pre-storm inventory in the segment parted by storm; no spill observed, no response required.

[8] This incident is still under investigation and the information provided here should be considered preliminary.

Sources: ABS Consulting Inc 2016; Anderson et al. 2012.

Taylor Energy Company Oil Discharge in the Mississippi Canyon Area Block 20 Site and Ongoing Federal Response Efforts

In September 2004, Hurricane Ivan caused a massive undersea mudslide just south of the Mississippi River Delta that toppled Taylor Energy Company’s (TEC) Platform A in Mississippi Canyon Area Block 20 (MC20), which is located about 9 mi (14 km) southeast of the nearest Louisiana shoreline in about 134-143 m (440-470 ft) of water (**Figure 2.9.1-5**).

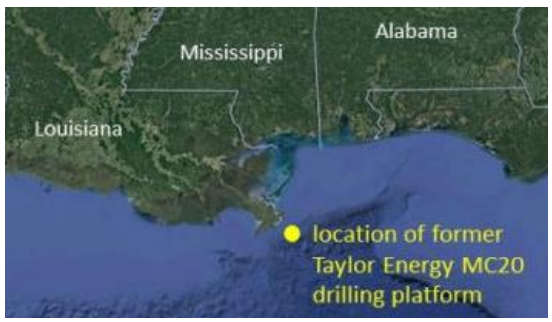


Figure 2.9.1-5. MC20 Location (Photo credit: Google).

The mudflow lobe that toppled the platform also sheared the eight jacket piles and bent/pulled the conductors from the jacket while depositing an average of 45 m (150 ft) of sediments on the site (Fugro-McClelland Marine Geosciences Inc. 2007). As a result, the mostly intact platform jacket and deck moved 137-213 m (450-700 ft) downslope from its original location and lies partially buried in a horizontal position on the seabed (**Figure 2.9.1-6**).

Prior to the storm and mudslide event, the platform’s well bay contained 28 separate, 30-in diameter well conductors; however, none of the wells were permanently abandoned in accordance with OCSLA regulations. Post-storm surveying indicates that the conductors were possibly bent near the original well bay location and pulled in the direction of the jacket and are currently buried 21-45 m (70-150 ft) below the mudline. During early recovery efforts, TEC tried to excavate sediments from the former platform site to gain access to the wells; however, the volume of sediments made the jetting efforts ineffective.

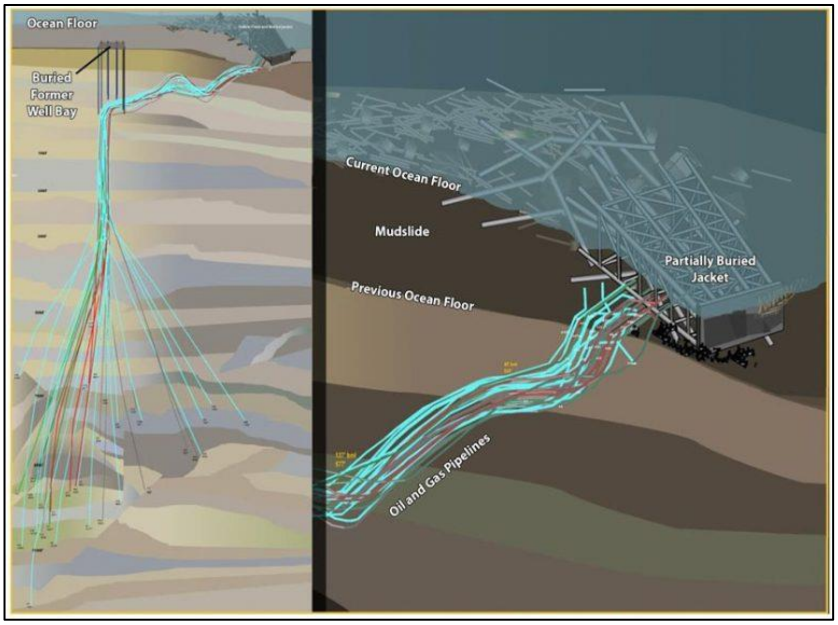


Figure 2.9.1-6. Illustration of the Collapsed Well Jacket and Damaged Pipes from Taylor Energy Company's Mississippi Canyon Area Block 20 Platform (Photo credit: Mason et al. 2019).

Initial Well Intervention and Pollution Containment Activities, 2009-2013

Pollution was observed over the site nearly every day since the toppling event occurred, often resulting in surface sheens that stretch for several miles. In response, a Unified Command was established and the USCG issued Administrative Order No. 006-008, which instructed TEC to identify the source(s) of the pollution event and provide spill response capable of containing and recovering all pollution discharges coming from the site. Seabed plumes consisting of crude oil and gas were eventually discovered near the original platform location and on the northeast side of the downed jacket, and a pollution containment system was designed and fabricated. Deployed to the site in 2009, the TEC pollution containment system functioned with limited success until equipment problems, seabed conditions, and minimal maintenance/repairs led to its disuse in 2013. The remaining TEC pollution containment system containment domes and collector/separator assembly are all currently partially/completely buried in the seabed around the downed jacket and are inoperable. The pollution event continued with daily sheening over/from the location. In addition to the USCG pollution containment efforts, the Minerals Management Service (predecessor agency of BSEE/BOEM) developed a team to help identify the wells with the highest potential for flow and establish an intervention/abandonment program to secure them. Between January 2009 and March 2011, nine intervention wells were drilled. Despite the intervention work, however, daily sheening over/from the location continued.

MC20 Survey/Study Efforts, 2017-2018

With the pollution/sheening continuing, the USCG issued a second Administrative Order to TEC in 2012 for development, fabrication, installation, and maintenance of a new pollution containment system. In response to the order, TEC independently contracted a 2015 remote-sensing survey of the former well bay and jacket locations to determine whether (1) a distinct release point/location for the leaking oil from the seabed could be identified and (2) if a new system could/should be installed or not. The TEC maintained that the surface sheen was the result of remnant/sediment-entrapped oil being sparged from the sediment due to the effects of current excavation and other phenomena. Therefore, the Unified Command established a Sheen Source Location Working Group with TEC, USCG, BSEE, BOEM, and NOAA members to develop surveying methodologies to detect where the oil was emanating for the Federal On-Scene Coordinator to execute containment.

However, after several months of discussions without an agreed-upon survey plan, BSEE, in coordination with the Unified Command, contracted *Norbit Subsea* to conduct a remote-sensing/ROV survey of the seabed at MC20. The Norbit-BSEE survey was conducted in September of 2017 and identified what appeared to be two large plumes coming from a large pit on the northeast end of the downed jacket. The plumes consisted of gas and oil and remained in the same locations throughout the entire survey period. Additionally, large globules/droplets of oil were observed in the plume on the ROV cameras ranging up to 1 in (25 mm) in diameter. Droplet sampling and testing conducted/managed by the USCG on the survey indicated that the samples contained components found in new/fresh oil and that it was not heavily weathered (NORBIT 2017).

Shortly after the Norbit-BSEE survey, TEC conducted a surface-/pole-mounted sonar survey. The TEC survey identified plumes coming from the same location as the Norbit-BSEE survey. However, TEC reported that the plumes were dynamic; in that, there was sometimes only a single plume and that the plume(s) moved around dozens of feet within the pit multiple times during their 2 weeks of surface surveying. The TEC asserted that the pit sediments were extremely saturated with remnant oil and that extremely small droplets of oil (ranging up to 7 microns [0.007 mm or 0.0002 in] in diameter) were continuing to be sparged from the sediments. The TEC survey, however, failed to conduct any subsea surveying or collect/test any new sediment samples. The TEC also countered that the gas observed during the Norbit-BSEE survey and TEC survey was from biogenic, shallow gas around the pit area, which they theorized was the driving mechanism for the micro-droplet release from the sediments as the gas passed through the oil-soaked sediments.

In September 2018, NOAA's National Centers for Coastal Ocean Science, BSEE, and other partners conducted 7 days of field operations to collect data for an integrated survey (2018 NOAA-BSEE survey) of conditions at the MC20 site (Mason et al. 2019). Multiple vessel- and ROV-mounted sonars performed numerous scans over the site, identifying four individual plumes (A-D) with distinct products coming from each. Plumes A and B discharged mostly oil globules/droplets and were approximately 8 ft (2.4 m) in diameter. Plume C released large combinations of oil and gas, and Plume D mostly consisted of gas; both of which were approximately 12-15 ft (4-5 m) in diameter. The four plumes remained constant in location, products, and intensity throughout several days of repeated scanning and ROV video observations. Additionally, the oil droplet sizes observed/recorded during the NOAA-BSEE survey were also similar to those observed during the Norbit-BSEE survey.

Over 165 oil, gas, and sediment samples were collected and analyzed during the 2018 NOAA-BSEE survey. Similar to the analyses of the Norbit-BSEE survey samples, the results indicated that the oil contained volatile components that are not found in weathered oil and that the gas was not attributed to a primarily biogenic source. Information regarding the specific methodologies and associated assumptions, provisions, concerns, and results are detailed in the final survey report prepared by NOAA's National Centers for Coastal Ocean Science (Mason et al. 2019) and are available on NOAA's website at https://repository.library.noaa.gov/view/noaa/20612. The aggregate estimates and final draft of the survey report were presented to DOI/BSEE management by NOAA's chief scientist for consideration in the development of an Administrative Order for TEC's resumption of well abandonment work.

Supplemental Pollution Containment Activities, 2018-Present

In July 2018, the USCG underwent efforts to renew and augment interagency coordination on the MC20 response that led to a restructuring of the MC20 Unified Command. The BSEE, in its revised role as Source Control Support Coordinator, provided the Norbit-BSEE survey report and several preliminary findings of the 2018 NOAA-BSEE survey to the USCG/Federal On-Scene Coordinator. The BSEE data were then incorporated into an evaluation of TEC's standing presumptions by an interagency team (e.g., USCG, NOAA, BSEE, and BOEM) at a workshop hosted by BSEE in October 2018. The team discussed and outlined the inconsistencies between the Federal assumptions and funded survey findings and the TEC's assumptions and funded survey findings. At the conclusion of the workshop, the USCG led the development of the following Federal Position regarding the MC20 pollution event:

- one or more wells are actively discharging oil and gas from the erosional pit;
- the worst-case estimate of the daily volume of release far exceeds previous estimates and is in the order of hundreds of barrels per day; and
- temporary containment and recovery of oil being discharged at the erosional pit near the former Dome C location is needed and feasible while a more permanent solution to stopping the source is developed.

Following the workshop, Administrative Order No. 19-001 outlined the Federal Position and instructed TEC to design, fabricate, install, and maintain a new containment system to capture oil from the ongoing pollution event and stop the daily sheening. When TEC failed to comply with the Federal On-Scene Coordinator's instructions, the USCG partially assumed response actions under Section 311(c) of the Federal Water Pollution Control Act and issued TEC a Notice of Federal Assumption on November 16, 2018. As outlined in the Notice of Federal Assumption, the USCG contracted Couvillion Group, LLC (Couvillion) to oversee the containment system design, fabrication, installation, and maintenance and prohibited TEC from participating in the associated response efforts.

In December 2018, Couvillion contracted Oceaneering International, Inc. to conduct an additional survey of the site to confirm the presence/composition of the plumes and conduct a high-resolution scan of the downed facility, which would be used to design their containment system. Oceaneering International, Inc.'s sonar survey was compared to the 2018 NOAA-BSEE survey and reconfirmed the identical locations and compositions of the four plumes. Couvillion and Oceaneering International, Inc. used the detailed survey data to design and fabricate their rapid response system, which utilizes the downed jacket as a fixed foundation for the system components, allowing a porch to remain suspended over the plumes without contact with the seabed, reducing the potential for sediment blockage. A large, adjustable dome is mounted to the porch capturing oil and gas coming from the seabed for transfer to a separator unit that removes the gas and reservoir water, which allows the oil to pass on to a set of five containment/storage caissons mounted to the top of the jacket (**Figure 2.9.1-7**). The rapid response system was installed to structural members on the downed jacket using a team of saturation divers and a support ROV between February and April 2019.

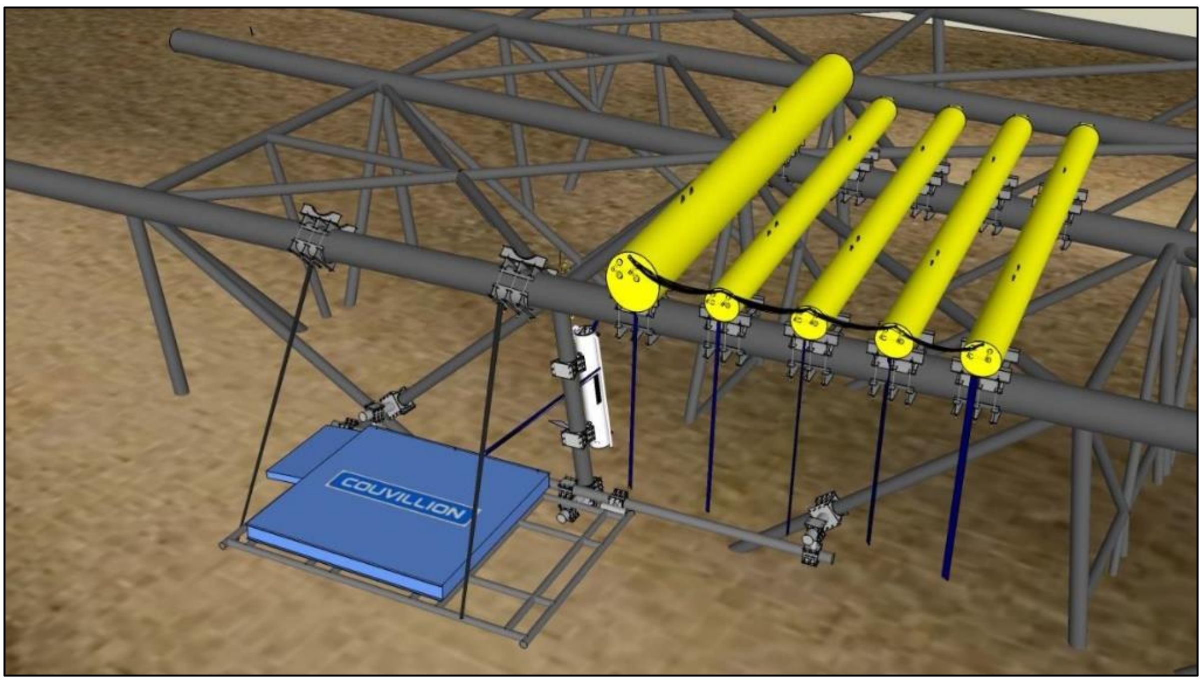


Figure 2.9.1-7. Digital Rendering of the Couvillion Rapid Response System Deployed for the Mississippi Canyon Block 20 Pollution Event Response.

The rapid response system is designed to store up to 1,350 bbl of captured oil; therefore, regularly scheduled "pump-off' operations are managed by the USCG and Couvillion to transfer the collected oil from the caissons up to storage tanks on an offshore service vessel. Once pumped and secure in the storage tanks, the offshore service vessel returns the oil to shore for proper processing. The USCG/Couvillion monitors all collection/transfer volumes, calculates the capture rates, and modifies the pump-off schedules to ensure that system capacity is not compromised. Additionally, pumping operations can be conducted earlier than planned in order to compensate for rapid response system maintenance intervals and weather. Currently, pump-off intervals average every 30 days and they are projected to continue for the foreseeable future or until the flow is stopped. Capture rates calculated from the volumes collected during the pump-offs average between 25 and 31 bbl per day.

Flow Rate Estimates/Capture Daily Volumes for the Continued MC20 Pollution Event

A breakdown of the various flow-rate/release estimates are provided in **Table 2.9.1-5**, along with the average daily volume calculated from the oil captured/recovered from the Couvillion rapid response system. It is expected that continued capture/recovery efforts could result in decreased or increased volumes, dependent upon possible reservoir fluctuations and recharging, drawdowns, and system performance. The USCG and Couvillion carried out a maintenance and refit operation on the rapid response system in February-March 2020 to flush the system and install additional “skirting” around the dome perimeter to help increase the efficiency of the system and reduce the amount of oil loss due to currents and other natural events.

Table 2.9.1-5. Mississippi Canyon Block 20 Pollution Volume Estimates.

Source	Methodology	Type	Volume Ranges (bbl/day)
TEC	Various sediment studies, acoustic data, and modeling	Release estimate	0.079-0.145
NOAA NCCOS	Acoustic survey analysis	Release estimate	9-47
FSU	Video bubble chamber/“Bubblometer”	Release estimate	19-108
Couvillion RRS	Daily-average calculations from captured oil	Captured volume	25-31

bbl = barrel; FSU = Florida State University; NCCOS = National Centers for Coastal Ocean Science; NOAA = National Oceanic and Atmospheric Administration; RRS = rapid response system; TEC = Taylor Energy Company

Pending and Future Response Needs

Despite the proven effectiveness of the rapid response system, it was only intended to serve as a temporary containment mitigation while a more permanent solution was developed. Considering that future GOM storms or subsea mudslide events have the potential to damage and/or destroy the system, the USCG, NOAA, BOEM, and BSEE have continued their coordination to focus response efforts on permanent source control. The interagency team concluded that the NOAA/Florida State University flow-rate estimates and rapid response system-capture volumes confirm that the source of the pollution is from one or more of TEC’s wells; therefore, permanent source control can only be attained through the requisite plugging and abandonment of the associated wells.

Abandonment regulations are implemented by BSEE under 30 CFR part 250 subpart Q. To assess the feasibility of abandonment methodologies, BSEE contracted a technical review of current abandonment options for use at MC20, considering site conditions, logistics, effectiveness, regulatory compliance, and incorporation of the best available and safest technology. The findings were developed into a report that BSEE will reference during review of TEC's abandonment proposal(s). The BSEE is finalizing a third administrative order that will summarize the results of the recent flow-rate research, survey reports, and technical reviews, as well as summarize the additional well abandonment being ordered to address TEC's outstanding regulatory obligations and the ongoing hazards to safety and the environment at MC20 from the ongoing spill and pollution event.

On December 22, 2021, a Federal District Court found Taylor Energy liabile for well decommissioning and affected environment restoration. Taylor has been ordered to provide DOI $432 million towards decommissioning efforts. The settlement was finalized on March 18, 2022, and includes $16.5 million to fund coastal natural resource restoration projects. In an effort to manage the restoration projects, BOEM, BSEE, and the USCG signed a Memorandum of Agreement on December 6, 2022.

As a part of the natural resource restoration efforts, PanGeo Subsea conducted a Full-Field Subsurface Survey to determine the extent, expanse, orientation, and characteristics of the well conductors and other below mudline components at the MC20 site. Data collected from the survey will be used to help develop options and plans for decommissioning. Subsurface scanning was completed in July 2022.

Shell Offshore Pipeline Spill in Green Canyon Block 248

On May 12, 2016, the USCG responded to an offshore oil spill that reportedly discharged from a Shell subsea wellhead flow line, approximately 90 mi (145 km) south of Timbalier Island, Louisiana, in Green Canyon Block 248. The release came from the Glider subsea system, which ties back to the Brutus platform in Green Canyon Block 158. The volume of the release was estimated at 2,100 bbl. Response efforts included on-water recovery vessels and skimming operations. There have been no reported impacts to wildlife or fisheries, and the sheen did not make contact with the shoreline. This information is preliminary and BSEE personnel are leading an investigation to determine the cause of the release and the effectiveness of the on-water response. Due to the timing of this event, this spill was not included in the ABS Consulting Inc's (2016) *Update of Occurrence Rates for Offshore Oil Spills*.

Spill Prevention

Beginning in the 1980s, BOEM (then the Minerals Management Service) established comprehensive pollution-prevention requirements that include redundant safety systems, as well as inspection and testing requirements to confirm that these devices are working properly (**Chapter 5.13**). Until the *Deepwater Horizon* explosion, oil spill, and response, an overall reduction in spill volume had occurred during the previous 40 years, while oil production had generally increased. BOEM attributes this improvement to BOEM and BSEE's operational requirements, ongoing efforts by the oil and gas industry to enhance safety and pollution prevention, and the evolution and improvement of offshore technology.

2.9.1.2 Chemical Spills

Chemical and synthetic-based drilling fluids are used in offshore oil and gas drilling and production activities, and may be accidentally spilled into the environment due to equipment failure, weather (i.e., wind, waves, and lightning), collision, and human error.

Chemicals are stored and used to condition drilling muds during production and in well completions, stimulation, and workover procedures. The relative quantity of their use is reflected in the largest volumes spilled. Well completion, workover, and treatment fluids, including zinc bromide, are the largest quantities used and are typically the largest accidental releases. Zinc bromide is of particular concern because it is persistent (nondegradable) and is comparatively toxic. A study of chemical spills from OCS oil- and gas-related activities in the GOM determined that only two chemicals could potentially impact the marine environment – zinc bromide and ammonium chloride (Boehm et al. 2001a). Ammonium chloride dissolves in seawater and undergoes several transformations to produce ammonia, which is toxic to fish and other marine life. Other common chemicals spilled include methanol and ethylene glycol, which are used in deepwater operations where gas hydrates tend to form due to cold temperatures. These alcohol-based chemicals are nonpersistent (degradable) and exhibit comparatively low toxicity.

The SBF has typically been used since the mid-1990s for the deeper well sections because SBF has superior performance properties. The synthetic oil used in SBF is relatively nontoxic (compared to crude oil) to the marine environment and has the potential to biodegrade. However, SBF is considered more toxic than water-based fluid, and spills of SBF are categorized separately from water-based fluid releases. Accidental riser disconnections can result in the release of large quantities of drilling fluids like SBFs.

The BSEE reports spill statistics for chemicals and SBFs in categories of 10-49 bbl (small spills) and >50 bbl (large spills) in the GOM (BSEE 2015d). During the period of 2007-2012, small SBF spills occurred at an average annual volume of 24.2 bbl, while large spills occurred at an annual average volume of 317.9 bbl. During the same period, small chemical spills occurred at an average volume of 15.9 bbl, while large chemical spills occurred at an average annual volume of 231.9 bbl. A spike in the volume of large chemical spills in 2008 is attributed to Hurricane Ike, which occurred on September 13, 2008.

2.9.1.3 Pipeline, Umbilical, or Jumper Failures

Significant sources of damages to OCS pipeline infrastructure can be caused by corrosion, physical pipeline stress due to location, mass sediment movements and mudslides that can exhume or push the pipelines into another location, and accidents due to weather or impacts from anchor drops or boat collisions. Pipelines that carry two-phase fluids (i.e., oil-gas and gas-condensate) are more prone to corrosion than single-phase fluids. Crude with high water vapor and sulfur content, and gas with high sulfur, CO_2, and water vapor content are corrosive, and the lower the flow pressure, the more corrosive the impact. Seafloor resistivity, water salinity, and seabed composition may promote corrosive activity and affect the probability of active corrosion. Pipelines that are inactive for a long period of time may not maintain their catholic protection (Mélot et al. 2009) and are more exposed to natural disturbances (e.g., hurricanes, slope failures, etc.), stress-induced motions, and third-body impacts.

Long unsupported pipelines subjected to strong bottom currents would experience vortex-induced vibrations, which substantially increase pipeline fatigue. Two potential causes for pipeline failure are regional-scale hydrodynamic forces and vortex-induced vibrations. Hydrodynamic forces are of most concern to pipelines with multiple unsupported spans. In conjunction with strong episodic events, these pipelines may experience lateral instability and movement. Although the effects of hydrodynamic forces warrant attention, vortex-induced vibrations are perhaps of greatest concern.

Hurricanes can be a destructive force involved in pipeline failures. Numerous pipelines were damaged after the 2004-2008 hurricanes passing through the CPA and WPA in the Gulf of Mexico. Following the 2004, 2005, and 2008 hurricane seasons in the GOM, BOEM commissioned studies to examine the failure mechanisms of offshore pipelines (Atkins et al. 2007; Atkins et al. 2006; Energo Engineering 2010). Much of the reported damage was riser or platform-associated damage, which typically occurs when a platform is toppled or otherwise damaged. While many pipelines were damaged, few resulted in a spill >50 bbl.

The largest spills in the GOM were typically due to pipeline movements, mudslides, anchor drops, and collisions of one type or another. Most pipeline damage occurs in shallow water (<200 ft; 61 m) because of the potential for increased impacts of the storm on the seabed in shallow water, the relative density of pipelines, or the age and design standards of the pipeline or the platforms to which the pipelines are connected. The future impact of hurricanes on damage to pipelines is uncertain. As part of the evacuation process during a hurricane, offshore personnel activate the applicable shut-in procedure, which can frequently be accomplished from a remote location. This involves closing the subsurface safety valves located below the surface of the ocean floor to prevent the release of oil or gas. During previous hurricane seasons, the shut-in valves functioned 100 percent of the time, efficiently shutting in production from wells on the OCS and protecting the marine and coastal environments. Shutting-in oil and gas production is a standard procedure conducted by industry for safety and environmental reasons (BSEE 2018b). As oil production shifts from shallow to deeper water, there may be a consolidation of pipeline utilization.

In the GOM, lack of awareness of the precise location of the pipeline has been a major contributing factor to accidents involving pipelines. An OCS-related spill ≥1,000 bbl would likely be from a pipeline accident; the median spill size is estimated to be 2,200 bbl for rig/platform and pipeline activities.

2.9.1.4 Losses of Well Control

All losses of well control are required to be reported to BSEE. In 2006, BOEM and BSEE's predecessor (the Minerals Management Service) revised the regulations for loss of well control incident reporting, which were further clarified in NTL No. 2010-N05, "Increased Safety Measures for

Energy Development on the OCS." Operators are required to document any loss of well control event, even if temporary, and the cause of the event by mail or email to the addressee indicated in the NTL. The operator does not have to include kicks that were controlled, but the operator should include the release of fluids through a flow diverter (a conduit used to direct fluid flowing from a well away from the drilling rig). The current definition for loss of well control is as follows:

- uncontrolled flow of formation or other fluids (the flow may be to an exposed formation [an underground blowout] or at the surface [a surface blowout]);
- uncontrolled flow through a diverter; and/or
- uncontrolled flow resulting from a failure of surface equipment or procedures.

Not all loss of well control events would result in a blowout as defined above, but it is most commonly thought of as a release to the human environment. A loss of well control could occur during any phase of development, i.e., exploratory drilling, development drilling, well completion, production, or workover operations. A loss of well control could occur when improperly balanced well pressure results in sudden, uncontrolled releases of fluids from a wellhead or wellbore (Neal Adams Firefighters Inc. 1991; PCCI Marine and Environmental Engineering 1999).

Of the 48 loss of well control events reported in the GOM from 2007 to 2015, 26 (54%) resulted in loss of fluids at the surface or underground (BSEE 2015c).

The BSEE reports 288 unique loss of well control incidents captured in their database from 1956 through 2010 (Herbst 2014), with an additional 22 incidents documented from 2010 through August 2015. A synopsis conducted by BSEE of the 288 well incidents that occurred from 1956 through 2010 shows the following:

- 69 of the 288 incidents had a duration ≥5 days (24%);
- 55 of the 69 incidents occurred in water depths <300 ft (91 m) (80%);
- 42 of the 69 incidents occurred within 50 mi (80 km) of shore (61%);
- a total of 31 fatalities occurred in 5 of the 69 incidents;
- a total of 84 injuries occurred in 7 of the 69 incidents; and
- 8 of the 69 incidents were oil blowouts (12%).

In contrast, the *Deepwater Horizon* oil spill continued uncontained for 87 days, between April 20 and July 15, 2010. The *Deepwater Horizon* explosion in Mississippi Canyon Block 252 resulted in the release of 4.9 MMbbl of oil and large quantities of gas (McNutt et al. 2011). For purposes of calculating the maximum possible civil penalty under the Clean Water Act, a January 2015 judgment used a quantity of 4.0 MMbbl of oil for total discharged and 3.19 MMbbl of oil as the actual amount that was released into the environment (Barbier and Shushan 2015). As shown by the

Deepwater Horizon explosion and oil spill, the loss of well control in deep water presents obstacles and challenges that differ from a loss of well control in shallow waters. Although many of the same techniques used for wild well control efforts in shallow water were used to attempt to control the *Macondo* well, these well control efforts were hindered by water depth, which required reliance solely upon the use of ROVs for all well intervention efforts. This is a concern in deep water because the inability to quickly regain control of a well increases the size of a spill.

There are several options that can be attempted to control a well blowout. Common kill techniques include (1) bridging, (2) capping/shut-in, (3) capping/diverting, (4) surface stinger, (5) vertical intervention, (6) offset kill, and (7) relief wells (Neal Adams Firefighters Inc. 1991). Although much has been learned about well control as a result of the *Deepwater Horizon* explosion, oil spill, and response, if a deepwater subsea blowout occurs in the future, it is still likely that an operator would be required to immediately begin to drill one or more relief wells to gain control of the well. This may be required whether or not this is the first choice for well control because a relief well is typically considered the ultimate final solution for regaining well control in such circumstances. Although it can take months, the actual amount of time required to drill the relief well depends upon the following: (1) the depth of the formation below the mudline; (2) the complexity of the intervention; (3) the location of a suitable rig; (4) the type of operation that must be terminated in order to release the rig (e.g., may need to complete a casing program before releasing the rig); and (5) any problems mobilizing personnel and equipment to the location.

The major difference between a blowout during the drilling phase versus the completion or workover phases is the tendency for a drilling well to “bridge off.” Bridging is a phenomenon that occurs when severe pressure differentials are imposed at the well/reservoir interface and the formation around the wellbore collapses and seals the well. Deepwater reservoirs are susceptible to collapse under “high draw down” conditions. However, a completed well may not have the same tendency to passively bridge off as would a drilling well involving an uncased hole. Bridging would have a beneficial effect for spill control by slowing or stopping the flow of oil from the well (PCCI Marine and Environmental Engineering 1999). There is a difference of opinion among blowout specialists regarding the likelihood of deepwater wells bridging naturally in a short period of time. Completed wells, or those in production, have more severe consequences in the event of a blowout due to the hole being fully cased down to the producing formation, which lowers the probability of bridging (PCCI Marine and Environmental Engineering 1999). Therefore, the potential for a well to bridge is greatly influenced by the phase of a well. Refer to **Chapter 2.9.2.3** for a discussion of planned well-source containment options that were designed to address an ongoing loss of well control event.

Blowout Preventers

A blowout preventer (BOP) is a device with a complex of choke lines and hydraulic rams mounted atop a wellhead designed to close the wellbore with a sharp horizontal motion that can cut through or pinch shut well casing and sever tool strings (**Figure 2.9.1-8**). The BOPs were invented in the early 1920s and have been instrumental in ending dangerous, costly, and environmentally damaging oil gushers on land and in water. The BOPs have been required for OCS oil and gas operations from the time offshore drilling began in the late 1940s.

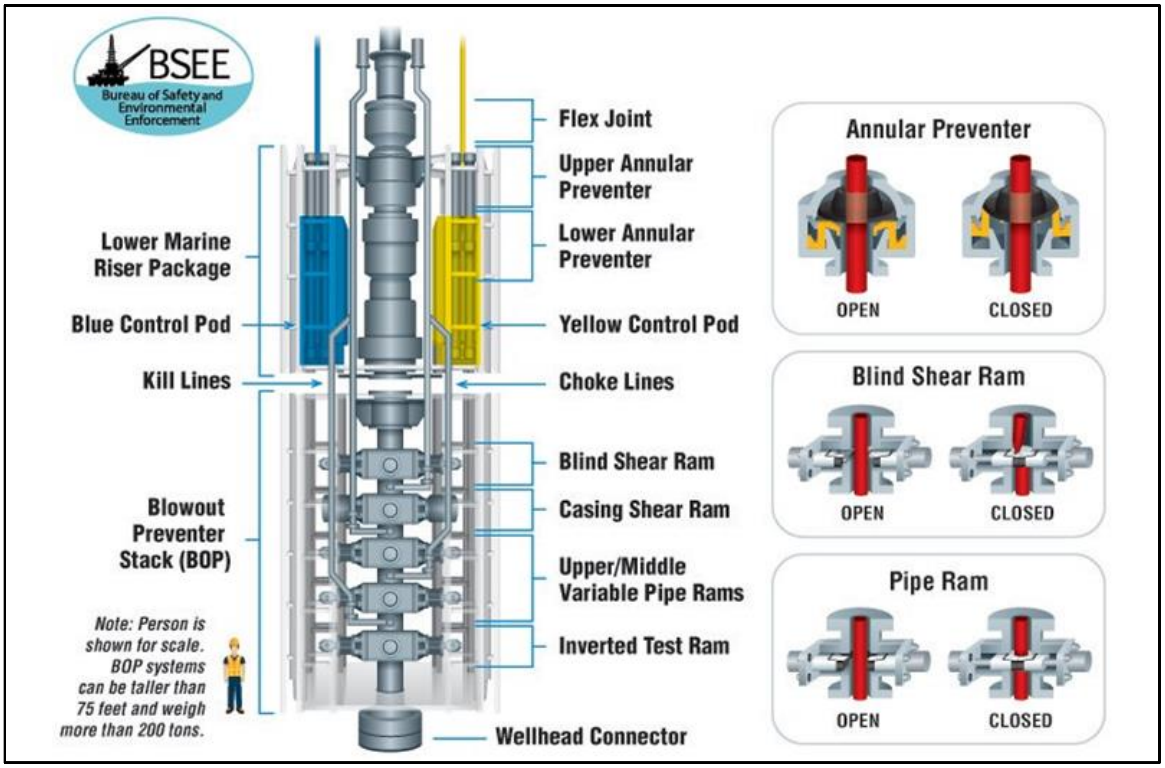


Figure 2.9.1-8. Example Diagram of a Blowout Preventer.

The BOPs are actuated as a last resort upon imminent threat to the integrity of the well or the surface rig. For cased wells, in a normal situation, the hydraulic ram may be closed if oil or gas from an underground zone enters the wellbore and destabilizes it. By closing a BOP, usually by redundant surface-operated and hydraulic actuators, the drilling crew can prevent explosive pressure release and allow control of the well to be regained by balancing the pressure exerted by a column of drilling mud with formation fluids or gases from below.

Because BOPs are important for the safety of the drilling crew, as well as the rig and the wellbore itself, BOPs are regularly inspected, tested, and refurbished. As part of the post-*Deepwater Horizon* explosion, oil spill, and response regulations and inspection program, BSEE issued NTL No. 2010-N10, “Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources,” which became effective on November 8, 2010. This NTL applies only to operators conducting operations using subsea or surface BOPs on floating facilities. It explains that lessees and operators submit a statement signed by an authorized company official with each application for a well permit, indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations. The NTL also informs lessees that BSEE will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. The NTL notifies the operator that BSEE intends to evaluate the adequacy of each operator to comply in the operator's current oil-spill response plan (OSRP); therefore, there is an incentive for voluntary compliance. The NTL lists the type of information that BSEE would review as follows:

- subsea containment and capture equipment, including containment domes and capping stacks;
- subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment;
- riser systems;
- remotely operated vehicles;
- capture vessels;
- support vessels; and
- storage facilities.

In May, 2019, BSEE released the final improved Blowout Preventer Systems and Well Control regulations (DOI and BSEE 2019). After thoroughly reviewing the original Blowout Preventer Systems and Well Control Rule and its subsequent implementation, BSEE identified provisions that could be revised to reduce unnecessary regulatory burdens while ensuring that any operations remain safe and environmentally responsible. Furthermore, BSEE considered all 424 recommendations arising from 26 separate reports from 14 different organizations developed in the wake of and in response to the *Deepwater Horizon* explosion, oil spill, and response and found that none of the revisions contravened any of these recommendations. The improvements to the requirements for BOP design and testing include the following:

- limiting the number of connection points to the BOP, reducing the number of potential failure points;
- equipping each BOP with a high-flow receptacle to ensure faster delivery of fluid from an ROV;
- requiring an array of rams, which are steel covers designed to close rapidly around and over a drill pipe to stop the flow of hydrocarbons, with specific capabilities, allowing the most effective use of each ram type and maximizing functionality; and
- improving the expected lifespan of a critical BOP component by specifying a testing methodology that provides a readiness check without putting unnecessary wear and tear on the component.

Refer to **Chapter 5.13.4** for more information on the 2019 Well Control Rule and improvements to BOP systems. In addition, the Technology Assessment Program, a research element within BSEE's regulatory program, supports research associated with operational safety and pollution prevention. Since the *Deepwater Horizon* explosion, oil spill, and response, several well control-related studies have been funded through this program, and the details of this research can be found on BSEE's website at http://www.bsee.gov/Technology-and-Research/Technology-Assessment-Programs/index/.

2.9.1.5 Accidental Air Emissions

Accidental events associated with offshore oil and gas activities can result in the emission of air pollutants. These OCS oil- and gas-related accidental events could include the release of oil, condensate, or natural gas; chemicals used offshore; pollutants from the burning of these products; fire; or hydrogen sulfide (H_2S) release. The air pollutants could include NAAQS criteria pollutants, volatile and semi-volatile organic compounds, hydrogen sulfide, and methane. Emissions sources related to accidents from OCS operations can include well blowouts, oil spills, pipeline breaks, tanker accidents, and tanker explosions.

If a fire was associated with an accidental event, it could produce a broad array of pollutants including VOCs, NAAQS primary pollutants, and greenhouse gases. Although temporary in nature, response activities could impact air quality. These response activities could include *in-situ* burning, the use of flares to burn gas and oil, and the use of dispersants applied from aircraft (**Chapter 2.9.2**). *In-situ* burning could impact air quality due to the possible release of toxic gases, and dispersants could impact air quality by possibly releasing toxic aromatics into the atmosphere. Atmospheric pollutants emitted from the *Deepwater Horizon* oil spill included plumes of organic aerosol particles and VOCs. In these plumes, the highly volatile species evaporated on time scales of <10 hours, while intermediate volatility evaporated between 10 and 1,000 hours. After the highly volatile species surfaced, they spread to a larger area due to surface currents and contributed to a wide spectrum of vapors (Bahreini et al. 2012). Additionally, in the presence of evaporating hydrocarbons from the oil spill, NO_x emissions from the recovery and cleanup activities produced ozone (Middlebrook et al. 2012).

The presence of H_2S within formation fluids occurs sporadically and may be released during an accident. Accidents involving the release of H_2S could result in irritation, injury, and lethality from leaks; exposure to sulfur oxides produced by flaring; equipment and pipeline corrosion; and outgassing and volatilization from spilled oil. Regulations include safeguards and protective measures, which are in place to protect workers from H_2S releases.

2.9.1.6 Hydrogen Sulfide and Sulfurous Petroleum

Sulfur may be present in oil as elemental sulfur, within gas as H_2S, or within organic molecules, all three of which vary in concentration independently. Safety and infrastructure concerns include the following: irritation, injury, and even lethality to workers who are exposed to H_2S from leaks; exposure to sulfur oxides produced by flaring; equipment and pipeline corrosion; and outgassing and volatilization from spilled oil.

Sour hydrocarbon tends to originate in carbonate source or reservoir rocks that may not have abundant clay minerals that serve as a binder for elemental sulfur. If not bound in clay minerals, the sulfur remains free and can become a part of any hydrocarbon produced or sourced from that rock.

BOEM would review all exploration and development plans for the possible presence of H_2S in the area(s) identified for exploration and development activities. Activities determined to be associated with a presence of H_2S are subjected to further review and requirements. Federal regulations at 30 CFR § 250.490(c) require all lessees, prior to beginning exploration or development operations, to request a classification of the potential for encountering H_2S. The classification is based on previous drilling and production experience in the areas surrounding the proposed operations, as well as other factors.

According to BSEE's regulations at 30 CFR § 250.490(f), all operators on the OCS involved in production of sour gas or oil (i.e., >20 ppm) are also required to file an H_2S Contingency Plan. This plan lays out procedures to ensure the safety of the workers on the production facility. In addition, all operators are required under 30 CFR § 250.107 to adhere to the National Association of Corrosion Engineers' (NACE) *Standard Material Requirements—Methods for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments* (NACE MR0175-2003) (National Association of Corrosion Engineers 2003) as best available and safest technology. The NACE standards that relate to an H_2S partial pressure of 0.05 pounds per square inch absolute primarily address stress cracking and stress corrosion resistance, while BSEE's definition of "H_2S present" addresses human safety and protecting the environment for H_2S concentrations equal to or exceeding 20 ppm. In the GOM, BSEE has addressed the concern if either threshold is crossed per NTL No. 2009-G31. These engineering standards preserve the integrity of infrastructure through specifying equipment to be constructed of materials with metallurgical properties that resist or prevent sulfide stress cracking and stress corrosion cracking in the presence of sour gas. The BSEE issued a final rule governing requirements for preventing H_2S releases, detecting and monitoring H_2S and sulfur dioxide, protecting personnel, providing warning systems and signage, and establishing requirements for H_2S flaring and venting (30 CFR § 250.490; DOI and MMS (1997a). In the GOM, NTL No. 2009-G31 establishes "Standard Material Requirements: Materials for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments" (NACE Standard MR0175-2003) as best available and safest technology, provides further guidance on classifying an area for the presence of H_2S, includes guidance on H_2S detection, updates regulatory citations, and includes a guidance document statement.

2.9.1.7 Trash and Debris

As discussed in greater detail in **Chapter 3.5**, marine trash and debris is a growing concern both regionally and globally. In the United States, about 80 percent of marine debris washes into the oceans from land-based sources and 20 percent is from ocean sources (USEPA 2017d). The oil and gas industry makes up only a small part of those sources. Common marine debris from OCS oil- and gas-related facilities and vessels may include gloves, various plastics (from packaging, etc.), light bulbs and tubes, oil and gas containers, pipe thread protectors, rope, and floats and buoys. Some trash items, such as glass, pieces of steel, and drums with chemical or chemical residues, can be a health threat to local water supplies and as a result, also to biological, physical, and socioeconomic resources; beachfront residents; and to users of recreational beaches.

The discharge of marine debris by the offshore oil and gas industry and supporting activities is subject to a number of laws and treaties. These laws and treaties include the Marine Debris Research, Prevention, and Reduction Act; the Marine Plastic Pollution Research and Control Act; and the International Convention for the Prevention of Pollution from Ships (MARPOL)-Annex V treaty. Regulation and enforcement of these laws is conducted by a number of agencies, such as the USEPA, NOAA, and USCG. The USEPA works with the International Maritime Organization to develop and implement legal standards that address vessel-source pollution and ocean dumping. It also partners with the Caribbean Environment Programme to reduce land-based sources of pollution in the GOM and the wider Caribbean region (UNEP 2017). In order to address the issue of oceans pollution, NOAA also engages in strong outreach and education activities dedicated to minimizing the introduction of debris into the marine environment.

The BSEE Marine Trash and Debris Prevention Program is intended to reduce the contribution of the oil and gas industry to marine debris. The BSEE's regulations prohibit the discharge of containers and other materials into the marine environment (30 CFR §§ 250.300(a) and (b)(6)) and require durable identification markings on skid-mounted equipment, portable containers, spools or reels, and drums; and the recordation and reporting of such items when lost overboard to the District Manager through facility daily operations reports (30 CFR §§ 250.300(c) and (d)). Therefore, in accordance with 30 CFR §§ 250.300(a) and (b)(6), lessees are encouraged to use caution when handling and transporting small items and packaging materials, particularly those made of nonbiodegradable, environmentally persistent materials such as plastic or glass that can be lost in the marine environment and washed ashore. Furthermore, the NMFS Biological Opinion (NMFS 2020b) applies additional guidelines for offshore operators. These various laws and regulations would likely minimize the discharge of marine debris from OCS operations.

Occasionally during construction or operation, equipment may be dropped to the seafloor. If this happens within the planned construction site, the bottom-disturbing impacts are conservatively considered as part of the routine impacts (refer to **Chapter 2.3.1**); however, equipment drops that may occur during transport are considered as accidental and are analyzed as such.

2.9.2 Response Activities

2.9.2.1 BSEE Spill-Response Requirements

The BSEE is tasked with a number of oil-spill response duties and planning requirements. Within BSEE, the Oil Spill Preparedness Division addresses all aspects of offshore oil-spill prevention, planning, preparedness, and response. Additional information about the Oil Spill Preparedness Division can be found on BSEE's website at http://www.bsee.gov/About-BSEE/Divisions/OSPD/index/.

The BSEE implements the following measures, which are found in 30 CFR parts 250 and 254:

- requires immediate notification to BSEE for spills ≥1 bbl (note that all spills require notification to USCG under the CWA);
- conducts investigations to determine the cause of a spill;
- assesses civil and criminal penalties, if needed;
- oversees spill source control and abatement operations by industry;
- sets requirements and reviews and approves OSRPs for offshore facilities;
- conducts unannounced drills to ensure compliance with OSRPs;
- requires operators to ensure that their spill-response operating and management teams receive appropriate spill-response training;
- conducts inspections of oil-spill response equipment;
- requires industry to show financial responsibility to respond to possible spills; and
- provides research leadership to improve the capabilities for detecting and responding to an oil spill in the marine environment.

BOEM receives and reviews the worst-case discharge information submitted for exploration plans, development and production plans, and DOCDs on the OCS. BOEM also has regulatory requirements addressing site-specific OSRPs and spill-response information. As required by BOEM at 30 CFR §§ 550.219 and 550.250, operators are required to provide an OSRP that is prepared in accordance with 30 CFR part 254 subpart B with their proposed exploration, development, or production plan for the facilities that they will use to conduct their activities; or to alternatively reference their approved regional OSRP by providing the following information:

- a discussion of the approved regional OSRP;
- the location of the primary oil-spill equipment base and staging area;
- the name of the oil-spill equipment removal organization(s) for both equipment and personnel;
- the calculated volume of the worst-case discharge in accordance with 30 CFR § 254.26(a) and a comparison of the worst-case discharge in the approved regional OSRP with the worst-case discharge calculated for the proposed activities; and
- a description of the worst-case discharge response scenario to include the trajectory information, potentially impacted resources, and a detailed discussion of the spill response proposed to the worst-case discharge in accordance with 30 CFR §§ 254(b)-(e).

All OSRPs are reviewed and approved by BSEE, whether submitted with a BOEM-associated plan or directly to BSEE in accordance with 30 CFR part 254. Hence, BOEM relies heavily upon BSEE's expertise to ensure that the OSRP complies with all pertinent laws and regulations, and demonstrates the ability of an operator to respond to a worst-case discharge. Additionally, NEPA Oil-Spill Analysis Reviews were created following the *Deepwater Horizon* oil spill to enable the BOEM postlease process to track oil spill-related reviews in the Technical Information Management System (TIMS). New reporting requirements and reviews, such as the NTL No. 2010-N06, were instituted as a result of post-spill reorganization efforts. The NEPA Oil-Spill Analysis Review was created to verify that all oil-spill information and associated reviews are completed prior to BOEM's final NEPA approvals.

The operator is also required to carry out the training, equipment testing, and periodic drills described in the OSRP. In addition, since 1989, MMS (BSEE's predecessor) and BSEE have conducted government-initiated unannounced exercises. In any given year, BSEE will hold both table-top, government-initiated unannounced exercises and a limited number of government-initiated, unannounced response equipment exercises. Equipment deployment exercises are held when BSEE elects to conduct an exercise of an operator's procurement, loading, and deployment of certain pieces of oil-spill response equipment that are cited within an operator's OSRP. The BSEE equipment deployment exercises are designed most often to take place offshore in order to test the equipment that is proposed to be used offshore during the response, but the exercise may be moved to an alternate location if BSEE's exercise parameters require it. In addition, BSEE can also require that the nearshore and onshore equipment be deployed if a BSEE-developed drill scenario requires it. Drills testing nearshore and onshore equipment would typically take place in an onshore or nearshore environment.

Any dispersant application included as part of the drill scenario simulates the application of dispersant during BSEE's drills. No actual dispersants are used during the drills. Likewise, the oil spill itself is only simulated during the unannounced drills. Typical BSEE unannounced deployment exercises last a few hours and rarely take longer than a day. Multi-day scenarios occur when a more complicated drill scenario is developed by BSEE to test an operator's ability to adequately respond.

The most recent improvements include the 2018 Oil and Gas Production Safety Systems Rule, which became effective on December 27, 2018, and the 2019 Well Control and Blowout Preventer Rule, which became effective on July 15, 2019. The revised rules remove unnecessary burdens on industry while leaving critical safety provisions intact. These rules address key recommendations made after the *Deepwater Horizon* explosion, oil spill, and response; close gaps in existing requirements; and update BSEE's regulations to reflect industry best practices.

2.9.2.2 BSEE Spill-Response Initiatives

For more than 25 years, BSEE and its predecessors have maintained a comprehensive long-term research program to improve oil-spill response knowledge and technologies. The major focus of the program is to improve the methods and technologies used for oil-spill detection, containment, treatment, recovery, and cleanup. The BSEE Oil Spill Response Research program is a cooperative effort bringing together funding and expertise from research partners in State and Federal government agencies, industry, academia, and the international community. The funded projects cover numerous spill-response-related issues such as chemical treating agents; *in-situ* burning of oil; research conducted at BSEE's Oil Spill Response Research and Renewable Energy Test Facility, known as the Oil and Hazardous Materials Simulated Environmental Test Tank (Ohmsett) located in Leonardo, New Jersey; behavior of oil; decisionmaking support tools; mechanical containment; and remote sensing.

A list of BSEE's Oil Spill Response Research Program-supported research projects can be found on BSEE's website at https://www.bsee.gov/what-we-do/research/oil-spill-preparedness/oil-spill-response-research.

2.9.2.3 Offshore Response, Containment, and Cleanup Technology

In the event of a spill, particularly a loss of well control, there is no single method of containment and removal that would be 100 percent effective. Spill cleanup is a complex and evolving technology. There are many situations and environmental conditions that necessitate different approaches. New technologies are consistently being developed providing additional benefits. Each new tool becomes part of the spill-response tool kit. Removal and spill-containment efforts to respond to an ongoing spill offshore would likely require multiple technologies, including source containment, mechanical spill containment and cleanup, *in-situ* burning of surface slicks, and the use of chemical dispersants. Even with the deployment of all of these spill-response technologies, it is likely that, with the operating limitations of today's spill-response technology, not all of the oil can be contained, recovered, or removed.

Because no single spill-response method is 100 percent effective, it is likely that larger spills under the right conditions would require the simultaneous use of all available cleanup methods (i.e., source containment, mechanical spill containment, recovery, and cleanup; dispersant application; and *in-situ* burning). The cleanup technique chosen for a spill response would vary depending upon the unique aspects of each situation. The selected mix of countermeasures would depend upon the distance to the shoreline; the natural resources that may be impacted; the size, location, and type of oil spilled; the oceanographic and weather conditions; and other variables. The overall objective of on-water recovery is to minimize the risk of impact by preventing the spread of free-floating oil. The physical and chemical properties of crude oil can greatly alter the effectiveness of containment and recovery equipment, the efficacy of chemical dispersants, and the ability to successfully perform *in-situ* burning.

2.9.2.3.1 Source Containment

The NTL No. 2010-N10 states that offshore operators address containment system expectations to be able to rapidly contain a spill as a result of a loss of well control from a subsea well. In the Gulf of Mexico, this resulted in the development of rapid response containment systems that are available through either the Marine Well Containment Company or Helix Well Containment Group.

In the event that activities on the Atlantic OCS move forward, BSEE's regulations require source containment equipment near the leased areas. The BSEE does not allow an operator to begin drilling operations until adequate subsea containment and collection equipment, as well as subsea dispersant capability, is available to the operator and is sufficient for use in response to a potential incident from the proposed well(s).

2.9.2.3.2 Mechanical Cleanup

Generally, mechanical containment and recovery is the primary oil-spill response method used (33 CFR § 153.305(a)). Mechanical recovery is the process of using booms and skimmers to pick up oil from the water surface.

Containment booms are used to control the spread of oil to reduce the possibility of polluting shorelines and other resources. Booms also concentrate oil in thicker surface layers, making recovery easier. In addition, booms may be used to divert and channel oil slicks along desired paths, making them easier to remove from the surface of the water. Although there is a great deal of variation in the design and construction of booms, all generally share the following four basic elements:

- an above-water "freeboard" to contain the oil and to help prevent waves from splashing oil over the top of the boom;
- a flotation device;
- a below-water "skirt" to contain the oil and help reduce the amount of oil lost under the boom; and
- a "longitudinal support," usually a chain or cable running along the bottom of the skirt, that strengthens the boom against wind and wave action; the support may also serve as a weight or ballast to add stability and help keep the boom upright.

Booms can be divided into several basic types.

- Fence booms have a high freeboard and a flat flotation device, making them least effective in rough water, where wave and wind action can cause the boom to twist.
- Round or curtain booms have a more circular flotation device and a continuous skirt. They perform well in rough water but are more difficult to clean and store than fence booms.
- Non-rigid or inflatable booms come in many shapes. They are easy to clean and store, and they perform well in rough seas. However, they tend to be expensive, more complicated to use, and puncture and deflate easily.
- Sorbent booms are specialized containment and recovery devices made of porous sorbent material such as woven or fabric polypropylene, which absorbs oil while it is being contained. Sorbent booms are used when the oil slick is relatively thin for

final polishing of an oil spill, removing small traces of oil or sheen, or as a backup to other booms.

All boom types are greatly affected by the conditions on the water; the higher the waves swell, the less effective booms become.

Booms can be fixed to a structure, such as a pier or a buoy, or towed behind or alongside one or more vessels. When stationary or moored, the boom is anchored below the water surface. It is necessary for stationary booms to be monitored frequently due to changes produced by shifting tides, tidal currents, winds, or other factors that influence water depth, direction, and force of motion. These forces may substantially impair the ability of a boom to hold oil. Most booms perform well in gentle seas with smooth, long waves. Generally, booms would not operate properly when waves are higher than 1 m (3 ft) or currents are moving faster than 1 kn (1.15 mph).

A skimmer is a device for recovering spilled oil from the water's surface. Skimmers may be self-propelled, used from shore, or operated from vessels. The efficiency of skimmers is highly dependent upon conditions at sea. In moderately rough or choppy water, skimmers tend to recover more water than oil. Different types of skimmers offer advantages and drawbacks depending on the type of oil being recovered, the sea conditions during cleanup efforts, and the presence of ice or debris in the water.

There are three types of skimmers.

- Weir skimmers use a dam or enclosure positioned at the oil/water interface. Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible. The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank for recycling or disposal. These skimmers are prone to becoming jammed and clogged by floating debris.
- Oleophilic (“oil-attracting”) skimmers use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface. The oil is then squeezed out or scraped off into a recovery tank. Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness. Some types, such as the chain or “rope-mop” skimmer, work well on water that is clogged with debris or rough ice.
- Suction skimmers operate similarly to a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks. Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation. Suction skimmers operate best on smooth water where oil has collected against a boom or barrier.

If an oil spill occurs during a storm, spill response from shore may be delayed until after the storm. Spill response would not be possible while storm conditions continued, given the sea-state limitations for skimming vessels and containment boom deployment. However, oil released onto the ocean surface during a storm event would be subject to accelerated rates of weathering and dissolution (i.e., oil and water would be agitated, forcing oil into smaller droplets and facilitating dissolution of the high end aromatic compounds present).

In rough seas, a large spill (i.e., ≥1,000 bbl) of low viscosity oil, such as a light or medium crude oil, can be scattered over many square kilometers within just a few hours. Oil recovery systems typically have swath widths of only a few meters and move at slow speeds while recovering oil. Therefore, even if this equipment can become operational within a few hours, it would not be feasible for it to encounter more than a fraction of a widely spread slick (International Tanker Owners Pollution Federation 2018). For this reason, it is assumed that a maximum of 10-30 percent of an oil spill in an offshore environment can be mechanically removed from the water prior to the spill making landfall (U.S. Congress, Office of Technology Assessment 1990).

A common difficulty when deploying booms and skimmers to recover oil is coordinating vessel activities to work the thickest areas of oil. It is a rule of thumb that 90 percent of the oil is in 10 percent of the area. The 10 percent of the oil that makes up 90 percent of a slick is typically sheen. For this reason, containment and recovery operations on water require extensive logistical support to direct the response effort. Additionally, the limitations that poor weather and rough seas impose on spill-response operations offshore are seldom fully appreciated. Handling wet, oily, slippery equipment on vessels that are pitching and rolling is difficult and can raise safety considerations. Winds, wave action, and currents can drastically reduce the ability of a boom to contain and a skimmer to recover oil. It is important to select equipment for a response that is suitable for the type of oil and the prevailing weather and sea conditions for a region. Efforts are generally made to target the heaviest oil concentrations and areas where collection and removal of the oil would reduce the likelihood of oil reaching sensitive resources and shorelines. As oil weathers and increases in viscosity, cleanup techniques and equipment are reevaluated and modified (International Tanker Owners Pollution Federation 2018).

Practical limitations of strength, water drag, and weight mean that generally only relatively short lengths of boom (tens to a few hundred meters) can be deployed and maintained in a working configuration. Towing booms at sea (e.g., in U or J configurations, which increase a skimmer's swath width) is a difficult task requiring specialized vessels and trained personnel. Because skimmers float on the water surface, they experience many of the operational difficulties that apply to booms, particularly those posed by wind, waves, and currents. The effectiveness of any skimmer depends upon a number of factors, in addition to the ambient weather and sea conditions, including the type of oil, the thickness of the oil, the presence of debris in the oil or in the water, the extent of weathering and emulsification of the oil, and the location of the spill. Even moderate wave motion can greatly reduce the effectiveness of most skimmer designs. In high sea-state conditions, many skimmers, especially weir and suction skimmers, take up more water than oil. Because of the various constraints placed upon skimmers in the field, their design capacities are rarely realized. Experience from numerous spills has consistently shown that skimmer recovery rates reported under test conditions cannot be sustained during a spill response. The availability of sufficient oil-storage facilities is also necessary to ensure continuous oil-spill recovery. This storage needs to be easy to handle and easy to empty once full so that it can be used repeatedly with the least interruption in recovery activity (International Tanker Owners Pollution Federation 2018).

Responding to spills of submerged oil is far more complex due to the problems associated with operating in an underwater environment where oil is spreading and dispersing in three dimensions, visibility is limited, and recovery equipment must be far more robust and complex than that used on the surface. The term submerged oil generally refers to any oil that is not floating on the surface. In an oil spill involving submerged oil, three location scenarios are possible.

- Overwashed: Thicker oil that is floating near the water surface but is covered by a layer of water due to wave action. This can obscure the oil slick from visual monitoring and remote sensing at the surface.
- Suspended: Oil globules or droplets are neutrally buoyant at depth and move in the water column under the influence of currents.
- Sunken: Oil that is negatively buoyant and rests on the bottom of the water body.

Spilled oil can be suspended in the water column in a number of ways, which can be considered in roughly three distinct scenarios. The physical and chemical properties of oil resulting from these three scenarios can be very different and change with time. Submerged oil can come from a number of sources:

- heavy oils from a surface spill that tend to sink under certain conditions and is generally called submerged oil while it is in the water column and sunken oil when it reaches the sea bottom;
- oil rising to the surface from a subsea blowout; and
- fine droplets of oil resulting from chemical dispersants being applied to either a surface spill or subsea blowout or due to natural dispersion.

Each of the above scenarios presents its own challenges depending on the location and condition of the oil. This is particularly true when attempting to detect, identify, and characterize oil that is suspended in the water column. Physically capturing oil samples using rope and net snares towed through the water column has been employed in several spills but is labor intensive and provides only a general indication of the amount of oil, geographical location, and depth. Recent advances in detecting submerged oil include the use of acoustic and optical systems to detect, identify, and characterize petroleum hydrocarbons.

2.9.2.3.3 Spill-Treating Agents

Treating oil with specially prepared chemicals is another option for responding to oil spills. An assortment of chemical spill-treating agents is available to assist in cleaning up oil. However, approval must be obtained in accordance with the provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) before these chemical agents can be used.

The USEPA issued a proposed rule to amend the requirements in Subpart J of the NCP that governs the use of dispersants, other chemical and biological agents, and other spill mitigating substances when responding to oil discharges into waters of the United States. The proposed rule addresses the efficacy, toxicity, environmental monitoring of dispersants, and other chemical and biological agents, as well as public, State, local, and Federal officials' concerns regarding their use (USEPA 2015b). The USEPA updated the NCP product schedule in December 2018 and lists the following types of products that are authorized for use on oil discharges:

- dispersants;
- surface washing agents;
- surface collecting agents;
- bioremediation agents; and
- miscellaneous oil-spill control agents.

In August 2020, the USEPA also published an updated NCP Product Schedule Technical Notebook that presents manufacturers' summary information that describes (1) the conditions under which each of the products is recommended for use, (2) handling and worker precautions, (3) storage information, (4) recommended application procedures, (5) physical properties, (6) toxicity information, and (7) effectiveness information (USEPA 2020i).

Dispersants

Dispersant use must be in accordance with a Regional Response Team's Preapproved Dispersant Use Manual and with any conditions outlined within a Regional Response Team's site-specific Area Contingency Plan (ACP). Consequently, dispersant use would be in accordance with the restrictions for specific water depths, distances from shore, and monitoring requirements. At this time, there are no scenarios where preapproval is granted for the use of subsurface dispersant injection. Aerial dispersants would likely be applied from airplanes as a mist, which settles on the oil on the water's surface.

Subpart J of the NCP directs the USEPA to prepare a schedule of dispersants, other chemicals, and oil-spill mitigating devices and substances that may be used to remove or control oil discharges. Due to the unprecedented volume of dispersants applied for an extended period of time in situations not previously envisioned or incorporated in existing dispersant use plans (i.e., during the *Macondo* spill response), the U.S. National Response Team has developed guidance for monitoring atypical dispersant operations. The guidance document, which was approved on May 30, 2013, is titled *Environmental Monitoring for Atypical Dispersant Operations: Including Guidance for Subsea Application and Prolonged Surface Application* (U.S. National Response Team 2013). The subsea guidance generally applies to the subsurface ocean environment and focuses on operations in waters below 300 m (984 ft) and below the pycnocline, or the interface between an upper mixed density gradient and a lower stable density gradient. The surface application guidance supplements and complements the existing protocols as outlined within the existing Special Monitoring of Applied Response Technologies monitoring program where the duration of the application of dispersants on discharged oil extends beyond 96 hours from the time of the first application. This guidance is provided to the Regional Response Teams by the U.S. National Response Team to enhance existing Special Monitoring of Applied Response Technologies' protocols and to ensure that their planning and response activities will be consistent with national policy (U.S. National Response Team 2013).

Other Spill-Treating Agents

Surface washing agents, emulsion breakers and inhibitors, recovery enhancers, solidifiers, and sinking agents are other types of chemical treatment agents that are available, if approval is obtained, for treating oil spills. The use of these chemical products is subject to approval in the same manner as dispersants. The use of bioremediation agents also requires approval in the same manner as dispersants. The U.S. Environmental Protection Agency's NCP Product Schedule Technical Notebook presents manufacturers' summary information that describes (1) the conditions under which each of the products is recommended for use, (2) handling and worker precautions, (3) storage information, (4) recommended application procedures, (5) physical properties, (6) toxicity information, and (7) effectiveness information (USEPA 2020i).

2.9.2.3.4 In-Situ Burning

In-situ burning, the burning of oil in place, has been employed as an oil-spill response technique in offshore waters since the late 1960s when the British military attempted to ignite fuel spilled after the oil tanker *SS Tory Canyon* went aground off the coast of the United Kingdom. *In-situ* burning proved to be a highly effective technique employed during the *Deepwater Horizon* oil spill and cleanup that removed significant amounts of oil from the surface of the water. *In-situ* burning requires less labor, less equipment, fewer storage vessels, and can safely minimize the effects of spilled oil in the environment. If conditions are ideal, *in-situ* burning can remove over 90 percent of the oil from the surface of the water. The decision to burn should be made early in an incident, taking into account its feasibility and appropriateness and with guidance from the Unified Command to make best use of windows of opportunity. Responders must consider the operational conditions before conducting *in-situ* burning, including the location of the spill, type and thickness of the oil, and level of emulsification and weathering, as well as the states of the weather and the sea. Field guides are available for both inland and on-water responses (American Petroleum Institute 2015a; 2015b). These guides contain a set of operational checklists, tools, and references to assist in the conduct of *in-situ* burning of spilled oil. Special fire-resistant booms are used to contain open-water burns, as burning oil may spread rapidly in water.

2.9.2.3.5 Natural Dispersion

Depending upon environmental conditions and spill size, the best response to a spill may be to allow the natural dispersion (e.g., evaporation, chemical wethering, and photodegradation) of a slick to occur. Natural dispersion may be a preferred option for smaller spills of lighter nonpersistent oils and condensates that form slicks that are too thin to be removed by conventional methods and that are expected to dissipate rapidly, particularly if there are no identified potential impacts to offshore resources and a potential for shoreline impact is not indicated. In addition, natural dispersion may also be a preferred option in some nearshore environments, such as a marsh habitat, when the potential damage caused by a cleanup effort could cause more damage than the spill itself.

2.9.2.4 Onshore Response and Cleanup

Offshore response and cleanup is preferable to shoreline cleanup; however, if an oil slick reaches the coastline, it is expected that the specific shoreline cleanup countermeasures identified and prioritized in the appropriate ACPs for various habitat types would be used. The sensitivity of the contaminated shoreline is the most important factor in the development of cleanup recommendations. Shorelines of low productivity and biomass can withstand more intrusive cleanup methods, such as pressure washing. Shorelines of high productivity and biomass are very sensitive to intrusive cleanup methods and, in many cases, the cleanup is more damaging than allowing natural recovery.

Oil-spill response planning in the U.S. is accomplished through a mandated set of interrelated plans. The ACPs cover subregional geographic areas and represent the third tier of the National Response Planning System mandated by the Oil Pollution Act of 1990. The ACPs are a focal point of response planning, providing detailed information on response procedures, priorities, and appropriate countermeasures. The USCG has worked diligently to improve coastal oil-spill response since the *Deepwater Horizon* oil spill by improving the ACPs for each coastal USCG sector. The ACPs are written and maintained by Area Committees assembled from Federal, State, and local government agencies that have pollution-response authority; nongovernmental participants may attend meetings and provide input. The coastal Area Committees are chaired by respective Federal On-Scene Coordinators from the appropriate USCG Office and are comprised of members from local or area-specific jurisdictions. Response procedures identified within an ACP or its Geographic Response Plans reflect the priorities and procedures agreed to by members of the Area Committees.

If an oil slick reaches the coastline, the responsible party should be prepared to deploy any of the shoreline cleanup countermeasures that were specified for the protection of the prioritized sensitive areas that are identified within the appropriate ACPs that cover these areas. The single, most-frequently recommended, spill-response strategy for the areas identified for protection in all of the applicable ACPs is the use of a shoreline boom to deflect oil away from coastal resources such as seagrass beds, marinas, resting areas for migratory birds, bird and turtle nesting areas, etc. Since oil spilled at sea tends to move and spread rapidly into very thin layers, boom is deployed to corral the oil on the water to enhance recovery effectiveness of skimmers and other response technologies. Booms are also used to protect shoreline areas and to minimize the consequences of an oil spill reaching shore. There are tradeoffs in deciding where and when to place boom because, once deployed, boom is time consuming to tend and relocate. For example, booming operations are sensitive to wind, wave, and currents and need to be tethered and secured to keep the boom from moving. Rough seas can tear, capsize, or shred boom. Currents over 1.5 kn (1.7 mph) or even a wake from a boat can send oil over or under a boom. Untended boom can become a barricade to wildlife and ship traffic. Boom anchors can damage some habitats. During the *Deepwater Horizon* response, it was discovered that hard boom often did more damage in the marsh it was intended to protect than anticipated after weather conditions ended up stranding the boom back into the marsh.

If a shoreline is oiled, the selection of the type of shoreline remediation to be used would depend on the following: (1) the type and amount of oil on the shore; (2) the nature of the affected coastline; (3) the depth of oil penetration into the sediments; (4) the accessibility and the ability of vehicles to travel along the shoreline; (5) the possible ecological damage of the treatment to the shoreline environment; (6) weather conditions; (7) the current state of the oil; and (8) jurisdictional considerations. To determine which cleanup method is most appropriate during a spill response, decisionmakers must assess the severity and nature of the injury using Shoreline Cleanup and Assessment Team survey observations. These onsite decisionmakers must also estimate the time it would take for an area to recover in the absence of cleanup (typically considering short term to be 1-3 years, medium term to be 3-5 years, and long term greater than 5 years) (U.S. National Response Team 2010).

Shoreline Cleanup Countermeasures

When spilled oil contaminates shoreline habitats, responders should survey the affected areas to determine appropriate response. Although general approvals or decision tools for using shoreline cleanup methods can be developed during pre-spill planning stages, responders' specific treatment recommendations should integrate gathered, filed, and documented data on shoreline habitats, oil type, degree of shoreline contamination, spill-specific physical processes, and ecological and cultural resource issues. Cleanup endpoints should be established early so that appropriate cleanup methods can be selected to meet the cleanup objectives. Shoreline surveys, as part of the Shoreline Cleanup and Assessment Team program, should be conducted systematically because they are imperative to the cleanup decisions. Also, repeated surveys are needed to monitor the effectiveness of the ongoing treatment methods so that the need for changes in methodology, additional treatment, or constraints can be evaluated (NOAA 2013b).

2.9.3 Strikes and Collisions

Strikes are defined as a vessel or aircraft unintentionally hitting a resource or habitat. Collisions are defined as a vessel or aircraft unintentionally hitting another vessel, aircraft, or structure. Both strikes and collisions can occur as a result of routine OCS oil- and gas-related activities, accidental events, or other events that are not related to OCS oil- and gas-related activities. Whatever the cause of the strike or collision, the result is an accidental event.

The OCS oil- and gas-related vessels could strike marine mammals, sea turtles, coral reefs and hard bottom benthic communities, and other marine animals during transit. To limit or prevent such strikes to marine mammals and sea turtles, NMFS provides all boat operators with whale-watching guidelines, which are derived from the MMPA. These guidelines suggest safe navigational practices based on speed and distance limitations when encountering marine mammals. The frequency of vessel strikes with marine mammals, sea turtles, or other marine animals probably varies as a function of spatial and temporal distribution patterns of the living resources, the pathways of maritime traffic (coastal traffic is more predictable than offshore traffic) and vessel speed, the number of vessel trips, and the navigational visibility.

BOEM issued NTL No. 2016-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, when 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 and sea turtles. On March 13, 2020, NMFS issued a biological opinion for the oil and gas program in the Gulf of Mexico (NMFS 2020b). As of March 13, 2020, BOEM will implement the terms and conditions and reasonable and prudent measures of the 2020 NMFS Biological Opinion (BiOp), including Appendix C, "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols," which will be applied in place of this NTL in future lease sale stipulations and conditions of approval for permits, plans, and other authorizations approved by BOEM[1].

Vessels in transit could strike coral reefs and hard bottom benthic communities in shallow water, particulatly if the vessel ventures outside of navigation channels. The vessels could also accidently drop an anchor on a shallow benthic community. Deeper hard bottom benthic communities could also accidentally be struck by anchors, infrastructure, or equipment falling from vessels or platforms. Although BOEM has many protections (described below) for sensitive seafloor features, it is possible that an operator may still accidently drop an anchor or equipment, or even possibly place a pipeline or structure on a sensitive benthic habitat.

As described in BOEM NTL No. 2009-G39, all bottom-disturbing activity must be distanced from topographic features, pinnacles, live bottoms, and potentially sensitive biological features in order to prevent injury to these sensitive habitats. Stipulations are attached to leases in topographic feature, pinnacle, and live bottom low-relief OCS lease blocks to ensure operators avoid these areas by the recommended distances in each stipulation. BOEM has No Activity Zones surrounding each protected topographic feature within which no bottom-disturbing activity is permitted. In addition, BOEM's

[1] In April 2021, NMFS amended the Incidental Take Statement associated with the 2020 BiOp (which also served as the intra-service consultation for the rule). The amendment updated Appendices A and C to align with the MMPA Incidental Take Regulation and updated the COAs developed since the release of the programmatic 2020 BiOp. The Appendices and COAs may be imposed on lessees and operators through compliance reviews associated with the Programmatic BiOp when lessees or operators submit requests for plans or permits, or through Letters of Authorization issued under the rule. As the final incidental take regulation took effect on April 19, 2021, survey operators are currently able to apply for Letters of Authorization under the MMPA.

Topographic Features Stipulation requires bottom-disturbing activity to be distanced 152 m (500 ft) from a No Activity Zone surrounding a topographic feature. The Pinnacle Trend and Live Bottom Low Relief Stipulations do not allow bottom-disturbing activity within 33 m (100 ft) of a pinnacle or live bottom feature. As part of the Topographic Features Stipulation, no bottom-disturbing activity is allowed within 33 m (100 ft) of a potentially sensitive biological feature, which is located outside of a No Activity Zone.

BOEM NTL No. 2009-G40 provides guidance to operators indicating that no bottom-disturbing activity is allowed within 610 m (2,000 ft) of a deepwater benthic community (including deepwater coral and chemosynthetic communities). BOEM conducts site-specific seafloor reviews prior to a permit approval to ensure pipelines and structures are not placed on sensitive benthic habitat (**Chapter 5.10**). Contitions of approval are attached to permits that describe the distancing requirements for deepwater benthic communities near the proposed activity to ensure that these sensitive habitats are protected from OCS oil- and gas-related activity.

Most collision mishaps are the result of service vessels colliding with platforms or vessel collisions with pipeline risers. Fires have resulted from hydrocarbon releases in several collision incidents in the GOM. Diesel fuel is the product most frequently spilled, while oil, natural gas, corrosion inhibitor, hydraulic fluid, and lube oil have also been released as the result of vessel collisions on the GOM. The BSEE's data show that, from 2008 to 2019 in the GOM, there were 160 OCS oil- and gas-related vessel collisions (Mathews 2020). Approximately 10 percent of vessel collisions with platforms in the OCS caused diesel spills. To date, the largest diesel spill associated with a collision occurred in 1979 when an anchor-handling boat collided with a drilling platform in the Main Pass leasing area, spilling approximately 1,500 bbl. In 2014, approximately 3,571 bbl of bunker fuel spilled into the Houston Ship Channel after a collision between a barge and a ship. Safety fairways, traffic separation schemes, and anchorages are the most effective means of preventing vessel collisions with OCS structures.

In general, fixed structures such as platforms and drilling rigs are prohibited in fairways. Temporary underwater obstacles, such as anchors and attendant cables or chains attached to floating or semisubmersible drilling rigs, may be placed in a fairway under certain conditions. A limited number of fixed structures may be placed at designated anchorages. The USCG's requirements for indicating the location of fixed structures on nautical charts and for lights, sound-producing devices, and radar reflectors to mark fixed structures and moored objects also help minimize the risk of collisions. In addition, the USCG's 8th District would provide Local Notices to Mariners (monthly editions and weekly supplements) to inform users of the Gulf of Mexico OCS about the addition or removal of drilling rigs and platforms, locations of aids to navigation, and defense operations involving temporary moorings. Marked platforms often become aids to navigation for vessels (particularly fishing boats and vessels supporting offshore oil and gas operations) that operate in areas with high densities of fixed structures.

Hill et al. (1999) summarized collision avoidance measures between a generic deepwater structure and marine vessels in the GOM, which were examined for possible implementing reccommendations by the National Offshore Safety Advisory Committee. Hill et al. (1999) offered

15 recommendations that can be grouped into three overarching categories: (1) voluntary initiatives for offshore operators; (2) joint government/industry cooperation or study; and (3) new or continued USCG action. Many of the recommendations discussed in Hill et al. (1999) have been incorporated into the U.S. version of the International Regulations for Preventing Collisions at Sea 1972, which are enforced by the U.S. Coast Guard (USCG 2020).

Accurately modelling vessel-to-platform collision risk, however, has been a challenge for over 20 years given the numerous social, technical, and environmental variables (Pengfei et al. 2016). Over time, other causal factors have proven their greater potential for causing an oil spill, as the likelihoods of collisions have decreased with advanced technology of ships, particularly dynamic positioning systems. As more vessels have incorporated the use of dynamic positioning systems, the potential risk of collision is now higher for those who do not operate with this system (Verhoeven et al. 2004). To date, a major collision between passing merchant vessels and offshore platforms has not been experienced. Though the likelihood of this causal factor is relatively low in all regions of the OCS, the consequences could be severe (Pengfei et al. 2016).

2.9.3.1 Service Vessels

Service vessels are expected to be one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges, and are required at practically every stage of the offshore drilling and production process. Service vessels are typically required for the following processes: wells (exploration and development drilling); plug and abandonment of wells; platform installation; platform operation; platform decommissioning; subsea installation; subsea removal; and pipeline installation. In addition to offshore personnel, service vessels carry cargo (i.e., freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, and food) offshore. Other vessel operations, including G&G activity associated with a leasing event, can also require service vessels. Based on the model provided by Kaiser (2015) for the GOM, there were an average of 4.46 supply vessels needed per week during exploration and development drilling in shallow water and 6.4 supply vessels needed per week during exploration and development drilling in deep water. Drilling operations in shallow water takes less time (5.9 weeks) when compared with deepwater drilling (10 weeks). A platform in shallow water (<800 m; 2,624 ft) is estimated to require one vessel trip every 3.1 days over the production life. A platform in deep water (≥800 m; 2,624 ft) is estimated to require one vessel trip every 1.2 days over the production life. All trips are assumed to originate from the designated service base to an offshore site and back. The duration a platform is considered operational with a vessel service is between 11 and 31 years (low to high). Service-vessel operations are typically most closely tied to actual production activities. Service vessels have the potential to collide with any structure, rig, or vessel they are servicing, as well as other vessels anchored, tied up, or underway.

Service vessels could also strike marine mammals and sea turtles during transport. BOEM's Protected Species Stipulation, explained to operators in BOEM NTL No. 2016-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting," helps minimize the risk of vessel strikes to protected species and explains how to report observations of injured or dead protected species.

Compliance with the guidance in the NTL is mandatory for lessees when the Protected Species Stipulation is applied to leases. Adherence to the NTL protocols is expected to reduce but not eliminate the risk of potential vessel strikes with marine mammals. As of March 13, 2020, BOEM will implement the terms and conditions and reasonable and prudent measures of the 2020 NMFS BiOp, including Appendix C, "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols," which will be applied in place of this NTL in future lease sale stipulations and conditions of approval for permits, plans, and other authorizations approved by BOEM.

2.9.3.2 G&G Vessel Activity

The majority of G&G activities are expected to be conducted from ships. The exception would be remote-sensing methods from aircraft and satellites, and some VSP surveys (when an airgun[s] is/are mounted to the platform or drillrig; refer to **Chapter 2.4.1.1**). Vessels are on average 200-300 ft (60-90 m) long for 2D and airgun HRG surveys, and the ship typically travels at 3.5-4 mph (3-3.5 kn). Ships used for 3D, 4D, and wide-azimuth surveys are typically 262-300 ft (80-90 m) long and have an average towing speed of 5.2 mph (4.5 kn). Larger vessels are required for these surveys because there is more equipment to be towed and the ships are likely to remain offshore for most, if not all, of the survey duration. Deep-penetration seismic airgun surveys conducted in association with a platform or drillship (e.g., VSP, checkshots, and seismic while drilling) are shorter in duration than the other surveys, and while they may use typical 2D or 3D vessels, more commonly a supply vessel or smaller vessel approximately 98-197 ft (30-60 m) in length is used for drilling-based surveys. These surveys typically do not require any support vessels due to their shorter durations and associations with a drilling platform.

Non-airgun HRG surveys can be conducted in conjunction with airgun surveys; however, there may be times when they are conducted separately. The vessel tow speed during non-airgun HRG surveys may be up to 4.6-5.8 mph (4-5 kn). In general, any combination of HRG techniques, which are employed for both hazard and archaeological surveys, may be conducted during a single deployment from the same vessel. Marine gravity and magnetic surveys are commonly conducted during seismic surveys, but they can also be done separately using ships.

Geotechnical surveys are typically conducted independently using a barge or ship approximately 65-328 ft (20-100 m) in length. Geotechnical vessels are stationary when conducting sampling and testing.

Vessels for G&G surveys are likely to remain offshore for most of the survey duration. The G&G activity may be supported by supply vessels operating from ports in the GOM, but service vessel support is not a requirement. Vessels towing streamers during 2D and 3D seismic surveys follow pre-plotted track lines and have limited maneuverability during data acquisition. The limited maneuverability could result in streamers becoming entangled with structures, other vessels, and equipment from other vessels. The vessel itself could also collide with other vessels or structures due to limited maneuverability as well as strike marine mammals and sea turtles. Accordingly, seismic vessels typically are accompanied by an escort vessel, which is used to scout the route ahead; identify hazards, such as adverse currents, vessel traffic, or fishing equipment; and ensure that other vessels do not cross over or interfere with the equipment being towed. For safety reasons, survey operators attempt to keep a zone around the source vessel and its towed streamer arrays clear of other vessel traffic. The size of the vessel exclusion zone that would be maintained around a source vessel and its towed streamer arrays varies depending on the array configuration. In addition, BOEM NTL No. 2016-BOEM-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting," explains how to minimize the risk of vessel strikes to protected species and to report observations of injured or dead protected species. Compliance with the Protected Species Stipulation, when applied, is expected to reduce the risk of potential vessel strikes with marine mammals. As of March 13, 2020, BOEM will implement the terms and conditions and reasonable and prudent measures of the 2020 NMFS BiOp, including Appendix C, "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols," which will be applied in place of this NTL in future lease sale stipulations and conditions of approval for permits, plans, and other authorizations approved by BOEM.

2.9.3.3 Barges

The capacity of oil barges used offshore in the GOM can range from 5,000 to 80,000 bbl of oil. Barges transporting oil may remain offshore for as long as 1 week while collecting oil; each round trip is assumed to be 5 days. Historically, barging in the GOM remained less than 1 percent of the oil transportation methods used, and the conventional barging of oil from offshore facilities located in the GOM to the onshore locations had almost completely stopped by the year 2019. Only one location continues to barge out production to another platform for further delivery to onshore by pipeline (Gadde et al. 2020, official communication).

Although barges make up a small percentage of vessels transporting oil in the GOM, there is a small potential for collision between barges, which are typically towed by a tugboat, and structures or other vessels at sea, due to their limited maneuverability and lengthy tow lines between the tugboat and barge. Barge and tugboats could also strike marine mammals and sea turtles during transport. Protected species strikes can be minimized through the application of the Protected Species Stipulation and adherence to BOEM NTL No. 2016-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting." As of March 13, 2020, BOEM will implement the terms and conditions and reasonable and prudent measures of the 2020 NMFS BiOp, including Appendix C, "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols," which will be applied in place of this NTL in future lease sale stipulations and conditions of approval for permits, plans, and other authorizations approved by BOEM.

2.9.3.4 Oil Tankers

The FPSOs are used to develop marginal oil fields or are used in areas remote from the existing OCS pipeline infrastructure. The FPSO systems are suitable for light and intermediate oils, as well as heavier oil. The use of FPSOs is only projected in water depths >800 m (2,625 ft). The FPSOs store crude oil in tanks in the hull of the vessel and periodically offload the crude to shuttle tankers for transport to refinery ports onshore or to offshore deepwater ports. Shuttle tankers are expected to have between 500,000 and 550,000 bbl in cargo capacity. The production transported by these shuttle tankers accounted for 2.58 percent of the total volume produced in the GOM during 2019 (Gadde et al. 2020, official communication). Shuttle tanker design and systems are in compliance with USCG regulations, the Jones Act, and the Oil Pollution Act of 1990 requirements. As such, shuttle tankers are required to be double hulled.

Offloading operations involve the arrival, positioning, and hook-up of a shuttle tanker to the FPSO. Offloading could occur at an average rate of 50,000 bbl per hour. Shuttle tankers can maintain their station during FPSO offloading operations using techniques that generally do not require anchoring. During the FPSO offloading procedure, the shuttle tanker would continue to operate its engines in an idle mode so that any necessary maneuvers of the vessel could be promptly executed. Safety features, such as marine break-away offloading hoses and emergency shut-off valves, would be incorporated in order to minimize the potential for, and size of, an oil spill. In addition, weather and sea-state limitations would be established to further ensure that hook-up and disconnect operations would not lead to accidental oil release. A vapor recovery system between the FPSO and shuttle tanker would be employed to minimize the release of fugitive emissions from cargo tanks during offloading operations.

Shuttle tankers could collide with the FPSO, as well as other vessels underway. Safety measures for offloading operations, which are discussed in the previous paragraphs, help ensure offloading occurs safely. Shuttle tankers could also strike marine mammals and sea turtles during transport. Protected species' strikes can be minimized through the application of the Protected Species Stipulation and adherence to BOEM NTL No. 2016-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting." As of March 13, 2020, BOEM will implement the terms and conditions and reasonable and prudent measures of the 2020 NMFS BiOp, including Appendix C, "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols," which will be applied in place of this NTL in future lease sale stipulations and conditions of approval for permits, plans, and other authorizations approved by BOEM.

2.9.3.5 Helicopters and Other Aircraft

Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In addition, equipment and supplies are sometimes transported. An operation includes one takeoff and landing.

Deepwater operations require helicopters that travel farther and faster, carry more personnel, are all-weather capable, and have lower operating costs. The number of helicopters operating in the GOM is expected to increase with development of production structures offshore, and heavy twin helicopters or larger and faster helicopters are expected to dominate the type of helicopter used in the GOM. The G&G activities also use helicopters and fixed wing aircraft on occasion. For example, helicopters could be used for personnel transport during vessel- and platform-based seismic surveys that stay onsite for extended periods. Helicopters or fixed wing aircraft may also be used to collect gravity and/or aeromagnetic data, but such surveys are more commonly done from ships because of the logistics required to keep the aircraft in the air for extended periods far from shore.

Helicopters and fixed wing aircraft could collide with structures, vessels, and each other during takeoff, landing, and survey operations. They could also strike birds during operations. On average, 3.4 helicopter accidents per year have occurred in the GOM since 2009. The year 2018 marked the fifth fatality-free year for helicopter accidents; however, there was a non-fatal accident in 2018 in which the landing gear of the helicopter collapsed during taxi. There was a second accident in 2018 that resulted in the ditching of a helicopter. In March 2019, however, a helicopter was lost shortly after takeoff, resulting in two deaths. The 2018 GOM oil industry helicopter accident rate per 100,000 flight hours was 0.55 with a 5-year average of 0.83 incidents per 100,000 flight hours (Duprie 2019). Between 2009 and March 2019, there have been 37 helicopter accidents, of which 8 were fatal. The leading causes, not all inclusive, of the accidents since 1999 were engine related, loss of control or improper procedures, helideck obstacle strikes, controlled flight into terrain, and other technical failures (Aerossurance 2019; Duprie 2019). There were at least two reported fatal accidents in 2019; however, as of October 2020, the 2019 Helicopter Safety Advisory Conference statistics remained unpublished (Aerossurance 2019).

2.9.3.6 Other Activities That Could Potentially Cause Strikes or Collisions

As a sovereign state, the United States has extensive authority to regulate ships entering its ports and to establish port-of-entry conditions. Therefore, the United States has the authority to require foreign flag vessels calling at U.S. ports to adhere to the vessel operational measures to reduce ship strikes.

2.9.3.6.1 Vessel Traffic Patterns

Several types of routing measures are used by the USCG and International Maritime Organization to provide safe access routes to and from ports, including recommended routes, anchorage/no anchorage areas, and traffic separation schemes (TSSs). The purpose of a TSS is to separate opposing streams of traffic by appropriate means and to establish traffic lanes per 33 CFR part 167. The TSSs have been adopted by the International Maritime Organization in certain areas of the world to aid in navigation safety; all vessels must adhere to operating rules within these routes, although vessels may enter a TSS anywhere along its course. There is one TSS in the waters along the Gulf Coast, in the approaches to Galveston Bay, which was designed to aid in the prevention of collisions in the approach to the harbor. The scheme consists of directed traffic lanes for inbound and outbound traffic, a separation zone, and two precautionary areas.

2.9.3.6.2 Types of Vessels

Many vessels operate in the GOM and only a relatively small portion of potential vessel strikes could be related to oil- and gas-related activity. Total port calls, or vessel stops at a port, in the GOM are increasing, as total port calls in the U.S. as a whole are increasing. Freight and cruise ship passenger marine transportation within the analysis area should continue to grow at a modest rate or remain relatively unchanged based on historical freight and cruise traffic statistics. In 2017, 656 cruise ships departed from ports in Galveston, New Orleans, and Tampa, greater than 172 more than were scheduled to depart from these ports in 2011 (American Association of Port Authorities 2017; MARAD 2011). As of 2015, tankers, followed by dry bulk ships, make up the majority of the port calls in the GOM (MARAD 2015). Total vessel calls in U.S. Gulf of Mexico ports made up more than half (51% of all calls) the total vessel calls in the United States (MARAD 2015). Tankers also make more calls (31% of all calls) in U.S. Gulf of Mexico ports than in other areas of the United States.

The NOAA's National Marine Fisheries Service whale ship strike records from 1975 to 2002 suggest that collisions between ships and whales were associated with a wide variety of vessel types and that the average speed of a vessel at the time of impact ranges from 5 to 51 kn (5.7 to 58.7 mph; (Jensen and Silber 2004). The following table (**Table 2.9.3-1**) summarizes information from Jensen and Silber (2004) about the type of vessels with the known number of strike incidences to large whales.

Table 2.9.3-1. Ship Strikes of Large Whales by Type of Vessel.

Unknown Vessel Strikes	158 cases
Known Vessel Strikes	134 cases
Navy Vessels*	17.1% (23 cases)
Container/Cargo Ships	14.9% (20 cases)
Whale-watching Vessels	14.2% (19 cases)
Cruise Ships	12.7% (17 cases)
Ferries	11.9% (16 cases)
Coast Guard*	6.7% (9 cases)
Tankers	6.0% (8 cases)
Recreational Vessels	5.2% (7 cases)
Steamships	5.2% (7 cases
Fishing Vessels	3.0% (4 cases)
Dredge Boat	0.75% (1 case)
Research Vessel	0.75% (1 case)
Pilot Boat	0.75% (1 case)
Whaling Catcher Boat	0.75% (1 case)

* It should be carefully noted that the relatively high incidence of Navy and Coast Guard collision reports may be largely a factor of standardized military and government reporting practice rather than an actual higher frequency of collisions relative to other ship types.

Non-OCS oil- and gas-related tankering includes ships carrying crude or ships carrying product. Overall, tankering (including U.S. ships and foreign ships) in the U.S. increased by 28 percent between 2003 and 2011 (MARAD 2013). While port calls by U.S.-flagged tankers declined between 2003 and 2011, port calls by foreign-flagged tankers increased, as listed in **Table 2.9.3-2**.

Table 2.9.3-2. Comparison of Port Calls by U.S.- and Foreign-Flagged Tankers Between 2003 and 2011.

Ship Origin	2003	2011
U.S. Tankers	3,759	2,956
Foreign Tankers	14,744	20,722

Source: MARAD 2013.

The Oil Pollution Act of 1990 included provisions for the double hulling of all oil tankers. The Act required new oil tankers to be double hulled and established a phase out scheme for existing single-hulled tankers. Older single-hulled tankers were phased out starting in 1995, and the final date for phase out of all single-hulled tankers was 2015.

Non-OCS oil- and gas-related vessels other than those listed above use the Gulf of Mexico OCS and pose potential vessel strike issues. These ships include research vessels, recreational vessels, and commercial vessels. Commercial and recreational fishing in the Gulf of Mexico OCS are regulated by NMFS.

Navy vessels operate differently from commercial vessels in ways important to the prevention of vessel strikes. As described in the *Atlantic Fleet Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Navy 2018), surface ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when a ship or surfaced submarine is moving through the water. Per vessel safety requirements, personnel standing watch for threats to the vessel also report any marine mammals sighted in the path of the vessel as a standard collision avoidance procedure. All vessels use extreme caution and proceed at a safe speed so they can to avoid a collision with any object, including marine mammals, and can be stopped at an appropriate distance from the object.

CHAPTER 3

REGIONAL SETTING AND PROGRAMMATIC CONCERNS

<u>What is in This Chapter?</u>

- A regional overview of the geology, oceanography, and meteorology across the Gulf of Mexico basin.
- An overview of natural events (e.g., major storms) and other regional-scale processes or environmental factors (e.g., climate change) that contribute to existing baseline conditions or have the potential to influence future baseline conditions in the Gulf of Mexico OCS.

<u>Key Points</u>

- The factors described in this chapter shape the environmental setting of the Area of Analysis and contribute significantly to existing baseline conditions in the GOM.
- Programmatic issues (e.g., climate change) and their influence on the various IPF categories are described in this chapter and acknowledged throughout **Chapter 2**, where applicable.
- These issues were analyzed programmatically as part of the existing and future baseline conditions rather than as unique IPF categories; however, cascading effects on marine ecosystems through additive or synergistic effects with the other stressors described in **Chapter 2** were also evaluated.

3 REGIONAL SETTING AND PROGRAMMATIC ENVIRONMENTAL FACTORS

This chapter provides a regional overview of the physical, geological, oceanographic, and meteorological characteristics of the GOM and a description of the various regional-scale natural events and processes, as well as other programmatic environmental concerns. The regional effects of these programmatic factors are summarized below and where applicable, **Chapter 4** discusses the unique impacts that these factors could pose to individual resource categories and whether the addition of OCS oil- and gas-related activities in the Gulf of Mexico could have any synergistic or additive effects.

3.1 PHYSICAL AND GEOLOGIC SETTING

The Gulf of Mexico OCS region is comprised of the OCS within the Gulf of Mexico, a semi-enclosed marginal sea, which is fed by the Atlantic Ocean. Formed during the breakup of Pangaea in the Mesozoic Era, this area contains abundant deposits of salt, limestone, and sandstone. Along the Gulf Coast, the Mississippi River has and continues to deposit an enormous fan of sediment, extending about 600 km (373 mi) offshore and containing about 400 trillion cubic yards of mud, silt, and sand, which is enough to fill over 70 Grand Canyons. Although the smallest by area, the GOM is currently the most important region for offshore energy production.

Hydrocarbon resources are naturally occurring liquid, gaseous, or solid compounds of predominantly hydrogen and carbon that exist in the subsurface as crude oil and natural gas. Oil is a liquid hydrocarbon resource and may include crude oil and/or condensate. Crude oil exists in a liquid state in the subsurface and at the surface. Condensate (natural gas liquids) may exist in a dissolved gaseous state in the subsurface and liquefy at the surface. Condensate that can be produced from the subsurface with conventional extraction techniques has been assessed for this report. The volumetric estimates of oil resources assumed for this document represent combined volumes of crude oil and condensate and are reported as standard stock tank barrels (hereafter “barrels” or “bbl”).

Natural gas is a gaseous hydrocarbon resource and may include associated and/or nonassociated gas; the terms natural gas and gas are used interchangeably in this report. Associated gas exists in spatial association with crude oil; it may exist in the subsurface as free (undissolved) gas within a “gas cap” or as gas that is dissolved in crude oil (“solution gas”). Nonassociated gas (dry gas) does not exist in association with crude oil. Oil-equivalent gas is a volume of gas (associated and/or nonassociated) expressed in terms of its energy equivalence to oil (5,620 cubic feet of gas per barrel of oil) and is reported as barrels. The combined volume of oil and oil-equivalent gas resources is referred to as combined oil-equivalent resources or barrels of oil equivalent and is reported as barrels.

Resource assessments are a critical component of energy policy analysis and provide important information about the relative potential of United States OCS areas as sources of oil and natural gas. More information on the assessment of offshore oil and gas resources can be found in the *2021 Assessment of Technically and Economically Recoverable Oil and Natural Gas Resources of the Gulf of Mexico Outer Continental Shelf* (BOEM 2021a).

The present-day GOM is a small ocean basin with a water-surface area of more than 1.5 million square kilometers (km^2) (371 million acres). The greatest water depth is approximately 3,700 m (roughly 12,000 ft). It is almost completely surrounded by land, opening to the Atlantic Ocean through the Straits of Florida and to the Caribbean Sea through the Yucatan Channel. The northern GOM may be divided into several physiographic subprovinces. In the OCS area, these include the Texas-Louisiana Shelf, the Texas-Louisiana Slope, the Rio Grande Slope, the Mississippi Fan, the Sigsbee Escarpment, the Sigsbee Plain, the Mississippi-Alabama-Florida Shelf, the Mississippi-Alabama-Florida Slope, the Florida Terrace, the Florida Escarpment, and the Florida Plain (**Figure 3.1-1**). In the GOM, the continental shelf extends seaward from the shoreline to about the 200-m (656-ft) water depth and is characterized by a gentle slope of a few meters per kilometer (less than 1 degree). The shelf is wide off Florida and Texas, but it is narrower where the Mississippi River delta has extended seawards to near the shelf edge. The continental slope extends from the shelf edge to the Sigsbee and Florida Escarpments in about 2,000- to 3,000-m (6,562- to 9,843-ft) water depth. The topography of the slope is irregular and characterized by canyons, troughs, and salt structures. The gradient on the slope is normally 1-2 degrees, while the gradient of the Florida Escarpment may reach 45 degrees in some places. The Mississippi Fan has a gentle incline, with slopes of 4 m (13 ft) or less per kilometer (21 ft or less per mile), with the lower Mississippi Fan having an even flatter slope at 1 m (3 ft) or less per kilometer (5 ft or less per mile). The Sigsbee and Florida abyssal plains (ocean floor) are basically horizontal physiographic subprovinces and are surrounded by features with higher topography.

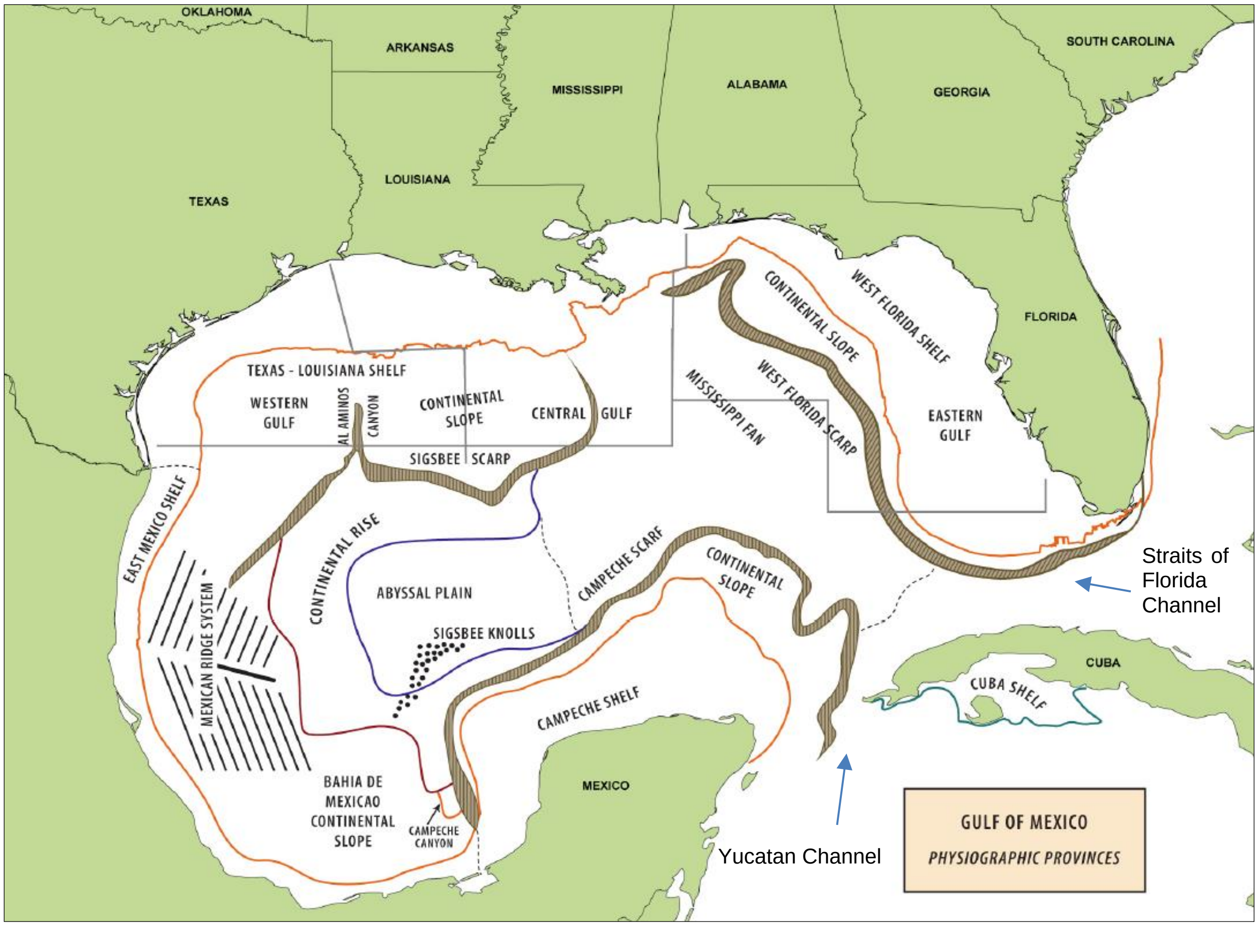


Figure 3.1-1. Generalized Physiographic Map of the Gulf of Mexico OCS (Adapted from The Encyclopedia of Earth 2011).

There are two major sedimentary provinces in the Gulf Coast region: Cenozoic (the western and central part of the GOM) and Mesozoic (the eastern GOM). Over 45,000 wells have been drilled in the GOM. As such, the geology of the GOM has been studied in detail for the identification, exploration, and development of natural gas and oil resources.

BOEM maintains an inventory of over 30,000 discovered oil and gas reservoirs in the GOM that, in aggregate, comprise over 1,300 unique BOEM-designated oil and gas fields. BOEM includes an analysis of 12 assessment units of Cenozoic age (6 on the modern shelf [shallow water] and 6 on the modern slope [deep water]) and 19 geologic plays of Mesozoic age (BOEM 2017b). Assessment units include all reservoirs of a specific geologic age in a specified geographic area, whereas geologic plays are a group of known and/or postulated pools that share common geologic, geographic, and temporal properties, such as history of hydrocarbon generation, migration, reservoir development, and entrapment. More detail on the assessment units, geologic plays, and geologic setting of the GOM can be found below and in the *Assessment of Technically and Economically Recoverable Hydrocarbon Resources of the Gulf of Mexico Outer Continental Shelf as of January 1, 2014* (BOEM 2017b).

To produce economically viable accumulations of oil and gas, five things must occur in the geologic setting. First, rocks must contain an enriched supply of organic material capable of forming oil and gas by the chemical and physical changes that occur during the burial process (the source). Second, a rock must have pores and openings sufficiently connected to hold and transmit oil or gas after it is generated (the reservoir rocks). Third, the hydrocarbons must migrate to the reservoir rocks from the source. Fourth, the layers of rock must be structurally and/or stratigraphically configured so as to capture a large accumulation of hydrocarbon resource (the trap). And fifth, the trapping structure and the reservoir rock must be overlain or configured so that the trap is sealed to prevent the escape of oil or gas (the seal). Upper Jurassic deposits are considered the major source rocks for gas and oil generation in the GOM. Other source rocks that have been identified in the GOM that may have generated hydrocarbons are as young as Pleistocene (approximately 2 million years ago [Mya]).

3.1.1 Cenozoic Province

The plays of the Cenozoic Province extend from offshore Texas eastward across the north-central GOM to the edge of the Cretaceous Shelf Edge (commonly known as the Florida Escarpment) offshore Mississippi, Alabama, and Florida. It incorporates the entire WPA, a large portion of the CPA, and the southwestern portion of the EPA. To date, all of the hydrocarbon production on the OCS in the Cenozoic Province is from sands ranging in age from Paleocene to Pleistocene (approximately 62-0.1 Mya).

3.1.2 Mesozoic Province

To date, the only discovered Mesozoic fields in the OCS are the Jurassic Norphlet (14 fields), the Cretaceous James (9), and the Cretaceous Andrew (1). BOEM identifies 24 plays in the Mesozoic Province: 3 proven and 21 conceptual (BOEM 2017a). Most of these fields are located in the northeastern portion of the CPA. The Mesozoic Province in the OCS extends eastward from the Cretaceous Shelf Edge off the coast of Mississippi, Alabama, and Florida towards the coastline of Florida. Most of this area, however, has experienced limited drilling, mainly on the shelf. In the area offshore of the Florida Panhandle (Pensacola and Destin Dome), a total of 34 wells have been drilled, with 18 of the wells penetrating the Norphlet Formation. The depths at which the Norphlet Formation is found in the Gulf Coast region vary from less than 5,000 ft (1,525 m) onshore to more than 24,000 ft (7,320 m) subsea offshore Mississippi and 15,000 ft (4,575 m) subsea in Apalachicola Embayment. This province has several potential Mesozoic hydrocarbon plays that are equivalents of onshore productive fields.

3.1.3 Deep Gas (Continental Shelf)

The sediments of the GOM are deposited mostly in deltaic environments of sands and shales, usually deposited as channel or delta front sands on the shelf. Shifting of the delta complex and ocean currents tend to widely disperse these sands laterally along the shelf. Drilling on the shelf targeted these sands as potential hydrocarbon accumulations. It was a general belief that, on the slope and abyssal fans, the sands gradually became less dense and less continuous farther from the proximity of the channels. The present-day shelf was once the slope environment during the Oligocene and Miocene age (approximately 34-5.3 Mya). The shelf area holds the potential for deepwater delta systems with channels, distributary bars, levees, overbank deposits, and large fan lobes in the older and deeper section. Subsequent faulting and salt movement created traps and supplied conduits for the migration of hydrocarbons. It is anticipated that these older, deeper reservoirs will be more likely located adjacent to or under the present shelf fields. The shelf off the western and central Louisiana coast is also prospective for the older and deeper Mesozoic age reservoir rocks. These rocks would also be under extreme pressure and high temperatures because of their depth.

3.1.4 Deep Water (Continental Slope and Abyssal Plain)

The continental slope in the GOM extends from the shelf edge to approximately 2,000-m (6,562-ft) water depth (**Figure 3.1-1**). The seafloor gradient on the slope varies from 3 to 6 degrees to over 20 degrees in places along the escarpments. At the base of the Cenozoic Province slope is an apron of thick sediment accumulation referred to as the continental rise. It gently inclines seaward into the abyssal plain. Bathymetric maps of the continental slope in the northwestern GOM (Bouma and Bryant 1994; Bryant et al. 1990) reveal the presence of over 105 intraslope basins with relief in excess of 150 m (492 ft), 28 mounds, and 5 major and 3 minor submarine canyons. These intraslope basins occupy much of the area of the continental slope.

The middle and lower portions of the Cenozoic Province continental slope contain a canopy of salt. The near-surface continental slope offshore Texas and Louisiana is the area of greatest concern with regard to submarine slope stability. Many slope sediments have been uplifted, folded, fractured, and faulted by diapiric action. Between diapirs (topographic highs) were fairways for sand-rich channels. Oversteepening on the basin flanks and resulting mass movements have resulted in highly overconsolidated sediments with extremely weak underlying sediments.

The construction of the Mississippi Canyon is in part a function of sidewall slumping and pelagic draping of low-shear-strength sediments. In contrast, slope oversteepening and subsequent mass movement have resulted in high pore pressures in rapidly deposited debris flows on the upper slope and on basin floors, resulting in unexpected decreased shear strengths. Biologically generated gas (from microbial activity) and thermally generated gas (from burial maturation) induce the accumulation of hydrates and underconsolidated gassy sediments, which are common on the upper slope. On the middle and lower slope, gassy sediments are uncommon except in basins that do not have a salt base, such as Beaumont Basin; the salt canopy restricts the upward movement of gas from below.

Seismic interpretation and drilling in the deep waters of the GOM over the last few decades have proven that prolific sands can be deposited in the slope environment and probably on the abyssal plain. Some of the largest fields in the GOM (Thunder Horse in Mississippi Canyon Block 778, Mad Dog in Green Canyon Block 826, Mars in Mississippi Canyon Block 807, Ursa in Mississippi Canyon

Block 810, Auger in Garden Banks Block 426, Ram-Powell in Viosca Knoll Block 956, etc.) have hydrocarbon accumulations in sands deposited in the slope environment. Gas hydrates are a naturally occurring “ice-like” combination of natural gas and water (gas trapped in ice crystals) that have the potential to be a significant new source of energy from the world’s oceans and polar regions. The gas hydrates form under low temperature and high pressure when natural gas comes into association with water, such as in the deep waters of the continental margins of the GOM.

CSA Ocean Sciences Inc et al. (2019) provides geospatial and resource summaries of the large submarine canyons in the Gulf of Mexico OCS, including Alaminos, Keathley, Perdido, Mississippi, and De Soto Canyons. The submarine canyons along the Sigsbee Escarpment (Alaminos, Keathley, Bryant, Cortez, Farnella, and Green Canyons) are the result of the coalescing of salt canopies, the migration of the salt over the abyssal plain, and erosion of the escarpment during periods of low-stand sea level (Bouma and Bryant 1994). In addition to these large submarine canyons, numerous small submarine canyons and gullies and large slumps occur along the escarpment. Submarine fans of various sizes extend seaward of the canyons onto the continental rise. “Growth faults,” that form with rapid accumulation of massive volumes of sediments, are found mostly on the outer shelf and upper slope where sediment accumulation is thickest (Rowan et al. 1999). Faulting resulting from the formation of salt diapirs is the most common type of faulting on the upper slope. On the middle and lower continental slope, faulting related to salt-stock and salt canopies is the most common type of faulting. Extensive faulting is present along the middle and lower continental slope. These faults are extensional faults caused by the upward movement of salt resulting from pressures created by sediment accumulation within basins. This type of faulting results in the occurrence of a large number of small faults in the area of the seafloor undergoing extension. In some areas of the slope, the upward migration of salt results in the seafloor being extensively fractured (i.e., faulted) and continuously displaced.

Portions of some of the submarine canyons (e.g., Bryant Canyon) are being filled with salt. Turbidity current flows that are active during times of low-stand sea level create the canyons. Subsequently, sediments that accumulate on the margins of the canyon create a differential loading on the salt causing the salt to migrate into the canyon. The migration of salt into the canyon can occur at a rate of centimeters or inches per year. On the middle and lower continental slope, salt may occur very close to the seafloor. For example, on the salt plug called “Green Knoll,” salt is exposed at the seafloor and is being dissolved by seawater, resulting in the collapse of the cap of the knoll. In the intraslope-interlobal Orca Basin, salt is exposed at the bottom of the northern portion of the basin forming a well-documented brine pool.

The most prolific play in the deepwater continental slope is identified to be the deposits of basin-floor fan environment ranging in age from Oligocene to Pleistocene. Recent drilling near the Sigsbee Escarpment indicates a large potential of hydrocarbons associated with the emerging Paleogene (Paleocene-Oligocene) Play. Relative to the thoroughly explored, mature plays on the shelf, plays on the slope and abyssal plain are estimated to have the most undiscovered resources, with Lower Tertiary sediments containing the highest potential for future discoveries (BOEM 2021a).

Also, efforts are made to assess natural gas resource potential from hydrates in the GOM. BOEM has a three-pronged effort regarding methane hydrates, focusing on (1) resource assessment and evaluation; (2) environmental assessment, protection, and monitoring; and (3) exploration and production activities, including offshore safety.

Hydrates have been observed and sampled from the Gulf of Mexico OCS in association with naturally occurring oil and gas seeps in localized deepwater areas of very cold temperature and high pressure at or near the seafloor. In the GOM and the Atlantic OCS, hydrates have been studied for two decades by academia, the oil industry, and BOEM. Naturally occurring seep features, including hydrates, result in higher seismic amplitude (higher reflectivity). Most hydrate occurrences in the GOM are associated with deep-seated faulting, which penetrates the seafloor. These faults provide migration pathways for gas to reach the zone where hydrates are stable. The geothermal gradient increases with depth, allowing ideal temperatures only in the upper couple thousand feet of sediments for hydrates to be stable.

3.1.5 Geologic Hazards

The seafloor geology of the GOM reflects the interplay between episodes of diapirism, mass sediment movement, and sea-level fluctuations. Geologic features on most of the continental shelf (shoreline to about 200-m [656-ft] water depth) are simple and uniform. The main hazards in this area are faulting, shallow-gas pockets, and buried channels. Deepwater regions in the GOM have complex regional salt movement, both horizontal and vertical, which makes it a unique ocean basin. This movement alters the seafloor topography forming sediment uplifts, mini-basins, and canyons. Salt moves horizontally like a glacier and can be extruded to form salt tongues, pillows, and canopies below an ever-increasing weight of sediment. Vertical salt forms range from symmetric bulb-shaped stocks to walls. While salt creates traps that are essential to petroleum accumulation, salt movement can cause potential hazards such as seafloor fault scarps, slumping from steep unstable slopes, shallow gas pockets, seeps and vents, and rocky or hard bottom areas. Gas hydrates (gas trapped in ice crystals) have been found in the GOM in localized deepwater areas of very cold temperature and high pressure at or near the seafloor. Gas hydrates can rapidly dissociate when heated or otherwise disturbed (for example, by an anchor) and cause sediment instability. Although the GOM has had no drilling incident associated with hydrates, they are a problem in other parts of the world. The Mississippi River delta presents a unique set of geologic hazards because of high sedimentation rates, which cause very unconsolidated, high-water-content, and low-strength sediments. Under these conditions, the sediments can be unstable, and slope failure or mass transport of sediments can result. These failures can be triggered by cyclic loading associated with hurricanes, overloading or oversteepening of the slope sediments, or uplift associated with movement of salt. These failures can form mudflow gullies, overlapping mudflow lobes, collapse depressions, slumps, and slides. Small, buried river channels can result in differential sediment compaction and pose a hazard to jack-up rigs.

Over-pressure conditions in a sedimentary section can result from loading by rapid deposition, sand collapse, in-leaking gas, or salt tectonics. Drilling through an over-pressured, shallow-gas pocket can cause loss of mud circulation or a blowout (a blowout occurs when improperly balanced well pressure results in sudden uncontrolled release of fluids from a well bore or well head). A shallow water flow can cause similar drilling problems. Over-pressured conditions can develop in deepwater when “water sand” is trapped by a shale seal. Over-pressured formation water may escape around or through the wellbore to the seafloor and wash out the well foundation. No shallow-water flow event in the GOM has resulted in an oil spill. Deep drilling may encounter abnormally high geopressures. Deep drilling may also encounter hydrogen sulfide, which can occur near salt domes overlain by caprock and is the product of sulfate-reducing microbes.

3.2 Physical Oceanography and Meteorology

The GOM is a semi-enclosed, subtropical sea with an area of approximately 1.5 million km^2 (371 million acres). The main physiographic regions of the Gulf Basin are the continental shelf (including the Campeche, Mexican, and U.S. shelves), continental slopes and associated canyons, abyssal plains, the Yucatan Channel, and Florida Straits. The continental shelf width along the U.S. coastline is about 10 mi (16 km) off the Mississippi River and 97 mi (156 km) off Galveston, Texas, decreasing to 55 mi (88 km) off Port Isabel near the Mexican border. The depth of the central abyss ranges to approximately 3,700 m (12,139 ft).

The relative humidity over the GOM is high throughout the year. Minimum humidity occurs during the late fall and winter when cold, continental air masses bring dry air into the northern GOM. Maximum humidity occurs during the spring and summer when prevailing southerly winds bring in warm, moist air. The GOM is influenced by a maritime subtropical climate controlled mainly by the clockwise circulation around the semi-permanent area of high barometric pressure commonly known as the Bermuda High. The GOM is located to the southwest of this center of circulation. This proximity to the high-pressure system results in a predominantly southeasterly wind flow in the GOM region. Two important classes of storms occasionally occur with this circulation pattern. During the winter months, cold fronts associated with cold air masses from land influence the northern coast of the GOM. Behind the fronts, strong north winds bring drier air into the region. Secondly, hurricanes may develop in or migrate into the GOM during the warmer months (refer to **Chapter 3.3.1**).

The western extension of the Bermuda High dominates the circulation throughout the year, weakening in the winter and strengthening in the summer. The average monthly pressure shows a west to east gradient along the northern GOM during the summer. In the winter, the monthly pressure is more uniform along the northern GOM. The minimum average monthly pressure occurs during the summer.

The maximum pressure occurs during the winter as a result of the presence and influence of transitional continental cold air. Average air temperatures at coastal locations vary with latitude and exposure. Air temperature ranges from highs in the summer of 24.7-28.0°C (76.5-82.4°F) to lows in the winter of 2.1-21.7°C (35.8-71.1°F). Winter temperatures depend on the frequency and intensity of penetration by polar air masses from the north. Air temperatures over the open GOM exhibit narrower limits of variations on a daily and seasonal basis due to the moderating effect of the large bodies of water. The average temperature over the center of the GOM is about 29°C (84°F) in the summer and between 17 and 23°C (63 and 73°F) in the winter.

3.2.1 Currents

The Loop Current, the dominant circulation feature in the Gulf, enters through the Yucatan Channel and exits through the Florida Straits. The sill depth at the Florida Straits is about 700 m (2,300 ft); the effective sill depth at the Yucatan Channel is nearly 2,000 m (6,560 ft) (Badan Jr. et al. 2005). Water masses in the Atlantic Ocean and Caribbean Sea that occur at greater depths cannot enter the GOM. The Loop Current is a part of the western boundary current system of the North Atlantic. This is the principal current and source of energy for the circulation in the Gulf of Mexico. The Loop Current has a mean area of 142,000 km^2 (35 million acres) (Hamilton et al. 2000). It may be confined to the southeastern GOM or it may extend well into the northeastern or north-central GOM, with intrusions of Loop Current water northward and on to the West Florida Shelf (Vukovich 2005). Closed rings of clockwise-rotating (anticyclonic) water, called Loop Current eddies (LCEs), separate from the Loop Current at intervals of 5 to 19 months (Vukovich 2005). These LCEs are also called warm-core eddies since they surround a central core of warm Loop Current water (**Figure 3.2.1-1**). The Loop Current usually penetrates about as far north as 27°N. latitude just prior to shedding an LCE (Vukovich 2005).

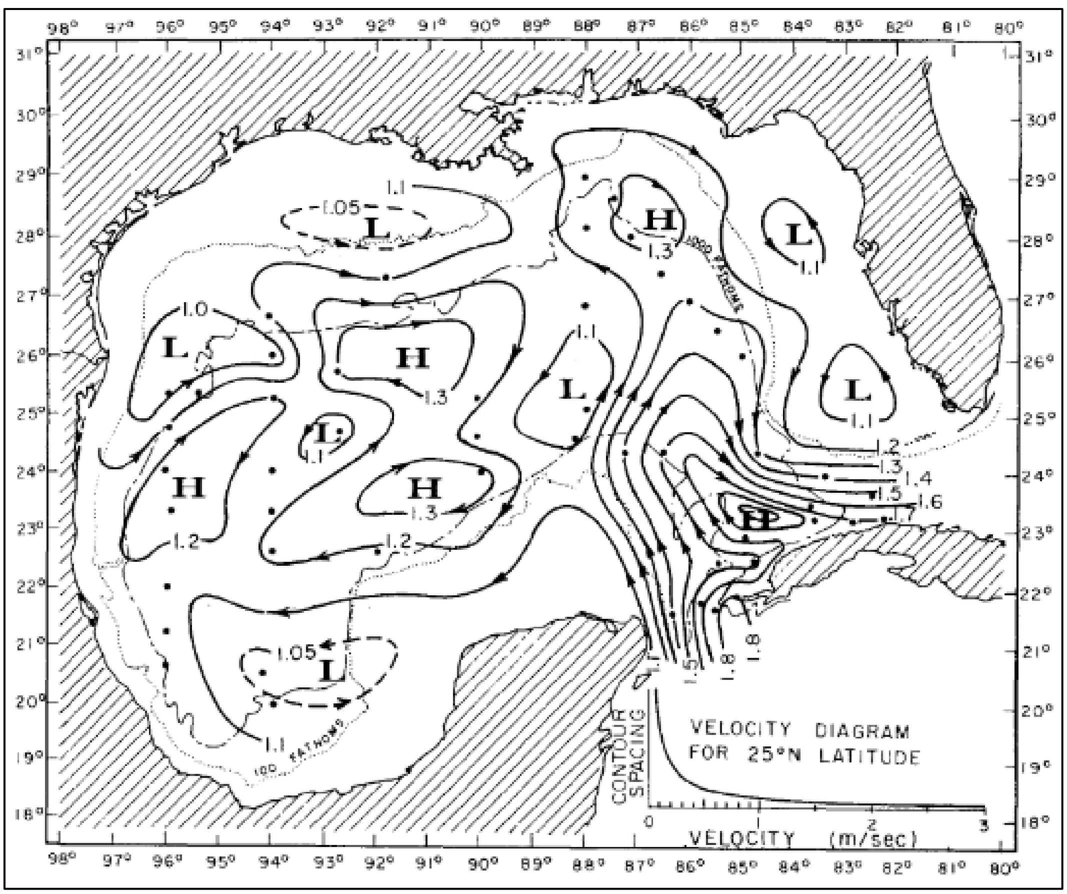


Figure 3.2.1-1. Relative Surface Circulation Patterns in the Gulf of Mexico (Adapted from Figure 1-3 in Nowlin Jr. 1972).

Studies on the frequency of Loop Current intrusions into the eastern Gulf and the frequency of LCE separation (Sturges 1994; Vukovich 2005) suggest these are chaotic processes. Currents associated with the Loop Current and its eddies extend to at least depths of 700 m (2,300 ft), the sill depth of the Florida Straits, and geostrophic shear is observed to extend to the sill depth of the Yucatan Channel. These features may have surface speeds of 150-200 centimeters/second (cm/s) (59-79 inches/second [in/s]) or more; speeds of 10 cm/s (4 in/s) are not uncommon at a depth of 500 m (1,640 ft) (Cooper et al. 1990). The average diameter of warm-core eddies is about 200 km (124 mi), and they may be as large as 400 km (249 mi) in diameter. Warm-core eddies can have life spans of 1 year or more (Elliott 1982). Therefore, their effects can persist at one location for long periods—weeks or even months (e.g., PREFIX) (Nowlin Jr. et al. 1998). After separation from the Loop Current, these eddies often translate westward across the GOM at a speed of about 5 km/day (3 mi/day) (range 1-20 km/day [0.6-12.4 mi/day]). Energetic, high-frequency currents have occurred when LCEs flow past structures, but they are not well documented. Such currents would be of concern to offshore operators because they could induce structural fatigue of materials. The LCEs decay and generate secondary cyclones and anticyclones (Science Applications International Corporation 1989) by interactions with boundaries, ring shedding, and ring-ring interactions. Consequently, the GOM is typically populated with numerous eddies, which are interacting with one another and with the margins (Hamilton and Lee 2005; Science Applications International Corporation 1989).

Cold-core cyclonic (counter-clockwise rotating) eddies have been observed in the study region as well (**Figure 3.2.1-1**). These cyclones are often cold-core eddies since they surround a central core of seawater that is cooler and fresher than adjacent waters. Cyclonic circulation is associated with upwelling, which brings cooler, deeper water towards the surface. A cyclone will form north of an LCE encountering northern GOM bathymetry because of off-shelf advection (Frolov et al. 2004). Cyclones are also associated with the Loop Current (Schmitz Jr. 2005). Small cyclonic eddies around 50-100 km (31-62 mi) in diameter have been observed over the continental slope off Louisiana (Ross et al. 2012). These eddies can persist for 6 months or longer and are relatively stationary.

Near the bottom of the Loop Current, velocities are low and fairly uniform in the vertical although with bottom intensification, a characteristic of Topographic Rossby Waves (TRWs). This indicates that the Loop Current is a source of the TRWs, which are a major component of deep circulation below 1,000 m (3,281 ft) in this part of the GOM (Hamilton 1990; Science Applications International Corporation 1989; Sturges et al. 1993). Exchange of surface and deep water occurs with descent of surface water beneath the Loop Current in the eastern GOM and with the ascent of deep water in the northwestern GOM where LCEs spin down (Welsh and Inoue 2002). The Sturges et al. (1993) model suggests a surprisingly complex circulation pattern beneath LCEs, with vortex-like and wave-like features that interact with the bottom topography (Welsh and Inoue 2000). These model findings are consistent with Hamilton's (1990) interpretation of observations. Occasionally currents have been directly measured at abyssal depths exceeding 3,000 m (9,843 ft) in the GOM. The major low-frequency fluctuations in velocity of these currents in the bottom 1,000-2,000 m (3,281-6,562 ft) of the water column have the characteristics of TRWs. These long waves have wavelengths of 150-250 km (93-155 mi), periods greater than 10 days, and group velocities estimated at 9 km/day (5.6 mi/day). They are characterized by columnar motions that are intensified near the seafloor. They move westward at higher group velocities than the translation velocity of 3-6 km/day (2-4 mi/day) that is typical of anticyclonic eddies. The Loop Current and LCEs are thought to be major sources of these westward propagating TRWs (Hamilton 1990; Oey and Zhang 2004). These TRWs transition from short to longer period in going from east to west over the GOM basin, probably because of bottom slope and regional bathymetric conditions (Donohue et al. 2008).

Deepwater GOM Currents

In general, past observations of currents in the deepwater GOM have revealed decreases in current speed with depth. During late 1999, a limited number of high-speed current events, at times approaching 100 cm/s (39 in/s), were observed at depths exceeding 1,500 m (4,921 m) in the northern GOM (Hamilton and Lugo-Fernandez 2001; Hamilton et al. 2003). Furrows oriented nearly parallel to depth contours have been observed recently in the region of 90°W. longitude just off the Sigsbee Escarpment and near the Bryant Fan, south of Bryant Canyon, from 91° to 92.5° W. longitude. Depths in those regions range from 2,000 to 3,000 m (6,562 to 9,843 ft). It is hypothesized that near-bottom speeds of currents responsible for the furrows that are closest to shore might be 50 cm/s (20 in/s), possibly in excess of 100 cm/s (39 in/s), and that these currents may be oriented along isobaths and increase in strength toward the escarpment. These currents might be sporadic or quasi-permanent. Mean deep (~2,000 m [~6,562 ft]) flow around the edges of the GOM circulates in a cyclonic (counterclockwise) direction (Sturges et al., 2004). A net counterclockwise circulation pattern was also observed at about 900-m (2,953-ft) depth around the borders of the GOM (Weatherly 2004). In deep water, several oil and gas operators have observed very high-speed currents in the upper portions of the water column. These high-speed currents can last as long as a day. Such currents may have vertical extents of less than 100 m (328 ft), and they generally occur within the depth range of 100-300 m (328-984 ft) in total water depths of 700 m (2,297 ft) or less over the upper continental slope. Maximum speeds exceeding 150 cm/s (59 in/s) have been reported. The mechanisms by which these currents are generated may include motions derived from the Loop Current and associated eddies, motions due to eddy-eddy and/or slope-shelf/eddy interaction, internal/inertial wave motions, instabilities along eddy frontal boundaries, and biases in the data record related to instrument limitations (DiMarco et al. 2004).

The major large-scale permanent circulation feature present in the western and central GOM is an anticyclonic (clockwise-rotating) feature oriented about ENE-WSW with its western extent near 24°N latitude off Mexico. There has been debate regarding the mechanism for this anticyclonic circulation and the possible associated western boundary current along the coast of Mexico. Elliott (1982) attributed LCEs as the primary source of energy for the feature, but Sturges et al. (1993) argued that wind stress curl over the western GOM is adequate to drive an anticyclonic circulation with a western boundary current. Sturges et al. (1993) found annual variability in the wind stress curl corresponding to the strongest observed boundary current in July and the weakest in October. Based on ship-drift data, Sturges et al. (1993) reported the maximum northward surface speeds in the western boundary current were 25-30 cm/s (10-12 in/s) in July and about 5 cm/s (2 in/s) in October; the northward transport was estimated to vary from 2.5 to 7.5 m^3/s. Sturges et al. (1993) reasoned that the contribution of LCEs to driving this anticyclonic feature must be relatively small. Others have attributed the presence of a northward flow along the western GOM boundary to ring-slope-ring interactions (Vidal et al. 1999).

3.2.2 Wind

In coastal areas, the sea breeze effect may become the primary circulation feature during the summer months of May through October. The primary wind pattern moves from shore to offshore, transporting air pollutants from land to offshore areas. In general, however, the subtropical maritime climate is the dominant feature in driving all aspects of the weather in this region; as a result, the climate shows very little diurnal or seasonal variation. Tropical conditions normally prevail over the GOM from May to November. Wind events such as cold-air outbreaks can also result in extreme waves and current speeds over the continental shelf. Surface waves and sea state can occasionally limit normal oil and gas operations as well as oil-spill response activities (Fingas and Fieldhouse 2003; French-McCay et al. 2005).

Winds are more variable near the coast than over open waters because coastal winds are more directly influenced by the moving cyclonic storms that are characteristic of the continent and because of the land and sea breeze regime. During the relatively constant summer conditions, the southerly position of the Bermuda High generates predominantly southeasterly winds, which become more southerly in the northern Gulf of Mexico. Winter winds usually blow from easterly directions with fewer southerlies but more northerlies. Precipitation is frequent and abundant throughout the year but does show distinct seasonal variation. Stations along the entire coast record the highest precipitation values during the warmer months of the year. The warmer months usually have convective cloud systems that produce showers and thunderstorms (NOAA 2020k). The month of maximum rainfall for most locations is July. Winter rains are associated with the frequent passage of frontal systems through the area. Rainfalls are generally slow, steady, and relatively continuous, often lasting several days. Snowfalls are rare, and when frozen precipitation does occur, it usually melts on contact with the ground. Incidence of frozen precipitation decreases with distance offshore and rapidly reaches zero.

Warm, moist GOM air blowing slowly over chilled land or water surfaces brings about the formation of fog. Fog occurrence decreases seaward, but visibility has been less than 800 m (2,625 ft) due to offshore fog. Coastal fogs generally last 3-4 hours, although particularly dense sea fogs may persist for several days. The poorest visibility conditions occur during winter and early spring. The period from November through April has the lowest visibility. Industrial pollution and agricultural burning also impact visibilities. The mixing height is very important because it determines the volume available for dispersing pollutants. Because the mixing height is directly related to vertical mixing in the atmosphere, a mixed layer is expected to occur under neutral and unstable atmospheric conditions. The mixing height tends to be lower in winter, and daily changes are smaller than in summer.

Mixing height *is the height of vertical mixing of air and suspended particles above the ground, which is largely driven by the vertical temperature profile of the air.*

The GOM is part of the Atlantic tropical cyclone basin. Tropical cyclones generally occur in summer and fall seasons; however, the Gulf of Mexico also experiences winter storms or extratropical storms. These winter storms generally originate in middle and high latitudes and have winds that can attain speeds of 9-50.5 kn (11.2-58.2 mph). The GOM is an area of cyclone development during cooler months due to the contrast of the warm air over the GOM and the cold continental air over North America. Cyclogenesis, or the formation of extratropical cyclones, in the GOM is associated with frontal overrunning (Hsu 1991). The most severe extratropical storms in the GOM originate when a cold front encounters the subtropical jet stream over the warm waters of the Gulf of Mexico. Statistics of 100-year data of extratropical cyclones reveal that most activity occurs above 25°N. latitude in the western GOM. The mean number of these storms range from 0.9 near the southern tip of Florida to 4.2 over central Louisiana (Florida A&M University 1988).

The frequency of cold fronts in the GOM exhibits similar patterns during the four-month period of December through March. During this time the area of frontal influence reaches 10°N. latitude. Frontal frequency is about nine fronts per month (1 front every 3 days on the average) in February and about seven fronts per month in March (1 front every 4-5 days on the average). By May, the frequency decreases to about four fronts per month (1 front every 7-8 days) and the region of frontal influence retreats to about 15°N. latitude. During June-August, frontal activity decreases to almost zero and fronts seldom reach below 25°N. latitude (Florida A&M University 1988).

3.2.3 Water Temperature

Cold fronts, as well as diurnal and seasonal cycles of heat flux at the air/sea interface, affect near-surface water temperatures, although water at depths greater than about 100 m (328 ft) remains unaffected by surface boundary heat flux. Water temperature is greater than air temperature at the air/sea interface during all seasons. Frontal passages over the region can cause changes in temperature and velocity structure in the upper layers, specifically increasing current speeds and variability. These fronts tend to occur with frequencies from 3 to 10 days (weatherband frequency). In the winter, the shelf water is nearly homogeneous due to wind stirring and cooling by fronts and winter storms.

Continental shelf waves may propagate along the continental slopes of the GOM. These are long waves similar to TRWs, but their energy is concentrated along a sloping bottom with shallow water to the right of the direction of propagation, and because of this constraint, they are effectively "trapped" by the sloping bottom topography. Cold water from deeper off-shelf regions moves onto and off of the continental shelf by cross-shelf flow associated with upwelling and downwelling processes.

A class of energetic surface currents previously unreported in the GOM were found over the Texas and Louisiana shelves during the Texas-Louisiana Shelf Circulation and Transport Process (LATEX) program of the early 1990s (Nowlin Jr. et al. 1998). July 1992 observations in 200 m (656 ft) water offshore of Louisiana were of maximum amplitudes of 40-60 cm/s (16-27 in/s) at a depth of 12 m (39 ft) during conditions of light winds. The period of diminished amplitudes followed an atmospheric frontal passage. These are near-circular, clockwise-rotating oscillations with a period near 24 hours.

They seem to be an illustration of thermally induced cycling (DiMarco et al. 2000) in which high-amplitude rotary currents can exist in thin mixed layers typical of summer. By contrast, December 1992 measurements evidence no such behavior. Many examples of such currents, in phase at distinct locations, exist for the Texas-Louisiana shelf and, by implication, farther offshore. Currents at a depth of 1 m (3 ft) have been observed to reach 100 cm/s (40 in/s). In deepwater regions of the GOM, clearly episodic wind events can cause major currents in the deep waters of the Gulf of Mexico. The initial currents give rise to inertial oscillations with decreasing amplitudes, which last for up to about 10 days and are superimposed on longer period signals.

Inner-shelf currents on the Louisiana-Texas continental shelf flow in the downcoast (south or west) direction during non-summer months, reversing to upcoast flow in the summer (Nowlin Jr. et al. 2005). Monthly averaged alongshore currents on the outer shelf are upcoast in the mean but showed no coherent pattern in the annual signal and were not often in the same alongshore direction at different outer-shelf locations (Nowlin Jr. et al. 1998). Mean cross-shelf geostrophic transport observed at the Louisiana-Texas shelf break was offshore during the winter (particularly in the upper 70 m [230 ft] of the water column) and onshore during the summer (Current and Wiseman Jr. 2000).

Circulation on the continental shelf in the northeastern GOM has been observed to follow a cyclonic pattern, with westward alongshore currents prevailing on the inner and middle shelf and opposing alongshore flow over the outer shelf and slope (Brooks and Giammona 1991). Inner shelf currents are primarily wind driven and are also influenced by river outflow and buoyancy forcing from water discharged by the Mississippi, Apalachicola, Tombigbee, Alabama, and other rivers in the region. Cold water from deeper off-shelf regions moves on and off the continental shelf by cross-shelf flow associated with upwelling and downwelling processes. Upwelling of nutrient rich, cold water onto the shelf in 1998 was correlated with hypoxia, anoxia, and mass mortalities of fishes and invertebrates in the region, although causation has not been established (Collard and Lugo-Fernández 1999).

Mean circulation on the West Florida inner shelf tends to be along the coast towards the southeast during the winter and reverses to be along the coast towards the northwest during the summer. These seasonal means in flow direction are because of the influence of seasonal local winds and heat flux forcing. Midshelf flow (around the 50-m [164-ft] isobath) can be in the opposite direction from inner shelf flow on the broad, gently sloping West Florida shelf because of the partial closure imposed by the Florida Keys to the south. The outer shelf is an area of transition between deepwater currents over the continental slope and the shelf regime. The nearshore regions are influenced by freshwater outflow from rivers and estuaries. Mississippi River water is advected onto the West Florida shelf at times in spring and summer because of strong currents along the shelf break. Fresh water from the Mississippi River is sometimes entrained by the Loop Current as well (Liu and Weisberg 2012).

Water mass property extremes are closely associated with specific density surfaces. Summer heating and stratification affect continental-shelf waters in the GOM. Salinity is generally lower nearshore, although fresh water from the Mississippi and other rivers occasionally moves into outer shelf waters. Freshwater intrusions further lower the salinity after local storms. Subsurface waters derive from outside the Gulf of Mexico and enter from the Caribbean Sea through the Yucatan Channel. Below about 1,800 m (5,906 ft), temperature and salinity across the GOM is relatively uniform (Nowlin Jr. 1972).

3.3 NATURAL EVENTS AND PROCESSES

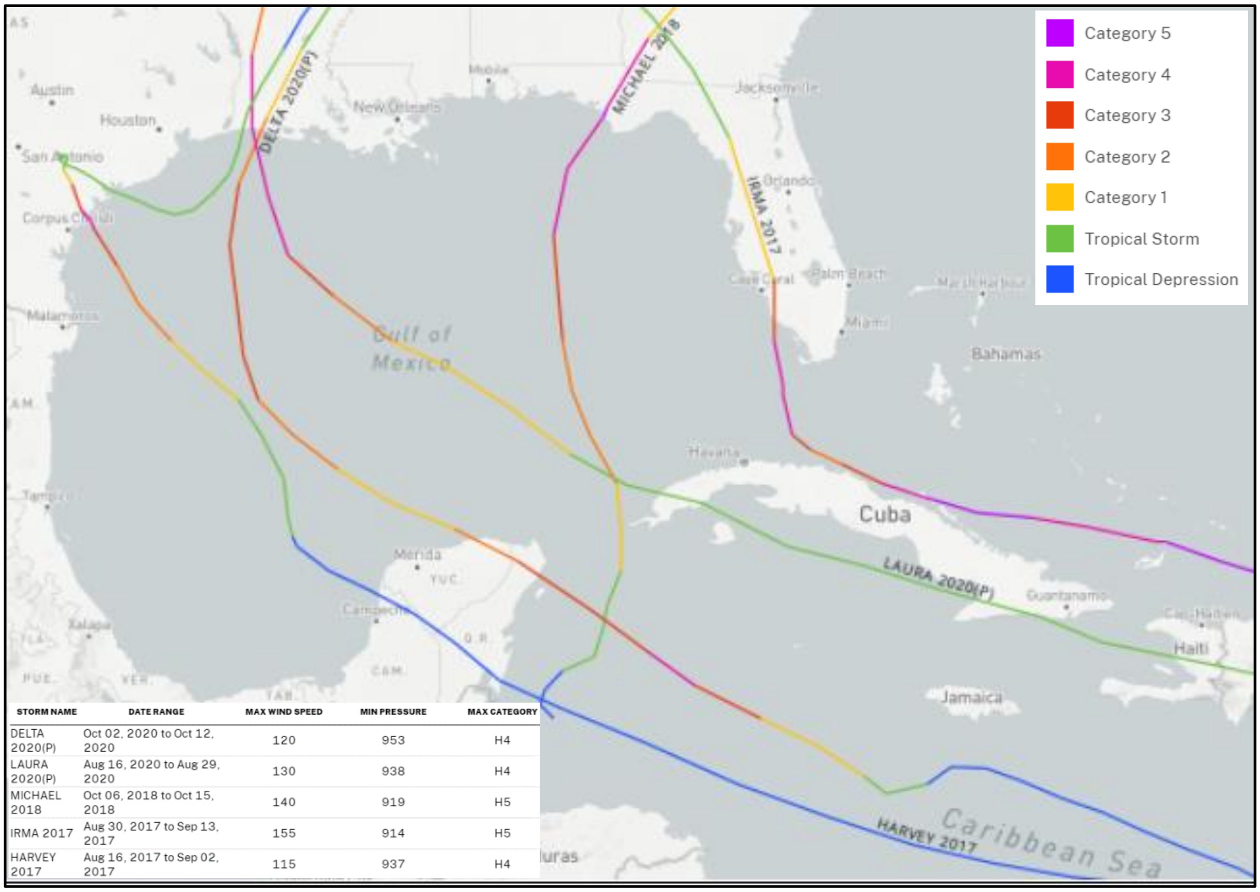
3.3.1 Major Storms

Tropical cyclones (especially hurricanes) affecting the Gulf of Mexico originate over the equatorial portions of the Atlantic Ocean, the Caribbean Sea, and the GOM. Tropical cyclones occur most frequently between June and November. Based on 50 years of data, there are about 10.2 storms per year with about 5.9 of those becoming hurricanes in the Atlantic Ocean. Data from 1950 to 2000 show that 81 percent of these storms could affect the GOM (Klotzbach et al. 2020). The Yucatan Channel is the main entrance of Atlantic storms into the GOM, and a reduced translation speed over Gulf of Mexico waters leads to longer residence times in this basin.

There is a high probability that tropical storms will cause damage to physical, economic, biological, and social systems in the Gulf of Mexico. Tropical storms also affect OCS operations and activities; platform design needs to consider the storm surge, waves, and currents generated by tropical storms. Most of the damage is caused by storm surge, waves, and high winds. Storm surge depends on local factors, such as bottom topography and coastline configuration, and storm intensity. Water depth and storm intensity control wave height during hurricane conditions. Sustained winds for major hurricanes (Saffir-Simpson Category 3 and above) are higher than 95.2 kn (109.6 mph).

Tropical cyclones (especially hurricanes) and extra tropical cyclones can result in extreme waves and cause currents with speeds of 100-150 cm/s (40-59 in/s) over the continental shelves. Brooks (1983; 1984), measured the effects of such phenomena down to depths of 700 m (2,297 ft) over the continental slope in the northwestern Gulf of Mexico. Hurricanes can trigger a series of internal waves with near inertial period. Waves as high as 91 ft (28 m) were measured under Hurricane Ivan (Wang et al. 2005). Tropical cyclones may develop or migrate into the GOM during the warmer months. These storms may affect any area of the GOM and substantially alter the local wind circulation around them.

There were 22 major hurricanes (Category 3 or higher at landfall) that impacted the Gulf Coast from 2000 through 2020. Hurricanes Katrina (2005) and Rita (2005) are notable historic major hurricanes, while more recent major storms include Hurricanes Harvey (2017), Irma (2017), Michael (2018), and Laura (2020) (**Figure 3.3.1-1**). In terms of accumulated cyclone energy, which measures the strength and duration of tropical storms and hurricanes, activity in the North Atlantic, Caribbean Sea, and GOM in 2020 was well above average, more than 40 percent above the long-term mean (NOAA 2020h). With less than a month remaining in the 2020 Atlantic hurricane season, the formation of Subtropical Storm Theta on November 10, 2020, over the northeastern Atlantic Ocean made the 2020 season the most active on record (NOAA 2020b).



STORM NAME	DATE RANGE	MAX WIND SPEED	MIN PRESSURE	MAX CATEGORY
DELTA 2020(P)	Oct 02, 2020 to Oct 12, 2020	120	953	H4
LAURA 2020(P)	Aug 16, 2020 to Aug 29, 2020	130	938	H4
MICHAEL 2018	Oct 06, 2018 to Oct 15, 2018	140	919	H5
IRMA 2017	Aug 30, 2017 to Sep 13, 2017	155	914	H5
HARVEY 2017	Aug 16, 2017 to Sep 02, 2017	115	937	H4

Figure 3.3.1-1. Major Hurricanes Making U.S. Landfall along the Gulf Coast Between 2015 and 2020 (NOAA 2020d).

The following summaries of each are provided from NOAA's National Hurricane Center's tropical cyclone reports, with the exception of Hurricane Laura, which was not currently available at the time this document was prepared. The National Hurricane Center's reports can be searched for all category storms online at http://www.hurricanes.gov/data/tcr/index.php?season=2020&basin=atl.

Hurricane Katrina was one of the costliest and deadliest hurricanes to ever strike the U.S. and caused a wide swath of catastrophic damage and inflicted large loss of life. There was also a significant storm surge west of the path of the eye of Hurricane Katrina. The level of Lake Pontchartrain rose; a 12- to 16-ft (4- to 5-m) storm surge pushed several feet of water into the northeastern shore of St. Tammany Parish. A storm surge of 15-19 ft (5-6 m) occurred in eastern New Orleans, St. Bernard Parish, and Plaquemines Parish, Louisiana. This storm surge severely strained the levee system in the New Orleans area and several of the levees and floodwalls were overtopped and/or breached. About 80 percent of the city of New Orleans flooded up to 20 ft (6 m). The most significant damage and loss of life was inflicted in Louisiana and Mississippi, and significant effects also extended into the Florida Panhandle, Georgia, and Alabama (Knabb et al. 2005).

Less than a month after Hurricane Katrina, Hurricane Rita impacted the Gulf Coast States and OCS-related infrastructure. The following information on Hurricane Rita is from the *Tropical Cyclone*

Report: Hurricane Rita, 18-26 September 2005 by the National Hurricane Center. Like Hurricane Katrina, Hurricane Rita was an intense hurricane that reached Category 5 strength over the central GOM and weakened prior to making landfall as a Category 3 hurricane near the Texas/Louisiana border (Knabb et al. 2006).

Hurricane Rita also produced significant storm surge. This storm surge devastated coastal communities in southwestern Louisiana, an area very vulnerable to surge. Unofficial visual estimates suggest that the storm surge was as high as 15 ft (5 m) in Cameron, Louisiana. Water was also pushed into Calcasieu Lake, flooding portions of communities along its shoreline, such as Grand Lake, with a storm surge of at least 8 ft (2 m). The surge then propagated up the Calcasieu River and flooded portions of the Lake Charles area. Flood waters in downtown Lake Charles were as deep as 6 ft (2 m). Farther east, most or all of Vermillion, Iberia, and St. Mary Parishes were inundated by the storm surge, visually estimated at 8-12 ft (2-4 m) in some of these areas. Hurricane Rita also produced storm surges of 4-7 ft (1-2 m) in coastal areas of southeastern Louisiana, flooding some areas already impacted by Hurricane Katrina. It took until early October to remove all floodwaters from the New Orleans area following these two storms (Knabb et al. 2006).

Hurricane Harvey made landfall on the northern end of San Jose Island, Texas, on August 25, 2017, with estimated sustained winds of 115 kn (132 mph) (**Figure 3.3.1-1**). The hurricane then made a second landfall on the Texas mainland 3 hours later, slightly weaker due to land interaction. The combined effect of the surge and tide produced maximum inundation levels of 6-10 ft (2-3 m) above ground level to the north and east of Harvey's center landfalls in Texas in the back bays between Port Aransas and Matagorda, including Copano Bay, Aransas Bay, San Antonio Bay, and Matagorda Bay. Copano Bay, where Hurricane Harvey made its second Texas landfall, also had significant storm surge flooding of 4-7 ft (1-2 m) above ground level. Harvey was the most significant tropical cyclone rainfall event in United States history, both in scope and peak rainfall amounts, since reliable rainfall records began around the 1880s. The highest storm total rainfall report from Harvey was 60.58 in (153.87 cm) near Nederland, Texas, with another report of 60.54 in (153.77 cm) from near Groves, Texas. The latest NOAA damage estimate from Harvey is $125 billion, with the 90 percent confidence interval ranging from $90 to $160 billion. Harvey is responsible for at least 68 direct deaths in the United States, all in Texas. Over half of the deaths (36) were in Harris County in the Houston metro area. The mid-point of the estimate would tie Katrina (2005) as the costliest United States tropical cyclone, which was also $125 billion (refer to https://www.ncdc.noaa.gov/billions/) (Blake and Zelinsky 2018).

Hurricane Irma made U.S. landfall in September 2017 as a Category 4 in the Florida Keys and struck southwestern Florida at Category 3 intensity (**Figure 3.3.1-1**). The hurricane continued northward across central Florida with hurricane conditions decreasing in areal coverage near the Orlando and Tampa areas; however, tropical storm conditions were experienced on both the west and east coasts of the state, as well as in part of Georgia and South Carolina. Irma produced heavy rain across much of the State of Florida, and rainfall totals of 10-15 in (25-38 cm) were common across the peninsula and the Keys. In coastal Georgia, rainfall totals were generally between 5 and 10 in (13-25 cm), with major flooding in St. Simon's Island and along the Satilla River. Southwestern Florida experienced maximum storm surge levels of 6-10 ft (2-3 m) along the unpopulated coast between

Cape Sable and Cape Romano, within Everglades National Park and the Ten Thousand Islands National Wildlife Refuge. Maximum inundation levels of 3-5 ft (1-2 m) above ground level occurred along the remainder of the southwestern coast of Florida from Marco Island northward through Naples to Ft. Myers. The east coast of Florida experienced maximum storm surge levels of 4-6 ft (1-2 m) around Miami-Dade County, especially along Biscayne Bay. In the U.S, 10 direct deaths were reported, and an additional 82 indirect deaths occurred, 77 of which were in Florida. Hundreds more were injured before, during, or after the hurricane. About 6 million residents in Florida were evacuated from coastal areas (Cangialosi et al. 2018).

Hurricane Michael made landfall as a Category 5 near Tyndall Air Force Base (AFB) in the Florida Panhandle, quickly weakening to a category 3 shortly after landfall (**Figure 3.3-1**). Maximum storm surge inundation heights were estimated at 9-14 ft (3-4 m) above ground level in the surrounding Gulf Counties near Tyndall AFB, with the highest inundation occurring in Mexico Beach. The storm center continued northeastward, eventually weakening to a tropical storm through North Carolina. Extratropical transition started as Michael moved into North Carolina, however, with the winds intensifying as it continued through North Carolina and eventually into Virginia. Storm surge flooding also occurred along portions of the North Carolina and Virginia coasts while Michael underwent extratropical transition, with localized maximum inundation heights of 2-4 ft (1-2 m) occurring in parts of the North Carolina sounds and Lower Chesapeake Bay. The storm eventually regained hurricane-force winds in October over the open ocean south of Nova Scotia and Newfoundland, followed by a sharp eastward motion and eventually dissipating just west of northern Portugal. Michael's track across the southeastern U.S. resulted in widespread rains of 3-6 (6-15 cm) and localized rainfall totals in excess of 10 in (25 cm). The maximum storm total rainfall reported was 13.01 in (33.05 cm) near Black Mountain, North Carolina, while Lynn Haven, Florida, reported a storm total of 11.62 in (25.91 cm). The winds, storm surge, and rains of the hurricane directly caused 16 deaths: 7 in Florida, 5 in Virginia, 3 in North Carolina, and 1 in Georgia. Michael's passage across the Florida Panhandle and the remainder of the southeastern U.S. left a swath of destruction, the worst of which occurred in Mexico Beach and at Tyndall AFB. As of May 2019, NOAA's National Centers for Environmental Information had estimated the total damage from Michael in the U.S. alone at approximately $25 billion. Of this total, about $18.4 billion occurred in Florida (with about $3 billion of this on Tyndall AFB), $4.7 billion occurred in Georgia, and $1.1 billion occurred in southeastern Alabama, with smaller amounts of damage in South Carolina, North Carolina, and Virginia (Beven II et al. 2019).

Hurricane Laura formed on August 21, 2020, and became the first major hurricane of 2020 on August 26. Laura made landfall as a Category 4 storm on August 27, 2020, near Cameron, Louisiana, close to the Texas-Louisiana border, bringing catastrophic storm surge, extreme wind, and flash flooding. Laura made landfall with 150 mph winds, stronger than Hurricane Katrina in 2005, and tied with the Last Island hurricane of 1856 as the strongest to strike Louisiana. The remnants of Laura traveled through the mid-Mississippi Valley and brought heavy rain to the Mid-Atlantic States. To date, Laura is responsible for six deaths in Louisiana and widespread property damage, especially in Lake Charles, Louisiana. Insured loss estimates by catastrophe modelers range from $4 billion to $12 billion (Insurance Information Institute Inc. 2020).

3.3.2 Eutrophication and Hypoxia

Nutrients are elements that are essential to both plant and animal growth. Common nutrients include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and silicon. While nutrients are an essential component to healthy ecosystems, excess amounts of nutrients added to water bodies (sometimes called "eutrophication") can create unintended side effects. Eutrophication occurs when excess nutrients cause an overproduction in the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen. Natural external sources include riverborne phytoplankton, organic detritus, and marginal vegetation, supplemented considerably by anthropogenic point sources and nonpoint sources (refer to **Chapter 2.3.3.7**) that include sewage and some industrial effluents. Natural internal production sources include phytoplankton, macroalgae, and aquatic organism feces. The increase in loads of nutrients (nitrogen and phosphorus) to the marine environment stimulates the production of organic matter, principally in the form of phytoplankton and macroalgae. These blooms of harmful algae species can cause neurotoxic shellfish poisoning and respiratory problems in humans and other mammals (Kirkpatrick et al. 2004). **Figure 3.3.2-1** provides a generalized depiction of eutrophication and its influence on aquatic environments.

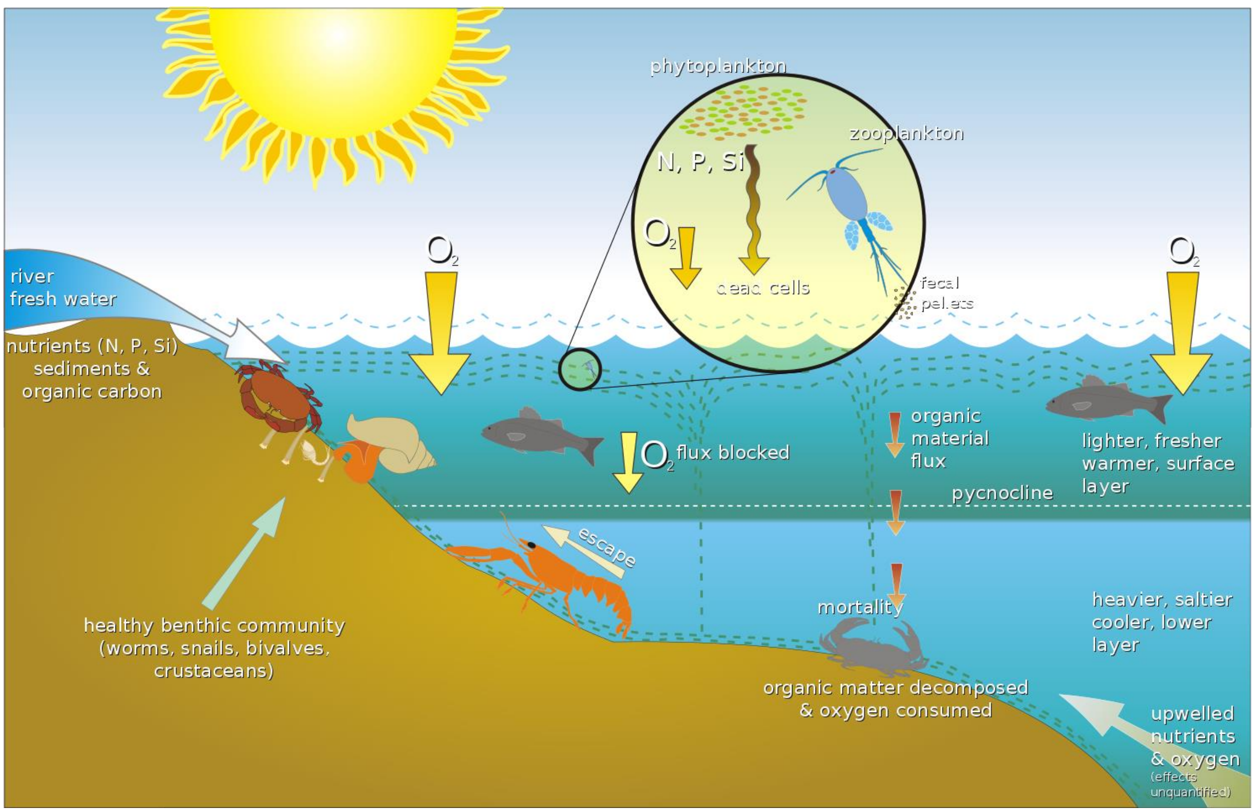


Figure 3.3.2-1. Generalized Schematic of Eutrophication Cycle (Hillewaert 2006).

The Mississippi River basin drains 41 percent of the contiguous United States. The basin covers more than 1,245,000 mi^2 (3,224,535 km^2) and includes all or parts of 31 states and 2 Canadian provinces (USACE 2020b). Dissolved pollutants, including nutrients, enter surface water within the Mississippi River basin via uncontained runoff and groundwater discharge (nonpoint sources).

The sources of nutrients in surface waters can be broadly divided as natural and anthropogenic. Natural sources are generally ubiquitous; however, their contribution is usually low because, over the course of time, natural systems have established balances between the production and consumption of nutrients. In addition to human activities, other factors contribute to excess nutrients reaching GOM waters including (1) historical landscape changes in the drainage basin, including conversion of perennial systems to annual cropping systems; (2) channelization and impoundment of the Mississippi River throughout the basin and the Mississippi Delta, and the loss of coastal wetlands; and (3) changes in the hydrologic regime of the Mississippi and Atchafalaya Rivers and the timing of fresh water inputs that are critical to stratification, and which can cause hypoxia (USEPA 2017c). Anthropogenic sources arise from many activities. In the agricultural setting of the Mississippi River drainage basin, farmers increase the productivity and yield of their crops by use of chemical fertilizers. If more fertilizers are applied than are used by the crops, they can move into ground and surface waters and become a major source of nutrients in rivers. Additionally, fertilizer that is bound to soil or "loose" fertilizer may be subject to erosion by wind or water and affect surface waters. Information regarding nutrient management can be found on the U.S. Department of Agriculture's Natural Resources Conservation Service website at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/mnm/. Other major sources of nutrients in surface waters are domestic and animal wastes. Although municipal wastewater is treated, only a fraction of the nutrients is removed. In addition to the nutrients derived from human sewage, municipal wastewater also contains nutrients from such things as lawn fertilizers, household cleaners, and detergents. Other anthropogenic sources of nutrients are industrial, either from the manufacture of fertilizers or as by-products of other manufacturing processes (Antweiller et al. 1995).

At the basin scale, agricultural inputs (i.e., manure, fertilizer, and legume crops) were the largest total nitrogen source into the GOM (60% of the total), with farm fertilizers contributing 41 percent of that amount. Atmospheric deposition, which may include volatilized losses from natural, urban, and agricultural sources, contributed 26 percent; urban sources contributed about 14 percent (7% from urban areas and 7% from wastewater treatment plants) (USEPA 2017c).

Agricultural inputs (i.e., manure and fertilizers) were also the largest total phosphorus source into the GOM: 49 percent of the total, with 27 percent from chemical fertilizers and 22 percent from manure. Urban sources contributed 29 percent: 16 percent from urban areas and 13 percent from wastewater treatment plants. Background sources of phosphorus included erosion of channels and banks of large streams where phosphorus was previously deposited from other upstream sources (14%), deeply weathered loess soils (5%), and forests (3%) (USEPA 2017c).

Nutrient enrichment results in eutrophication, causing growth of algae (algal bloom) and other aquatic plants. A second effect of eutrophication is the increased uptake of dissolved oxygen by bacteria in response to higher concentrations of organic matter. If oxygen is taken up by decaying organic matter faster than it is imported from the atmosphere or produced by photosynthesis, it becomes depleted and the aquatic species that require it are adversely affected. Furthermore, oxygen depletion causes basic changes in the chemical environment (i.e., a reduced environment) that allow materials (including many metals) that were formerly associated with the solid phase sediments (e.g., sorbed) to become soluble and, therefore, more mobile in the aqueous phase (National Research Council 2003b).

On October 21, 2014, the U.S. Department of the Interior and the U.S. Department of Agriculture announced a new partnership to strengthen the effectiveness of State and Federal nutrient-reduction strategies (USGS 2014). As a result of this and other efforts, states are beginning to impose Best Management Practices on growers within the Mississippi River basin to develop nutrient management plans, including fertilizer applicator certification programs, and monitoring to minimize excess nutrients from washing into waterways.

Oxygen enters the ocean at the air-sea boundary via exchange with the atmosphere. The main factors controlling oxygen concentrations in the water column are physical (temperature) and biological (respiration, photosynthesis, and bacterial decomposition). Nutrient overload to the marine environment can drive biological oxygen demand to exceed the oxygen content of the water. Low dissolved oxygen concentration (<2 mg/L) is referred to as hypoxia.

"Hypoxia" occurs when the amount of dissolved oxygen in the water becomes too low to support most aquatic life (typically below 2 mg/L).

The Gulf of Mexico hypoxic zone is a band of oxygen-stratified water that stretches along the Texas-Louisiana shelf each summer where the dissolved oxygen concentrations are less than 2 mg/L (USEPA 2019a). Other small hypoxic areas infrequently form at the discharge of smaller rivers along the Gulf Coast; however, in the Gulf of Mexico, the hypoxic zone resulting from the Mississippi and Atchafalaya Rivers is by far the predominant feature. The hypoxic zone is the result of excess nutrients, primarily nitrogen, carried downstream by rivers to discharge to coastal waters. Density stratification results where the less dense, nutrient-rich freshwater spreads on top of the denser seawater and prevents oxygen from replenishing the bottom waters. The excess nutrients cause phytoplankton blooms that eventually die and sink to the bottom, where bacterial decomposition consumes dissolved oxygen. The oxygen-depleted bottom waters occur seasonally and are affected by the timing of the Mississippi and Atchafalaya Rivers' discharges carrying nutrients and freshwater to shelf surface waters. Hypoxic zones are sometimes called "dead zones" because of the absence of commercial quantities of shrimp and fish in the bottom layer.

The hypoxic zone on the Louisiana-Texas shelf is the largest such zone in the United States and the entire western Atlantic Ocean (Rabalais et al. 2010). The Louisiana Universities Marine Consortium generally forecasts the seasonal maximum size of the Louisiana-Texas hypoxic zone based on nitrogen loading in the Mississippi River (as measured in May of each year), and the actual size reported is based on cruise data collected by the Louisiana Universities Marine Consortium in July of each year. Recent estimates of the area of low oxygen measured 6,952 mi^2 (18,006 km^2) (NOAA 2019b). As of August 1, 2019, the hypoxic zone, is the 8th largest in the 33-year record and exceeds the 5,770-mi^2 (14,944-km^2) average from the past 5 years. In June 2019, NOAA forecasted a near historic hypoxic zone of 7,829 mi^2 (20,277 km^2), close to the record size of 8,776 mi

(22,730 km^2) set in 2017 (NOAA 2019b). In-situ measurements taken by the Louisiana Universities Marine Consortium in July 2019 showed the GOM hypoxic zone to be 6,952 mi^2 (18,006 km^2) (**Figure 3.3.2-2**), which was lower than the estimated size (Louisiana State University and Louisiana Universities Marine Consortium 2019).

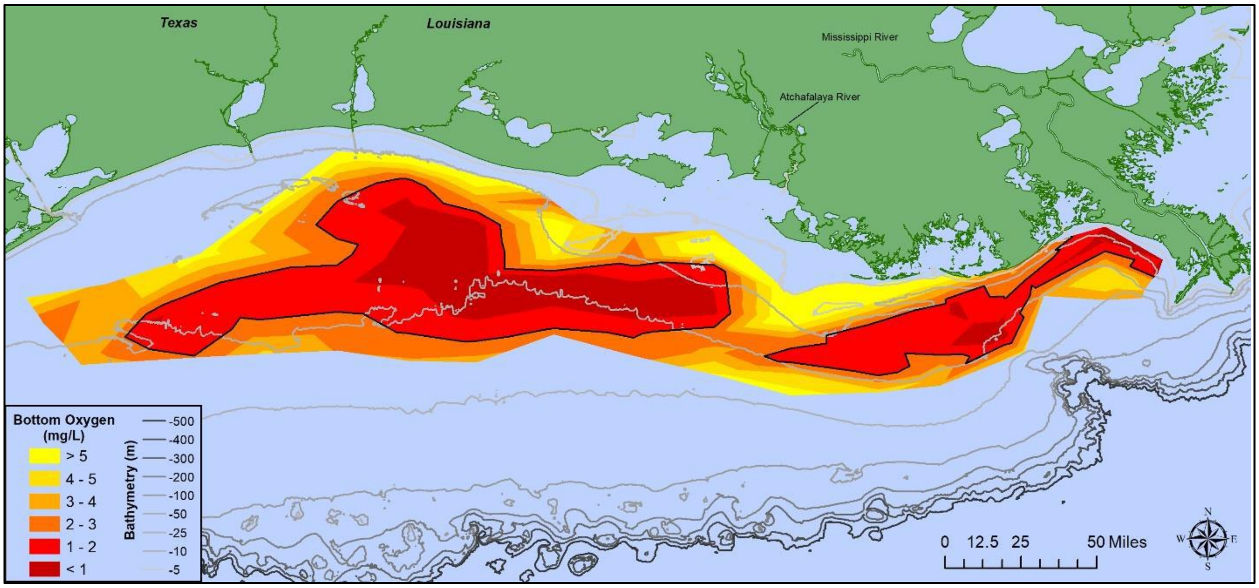


Figure 3.3.2-2. 2019 Gulf of Mexico Hypoxic Zone (Louisiana State University and Louisiana Universities Marine Consortium 2019).

Rabalais (2005) and Bierman et al. (2008) evaluated the potential contributions of carbon and nitrogen in discharged produced waters on the hypoxic zone. Both studies found that the effects due to produced water from OCS oil- and gas-related activities were minimal compared with those of the Mississippi River. As such, the Louisiana-Texas hypoxic zone is considered unrelated to OCS oil- and gas-related activities but is discussed and considered when assessing cumulative effects from OCS oil- and gas-related activities.

The Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) was passed in 1998 in response to a surge in blooms nationwide, which resulted in fish kills, beach and shellfish bed closures, and manatee deaths. It has since undergone numerous reauthorizations and amendments (U.S. Congress 2004; 2014; 2018) which reaffirmed and expanded the mandate for NOAA to advance the scientific understanding and ability to detect, monitor, assess, and predict harmful algal bloom and hypoxia events. The Act also requires an assessment of the causes and consequences of hypoxia in the GOM and the development of a plan to reduce hypoxia. Six reports commissioned by the White House Committee on Environment and Natural Resources comprise the assessment. The Interagency Working Group on HABHRCA (IWG-HABHRCA) is tasked with coordinating and convening Federal agencies, which includes BOEM, and their stakeholders to discuss harmful algal bloom and hypoxia events in the United States and to develop action plans and assessments of these situations (BOEM 2020c).

The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force was established in the fall of 1997 to understand the causes and effects of eutrophication in the Gulf of Mexico; coordinate activities to reduce the size, severity, and duration; and ameliorate the effects of hypoxia. Activities include coordinating and supporting nutrient management activities from all sources, restoring habitats to trap and assimilate nutrients, and supporting other hypoxia-related activities in the Mississippi River and Gulf of Mexico watersheds.

The Task Force includes Federal and State agencies and tribes. Federal agencies include those with responsibilities over activities in the Mississippi River and its basin, and in the Gulf of Mexico. The role of the Task Force is to provide executive level direction and support for coordinating the actions of participating organizations working on nutrient management within the Mississippi River/Gulf of Mexico watershed. The Task Force has designated members of a Coordinating Committee and solicits information from interested stakeholders.

The goal, as stated in the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force's January 2001 Action Plan, was as follows: "By the year 2035, subject to the availability of additional resources, reduce the 5-year running average aerial extent of the Gulf of Mexico hypoxic zone to less than 5,000 square kilometers through implementation of specific, practical, and cost effective voluntary actions by all States, Tribes, and all categories of sources and removals within the Mississippi/Atchafalaya River Basin to reduce the annual discharge of nitrogen into the Gulf" (USEPA 2017c).

3.3.3 Natural Seeps

Natural petroleum seeps, in which crude oil and gas naturally migrate up through the seafloor and into the water column, are very common in the Gulf of Mexico and have likely been active throughout history. Gulf of Mexico seeps are highly variable in composition and volume and include gases, volatiles, liquids, pitch, asphalt, tars, water, brines, and fluidized sediments. Seeps are most abundant and most prolific in the central and western regions of the northern GOM (Garcia-Pineda et al. 2010).

Natural seeps are difficult to quantify due to challenges in detection (e.g., occurs subsea), differences in quantification methods (e.g., satellite observations and sampling by corer), dispersion by ocean currents, gaps in geographic coverage, and variable and uncertain seep volumes and rates (National Research Council 2003a). According to the National Research Council (2003a), annual seepage for the entire GOM was estimated to be between 80,000 and 200,000 tonnes per year (roughly 24.6 million to 61.6 million gallons [crude oil equivalent]), slowly entering the GOM from thousands of locations across the entire region (National Research Council 2003a). More recently, natural seepage of oil has been estimated to exceed 42 million gallons annually: 21 million gallons in the northeastern GOM and 21 million gallons in the northwestern GOM (Kennicutt II 2017a; National Research Council 2003a). MacDonald et al. (2015) further observed that oil from natural slicks was regionally concentrated as follows: 68 percent in the northwest, 25 percent in the southwest, 7 percent in the northeast, and <1 percent in the southeast Gulf of Mexico.

In contrast to a large accidental oil spill resulting from human-related activities, this volume of oil slowly enters the GOM from thousands of locations over a huge area annually. Oil from these seeps contributes to the region's "background" chemicals, but the magnitude and effects of this oil source are very different from acute effects that would be typical of an accidental oil spill.

3.4 CLIMATE CHANGE

The Earth's climate system is driven by solar radiation, which provides heat to the planet. Increasingly, human- influenced changes to the Earth's atmosphere have slowed the rate at which this incoming solar radiation is re-radiated back into space, resulting in a net increase of energy in the Earth system (IPCC 2014). The climate's subsequent response is complicated by a number of positive and negative feedback processes among atmospheric, terrestrial, and oceanic systems, but the overall result is climatic warming, as is evident by observed increases in air and ocean temperatures, melting snow and ice, and rising sea levels (IPCC 2014). These planet-wide chemical and physical changes are collectively referred to as climate change. **Figure 3.4-1** shows factors that have increased and decreased as a result of climate change.

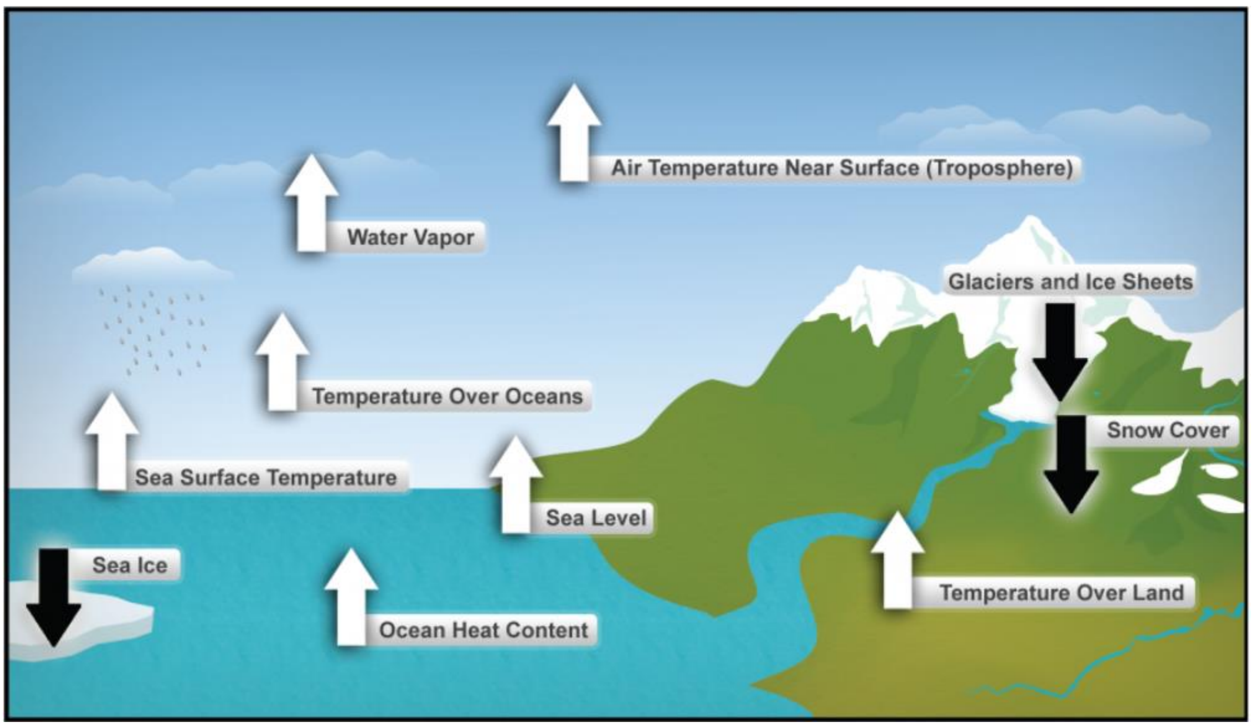


Figure 3.4-1. Effects of Climate Change (white arrows indicate increases and black arrows indicate decreases) (Melillo et al. 2014).

Chief among drivers of climate change are increasing atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs), such as methane (CH_4, also known as natural gas), and nitrous oxide (N_2O). In November 2016, BOEM released *OCS Oil and Natural Gas: Potential Lifecycle Greenhouse Gas Emissions and Social Cost of Carbon* (Wolvovsky and Anderson 2016). This report is a comprehensive analysis of potential greenhouse gas emissions that may result from offshore oil and gas leasing. This includes emissions released during offshore operations for which BOEM has jurisdiction, along with the onshore processing, distribution, and consumption of oil and gas products. In February 2023, BOEM updated this analysis for the GOM region in the Gulf of Mexico OCS Oil and Gas Leasing Greenhouse Gas Emissions and Social Cost Analysis: Addendum to the Gulf of Mexico Lease Sales 259 and 261 Supplemental EIS and Technical Report – Corrected (BOEM 2023).

Anthropogenic GHG emissions have increased since the pre-industrial era, which increase is driven largely by economic and population growth. From 2000 to 2010 emissions were the highest in history, with CO_2 being the major anthropogenic GHG, accounting for 76 percent of total anthropogenic GHG emissions (IPCC 2014). Greenhouse gases are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat within the lowest portion of the Earth's atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. Other climate forcers, such as black carbon, a specific kind of fine particulate matter ($PM_{2.5}$), also contribute to Earth's rising surface temperature.

3.4.1 Temperature Shifts and Sea-Level Rise

Average temperature in the continental United States has increased approximately 0.3°C (0.5°F) since 1895, and most of this increase has occurred since 1970. The most recent decade (2010-2020) was the Nation's and the world's hottest since 1880, and 2016 was the hottest year since 1880 (NOAA 2020a). The rate of warming for the past 50 years is about twice as high as the rate of the past 100 years (IPCC 2014). Across the U.S., temperatures are generally expected to rise another 1.1 to 2.2°C (2 to 4°F) over the next few decades. During the 21st century, average global atmospheric temperature is projected to rise 1.65 to 2.75°C (3 to 5°F), which is under the lowest emissions scenarios (IPCC 2014). Even if significant emissions reductions occur, many of the effects from sea-level rise over this century—and particularly through mid-century—are already locked in due to historical emissions, and many communities are already dealing with the consequences (U.S. Global Change Research Program 2018).

The majority of heat energy associated with climate change is being absorbed by the oceans (Levitus et al. 2012), offsetting what would otherwise be a more rapid rise in atmospheric temperatures. Although there are annual and decadal shifts in ocean heat content (Levitus et al. 2012), temperatures in the upper 2,000 m (6,562 ft) of the water column have increased dramatically since the 1950s (IPCC 2014). The IPCC (2014) indicates a high likelihood of Atlantic meridional overturning circulation slowdown in the next 100 years; however, overall understanding is limited by both a lack of direct observations and high uncertainty among the various model results.

The entire Gulf Coast has seen an increase in long-term sea-level rise (**Figure 3.4.1-1**). Sea-level rise poses a large and continuing threat to regional activities, economy, and environments. The Gulf Coast is a major producer of seafood and home to many significant ports that could be vulnerable. Yin et al. (2020) suggested that, in the Gulf of Mexico, increased rates of sea-level rise will increase the risk of hurricane-induced flooding substantially. This is also applicable to the mid- and south Atlantic region, especially as barrier island complexes shift (Stutz and Pilkey 2011). Some low-lying metropolitan areas of the GOM region are already experiencing more frequent tidal flooding, even in the absence of storms or rainfall events. The GOM region's subsiding land and higher-than-average relative sea-level rise both contribute to this increase in flooding. Dahl et al. (2017a) describe how climate change will promote changes in flushing regime, freshwater inputs, water chemistry, and inundation from sea-level rise.

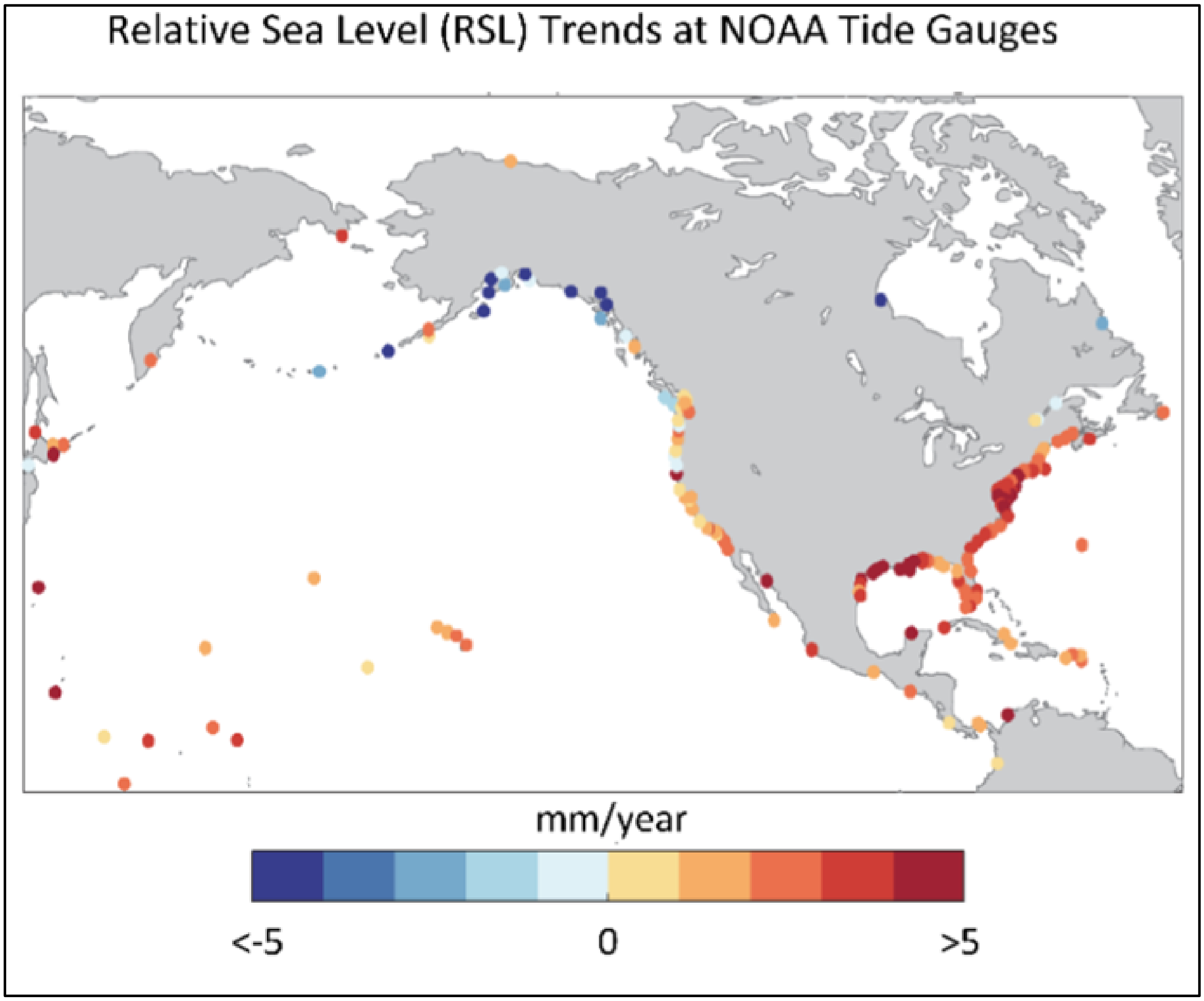


Figure 3.4.1-1. Long-term, Sea-level Rise Recorded at Tide Gauges Over the Past 30 Years (note that the entire Gulf Coast has seen an increase in sea level) (NOAA and South Florida Water Management District 2018).

3.4.2 Changes in Weather Patterns and Ecosystem Shifts

With the advent of human-induced climate change, spatial and temporal variations in weather patterns and extreme weather events (e.g., hurricanes and flood events) have become more pronounced. Very heavy precipitation events have increased across the southeastern half of the U.S. For example, the number of days with 3 or more inches of precipitation has been historically high over the past 25 years, with the 1990s, 2000s, and 2010s ranking as the decades with the 1st, 3rd, and 2nd highest number of events, respectively (U.S. Global Change Research Program 2018).

High-intensity storms, coupled with higher sea levels, could increase coastal flooding and erosion, damage coastal infrastructure, and degrade coastal habitats. High-intensity storms can also have significant impacts on the resuspension and distribution of bottom sediment (Wren and Leonard 2005). However, no consensus appears to exist on whether climate change will generate more tropical storms or whether those storms will be more intense (NOAA 2012). If storm frequency and intensity increase, the additional disturbance of sediment may impact water quality in nearshore and coastal areas. Fragile marine ecosystems like coral reefs can also be directly damaged by such storms, while other sensitive areas like seagrass beds may experience indirect impacts from increased water turbidity and nutrient runoff. Storm impacts on coastal communities will be exacerbated if shoreline vegetation is lost. Strong storms can also move or damage marine archaeological sites; Hurricane Irma (Fall 2017) moved a 107-ft (32.6-m) wreck about 200 ft (61 m) off the coast of Florida (Emmons 2018).

These changes to weather patterns have long-term consequences for regional climates and the flora and fauna of the regions. Warming ocean and coastal temperatures can push species to the edge of their optimal temperature ranges, with poleward shifts predicted for some species (Sigler et al. 2011; Simpson et al. 2011). Certain ecosystems in the region are located near thresholds where small changes in winter air temperature regimes can trigger comparatively large and abrupt landscape-scale ecological changes (in other words, ecological regime shifts) (U.S. Global Change Research Program 2018). These changes may affect marine ecosystems by increasing the vertical stratification of the water column, shifting prey distribution, impacting competition, and generally impacting species' ranges (Learmonth et al. 2006; Richardson and Schoeman 2004). Some species, however, cannot readily shift their range (e.g., corals) and could experience significant impacts from temperature and salinity changes due to climate change. For example, warmer ocean temperatures have caused severe bleaching in reef-building corals, and this is expected to continue in future years (IPCC 2014). Zooplankton may serve as "beacons of climate change" because they are short-lived and particularly sensitive to changes in water temperature, making them tightly coupled to environmental changes (Richardson 2008). Warming waters can affect the timing of annual events like plankton blooms, migration, and reproduction in some species, which can in turn affect the animals and people who eat them, potentially disrupting predator-prey relationships with cascading effects throughout the food web (Ullah et al. 2018).

Climate change models show a higher likelihood of extinction of local species by 2050, with species invasion and replacements also occurring but less prominent (Cheung et al. 2009). Some predict that climate change will cause large-scale redistribution of global fishing catch and alter coastal economies (Cheung et al. 2010). As species extend their spatial ranges, there can be negative consequences related to expansion and colonization by non-native and invasive species (Stotz et al. 2016), but on the whole it remains unclear how species, particularly those directly harvested, would fare in response to climate change (Cheung et al. 2015).

3.4.3 Sector Interactions, Sustainability, and National Interest

Ecosystem level changes could also negatively affect national security by changing food and water availability, and increasing the frequency of climate-driven emergencies. For example, based on the currently projected climate change by the mid-21st century, global marine species redistribution and marine biodiversity reduction in sensitive regions could challenge fisheries productivity and other ecosystem services (IPCC 2014). Climate change, including changes in some extreme weather and climate events, can adversely affect global and U.S. food security by, for example, threatening food safety, disrupting food availability, decreasing access to food, and increasing food prices (U.S. Global Change Research Program 2018). Globally, rural and disadvantaged areas are most likely to experience the major impacts on water availability, food security, infrastructure, and agricultural incomes, including shifts in the production areas of food and non-food crops around the world (IPCC 2014). Projected changes in carbon dioxide concentrations and climate change could diminish expected gains in global nutrition; however, any impact on human health will depend on the many other drivers of global food security and factors such as food chain management, human behavior, and food safety governance.

The sectors and systems subject to climate-related risks do not exist in isolation; they interact with one another and with other sectors and systems. In addition, while climate-related risks such as heat waves, floods, and droughts have an important influence on these interdependent systems, these systems are also subject to a range of other factors, such as population growth, economic forces, technological change, and deteriorating infrastructure (**Figure 3.4.3-1**). The number and complexity of possible interactions among systems affected by climate expand the scope of climate change risk assessment. Recent assessments discuss interactions among climate changes and the sectors that people and economies depend on. Other recent climate change impact assessments have highlighted risks emerging from interactions among different energy, water, and land systems, economic sectors, and stressors (IPCC 2018; Rosenzweig et al. 2017). An important research challenge is therefore advancing scientific methods and tools that can be applied in climate research, risk assessment, and risk management for complex, interdependent systems under deep uncertainty.

There are specific U.S. interests that can be affected by climate-related impacts outside of U.S. borders, such as climate variability (e.g., El Niño/La Niña events), climate extremes (e.g., floods resulting from extreme precipitation), and long-term changes (e.g., sea-level rise). These interests include economics and trade, international development and humanitarian assistance, national security, and transboundary resources (U.S. Global Change Research Program 2018). For example, climate-related disasters in developing countries not only have significant local and regional socioeconomic impacts but can also set back U.S. development investments, increase the need for U.S. humanitarian assistance, and affect U.S. trade and national security. United States citizens have long been concerned about the welfare of those living beyond U.S. borders and their vulnerability to the global impacts of climate.

The national security implications of climate change within U.S. borders include risks to energy and other critical infrastructure. Critical infrastructure, major military installations, and hurricane evacuation routes are increasingly vulnerable to impacts, such as higher sea levels, storm surges, and flooding exacerbated by climate change. Reports by the The White House (2015) and Navy through the National Research Council (2011) provide expansive descriptions of the cascading effects of climate change on national security.

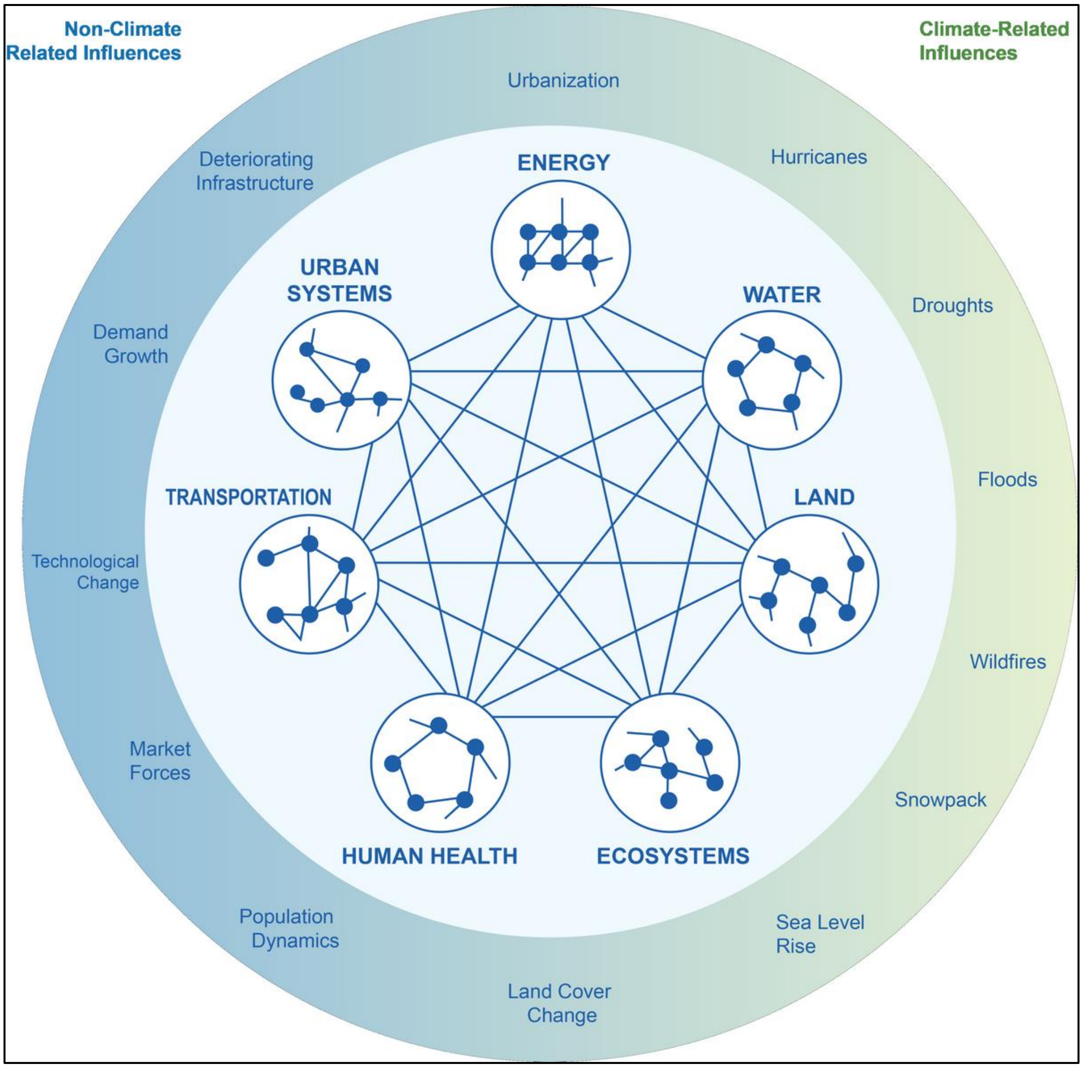


Figure 3.4.3-1. Illustration of Common Sectors and the Interactions Among the Climate-related and Non-climate-related Influences (Adapted from the U.S. Global Change Research Program (2018).

3.4.4 Changes in Ocean Chemistry

Additional CO_2 in the Earth's atmosphere also changes ocean chemistry, affecting marine life. As seawater absorbs CO_2, it becomes more acidic, a phenomenon known as "ocean acidification." Anthropogenic ocean acidification refers to the component of pH (potential hydrogen) reduction that is caused by human activity (IPCC 2014). Ocean acidification can also be caused by other chemical additions or subtractions from the oceans that are natural (e.g., increased volcanic activity, methane hydrate releases, and long-term changes in net respiration). Since the beginning of the industrial era, oceanic uptake of CO_2 has resulted in ocean acidification corresponding to a 26 percent increase in acidity measured by hydrogen ion concentration with reductions in the availability of carbonate ions (IPCC 2014).

The skeletons and shells of some organisms, including crustaceans, foraminiferans, and some types of phytoplankton, are made from calcium carbonate, which dissolves in acid. Increased seawater acidity and the resulting lower concentrations of carbonate ion makes it more difficult for these organisms to build and maintain their shells and exoskeletons, potentially impacting individuals and populations (Fabry et al. 2008; Perry et al. 2015). Refer to **Figure 3.4.4-1** for an example of a shell that is being dissolved as a result of exposure to acidified ocean waters. Raised acidity is also a challenge for both shallow and deepwater coral species by decreasing calcification rates or even dissolving exoskeletons (Doney et al. 2009; Thresher et al. 2015). Ocean acidification can also affect the growth and physiology of fishes at different life-history stages. Larval stages may be the most vulnerable (Llopiz et al. 2014), but it is not well understood whether fish can adapt to new environmental conditions (Ishimatsu et al. 2008). Finally, not only will ocean acidification affect the success of some species, it will also impact oceanic carbon sequestration, as some calcifying plankton play a crucial role in the global carbon cycle (Hofmann and Schellnhuber 2009). Changes to the global carbon cycle could lead to additional impacts on habitats and food webs, potentially triggering larger scale ecosystem responses (refer to **Chapter 3.4.2**).

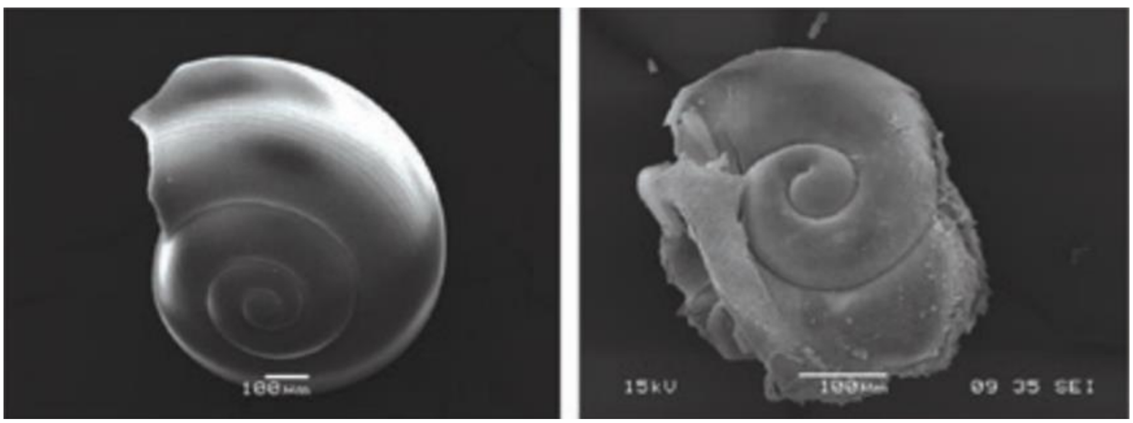


Figure 3.4.4-1. Example of a Calcified Shell Dissolving from Exposure to Ocean Acidification (Melillo et al. 2014).

Scarcity of dissolved oxygen may become a more widespread problem, even in offshore waters, as temperatures increase with climate change because warmer water holds less oxygen. Climate-induced oxygen loss associated with ocean warming and reduced vertical mixing of deep and shallow waters has become evident locally, regionally, and globally (Jewett and Romanou 2017). This oxygen loss could be further exacerbated by increasing nutrient input to coastal waters through excess runoff, which leads to earlier onset and longer periods of seasonal hypoxia in many eutrophic sites, most of which occur in areas that are also warming (Altieri and Gedan 2015). At the same time, however, other factors could partially offset that trend. For example, climate change is expected to increase the frequency of severe storms and windiness, which serve to "mix" air into seawater and increase dissolved oxygen.

Perry et al. (2015) emphasized the importance of integrating measurements of biogeochemistry in concert with studies assessing the effects on keystone species in order to better understand how organisms and ecosystem functions are impacted by ocean acidification. A national strategy and recommended plans have been put forward supporting the development of a more integrated observing network to better understand the extent and effects of ocean acidification (Mathis and Feely 2013). As part of this effort, for example, BOEM has partnered with NOAA and other stakeholders to establish a "sentinel site" in the Flower Garden Banks. This site is actively collecting field data to assess ocean acidification variability in the Flower Garden Banks National Marine Sanctuary, which will eventually help BOEM and other stakeholders better understand the implication of regional ocean acidification changes (Perry et al. 2015). More information on this ongoing study and partnership can be found at https://flowergarden.noaa.gov/science/sciencereports.html.

3.4.5 Marine and Vector-Borne Diseases

Marine diseases illustrate how host-pathogen relationships are very sensitive to environmental conditions and how climate change can affect disease risk (Burge et al. 2014). However, the prevalence of these diseases is extremely difficult to ascribe to any one particular governing factor such as a change in temperature, precipitation, or runoff. Most host-parasite systems are predicted to experience more frequent or severe disease impacts with warming (Harvell et al. 2002). For example, *Perkinsus marinus* (an oyster parasite) thrives in warmer temperatures, and as winters have become warmer, this pathogen has spread northward along the U.S. East Coast (Burge et al. 2014). Changes in El Niño-Southern Oscillation events have also had a detectable influence on oyster pathogens as well as coral diseases (Harvell et al. 2002). Although there is evidence for climate-related links in some marine diseases, lack of reliable baselines and incomplete disease time series complicate the partitioning of climate effects and other anthropogenic disturbances (Harvell et al. 2002).

Climate change is expected to alter the geographic range, seasonal distribution, and abundance of disease vectors, exposing more people in North America to ticks that carry Lyme disease or other bacterial and viral agents, and to mosquitoes that transmit West Nile, chikungunya, dengue, and Zika viruses (Linthicum et al. 2016). Changing weather patterns interact with other factors, including how pathogens adapt and change, changing ecosystems and land use, demographics, human behavior, and the status of public health infrastructure and management. Increased temperatures and more frequent and intense extreme precipitation events can create conditions that favor the movement of vector-borne diseases into new geographic regions (Belova et al. 2017; Monaghan et al. 2018).

3.4.6 Resource-Specific Effects

Climate change is likely to continue contributing to existing stressors on the OCS and resources in the Area of Interest; however, determining how it influences existing stressors and the potential consequences of OCS energy development remains a challenge. All the climate change-related impacts described above can have cascading effects on marine ecosystems because they may act additively or synergistically with the other stressors described in **Chapter 2**, including those introduced by oil and gas activities (Doney et al. 2012).

Where applicable, each resource category in **Chapter 4** will discuss the unique impacts that climate change could pose and whether the addition of oil and gas activities along the Gulf of Mexico OCS could have any synergistic effects (**Figure 3.4.6-1**).

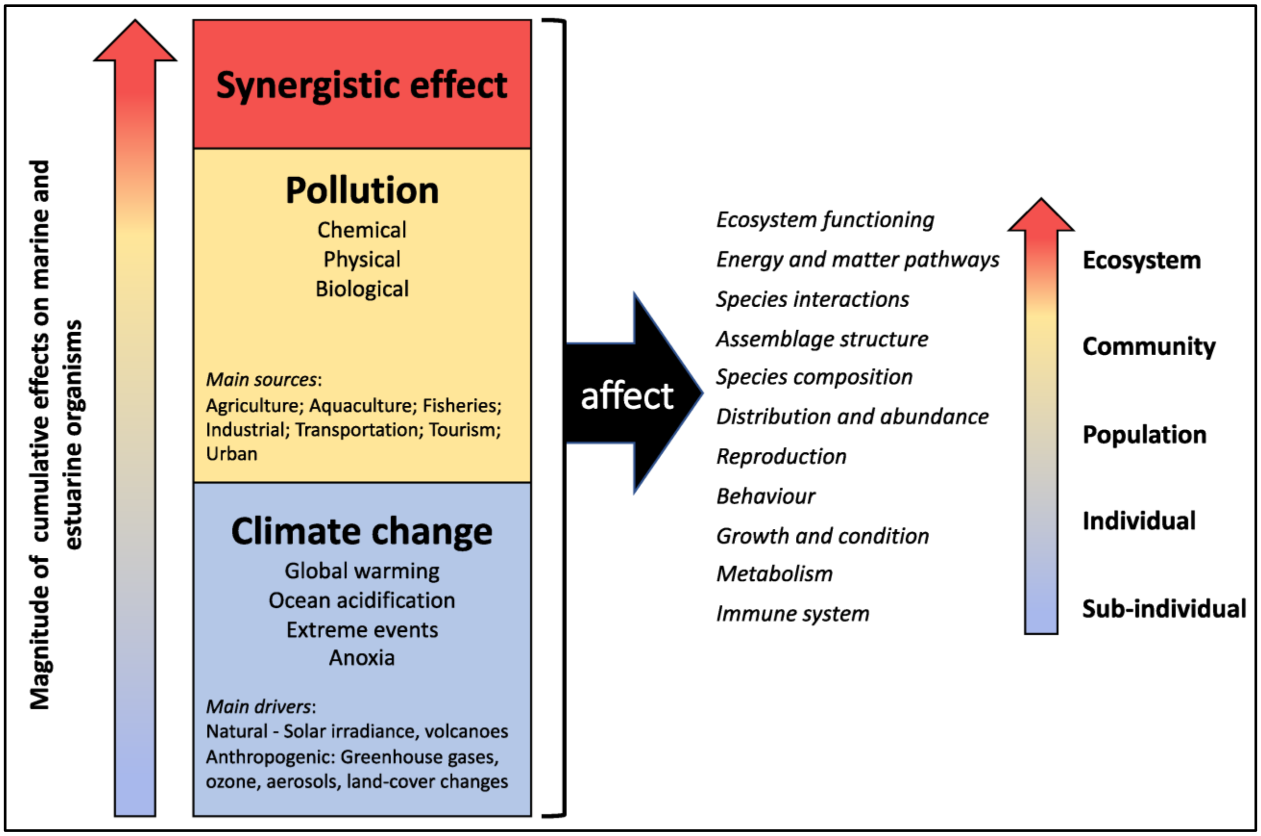


Figure 3.4.6-1. Conceptual Diagram of the Cumulative and Synergistic Effects of Climate Change and Pollution on Marine and Coastal Systems (Adapted from Cabral et al. 2019).

3.5 MARINE TRASH AND DEBRIS

In the United States, about 80 percent of marine debris washes into the oceans from land-based sources and 20 percent is from ocean sources (USEPA 2017d). Plastic debris and microplastics are by far the main components of marine litter, forming sometimes up to 95 percent of the waste that accumulates on shorelines, the sea surface, and the seafloor (Galgani et al. 2015). Some of the sources of land-based marine debris are beachgoers, storm-water runoff, landfills, solid waste, rivers, floating structures, and ill-maintained garbage bins. Marine debris also comes from combined sewer overflows and typically includes medical waste, street litter, and sewage. To compound this problem, there is population influx along the coastal shorelines. These factors, combined with the growing demand for manufactured and packaged goods, has led to increases in nonbiodegradable solid wastes in waterways. The quantity of plastic observed in coastal waters off densely populated regions, however, represents only a fraction of the total amount in the marine environment.

Ocean-based sources of marine debris include galley waste and other trash from ships, recreational boaters, fishermen, military operations, renewable and marine mineral operations, and offshore oil and gas exploration and production facilities. The oil and gas industry makes up only a small part of those sources. Oil and gas operations on the OCS sometimes lose hard hats, plastic bags and packaging, rope, wood, and other items. Commercial and recreational fishers produce trash and debris by discarding plastics (e.g., ropes, buoys, fishing line and nets, strapping bands, and sheeting), wood, and metal traps. Some trash items, such as glass, pieces of steel, and drums with chemicals or chemical residues, can be a health threat to local water supplies and as a result to biological, physical, and socioeconomic resources; beachfront residents; and users of recreational beaches.

Likewise, 90 percent of the litter collected from seafloor trawls is made up of plastic (Galgani et al. 2015). Many types of plastic waste are denser than water and will sink to the seafloor. Surface accumulations in mid-ocean subtropical gyres make up only a small fraction of marine trash and debris. While uncertainties remain, it is estimated that open-ocean floating plastic accounts for less than 1 percent of the total that has reached the oceans since plastic began to be produced (UNEP and GRID-Arendal 2016).

CHAPTER 4

RESOURCE DESCRIPTIONS AND EFFECTS ANALYSIS

What is in This Chapter?

- This chapter provides a summarized description of the relevant environmental resources in or near the Gulf of Mexico OCS and provides a broad overview of the types of interactions that could occur between the various resource categories and the impact-producing factors identified in **Chapter 2**.
- This chapter provides an overview of potential activity interactions and effects to resources that might occur should OCS oil and gas leasing and subsequent exploration and development activities occur in the Gulf of Mexico OCS.
- In addition, this chapter considers the effects to resources that might occur from stressors not associated with OCS oil- and gas-related activities such as ongoing baseline activities and stressors (e.g., commercial fishing, State oil and gas activities), natural events (e.g., hurricanes), and programmatic issues (e.g., climate change).
- Resources analyzed are as follows:
  - Air Quality
  - Water Quality
  - Coastal Communities and Habitats (Estuarine Systems, and Coastal Barrier Beaches and Associated Dunes)
  - Benthic Communities and Habitats
  - Pelagic Habitats and Communities (Including *Sargassum* and Associated Communities)
  - Fishes and Invertebrates
  - Birds
  - Marine Mammals
  - Sea Turtles
  - Land Use and Coastal Infrastructure
  - Commercial Fisheries
  - Recreational Fishing
  - Subsistence Use
  - Tourism and Recreational Resources
  - Social Factors (Including Environmental Justice)
  - Economic Factors,
  - Cultural, Historical, and Archaeological Resources

Key Points

- The potential ranges and types of effects included herein do not pre-suppose, nor propose or authorize, any specific OCS oil- and gas-related activities nor do they make any conclusive impact determinations as a result of future oil and gas leasing.
- Programmatic issues such as climate change and ocean acidification (refer to **Chapter 3**), and their influence on the baseline conditions for each resource, are discussed as part of the resource description.

4 RESOURCE DESCRIPTIONS AND EFFECTS ANALYSIS

4.0 INTRODUCTION

4.0.1 Chapter Overview

This chapter provides a description of each resource considered, as well as the potential effects to those resources from IPFs identified in **Chapter 2**. Typical potential effects from previous or existing routine OCS oil- and gas-related activities, as well as historical accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities were evaluated for each resource and are described herein. The potential ranges and types of effects included herein do not pre-suppose, nor propose or authorize, any specific OCS oil- and gas-related activities nor do they make any conclusive impact determinations as a result of future oil and gas leasing. Following the discussion of potential effects from each IPF, if BOEM has determined an IPF would not affect the resource, this document includes a discussion of why the IPF does not affect the resource and indicates that the IPF may be scoped out of future NEPA analyses for that resource.

This chapter is organized by groups of resources divided into the physical factors (i.e., air and water quality), biological resources and habitats (i.e., habitat resources followed by the fauna that are found in or utilize these habitats), and the socioeconomic aspects. Below is an abbreviated outline for the resource categories considered in this chapter.

- 4.0 Introduction
- 4.1 Air Quality
- 4.2 Water Quality
- 4.3 Biological Resources and Habitats
  - 4.3.1 Coastal Communities and Habitats
  - 4.3.2 Benthic Communities and Habitats
  - 4.3.3 Pelagic Habitats and Communities (including *Sargassum*)
  - 4.3.4 Fish and Invertebrates
  - 4.3.5 Birds
  - 4.3.6 Marine Mammals
  - 4.3.7 Sea Turtles
- 4.4 Social and Economic Factors
  - 4.4.1 Land Use and Coastal Infrastructure
  - 4.4.2 Commercial Fisheries
  - 4.4.3 Recreational Fishing
  - 4.4.4 Subsistence Use
  - 4.4.5 Tourism and Recreational Resources
  - 4.4.6 Social Factors (Including Environmental Justice)
  - 4.4.7 Economic Factors
- 4.5 Cultural, Historical, and Archaeological Resources

Each resource chapter provides a description of the resource and current "baseline" conditions, including past and present OCS oil and gas activity as well as all other non-OCS oil- and gas-related activities that affect the resource (refer to **Figure 4.0.1-1**). Natural or anthropogenic influences to current or future baseline conditions of each resource, such as climate change and ocean acidification, are also discussed in the resource description. For biological resources, BOEM's stand-alone Biological Environmental Background Report has been prepared, which is incorporated by reference into this report. Furthermore, supporting technical reports have been developed and are summarized and incorporated by reference along with previous NEPA documents as appropriate. All of these documents can be found on BOEM's website at https://www.boem.gov/nepaprocess.

Following the resource summary, each resource chapter then provides a discussion of the potential effects or interaction that exist or could occur for each IPF category. For this report, a set of assumptions were developed and are presented in **Chapter 2**, along with descriptions of impact-producing factors that could occur from routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities. Each resource chapter is set up as follows:

4.x Resource or Resource Grouping
- 4.x.x Resource (if within a Group)
  - 4.x.x.1 Resource Description
  - 4.x.x.2 Description of Potential Effects
    - 4.x.x.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities
    - 4.x.x.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities
    - 4.x.x.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.0.1-1 is a "sand diagram" that shows the different layers of factors that could affect each resource category considered in this document. The bottom two layers of the sand diagram (green and blue) are discussed in this document. The potential effects from routine OCS oil- and gas-related activities are derived from knowledge and analyses of past and present activities (i.e., "blue layer") but can be applied to assessments of future OCS oil- and gas-related activities as well (i.e., "orange layer"). The top two layers (orange and yellow) will be analyzed in further detail in future NEPA analyses once a specific development scenario is applied, incorporating this initial screening and description of potential effects by reference.

Baseline conditions, including existing and past stressors (green), is the first "stressor" discussed in this document. The discussion of the stressors and baseline conditions considers everything that is currently affecting the resource and includes all existing and past natural and anthropogenic stressors other than OCS oil- and gas-related activities associated with past or future Gulf of Mexico OCS oil and gas leasing. Non-OCS oil- and gas-related stressors include, but is not limited to, natural events such as storms and hurricanes, programmatic issues such as climate change and ocean acidification, and other stressors not associated with the Bureau of Ocean Energy Management's OCS Oil and Gas Program such as commercial fishing, nonpoint-source runoff, fossil fuel combustion, military operations, and State oil and gas activities (refer to **Chapter 3**).

Past and present OCS oil- and gas-related activities (blue) is the second stressor considered in this document. First, effects that could occur to a resource from routine OCS oil- and gas-related activities are discussed. Routine OCS oil- and gas-related activities include drilling and producing a well, structure and pipeline emplacement offshore, traveling offshore by vessel or helicopter, building coastal infrastructure, and decommissioning. Effects that could occur to a resource as a result of an accidental OCS oil- and gas-related event are discussed next. Accidental events include unintended releases into the environment (oil and chemical spills), spill response, and vessel strikes and collisions.

Effects associated with a proposed lease sale (orange), as well as future stressors not associated with OCS oil- and gas-related activities (yellow), were not specifically discussed in this document, although the effects to each resource for those two layers of the sand diagram could apply based on the high-level discussion in the analysis of OCS oil- and gas-related and non-OCS oil- and gas-related effects. In future NEPA analyses, the effects of a proposed lease sale (orange) would be compared to the effects of all past, present, and future stressors (both OCS oil- and gas-related and non-OCS oil- and gas-related) to determine the potential incremental effects of the lease sale on the resource in relation to all cumulative stressors. Then, all of these effects together would be compared to a threshold (red line) to determine if the incremental effects of a lease sale could significantly affect the resource (i.e., push it over the threshold line).

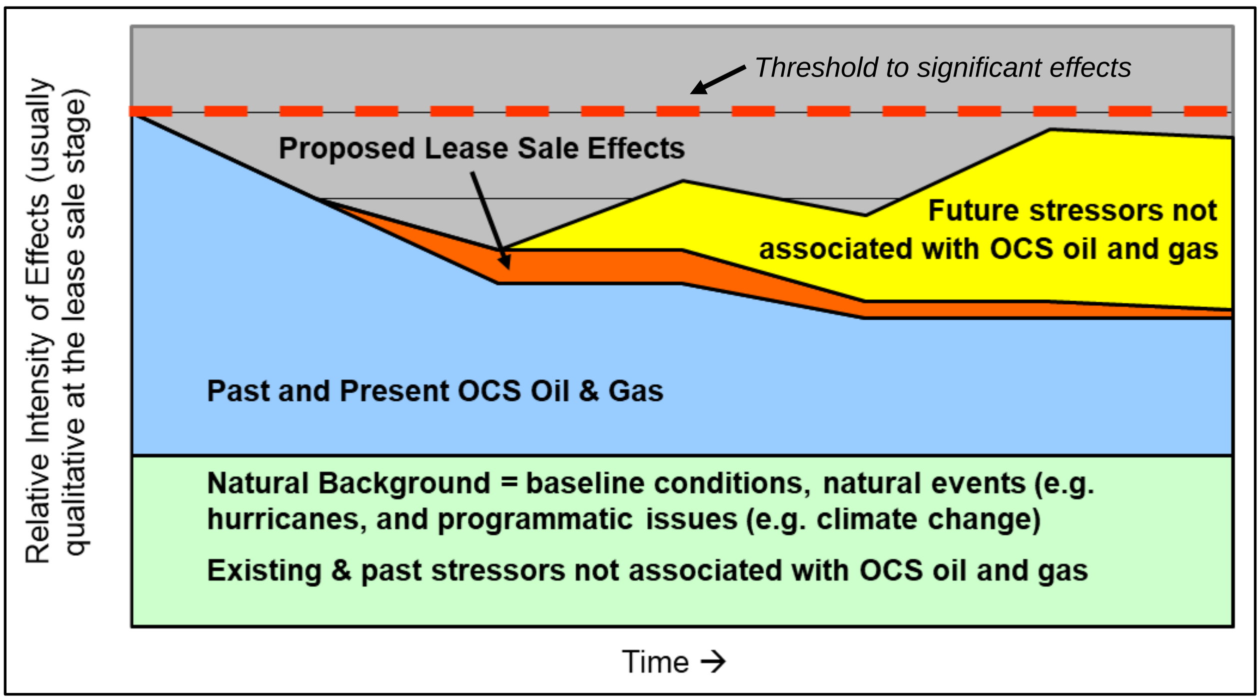


Figure 4.0.1-1. Future NEPA Analysis Will Consider Cumulative Effects from All Past, Present, and Future Stressors to Assess What the Incremental Contribution of an Oil and Gas Lease Could Be (sand diagram is illustrative only and is not intended to depict actual scale or estimates for the various activities).

4.0.2 Issue Driven Effects Analysis

As defined in **Chapter 2**, an IPF is the outcome or result of any proposed activities that may pose a potential to positively or negatively affect physical, biological, cultural, and/or socioeconomic resources. To focus the analysis on the issues potentially causing impacts to resources, an issue-based analysis was conducted by grouping the IPFs into eight overarching issue categories (e.g., noise and bottom disturbance) for routine OCS oil- and gas-related activities, and those same eight categories are analyzed for the non-OCS oil- and gas-related activities. Three IPF categories were considered for accidental OCS oil- and gas-related events. The "issue" categories are based on BOEM's internal scoping and consideration of the extensive history of public input received through previous and ongoing assessments and outreach efforts. Both OCS oil- and gas-related activities, as well as other, non-OCS oil- and gas-related activities, can contribute to one or multiple IPF categories. **Chapter 2** provides a description of all possible IPFs considered in this analysis.

4.0.2.1 Non-OCS Oil- and Gas-Related Activities

The "non-OCS oil- and gas-related activities" analysis considers effects to physical, biological, and socioeconomic resources that may result from all activities other than those related to OCS oil- and gas-related activities. However, analysis of most resources consider past and present non-OCS oil- and gas-related effects as part of the baseline environmental conditions, and they are covered where relevant in the affected resource description. 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; OCS sand borrowing; renewable energy; and natural processes. The types of non-OCS oil- and gas-related activities that could reasonably occur are described in **Chapter 2**. These activities were categorized by the type of effect they produce and include

- Air Emissions and Pollution (**Chapter 2.1.2**)
- Discharges and Wastes (**Chapter 2.2.2**)
- Bottom Disturbance (**Chapter 2.3.2**)
- Noise (Chapter 2.4.2)
- Coastal Land Use/Modification (**Chapter 2.5.2**)
- Lighting and Visual Impacts (**Chapter 2.6.2**)
- Offshore Habitat Modification/Space Use (**Chapter 2.7.2**)
- Socioeconomic Changes and Drivers (**Chapter 2.8.3**)

4.0.2.2 Routine OCS Oil- and Gas-Related Activities

The types of routine activities that could occur from all operations as a result of OCS oil- and gas-related activities are described in **Chapter 2**. The major types of routine OCS oil- and gas-related activities include G&G 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. These activities were categorized by the type of effect they produce and include:

- Air Emissions and Pollution (**Chapter 2.1.1**)
- Discharges and Wastes (**Chapter 2.2.1**)
- Bottom Disturbance (**Chapter 2.3.1**)
- Noise (**Chapter 2.4.1**)
- Coastal Land Use/Modification (**Chapter 2.5.1**)
- Lighting and Visual Impacts (**Chapter 2.6.1**)
- Offshore Habitat Modification/Space Use (**Chapter 2.7.1**)
- Socioeconomic Changes and Drivers (**Chapter 2.8.2**)

4.0.2.3 Accidental OCS Oil- and Gas-Related Events

A summary of the information on accidental OCS oil- and gas-related events that are reasonably foreseeable from all operations conducted under the OCS Oil and Gas Program is provided in **Chapter 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. These activities were categorized by the type of effect they produce and include

- Unintended Releases into the Environment (**Chapter 2.9.1**)
- Response Activities (**Chapter 2.9.2**)
- Strikes and Collisions (**Chapter 2.9.3**)

4.0.3 Potential Effects Analysis

This analysis aims to screen (1) the relevant affected environment and baseline conditions for each resource; (2) identify the other activities or processes, not associated with OCS oil and gas exploration and development, that could affect each resource; (3) what types of resource and activity interactions and effects have the *potential* to occur should oil and gas leasing and subsequent exploration and development activities occur in the Gulf of Mexico OCS; and (4) when possible, whether these potential effects are positive or negative, or both (e.g., the effect could be positive to one organism or user group and simultaneously negative to another) is disclosed. The potential to cause effects was determined for each IPF and is discussed herein. However, the magnitude and severity of the potential effects discussed herein could vary depending on numerous factors such as location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. Therefore, the magnitude and severity of potential effects are not addressed in this document but will be addressed in future NEPA analyses when specific exploration and development scenarios are applied.

BOEM will use this preliminary identification and disclosure of the potential range of effects to each resource, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development in the Gulf of Mexico OCS. While this document does not make impact determinations, future NEPA analyses will include such determinations.

The effects from each IPF are shown visually in a "pie diagram" at the beginning of the effects analysis for each resource. Example pie diagrams and potential effects definitions are shown below **Figures 4.0.3-1 and 4.0.3-2**. For each resource, the pie wedge for each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the anticipated effect. Blue pie wedges indicate potential negative effects, green pie wedges indicate potential positive effects, and a blue and green pie wedge indicates potential for both positive and negative effects from that IPF. If no observable effects are anticipated, the pie wedge is colored grey. NOTE: For biological resources, hashed blue or green coloring was used to distinguish IPFs where potential effects were identified; however, based on currently available information and the conclusions reached in BOEM's Biological Environmental Background Report, it would not be expected to create a potential for population-level effects to organismal resources (i.e., fish and invertebrates, birds, sea turtles, and marine mammals) or long-term consequences to habitat function or use by biota for coastal, pelagic, and benthic habitats (**Figure 4.0.3-2**).

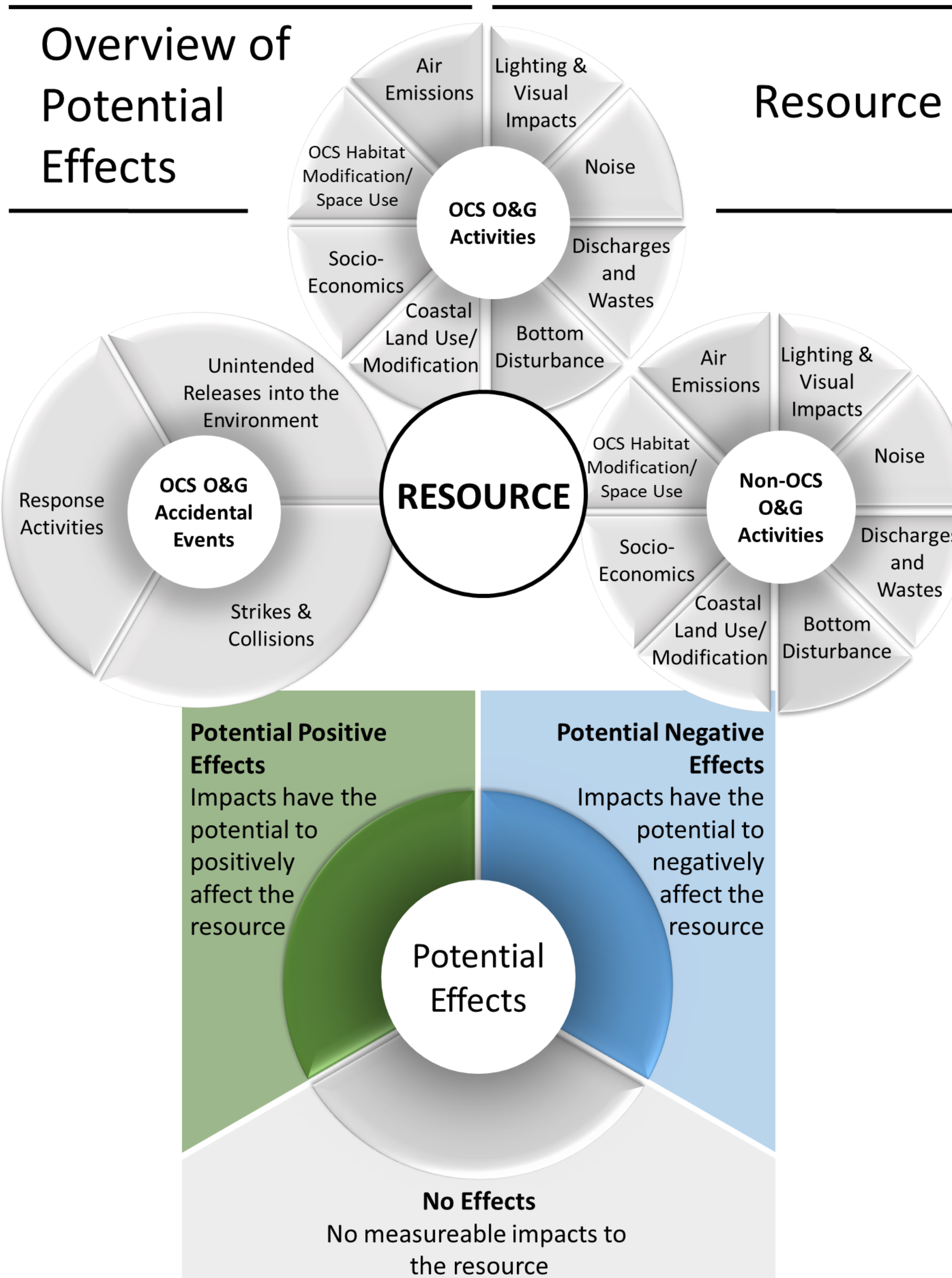
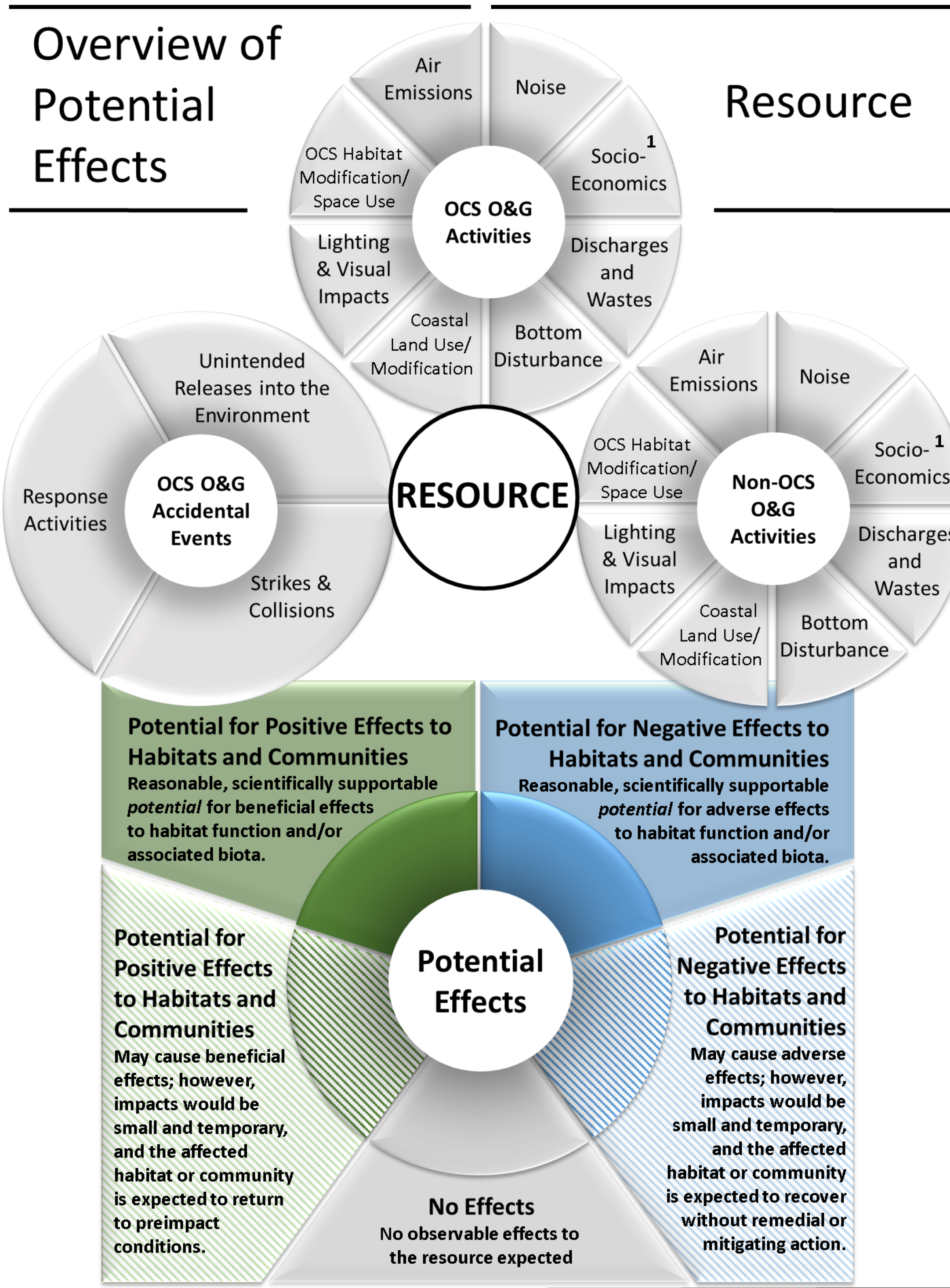


Figure 4.0.3-1. Example Pie Diagram for Physical and Socio-economic Resource Categories. The effects analysis for each resource is preceded by a pie diagram to identify the relevant categories and provide the framework for the subsequent discussions of potential effects. (O&G = oil and gas). NOTE: The diagrams for biological resources vary as discussed above.



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

Figure 4.0.3-2. Example Pie Diagram for Biological Resource Categories. The effects analysis for each resource is preceded by a pie diagram to identify the relevant categories and provide the framework for the subsequent discussions of potential effects. (O&G = oil and gas). NOTE: The diagrams for biological resources vary as discussed above.

4.1 AIR QUALITY

4.1.1 Resource Description

Ambient air means that portion of the atmosphere, external to buildings, to which the general public has access (40 CFR § 50.1(e)).

Air quality is the degree to which the ambient air is free of pollution. Ambient air pollution occurs when emissions (i.e., gases and particles) are emitted into the atmosphere. Air pollution can transport and/or chemically transform in the atmosphere and can deposit on the surfaces of soils and waters. The transport of air pollution can also be influenced heavily by the meteorology of the region (Biazar et al. 2010); therefore, evaluating both emissions and meteorology (e.g. temperature, sunlight, precipitation, and wind) is important when assessing air quality. Circulation patterns, geography, time of day, season, and other variables can also influence the transport and/or chemical transformation of pollutants and overall air quality of a region. For example, the Bermuda High influences the direction of air flows (refer to **Chapter 3.2**). During the summer, it has been demonstrated that the Bermuda High causes southerly air flows transporting air pollution from the northeast to the GOM (Biazar et al. 2010). Reidmiller et al. (2009) demonstrated that intercontinental transport of emissions can lead to exceedances in the O_3 National Ambient Air Quality Standards (NAAQS).

For this 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, as depicted in **Figure 4.1.1-1**. The Clean Air Act (CAA) Amendments of 1990 require the USEPA to set the NAAQS for six common air pollutants of concern called criteria air pollutants. BOEM's regulatory authority under Section 5(a) of the OCSLA is focused on the six criteria air pollutants for which the USEPA has defined NAAQS in accordance with the requirements of the CAA. Refer to **Chapter 2.1** and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for more information. Therefore, criteria air pollutants were analyzed in this document. In addition to the NAAQS, the CAA Amendments give special air quality and visibility protection to national parks and wilderness areas because air pollution can impact scenic resources. Each of these parks and wilderness areas are identified as Class 1 (highest air quality protection), Class 2 (moderate air quality protection), or Class 3 (least air quality protection) areas. These areas are protected by the maximum allowable concentration increases (also referred to as the Prevention of Significant Deterioration [PSD] increments). However, the PSD increments are used for proposed single facility impacts and therefore are typically analyzed during site-specific NEPA reviews as opposed to in lease sale NEPA analyses (refer to **Chapter 5.6**, Air Quality Reviews). Moreover, under the CAA Amendments, the Federal Land Manager is responsible for the management of PSD Class 1 parks and wilderness areas to protect the air quality-related values (AQRVs) (including visibility) of such lands and to consider adverse impacts on such values. The AQRVs include a visibility assessment, potential deposition (sulfur [S] and nitrogen [N]) effects, and potential O_3 effects on vegetation (USFS et al. 2010). Since Class I areas are of concern, these areas located in or near the GOM region were considered in this analysis and are shown in **Figure 4.1.1-1**. The protected Class I areas in the GOM region include the following: the Breton Wilderness Area in Louisiana; and the Bradwell Bay Wilderness Area, Chassahowitzka National Wilderness Area, Everglades National Park, and St. Marks Wilderness Area in Florida

(**Figure 4.1.1-1**). However, the Breton Wilderness Area was the only Class I area considered in the AQRV analysis for this document as it would likely have higher impacts from air pollution due to its proximity to the majority of oil and gas activities.

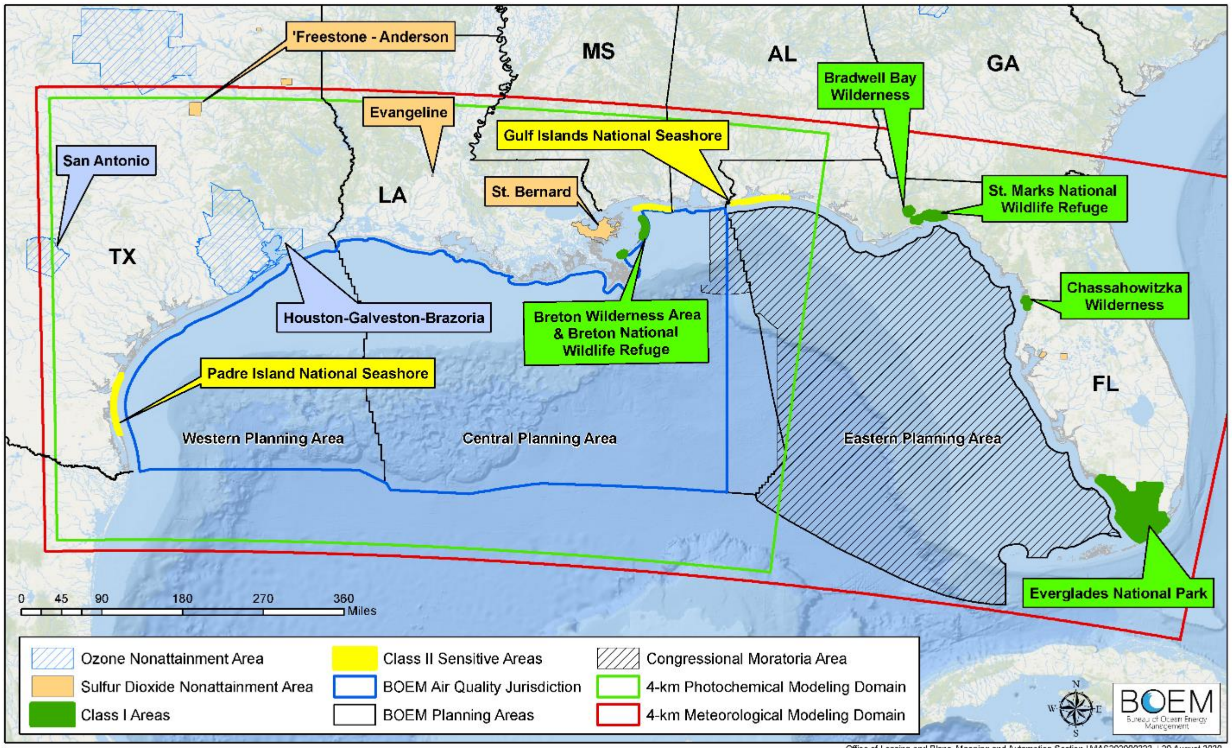


Figure 4.1.1-1. Gulf of Mexico Region with the Planning Areas, Nonattainment Areas, BOEM's Air Quality Jurisdiction, and Class I and Sensitive Class II Areas.

The current conditions of the air quality onshore along the Gulf Coast are known through ambient air quality monitoring. Most criteria air pollutants along the Gulf Coast are below the NAAQS; however, O_3 and sulfur dioxide (SO_2) are still a concern in nonattainment areas (USEPA 2020c). In accordance with the CAA Amendments, only areas within State boundaries are designated as either unclassifiable/attainment or nonattainment status. The OCS, which includes GOM waters, are not designated areas for the NAAQS since there are no regulatory provisions under the CAA or OCSLA. However, the OCSLA does require compliance with the NAAQS "to the extent that activities authorized under the subchapter significantly affect the air quality of any State." Refer to the *Gulf of Mexico OCS Regulatory Framework* technical report for more information (BOEM 2020c). A discussion of the most recent emissions inventories for onshore and offshore sources in the GOM region, as well as BOEM's recently completed *Air Quality Modeling in the Gulf of Mexico Region* study (Wilson et al. 2019b), is presented below. Further information on the emissions inventories is provided in **Chapter 2.1**.

4.1.1.1 Air Emissions Inventory Data

The *Year 2017 National Emissions Inventory Report* (USEPA 2020a) and *Year 2017 Emission Inventory Study* (Wilson et al. 2019a) are the most recent inventory reports and the basis for the following overview of air emissions in the GOM. The primary pollutants covered in the inventories and analyzed in this chapter are as follows:

- criteria air pollutants[2] (CAPs)—CO, Pb, NO_x (includes NO_2), SO_2, PM_{10}, and $PM_{2.5}$;
- criteria precursor air pollutants (CPAPs)—NH_3, VOCs, and NO_x;
- select hazardous air pollutants (HAPs) and sources; and
- greenhouse gases (GHGs)—CO_2, CH_4, and N_2O.

Between the two emission inventory reports, it was indicated that most of the CAP and CPAP emissions come from onshore sources, which contributed to the total CAP and CPAP emissions in the GOM – about 99 percent for SO_2, PM_{10}, $PM_{2.5}$, Pb, VOCs, NH_3, and CO, and about 91 percent for NO_x. The CAP and CPAP emissions from onshore sources are summarized in **Chapter 2.1.2.2**. Offshore sources including oil- and gas-related activities, contributed to the total CAP and CPAP emissions in the GOM – about 1 percent for SO_2, $PM_{2.5}$, Pb, VOCs, NH_3, and CO, and about 9 percent for NO_x. The CAP and CPAP emissions from offshore sources are summarized in **Chapters 2.1.1.5 and 2.1.2.1**.

For the HAP emission inventories, onshore sources contribute to the total HAP emissions in the GOM, about 95-99 percent for each of the 28 HAPs. The HAP emissions from onshore sources are summarized in **Chapter 2.1.2.2**. Offshore sources, including oil- and gas-related activities, contribute to the total HAP emissions in the GOM, about 1-5 percent for each of the 28 HAPs. The HAP emissions from offshore sources are summarized in **Chapters 2.1.1.5 and 2.1.2.1**. Any HAP emissions could be of concern; however, HAPs generally are not common air pollutants and are usually emitted by a limited number of specific and discrete sources. As stated above, the emission inventories indicate that the vast majority of the 28 HAP emissions come from onshore sources.

For GHG emission inventories, onshore sources contribute to the total GHG emissions in the GOM, about 99 percent for CO_2, 88 percent for CH_4, and 96 percent for nitrous oxide (N_2O). The GHG emissions from onshore sources are summarized in **Chapter 2.1.2.2**. Offshore sources, including oil- and gas-related activities, contribute to the total GHG emissions in the GOM, about 1 percent for CO_2, 12 percent for CH_4, and 4 percent N_2O. The GHG emissions from offshore sources are summarized in **Chapters 2.1.1.5 and 2.1.2.1**. The emission inventories show that most GHG emissions come from onshore sources. However, studies on CH_4 emissions from offshore sources (Gorchov Negron et al. 2020; Yacovitch et al. 2020) potentially indicate that emission inventory estimates for CH_4 are underestimated.

In addition to the CAP and CPAP emission inventories, air quality modeling studies have been conducted to better understand the criteria air pollutant concentrations in the GOM. More recently, the *Air Quality Modeling in the Gulf of Mexico Region* study (Wilson et al. 2019b) has conducted air

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[2] Though not directly emitted, O_3 is also a criteria air pollutant formed from photochemical reactions.

quality modeling with a 4-km (2.5-mi) domain, as shown in **Figure 4.1.1-1**. Wilson et al. (2019b) used year 2011 emission inventory data from the *Year 2011 Gulfwide Emission Inventory Study* (Wilson et al. 2014) for offshore OCS emissions and the *Year 2011 National Emissions Inventory* report (USEPA 2020a) for onshore emissions. Using the emission inventory data, emission estimates (referred to as "base case year" in Wilson et al. (2019b) to define current baseline air quality conditions) were modeled, using a photochemical model, in order to evaluate the predicted criteria air pollutant (i.e., O_3, CO, NO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$) concentrations against concurrent measured ambient concentrations from available monitors. Refer to Chapter 3.3 of Wilson et al. (2019b) for more information on the base case modeling scenario emission estimates. **Table 4.1.1-1** shows the modeled minimum and maximum air pollutant levels of the 4-km (2.5-mi) domain in the GOM for all existing sources based on the NAAQS. The maximum modeled criteria air pollutant concentrations (i.e., potential worst-case modeled baseline conditions) of the 4-km (2.5-mi) domain for the 1-hour (hr) SO_2, 8-hr O_3, 24-hr PM_{10}, 24-hr $PM_{2.5}$, and annual $PM_{2.5}$ NAAQS were exceeded. The Pb level was undetermined. All other criteria air pollutants were below the NAAQS.

Table 4.1.1-1. Modeled Criteria Air Pollutant Concentrations in the Gulf of Mexico for All Existing Sources.

Criteria Air Pollutant	Minimum Concentration of the 4-km (2.5-mi) Domain – Base Case Year Results	Maximum Concentration of the 4-km (2.5-mi) Domain – Base Case Year Results
1-hr CO	0.2 ppm	8.9 ppm
8-hr CO	0.2 ppm	6.9 ppm
Pb	Unknown	Unknown
1-hr NO_2	0.8 ppb	99.9 ppb
Annual NO_2	0.1 ppb	42 ppb
24-hr PM_{10}	14.1 µg/m^3	414.7 µg/m^3
24-hr $PM_{2.5}$	7.9 µg/m^3	98.5 µg/m^3
Annual $PM_{2.5}$	2.6 µg/m^3	26.5 µg/m^3
1-hr SO_2	0.5 ppb	148.4 ppb
3-hr SO_2	0.5 ppb	154.9 ppb
8-hr O_3	38.6 ppb	86.5 ppb

CO = carbon monoxide; ppb = parts per billion; Pb = lead; NO_2 = nitrogen dioxide; PM_{10} = particulate matter with diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with diameter less than or equal to 2.5; microns µg/m^3 = micrograms per cubic meter of air; SO_2 = sulfur dioxide; O_3 = ozone

However, there are uncertainties in the modeled data. The influence of environmental variables, modeling uncertainties, as well as a lack of ambient air monitors offshore, present many challenges and limit information for assessing air quality in the GOM at a regional level. Nevertheless, BOEM can use these regional-scale studies as a basis in oil and gas leasing environmental impact assessments to broadly estimate the potential incremental air quality effects associated with oil and gas leasing, as well as to broadly evaluate cumulative air quality effects. BOEM can also use this information to assess site-specific impacts during postlease reviews by using emission exemption threshold formula screening methods to determine whether a proposed source would cause or contribute to a violation of the NAAQS (refer to **Chapter 5.6**, Air Quality Reviews).

The *Air Quality Modeling in the Gulf of Mexico Region* study was peer reviewed by the National Academies of Sciences, Engineering, and Medicine (NASEM), who published a consensus study report (National Academies of Sciences, Engineering, and Medicine 2019). The committee that reviewed the *Air Quality Modeling in the Gulf of Mexico Region* study concluded that there were "potential underestimates of the impacts of GOMR emissions on air quality" (National Academies of Sciences, Engineering, and Medicine 2019). Their reasons included the lack of performance evaluations of the highest air quality impacts from offshore to onshore and not using warmer years for modeling O_3, PM_{10}, and $PM_{2.5}$ formation (National Academies of Sciences, Engineering, and Medicine 2019). The *Air Quality Modeling in the Gulf of Mexico Region* study also had similar conclusions regarding uncertainties, stating, "one of the key uncertainties associated with analyzing the air quality impacts from offshore oil and gas sources in the Gulf of Mexico is the magnitude of the modeled O_3 and particulate matter concentrations over the Gulf waters" (Wilson et al. 2019b). These uncertainties are likely due to the lack of available offshore air quality monitoring data.

Air Pollution at National Parks and Wilderness Areas

The closest onshore wilderness area to be impacted by OCS air emissions sources in the GOM west of 87.5 degrees longitude is the Breton Wilderness Area. The Breton Wilderness Area is a PSD Class 1 area, which is further protected by the AQRVs. The AQRVs include a visibility assessment, potential deposition (sulfur [S] and nitrogen [N]) effects, and potential O_3 effects on vegetation (USFS et al. 2010). In visibility assessments, deciview is used as a measure of visibility derived from calculated light extinction measurements. It corresponds to the incremental changes in visual perception between clear and highly impaired, so a lower value would correspond to better visibility. In year 2017, the haze index for the clearest days (based on the 20% best or clearest visibility days monitored) were reported to be a maximum of 12 deciview (USEPA 2020m). In year 2002, the haze index for the clearest days were reported to be a maximum of 17.4 deciview. In year 2017, the haze index for the most impaired days (based on the 20% worst visibility days monitored) were reported to be a maximum of 22.8 deciview. In year 2002, the haze index for the most impaired days were reported to be a maximum of 29.9 deciview. The visibility trend assessment for the Breton Wilderness Area up to year 2017 has shown improvements.

Sulfur and nitrogen deposition (wet and dry) may cause acidification or nutrient imbalances to ecosystems. The National Atmospheric Deposition Program's (NADP) most recent available deposition report was published in year 2019 (National Atmospheric Deposition Program 2019). The two NADP monitoring sites for sulfur and nitrogen deposition are (1) the Southeast Research Station (LA30) located in Washington Parish, Louisiana; and (2) the Grand Bay National Estuarine Research Reserve (MS12) located in Jackson, Mississippi, which monitors for potential deposition impacts to the Breton Wilderness Area. **Table 4.1.1-2** shows NADP values for the wet deposition of nitrogen from nitrate and ammonium, and sulfur from sulfate (National Atmospheric Deposition Program 2018; 2019). The wet deposition of nitrogen in 2018 decreased in comparison with 2017. The wet deposition of sulfur at LA30 did not change from 2017 to 2018, while a decrease was observed at MS12. The *Air Quality Modeling in the Gulf of Mexico Region* study base case year modeled a maximum nitrogen deposition (dry and wet) impact of 8.0 kilograms per hectare per year (kg/ha/yr) and maximum sulfur deposition (dry and wet) impact of 4.1 kg/ha/yr (Wilson et al. 2019b); however, there are uncertainties in the modeled data (National Academies of Sciences, Engineering, and Medicine 2019; Wilson et al. 2019b).

Table 4.1.1-2. National Atmospheric Deposition Program's Deposition Concentration Reported in Years 2017 and 2018.

Year	Monitoring Site	Wet Deposition	Concentration (kg/ha)
2017	LA30	Sulfur	9
2017	LA30	Nitrogen	4.2
2017	MS12	Sulfur	8
2017	MS12	Nitrogen	5.1
2018	LA30	Sulfur	9
2018	LA30	Nitrogen	4
2018	MS12	Sulfur	7
2018	MS12	Nitrogen	4.2

Ozone is not only an issue for humans but for vegetation as well. Plant leaves adsorb ozone through pores (stomata), where it can kill plant tissues. This causes visible damage like bleaching, dark stippling, or reduced photosynthesis, growth, and reproduction abilities (Ashmore et al. 2004). The closest ozone monitoring site near the Breton Wilderness Area is in Meraux, Louisiana (air quality site ID 22-087-0004). As of 2019, the maximum value of O_3 was reported to be 0.064 ppm for the 8-hr standard, which is below the primary and secondary NAAQS (USEPA 2020d). Discussion of the modeled O_3 concentrations is addressed in **Chapter 4.1.1.1**.

4.1.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and air quality. **Figure 4.1.2-1** provides a synopsis of the IPF categories that currently affect or have the potential to affect air quality in the GOM. Following **Figure 4.1.2-1** is an assessment of those potential effects, broken down by the categories identified in the figure, as well as brief discussions of the IPF categories identified in **Figure 4.1.2-1** as not likely to affect air quality and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities; time of year; and/or the current condition of the air quality in the region; as well as meteorological conditions and other variables. BOEM will use this preliminary identification and disclosure of the potential range of effects to air quality, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development in the Gulf of Mexico OCS. While this document does not make impact determinations, future NEPA analyses will include such determinations.

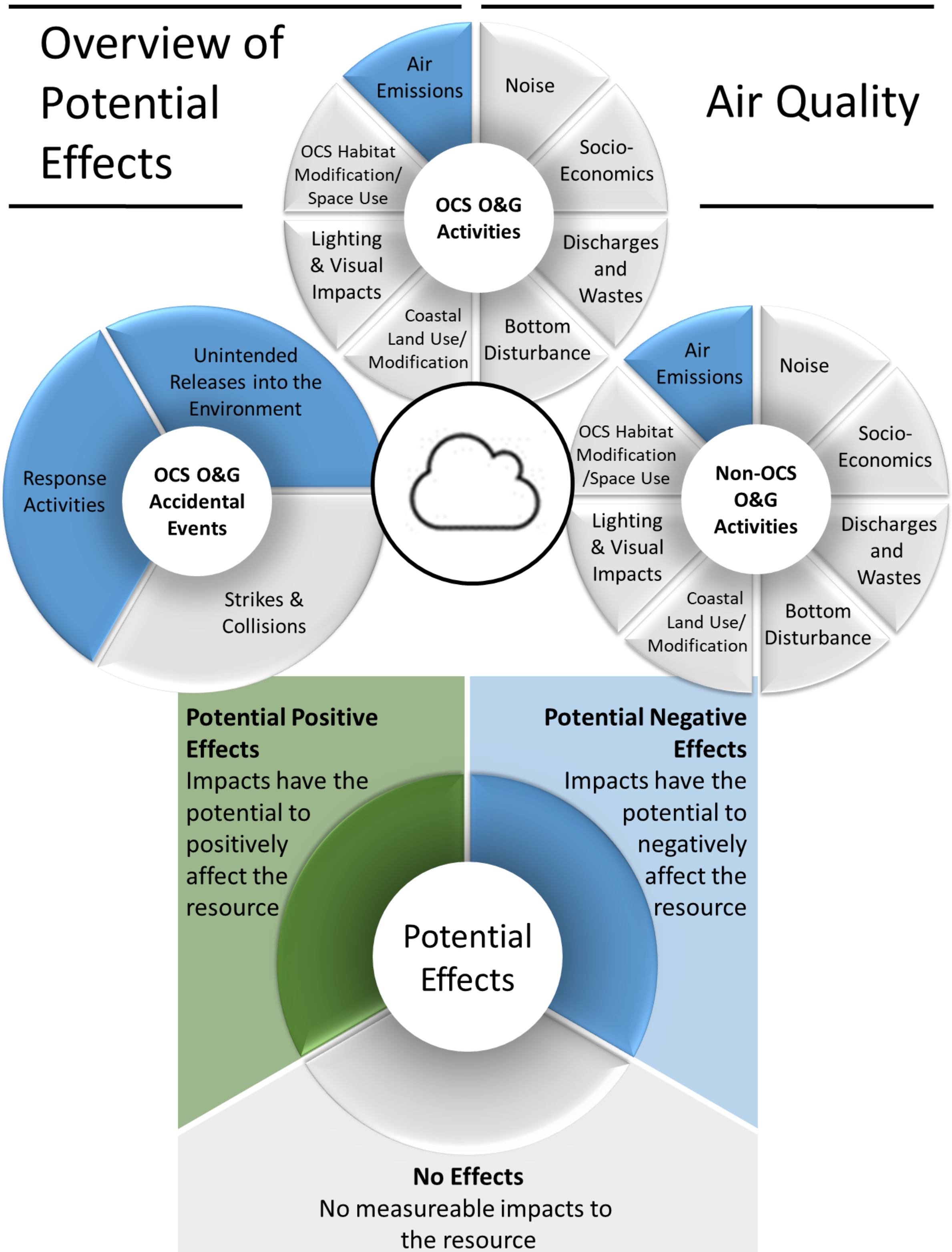


Figure 4.1.2-1. Potential Interactions Between the IPFs Identified in ***Chapter 2*** *and Air Quality. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

Criteria Air Pollutants and Other Air Pollutants

Below is a summary of the relevant air pollutants of concern and their potential effects to humans and the environment. These effects for each pollutant are applicable to both OCS oil- and gas-related and non-OCS oil- and gas-related activities and therefore, are discussed more generally within the introduction. Following this generalized overview of the potential effects by a pollutant is a discussion of the estimated contributions to these pollutants by non-OCS oil- and gas-related activities, OCS oil- and gas-related activities, and accidental OCS oil- and gas-related events, respectively. Air quality is generally assessed cumulatively given the challenges and uncertainties inherent with delineating what effects are directly correlated to specific sources. As such, the subsequent sections aim to provide a general understanding of how existing OCS oil- and gas-related activities and potential activities related to a future oil and gas lease sale, contribute to the overall emission levels in comparison to existing non-OCS oil- and gas-related sources.

Carbon Monoxide

The first criteria air pollutant of concern is carbon monoxide (CO). Carbon monoxide is a colorless and odorless gas that can be directly emitted or formed in the atmosphere from chemical reactions. Refer to **Chapter 2.1** for more information on sources of emissions. Carbon monoxide pollution can be harmful to humans and the environment. At high levels, CO can cause death to humans and animals USEPA (2010). At lower levels, it can also increase the risk of cardiovascular morbidity and potentially have effects on the central nervous system, birth and development, and mortality (USEPA 2010).

Lead

Lead (Pb), another criteria air pollutant, is also toxic. Lead is a toxic metal directly emitted into the atmosphere. Refer to **Chapter 2.1** for more information on sources of emissions. Lead can cause cancer in humans and health effects to the nervous, immune, hematologic, and reproductive and development systems USEPA (2013a). Any exposure of Pb to children is known to cause cognitive effects (USEPA 2013a). Also, exposure of Pb to ecosystems has been shown to affect the reproductive and development, growth, and survival of plants, invertebrates, and vertebrates (USEPA 2013a).

Nitrogen Oxides

Nitrogen oxides (NO_x) consists primarily of nitrogen dioxide (NO_2) and, to a lesser degree, nitric oxide (NO); therefore, NO_2 is used as an indicator. Refer to **Chapter 2.1** for more information on sources of emissions. NO_2 can either be directly emitted or formed in the atmosphere from chemical reactions between NO and O_3. There are other various pathways involving the presence of sunlight and other nitrogen containing compounds that can form NO_2 and NO. Nitrogen dioxide is harmful to humans and the environment. In humans, NO_2 can cause inflammation of the lung tissue, triggering respiratory health effects (USEPA 2016). In the environment, damaging acid particles like nitric acid are derived from NO_x. Nitrogen oxides interacts with other compounds in the atmosphere like water and oxygen and can be transformed into acid particles. Acidic deposition can then occur when these wet or dry acid particles descend to the ground, causing effects and nutrient imbalances to the soil, water, and vegetation (Driscolll et al. 2003; Paerl et al. 2002; Vitousek et al. 1997). Also, nitrate (NO_3) ions of nitric acid can contribute to haze effects, which decrease visibility (USEPA 2008). Haze is caused by small particles that have absorbed sunlight and scattered it.

Sulfur Oxides

Sulfur oxides (SO_x) consists mostly of sulfur dioxide (SO_2) and, to a lesser degree, sulfur monoxide (SO), disulfur monoxide (S_2O), and sulfur trioxide (SO_3); therefore, SO_2 is used as an indicator. Refer to **Chapter 2.1** for more information on sources of emissions. Sulfur dioxide can either be directly emitted or formed in the atmosphere from chemical reactions. In humans, SO_2 decreases lung function, triggering respiratory health effects, and potentially enhances the risk of mortality (USEPA 2017b). Sulfur dioxide can also transform into acid particles that effect the soil, water, and vegetation (Brimblecombe 2014; USEPA 2008).

Ozone

Unlike other criteria air pollutants, ground-level (troposphere) O_3 is not directly emitted into the atmosphere. Ground-level O_3 is formed from photochemical reactions between NO_x (NO_2 + NO) and carbon containing air pollutants (VOCs, CO, and methane [CH_4]) in the presence of sunlight and heat. Refer to **Chapter 2.1** for more information on sources of emissions. The ground-level O_3 can be harmful to humans and the environment. In humans, ground-level O_3 can damage the lung tissue, triggering respiratory health effects (USEPA 2020f). Other potential health effects caused by ground-level O_3 could include cardiovascular, metabolic, and mortality (USEPA 2020f). In the environment, ground-level O_3 has been shown to cause ecological effects, including visible damage to plants, reduced reproduction of plants, reduced growth of vegetation, and changes to soil nutrients (USEPA 2020f).

Particulate Matter

One more complex criteria air pollutant is particulate matter (PM_{10} and $PM_{2.5}$). Particulate matter is a mixture of solid particles and liquid droplets found in the air. These particles are either directly emitted or formed in the atmosphere as a result of chemical reactions from other air pollutants like SO_x, NO_x, and ammonia (NH_3). Refer to **Chapter 2.1** for more information on sources of emissions. Particulate matter can be harmful to humans and the environment. In humans, particulate matter can damage lung tissue, triggering respiratory health effects (USEPA 2019b). Other potential health effects caused by particulate matter could include cardiovascular, metabolic, mortality, nervous system, reproductive and development, and cancer (USEPA 2019b). Smaller sizes of particulate matter like $PM_{2.5}$ can deposit in higher amounts in the human respiratory system and can transport longer distances (USEPA 2019b). In the environment, particulate matter has been shown to negatively affect soils, water, wildlife, vegetation, visibility, weather, climate, and man-made materials (USEPA 2008). Potential environmental effects caused by particulate matter could include acidification and nutrient imbalances (USEPA 2008).

Hazardous Air Pollutants

More serious health effects can be caused by hazardous air pollutants (HAP), which are known to cause cancer. Refer to **Chapter 2.1** for more information on sources of emissions. The HAPs are distinct from the criteria air pollutants. Hazardous air pollutants can cause health effects such as reproductive harm and respiratory and immune damage. Also, some HAPs can deposit on the surfaces of soils and waters. Though HAPs are not criteria air pollutants, the CAA requires the USEPA to regulate the HAPs, and currently there are 187 listed HAPs (42 U.S.C. § 7412(b)(1)) whose levels the USEPA is working on reducing within State boundaries. For example, benzene is a known human carcinogen. Benzene has been shown to increase the risk of leukemia and cause disorders in human blood and adverse effects on fetuses (USEPA 2020e). Another HAP, formaldehyde, is a probable human carcinogen shown to irritate the respiratory system (USEPA 2020e).

Greenhouse Gases

Greenhouse gases (GHG) are distinct from the criteria air pollutants. Greenhouse gases trap heat in the atmosphere by absorbing radiation from the sun. Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Refer to **Chapter 2.1** for more information on sources of emissions. Greenhouse gases can be found naturally in the environment, except for fluorinated gases. The main fluorinated gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). The major environmental concern of GHGs is their effect on global temperatures (USEPA 2020g). Also, CO_2 is known to contribute to ocean acidification (Caldeira and Wickett 2003; Wanninkhof et al. 2015).

4.1.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.1.2-1 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect air quality in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Refer to **Chapter 2.1.2** for more information on emission sources from non-OCS oil- and gas-related activities. Various air pollutants are emitted from these non-OCS oil- and gas-related sources, but the CAP and CPAP emissions (NO_x, SO_x, PM, VOCs, Pb, CO, and NH_3) are controlled through laws and regulations. These CAPs and CPAPs (NO_x, SO_2, PM, VOCs, Pb, CO, and NH_3) contribute, whether directly or through chemical reactions, to increased NAAQS levels of criteria air pollutants.

The most recent *Year 2017 National Emissions Inventory* (USEPA 2020a) and *Year 2017 Emission Inventory Study* (Wilson et al. 2019a) provided non-OCS oil- and gas-related activity emissions per air pollutant listed in **Tables 2.1.2-1 and 2.1.2-2**. When the total CAP and CPAP emissions of the GOM are combined, non-OCS oil- and gas-related sources contribute to the total CAP and CPAP emissions in the GOM, about 99 percent for SO_2, PM_{10}, $PM_{2.5}$, Pb, VOCs, NH_3, and

CO and 97 percent for NO_x. Air quality modeling studies have not been conducted to understand the criteria air pollutant concentrations from non-OCS oil- and gas-related activities. Therefore, only the emissions inventories were discussed.

For HAP emissions, non-OCS oil- and gas-related activities contribute to the total HAP emissions in the GOM, about 96-99 percent for each of the 28 HAPs (refer to **Chapter 2.1.2.2**). For GHG emissions, non-OCS oil- and gas-related activities contribute to the total GHG emissions in the GOM, about 99 percent for CO_2, 89 percent for CH_4, and 99 percent for N_2O.

Air emissions and pollution from non-OCS oil- and gas-related activities can also affect other resources including water quality (**Chapter 4.2**), biological resources and habitats (**Chapter 4.3**), social and economic factors (**Chapter 4.4**), and cultural, historical, and archaeological resources (**Chapter 4.5**).

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories, other than air emissions, that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined that discharges and wastes, bottom disturbance, noise, coastal land use/disturbance, offshore habitat modification/space use, visual impacts, and socioeconomic changes and drivers are not likely to affect air quality. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Discharges and wastes involve effluent (liquid waste) being released into the waters of the GOM. The effluent is denser than the liquid matter that can be suspended in the air; therefore, discharges and wastes were not analyzed in detail.

Bottom disturbance has impacts on the seabed below the surface of the sea. Air quality refers to the atmosphere and is located above the surface of the sea. Therefore, bottom disturbances were not analyzed in detail.

Noise is considered unwanted sound that can disturb routine behavioral patterns and life functions (e.g., communication and feeding) and cause annoyance or physical injury. Sound is vibrations that travel through a medium such as air, water, or land and are then heard by living organisms. Air quality is not heard by living organisms. Therefore, noise was not analyzed in detail.

Coastal land use and disturbance relate to impacts from human infrastructure like pipeline landfalls, navigation channels, and facility buildings. These are terrain effects not caused by changes in the atmosphere. Therefore, coastal land use and disturbances were not analyzed in detail. The emissions related to these activities are included and discussed in the air emissions IPF category.

Offshore habitat modification/space use considers the effects of the physical presence of structures. Therefore, offshore habitat modification and space-use impacts to air quality were not analyzed in detail. The emissions related to the associated activities are included and discussed in the air emissions IPF category.

Lighting and visual impact on natural scenery can be caused by lighting, visible infrastructure, and air pollution. Visual impacts do not affect air quality; however, PM, SO_2, NO_x, and NH_3 air emissions can lead to visual impacts like haze (refer to **Chapters 2.1.1, 2.1.2.2, and 2.6.2**). Therefore, visual impacts were not analyzed in detail.

Socioeconomic changes and drivers are concerned with social and economic factors like employment and revenue. Changes in these factors can cause changes in human behavior but are not expected to affect or have any discernable influence on air quality. Therefore, socioeconomic changes and drivers were not analyzed in detail.

4.1.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.1.2-1 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect air quality in the GOM. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

Refer to **Chapter 2.1.1** for more information on emission sources for routine OCS oil- and gas-related activities (e.g., gasoline engines, diesel engines, venting, and flaring). Various air pollutants are emitted from these routine OCS oil- and gas-related sources, but the air pollutants NO_x, SO_x, PM, VOCs, Pb, CO, and NH_3 are controlled through laws and regulations. These air pollutants (NO_x, SO_2, PM, VOCs, Pb, CO, and NH_3) contribute, whether directly or through chemical reactions, to increased levels of criteria air pollutants.

The *Year 2017 Emission Inventory Study* (Wilson et al., 2019a) reported CAP and CPAP emissions from routine OCS oil- and gas-related activities in **Table 2.1.1-2**. Overall, the routine OCS oil and gas CAP and CPAP emissions reported in year 2017 decreased in comparison with year 2014 and 2011 (except for Pb, which was not provided in year 2011) (Wilson et al. 2019a). When the total CAP and CPAP emissions of the GOM are combined, the routine OCS oil- and gas-related activities contribution to the total CAP and CPAP emissions is about less than 1 percent for SO_2, PM_{10}, $PM_{2.5}$, Pb, VOCs, NH_3, and CO, and 3 percent for NO_x.

Wilson et al. (2019b) modeled the criteria air pollutants concentrations from “Group A2” and “Group B2” and the maximum concentrations of the 4-km (2.5-mi) modeling domain are shown in **Table 4.1.2-1**. Group A2 is all of BOEM’s existing oil and gas sources under a no sale scenario using the *Year 2014 Gulfwide Emission Inventory Study* (Wilson et al. 2017) and their future projected impacts out to year 2066. Group B2 is all potential oil and gas sources for a single future lease sale. Refer to Chapter 3.5 of Wilson et al. (2019b) for the single sale emission estimates.

BOEM developed the hypothetical future scenarios (A2 and B2) based on estimated amounts, timing, and general locations of OCS exploration, development, and production for offshore activities, assuming a mid-level price of fuel and projected future activity such as number of wells drilled, number of platforms installed, vessel trips, and other emissions-generating activities. Developing these scenarios and estimates based on historical trends in the OCS oil and gas industry is reasonable for this initial screening of potential future lease sale impacts and for estimating potential impacts at the regional level in any subsequent NEPA analyses for oil and gas leasing in the GOM. Chapter 6 and Appendix E.1 of Wilson et al. (2019b) provide detailed discussions on the assumptions, limitations, and justification used to support the emissions estimates and the dispersion modeling referred to in that report.

The modeled criteria air pollutants concentrations were also compared to the NAAQS, as shown in **Table 4.1.2-1**. Since the routine OCS oil- and gas-related activities CAP and CPAP emissions reported in year 2017 decreased in comparison with year 2014 (Wilson et al. 2019a), the effects on air quality from existing OCS oil- and gas-related sources should be less. Though, there are uncertainties in the data (refer to **Chapter 4.1.1.1**). BOEM asserts, however, that Wilson et al. (2019b) modeled a reasonable scenario based on reasonably foreseeable future actions that was developed using historical trends and existing data without being overly speculative (refer to 43 CFR § 46.30). As with any modeling process, it is necessary to make reasonable simplifying assumptions to address the complexity inherent with all modeling, which cannot cover every possible real-world scenario.

Table 4.1.2-1. Percent of NAAQS Consumed by OCS Oil- and Gas-Related Sources in the Gulf of Mexico. (The criteria air pollutants shaded in green were determined to be negligible to overall contributions and likely not to warrant additional analysis.)

Air Pollutant	Maximum Potential Concentration Modeled from Existing O&G Sources (Group A2)	Maximum Potential Concentration Modeled from a Single Future Lease Sale (Group B2)	Group A2 + Group B2	NAAQS Attainment Thresholds	Contribution to NAAQS by Existing and Future OCS Oil- and Gas-Related Sources
1-hr CO	Unknown	Unknown	Unknown	Unknown	Unknown
8-hr CO	Unknown	Unknown	Unknown	Unknown	Unknown
Pb	Unknown	Unknown	Unknown	Unknown	Unknown
1-hr NO_2	35.7 ppb	7.2 ppb	42.9 ppb	100 ppb	42.9%
Annual NO_2	8.2 ppb	2.4 ppb	10.6 ppb	53 ppb	20%
24-hr PM_{10}	2.8 μg/m³	0.5 μg/m³	3.3 μg/m³	150 μg/m³	2.2%
24-hr $PM_{2.5}$	1.9 μg/m³	0.7 μg/m³	2.6 μg/m³	35 μg/m³	7.4%
Annual $PM_{2.5}$	0.5 μg/m³	0.5 μg/m³	1.0 μg/m³	12 μg/m³	8.3%
1-hr SO_2	1.5 ppb	0.03 ppb	1.53 ppb	75 ppb	2.0%
3-hr SO_2	2.1 ppb	0.1 ppb	2.2 ppb	500 ppb	0.4%
8-hr O_3	25.9 ppb	4.2 ppb	30.1 ppb	70 ppb	43%

CO = carbon monoxide; ppb = parts per billion; Pb = lead; NAAQS = National Ambient Air Quality Standards; NO_2 = nitrogen dioxide; O&G = oil and gas; PM_{10} = particulate matter with diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with diameter less than or equal to 2.5; microns μg/m³ = micrograms per cubic meter of air; SO_2 = sulfur dioxide; O_3 = ozone; % = percent

Other air pollutants of concern from routine OCS oil- and gas-related activities can include HAPs and GHGs. For total HAP emissions in the GOM, routine OCS oil- and gas-related activities contribute an estimated 1-4 percent for each of the 28 HAPs. The HAP emissions from routine OCS oil- and gas-related activities are summarized in **Chapter 2.1.1.1**. For total GHG emissions in the GOM, routine OCS oil- and gas-related activities contribute an estimated 1 percent for CO_2, 11 percent for CH_4, and 1 percent for N_2O. Greenhouse gas emissions from routine OCS oil- and gas-related activities are summarized in **Chapter 2.1.1.1**, though some variability in these estimates may exist as discussed in **Chapter 4.1.1**.

The AQRVs of the Breton Wilderness Area include a visibility assessment, as well as assessments of potential deposition (sulfur [S] and nitrogen [N]) effects and potential O_3 effects on vegetation (USFS et al. 2010). In visibility assessments, the *Air Quality Modeling in the Gulf of Mexico Region* study found the maximum incremental visibility impacts to the Breton Wilderness Area from Group A2 to be 4.03 deciview and 0.31 deciview from Group B2 (Wilson et al. 2019b). Deposition effects from sulfur and nitrogen depositing from the air may cause acidification or nutrient imbalances to ecosystems. The *Air Quality Modeling in the Gulf of Mexico Region* study modeled Group A2 and B2 found the annual maximum nitrogen deposition (wet and dry) impact of 0.4303 kg/ha/yr and 0.0180 kg/ha/yr and maximum sulfur deposition (wet and dry) impact of 0.0061 kg/ha/yr and 0.0002 kg/ha/yr, respectively (Wilson et al. 2019b). Potential O_3 effects on vegetation are uncertain. **Table 4.1.2-1** showed Group A2+B2 maximum 8-hr O_3 concentration to be 30.1 parts per billion (ppb). However, there are uncertainties in the data (refer to **Chapter 4.1.1.1**).

The above air emissions and pollution from routine OCS oil- and gas-related activities can also affect other resources including water quality (**Chapter 4.2**), biological resources and habitats (**Chapter 4.3**), social and economic factors (**Chapter 4.4**), and cultural, historical, and archaeological resources (**Chapter 4.5**).

4.1.2.2.1 Air Pollutants Preliminary Screening

This chapter is intended to identify the CAPs not likely to have an effect on air quality and, therefore, could likely be scoped out of future NEPA analyses for Gulf of Mexico OCS oil and gas leasing. This preliminary screening is based on the results of the conservative modeling discussed earlier and in detail in Wilson et al. (2019b). BOEM may utilize this screening to narrow the focus of future NEPA analyses of the key pollutants of concern related to BOEM's action (i.e., any future oil and gas leasing).

Air Pollutants Eliminated from Further Analysis

No air quality modeling of the carbon monoxide and lead criteria air pollutant concentrations in the GOM has been completed. However, based on the emission inventory data and ambient air quality monitoring, carbon monoxide and lead may be excluded from future analyses. The carbon monoxide and lead emissions from existing oil- and gas-related activities, contributed less than 1 percent to the total emissions in the GOM, and there are currently no nonattainment areas in any of the Gulf Coast States for carbon monoxide and lead. Furthermore, the potential carbon monoxide emissions are assessed for site-specific impacts during postlease reviews (refer to **Chapter 5.6**).

Based on the emission inventory data, SO_2 emissions from existing oil- and gas-related activities also contributed less than 1 percent to the total emissions in the GOM. There are no 3-hour SO_2 nonattainment areas in any of the Gulf Coast States, and the air quality modeling results from **Table 4.1.2-1** show existing oil- and gas-related activities plus future activities for a single lease sale could potentially consume less than 0.5 percent of the NAAQS. However, there is one nonattainment area in Louisiana and two maintenance areas in Florida for the 1-hr SO_2 (USEPA 2020c). The air quality modeling showed that the existing oil- and gas-related activities plus future activities for a single lease sale could potentially consume 2 percent of the 1-hr SO_2 NAAQS, which is negligible. Furthermore, the potential SO_2 emissions are assessed for site-specific impacts during postlease reviews (refer to **Chapter 5.6**).

Based on the emission inventory data, PM_{10} emissions from existing oil- and gas-related activities also contributed less than 1 percent to the total emissions in the GOM. There are no nonattainment areas for 24-hr PM_{10} in any of the Gulf Coast States and the air quality modeling results from **Table 4.1.2-1** show existing oil- and gas-related activities plus future activities from a single lease sale would only consume potentially up to 2.2 percent of the 24-hr PM_{10} NAAQS, which is negligible.

Based on the emission inventory data, 21 out of the 28 HAP emissions from existing oil- and gas-related activities contribute less than 1 percent per pollutant to the total emissions in the GOM. The 21 HAP emissions can be excluded from future NEPA analyses because those HAP emissions for all existing oil- and gas-related activities emit less than the 10 tons per year threshold (CAA § 7412(a)(1)) per HAP. Acetaldehyde, benzene, ethyl benzene, formaldehyde, hexane, toluene, and xylenes, however, may still be analyzed in future NEPA analyses.

Based on the emission inventory data, CO_2 and N_2O emissions from existing oil- and gas-related activities contribute less than 1 percent per pollutant to the total emissions in the GOM.

Since Group B2 impacts for multiple future facilities are under the 0.5 deciview threshold for single facility assessments (USFS et al. 2010), visibility effects could be scoped out of future NEPA analyses. Also, since Group B2 sulfur deposition impacts for multiple future facilities are under the 0.01 kg/ha/yr sulfur deposition threshold for single facility assessments (USFS et al. 2010), sulfur deposition impacts could be scoped out of future NEPA analyses.

Air Pollutants Warranting Further Analysis

Based on the estimated contributions presented in **Table 4.1-2** and the existing conditions in the GOM region, the level of impacts for the following CAPs, HAPs, and GHGs would likely require additional evaluation in a future NEPA analysis for OCS oil and gas leasing: 1-hr NO_2, annual NO_2, 24-hr $PM_{2.5}$, annual $PM_{2.5}$, 8-hr O_3, acetaldehyde, benzene, ethyl benzene, formaldehyde, hexane, toluene, xylenes, and CH_4. Future NEPA analysis is also needed for AQVRs on nitrogen deposition impacts and potential O_3 effects on vegetation.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil- and gas-related activities and determined discharges and wastes, bottom disturbance, noise, coastal land use/disturbance, offshore habitat modification/space use, visual and lighting impacts, and socioeconomics changes and drivers are not likely to affect air quality. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Discharges and wastes involve effluent (liquid waste) being released into the waters of the GOM. The discharges and wastes can include produced water, drilling cuttings, deck drainage, and sanitary wastes. The effluent is denser than the liquid matter that can be suspended in the air. Therefore, discharges and wastes were not analyzed in detail. However, gas can be entrained in drilling muds that are brought to the surface. Mud degassing involves the separation of the gas from the mud. Emissions associated with mud degassing were analyzed since they were included in the *Year 2017 Emission Inventory Study* (Wilson et al. 2019a).

Bottom disturbance has impacts on the seabed below the surface of the sea. Air quality refers to the atmosphere and is located above the surface of the sea. Therefore, bottom disturbances were not analyzed in detail.

Noise is considered unwanted sound that can disturb routine behavioral patterns and life functions (e.g., communication and feeding) and cause annoyance or physical injury. Sound is vibrations that travel through a medium such as air, water, or land and then heard by living organisms. Noise is not known or expected to influence or effect air quality and therefore.

Coastal land use/modification relates to impacts from human infrastructure like pipeline landfalls, navigation channels, and facility buildings. These are terrain effects not caused by changes in the atmosphere. Therefore, coastal land use and disturbances were not analyzed in detail. Any emissions generated from these activities are regulated under the CAA Amendments.

Offshore habitat modification/space use considers the effects of the physical presence of structures. Therefore, offshore habitat modification/space use was not analyzed in detail. The emissions related to these activities are addressed in the air emissions IPF category.

Lighting and visual impact on natural scenery can be caused by lighting, visible infrastructure and air pollution. Visual impacts do not affect air quality; however, PM, SO_2, NO_x, and NH_3 air emissions can led to visual impacts like haze (refer to **Chapters 2.1.1, 2.1.2.2, and 2.6.2**). Therefore, visual impacts were not analyzed in detail.

Socioeconomic changes and drivers are concerned with social and economic factors like employment and revenue. Changes in these factors can cause changes in human behavior but are not expected to affect or have any discernable influence on air quality. Therefore, socioeconomic changes and drivers were not analyzed in detail.

4.1.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.1.2-1 highlights the accidental events associated with OCS oil- and gas-related activities that could potentially affect air quality in the GOM. Effects from these categories of IPFs would vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Air quality can be impacted by accidental releases such as oil spills, uncontrolled releases of natural gas, condensate, hydrogen sulfide (H_2S) releases, fires, and emergency flaring and venting. All these events could contribute to air pollution potentially for a short duration until the event is resolved. Air pollutants associated with these events depend on the chemical composition of the product. The more likely event of accidental releases of air pollutants are associated with fires and emergency flaring and venting. Emergency flaring and venting can help prevent more dangerous situations like an explosion. Flaring involves the burning of gas while venting releases unburned gas.

Fires and emergency flaring would likely result in the release of CO_2, NO_x, PM, and depending on the sulfur content, SO_2. An image on the National Aeronautics and Space Administration's (NASA) website shows flaring and its associated plume in the Gulf of Mexico (NASA Earth Observatory 2012; 2017). Emergency venting may be necessary when 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 gas pressure. Emergency venting would likely result in the release of VOCs, CH_4 and potentially H_2S. Venting of CH_4, which is a flammable gas, is more of a hazard to helicopters (BSEE 2015b) but can also be hazardous to nearby humans and animals. The source of "disproportionately high" CH_4 emissions estimates reported at shallow-water oil and gas facilities (Gorchov Negron et al. 2020) is unclear and may potentially be uncontrolled releases of CH_4. BOEM may analyze these sources in more detail when determining the potential impacts from accidental OCS oil- and gas-related events in future NEPA analyses.

Response Activities (Chapter 2.9.2)

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. Response activities can impact air quality through emissions from the equipment used to operate vessels and aircraft, burning of gas and oil, and the use of dispersants applied from vessels or aircraft. NO_x, CO, and PM can be emitted from in-situ burning of oil. The levels of $PM_{2.5}$ could be a hazard to personnel working in the area, but this could likely be mitigated through monitoring, personal protective equipment, and relocating vessels to avoid areas of highest concentrations. All these events could contribute to air pollution potentially for a short duration until the event is resolved. Air pollutants associated with these events depend on the type of spill response, which depends on the chemical composition of the product spilled, and the equipment.

Accidental Events Determined Not Likely to Cause Effects

BOEM evaluated the accidental events associated with OCS oil- and gas-related activities as described in **Chapter 2.9** and determined that strikes and collisions are not likely to affect air quality as this IPF pertains to vessel(s) or aircraft unintentionally hitting a physical object (e.g., platform) or living organism (e.g., sea turtle) and the damage caused. These types of effects would not apply to air quality.

Collisions between vessels, platforms, and/or helicopters can result in the release of fuel or oil, natural gas, or chemicals. The impact on air quality would depend on the type and amount of fuel or chemical composition of the product released from the collision. Any fire that can occur as a result of a collision will release CO_2, NO_x, PM, and depending on the sulfur content, SO_2 into the atmosphere. Potential spills and/or fires associated with collisions were evaluated as part of **Chapter 2.9.1**. Therefore, strikes and collisions were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

4.2 WATER QUALITY

This chapter provides a summary overview of (1) the baseline information for water quality in the GOM, (2) natural and human-induced influences, (3) the current condition of coastal water quality and offshore water quality, and lastly (4) an assessment of the potential effects to water quality from the IPFs described in **Chapter 2**. The effects analysis also identifies which IPF categories are not likely to affect water quality and why.

4.2.1 Resource Description

Clean water is essential to human and environmental health. It is especially important to marine ecosystems and humans who live near the coast and rely on the sea for their livelihood. Water quality relates to the condition or environmental health of a waterbody, reflecting its chemical, physical, and biological integrity, as well as its interrelationship with human health and ecosystem functions. In addition to sustaining life, water also links land, ocean, and atmosphere as an integrated system.

4.2.1.1 Physio- and Oceanographic Influences on Water Quality

__Water quality__ can be defined as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics.

Primary indicators of water quality in coastal and offshore environments include temperature, salinity, dissolved oxygen, chlorophyll content, nutrients and other trace constituents (e.g., metals), potential of hydrogen (pH), oxidation reduction potential (Eh), pathogens, optical properties (i.e., clarity, turbidity, and dissolved and suspended matter), and contaminant concentrations (i.e., heavy metals and hydrocarbons). These indicators, and water quality in general, are influenced primarily by (1) the configuration of the basin, including influx of water from the Caribbean Sea and the output of water through the Straits of Florida; and (2) runoff from the land masses, which controls the quantity and quality of freshwater input. With increasing distance from shore, oceanic circulation patterns play an increasingly large role in dispersing and diluting anthropogenic contaminants and thus determining water quality.

The physical oceanography of GOM waters deeper than 3,281 ft (1,000 m) can be approximated as a two-layer system, with an upper layer that is dominated by the Loop Current and associated anticyclonic eddies (Inoue et al. 2008; Welsh et al. 2009) and a lower layer that has near uniform currents (Inoue et al. 2008; Welsh et al. 2009). Sea-surface temperatures are determined by the interaction of the atmosphere and ocean over seasonal cycles, through the mixing of Loop Current water and associated eddies, and by upwelling and mixing of waters along the shelf (Muller-Karger et al. 2015). Strong cross-latitudinal temperature differences occur, with warmest temperatures in the southern GOM and coldest temperatures in the northern GOM. Salinity is strongly influenced by freshwater inputs from rivers, especially the Mississippi and Atchafalaya Rivers, and by the Loop Current that transports warm, high salinity water in from the Caribbean Sea.

4.2.1.2 Programmatic Concerns Influencing Water Quality

Major Storm Events (Chapter 3.3.1)

Sediment quality poses an impact risk to coastal water quality as contaminants in sediments may be resuspended into the water by storms events. Sediments in the GOM coastal region have been found to contain pesticides, metals, polychlorinated biphenyls (PCBs), and occasionally polycyclic aromatic hydrocarbons (PAHs) (USEPA 2012a).

Eutrophication and Hypoxia (Chapter 3.3.2)

Nitrogen and phosphorous are particularly important nutrients in coastal and oceanic waters and are critical for the growth of phytoplankton (Kennicutt II 2017b). High levels of these nutrients, however, can contribute to eutrophication and degraded water quality. Anthropogenic sources, including runoff from agriculture and municipal or industrial wastewater, generally contribute greater amounts of nutrients and contribute to hypoxia. Hypoxia is a widespread phenomenon on the continental shelf of the northern GOM and leads to the largest hypoxic zone in the western Atlantic Ocean (Rabalais and Turner 2001a). The hypoxic zone in the GOM occurs seasonally and is influenced by the timing of the Mississippi and Atchafalaya Rivers discharge.

A common indicator of degraded water quality is an increase in phytoplankton biomass. Nutrient inputs from the Mississippi and Atchafalaya Rivers lead to excessive phytoplankton growth and chlorophyll concentrations along the Louisiana and Texas coasts and contribute to the creation of summertime hypoxic conditions (Rabalais and Turner 2001a). There is also a surface turbidity layer associated with the freshwater plumes from the Mississippi and Atchafalaya Rivers due to suspended sediment and dissolved organic matter in the river discharge, especially during seasonal periods of heavy precipitation and melting upriver during spring thaw. Similarly, storm events can have a substantial impact on the quality of coastal waters in the GOM, causing runoff of nutrients, contaminants, and increased turbidity. Offshore waters are typically clearer, with phytoplankton and other organisms mostly contributing to observed turbidity.

Harmful Algal Blooms

Some phytoplankton species can produce toxic substances that impair water quality and, under certain conditions, can form harmful algal blooms. In the GOM, toxic red and nontoxic brown tides caused by dinoflagellates, diatoms, and other phytoplankton can contribute to decreased water quality, hypoxic conditions, and result in health impacts to humans and marine life. Waterborne pathogens in the marine environment can also degrade water quality and are a serious concern in some areas of the GOM. For example, along coastal areas and beaches, faecal indicator bacteria (e.g., faecal coliforms, *Escherichia coli*, and enterococci) from stormwater runoff and sewage spills are a common issue that can impact public health (Korajkic et al. 2011).

Marine snow derives from a wide variety of detrital particles that originate mostly from near the surface and can play an important role in transporting nutrients and contaminants through the water column to the seafloor and sediments. Sediments in the northern GOM tend to be rated as poor to fair in coastal areas, with anthropogenic sediment contaminants decreasing with increasing distance from the coast. Contaminated sediments are diluted by natural processes, such as oceanic currents, as they are moved offshore.

Natural Seeps (Chapter 3.3.3)

Releases from natural oil and gas seeps can also directly impact offshore water and sediment quality. Seeps are found throughout the GOM, contributing the majority of the annual input of petroleum into the GOM and totaling over 42 million gallons released into the environment each year (Kvenvolden and Cooper 2003; MacDonald et al. 2015; National Research Council 2003a).

Climate Change (Chapter 3.4)

Programmatic concerns regarding climate change were discussed in **Chapter 3.4**. The rise in ocean temperature over the last century will persist into the future, with continued impacts on climate, ocean circulation, chemistry, and ecosystems (Doney et al. 2014). Aspects of climate change that influence water and sediment chemistry include increasing ocean acidity (pH), increasing sea-surface water temperatures, and increasing storm activity. Climate change will promote changes in flushing regimes, freshwater inputs, and water chemistry and will influence how these changes could affect ecosystem services, particularly along the coast (Cabral et al. 2019). Additional CO_2 in the earth's atmosphere also changes ocean chemistry, which in turn can influence water quality. Climate change contributes to ocean acidification, which can in turn impact chemical and biological aspects of the marine environment and which also could affect oceanic carbon sequestration (Hofmann and Schellnhuber 2009). In the GOM, ocean acidification is an increasing threat to water quality particularly along the coasts (Cai et al. 2011; Hu et al. 2015), as hypoxia also leads to decreased pH in the water column.

4.2.1.3 Overview of Current Water Quality Conditions

Coastal Waters

Coastal waters of the GOM are defined to include all bays and estuaries from the Rio Grande River to Florida Bay. Coastal water quality ratings in the GOM region ranges from poor to good, with an overall rating of fair (USEPA 2012a). 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. 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, PCBs, and occasionally PAHs (USEPA 2012a). Coastal water quality also is affected by the loss of wetlands, water temperature, total dissolved solids (salinity), suspended solids (turbidity), nutrients, and anthropogenic inputs via runoff, terrestrial point source discharges, and atmospheric deposition.

Offshore Waters

Offshore waters include those waters located within State waters and the Federal OCS, extending from outside the barrier islands to the Exclusive Economic Zone. With increasing distance from shore, oceanic circulation patterns play an increasingly large role in dispersing and diluting anthropogenic contaminants and thus determining water quality. Water quality of the deep GOM may also be closely tied to sediment quality, and the two can affect each other, though research is limited.

4.2.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and water quality. **Figure 4.2.2-1** provides a synopsis of the IPF categories that currently affect or have the potential to affect water quality in the Gulf of Mexico OCS. Following **Figure 4.2.2-1** is an assessment of those potential effects, broken down by three broad categories, as identified in the figure, in the following order: (1) non-OCS oil- and gas-related activities; (2) routine OCS oil- and gas-related activities; and (3) accidental OCS oil- and gas-related events. Within each of these chapters is a description of the types of potential effects that could occur, as well as brief discussions of the IPF categories determined not likely to affect water quality and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to water quality, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development in the Gulf of Mexico OCS. While this document does not make impact determinations for water quality, future NEPA analyses will include such determinations.

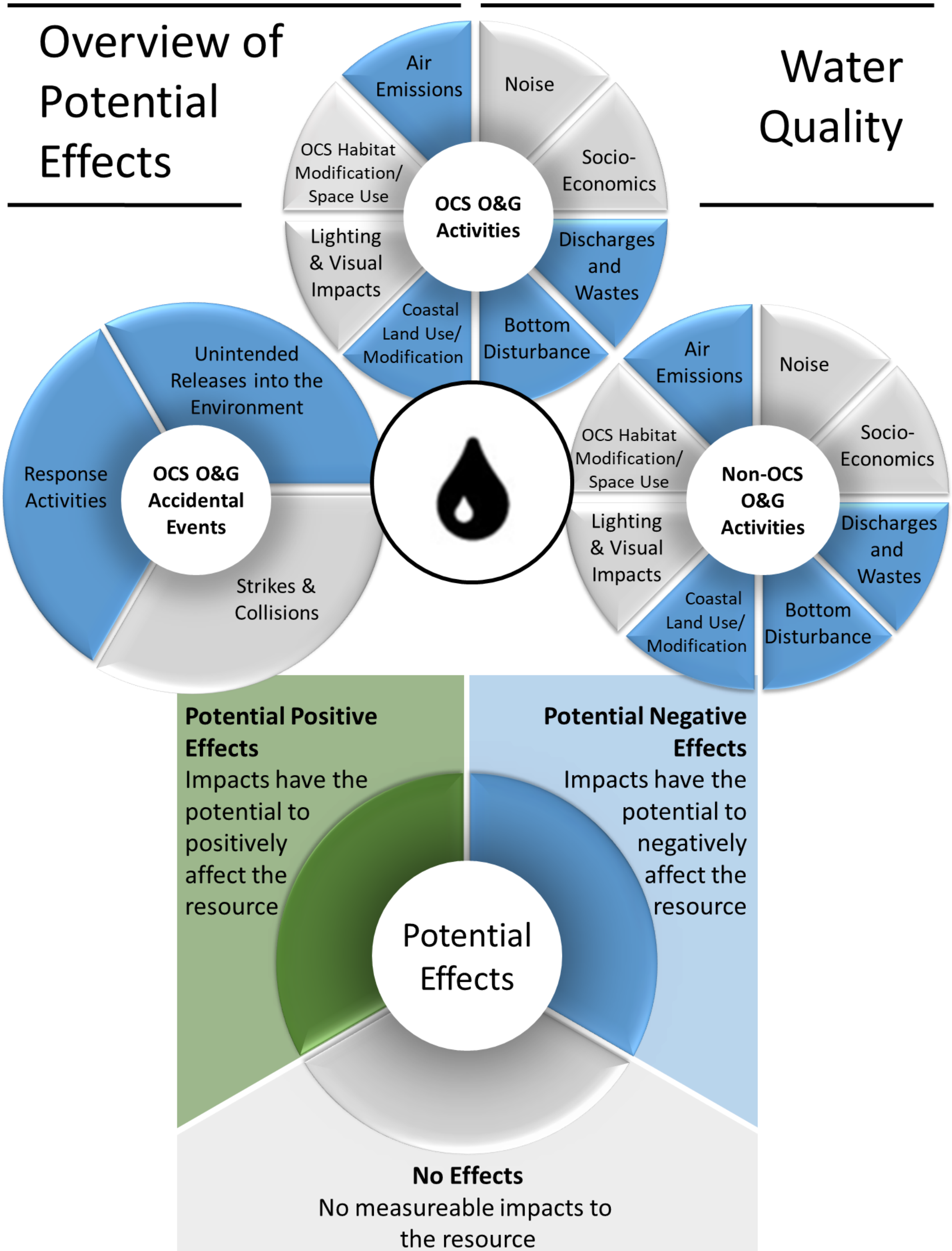


*Figure 4.2.2-1. Potential Interactions between the Impact-Producing Factors Identified in **Chapter 2** and Water Quality. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.2.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.2.2-1 highlights the IPF categories of non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect water quality in the GOM region. These IPFs could potentially affect water quality through the following:

- releasing materials into the water column or at the sea surface that subsequently disperse, react with seawater, or may dissolve over time;
- depositing materials on the ocean bottom and any subsequent interactions with sediments or the accumulation of such materials over time;
- depositing materials or substances on the ocean bottom and any subsequent interaction with the water column; and
- depositing materials on the ocean bottom and any subsequent disturbance of those sediments or their resuspension in the water column.

These various factors may directly affect water quality by altering its physical and chemical characteristics. The environmental fate of chemicals, nutrients, and other inputs depends on environmental factors, geochemical conditions, and various mechanisms that transport the constituents in the environment. Some natural transport mechanisms, such as advection by currents, dispersion, dissolution (dissolving), precipitation by chemical reaction, and adsorption (the adhesion of a chemical constituent onto the surface of a particle in the environment [e.g., clay]) reduce concentrations in water and redistribute constituents between the water and sediments. The following sections summarize the various types of effects that occur from non-OCS oil- and gas-related activities by IPF category.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions and pollution from non-OCS oil- and gas-related sources contribute to acidic deposition, ocean acidification, and eutrophication in the Gulf of Mexico (Caldeira and Wickett 2003; Driscoll et al. 2003; Paerl et al. 2002; Vitousek et al. 1997; Wanninkhof et al. 2015). Both CO_2 uptake and acidic deposition (wet + dry deposition) of sulfur and nitrogen can increase acidification in GOM seawater by changing the pH value (Doney et al. 2007; Echeverria et al. 2020; Paerl et al. 2002; USEPA 2008; Wanninkhof et al. 2015). Also, acidic deposition can contribute to eutrophication (Glibert 2020; USEPA 2008). CO_2 could indirectly change the temperature of GOM seawater (refer to **Chapter 3.4**). Thus, CO_2 emissions in the atmosphere could have a direct and indirect effect on the GOM seawater.

Discharges and Wastes (Chapter 2.2.2)

Human activities have introduced thousands of substances and/or materials into the marine environment that, once above certain threshold values, might present negative effects on biological components of these ecosystems and, therefore, become pollutants. Pollutants might originate from a large number of human activities (e.g., agriculture; industrial, urban and port development;

transportation; fisheries and aquaculture; and recreation) and may be of a different nature—chemical (e.g., nutrients, biocides, metals, oil, and pharmaceuticals), physical (e.g., plastic debris, large hard structures, temperature, radiation, and noise), or biological (e.g., introduced non-indigenous species) (Cabral et al. 2019).

Land-based point source discharges result in the release of contaminants directly into coastal and marine environments. The NPDES permits are issued by the USEPA (40 CFR part 435), and State permits are issued by the State environmental regulatory agencies to regulate the discharge of pollutants from point sources. These permits generally allow facilities or a group of facilities to discharge a specified amount of pollutants under certain conditions, and any discharges greater than those permitted are considered a violation. Non-oil- and gas-related sources of anthropogenic pollutants that are regulated include marine vessel activity, LNG ports and terminals, land-based point-source discharges, aquaculture, OCS sand borrowing, maintenance dredging, dredged material disposal, and any potential future renewable energy projects. Discharges as a result of these activities require State or national NDPES permits, which consider variables such as dissolution, circulation, and bioaccumulation when determining maximum allowable discharge rates and toxicity levels. Discharges in compliance with regulations, including any future NPDES permit(s) requirements and other provisions of the CWA, are monitored to demonstrate compliance and ensure that short-term and additive impacts are minimal as defined under the CWA.

Non-point source agricultural and urban runoff or discrete point-source wastewater discharges from industrial sites and sewage plants contribute a wide variety of nutrients and other chemical contaminants to the GOM. These pollutants are released into streams, rivers, bays, and estuaries, and many make their way to the open ocean where they stress marine life. Nonpoint-source discharges from uncontained runoff and groundwater discharge are a source of suspended solids, organic matter, nutrients, and other pollutants. Nutrients, often transported through river outflow, cause eutrophication and hypoxia, which affect water quality and can contribute to increased environmental degradation (refer to **Chapter 3.3.2**). Vessels periodically release sewage, wastewater, and bilge water, which can impact water quality both in the coastal environment and offshore. Pollutants in nonpoint-source discharges can be incorporated into bottom sediments within the coastal zone and have the potential to cause impacts to water quality.

There are estimated to be at least 4,000 shipwrecks in the GOM, some of which could pose risks to water quality due to leaks from oil tanks or fuel bunkers and corrosion of cargo and electronicss (NOAA 2013a). This includes at least 56 ships sunk by German submarines in World War II, which are particularly at risk to leak oil and other contaminants (Monfils 2005; NOAA 2013a). The impacts to water quality from shipwrecks are dependent on the type and amount of fuel and cargo present on the wreck and the flow rate of contaminants into the water column (Dimitrakakis et al. 2014; NOAA 2013a). Additionally, corrosion of electronics and other components of the wreck can lead to locally elevated concentrations of heavy metals and other contaminants in the sediment and water column in the vicinity of the wreck (Dimitrakakis et al. 2014). Light oils released from wrecks are typically localized and generally degrade in the short term. Refer to **Chapter 2.2.2.1** for more information on contaminants and potential effects as a result of shipwrecks.

Legacy disposal in the GOM of military munitions, including chemical weapons (Bearden 2007), was widespread. Corrosion of these materials leading to releases into the environment could cause impacts to water quality (Beck et al. 2018). Additionally, offshore waters in the GOM are home to several active military operations areas and testing ranges that can introduce discharges and wastes that could affect water quality (U.S. Fleet Forces 2010). Discharges and wastes associated with military activities include jettisoned fuel; chemicals; plastics and metals from expended ammunition and bombs, propellants, chaff, flares, smokes, and obscurants; and debris and fuel from aerial, submarine, and towed targets (U.S. Fleet Forces 2010). Chemical weapons and other military wastes and discharges are known to contain extremely toxic and persistent substances that, if leaked into the water column, could impact water quality over long periods of time (Lawrence et al. 2015).

The degree of risk from weapons leaking chemical agents into seawater depends on numerous factors. The extent to which an agent is diluted and the duration of exposure determine whether there is potential for harm. For example, most nerve agents are soluble and dissolve in water within several days. Less soluble agents still degrade over time as a result of hydrolysis. However, certain agents are less susceptible to hydrolysis, allowing them to remain in harmful forms for longer periods. For example, sulphur mustard in liquid or solid form turns into an encrusted gel when released in seawater. In this form, it can persist for many years before degrading. Potential exposures to discharges from these sources to marine organisms and human beings could occur through direct exposure in the water column and sediment or through ingestion and bioaccumulation up the food chain. For example, a mustard gas bomb floated ashore in the Gulf of Mexico in 1946 (location unspecified) after it and 32 others were disposed of 20 mi (32 km) off the coast at depths ranging from 200 to 600 ft (51 to 183 m) (Bearden 2007).

Marine debris and microplastics are of increasing concern in the GOM waters. They are found at the surface, throughout the water column, at the seabed, and along all shorelines, and are a source of degraded water quality (Di Mauro et al. 2017; Kane et al. 2020; Lecke-Mitchell and Mullin 1997; Wessel et al. 2016). Sources include the commercial fishing and oil and gas industries, commercial shipping, recreational boaters, and rivers that empty into the GOM. Di Mauro et al. (2017) reported some of the highest concentrations of microplastics observed in the ocean worldwide and suggested that the numbers were strongly influenced by input from the Mississippi River and other rivers, as over 60 percent of the continental United States drains into the GOM. Microplastics can adsorb contaminants (Brennecke et al. 2016) and occur in the same size range as zooplankton and can make it into the food chain through grazing by zooplankton and fish (Cole et al. 2013; Di Mauro et al. 2017; Kurtela and Antolović 2019; Phillips and Bonner 2015; Romeo et al. 2016). Larger marine debris are found both at the surface and at depth, with trash even being found in the deepest parts of the GOM (Wei et al. 2012). Larger debris also degrades water quality through its physical presence, which obstructs the water, can limit sunlight penetration, and potentially leak contaminants stored within the debris into the water. Both microplastics and larger marine debris can introduce toxic chemicals into the water column as they break down and decompose, but the potential impacts of this remain largely inconclusive (Ziccardi et al. 2016).

Bottom Disturbance (Chapter 2.3.2)

Water quality can be affected by bottom disturbance in rivers that outflow into the ocean, as well as in coastal and deepwater areas of the OCS. Non-oil- and gas-related activities likely contributing to bottom disturbance include anchoring, buoys, and moorings; OCS sand borrowing; military operations; and mass wasting events (commonly referred to as mud slides). All of these activities can affect water quality by potentially increasing turbidity and resuspending sediments and thus potential contaminants into the water.

Placement of anchors, buoys, and moorings can cause turbidity in the water column. If an anchor does not grip the seafloor when it is set, the anchor could scour the seafloor if it is dragged by the motion of the attached vessel. Moorings can be attached to the seafloor by large seafloor foundations or buried piles or foundations. Piles and buried foundations could be jetted or pounded into the seafloor, which could cause suspended sediment and turbidity, followed by sediment deposition in the area of disturbance. Resuspension of sediments can also result in contaminants in the sediment being redistributed back into the water column.

Dredging activities in offshore waters, primarily associated with disposal at approved offshore sites, can cause elevated turbidity through resuspension of sediments. Such disposal sites are located, designed, and operated under permit guidelines of the CWA and the Marine Protection, Research, and Sanctuaries Act to ensure that any changes in turbidity are localized and short term. Typically, OCS sand-borrow areas are located in 9 to 18 m (30 to 60 ft) of water in close proximity to the coast so that any expected turbidity impacts would likely be limited to coastal and shallow water areas. Turbidity in the water column can result from the overflowing process, as well as near the draghead where not all of the sediment is suctioned up. Dredges use side anchors, which are frequently repositioned, to allow movement, and spuds walk the dredge in the direction of movement (USACE 2015). The placement of anchors can also contribute to turbidity. The suspended sediment from anchoring and excavation would remain fairly localized and would eventually fall out of the water column and settle on the seafloor. Because sediment sources used for beach nourishment are sandy material, the sand grains tend to settle out of the water column fairly rapidly after disruption. The distance sediment travels in the water column before it settles will depend on local currents and sediment grain size.

A variety of military activities can also result in bottom disturbance, which can result in resuspension of sediments and increased turbidity. Military vessel activities, including anchoring, and training activities can disturb the seafloor. Explosions on or near the seabed can result in large craters on the seafloor. The sediment forced from the crater could cause turbidity in the surrounding water column, followed by sediment deposition on the seafloor. The size of the crater and amount of displaced sediment would be dependent on the size of the blast. Where combinations of explosives, explosives byproducts, metals, and other chemicals and materials are co-located, the potential for combined impacts is present (Thompson et al. 2009). The impact from these contaminants would be additive; however, the Navy recently concluded these additive effects are likely minimal (U.S. Navy 2018).

Mudslides could also affect water quality through turbidity and resuspension. These events typically cause turbidity currents that can flow for long distances at high velocities (refer to **Chapter 2.3.2.9**). If resuspended, fine-grained sediments (and any substances bound to them) can be transported long distances as well as be subjected to biological and chemical processes that would not have originally occurred when the sediments were settled (i.e., undisturbed).

Coastal Land Use/Modification (Chapter 2.5.2)

The construction of residential areas, industrial centers, ports, and other infrastructure is expected to continue in the coming decades to match steadily increasing population growth on the coasts (Kildow et al. 2016; Sengupta et al. 2018). The majority of the contaminant point sources along the northern Gulf Coast are derived from petroleum refineries or petrochemical plants. Expansions of ports and dredging of port areas will continue to accommodate increased shipping and increasingly larger vessels (Merk et al. 2015). To support coastal residents and tourists, the construction of additional hotels, resorts, marinas, docks, seawalls, bridges, and roads is also expected to continue in the coming years (Kildow et al. 2016; Sengupta et al. 2018). Coastal construction can degrade or destroy coastal habitats and put species at risk (Huettmann and Czech 2006; Morrison et al. 2006). Direct habitat loss is particularly problematic for buffer species like mangroves, which naturally protect the shoreline from storm damage and filter sediments from coastal runoff (Burge et al. 2014; Marshall et al. 2011). Agricultural activities near the coast and adjacent to rivers that feed out into the GOM can contribute to soil erosion, which results in sediments being added into the water. Overall, coastal land use can indirectly affect water quality because it can result in increased erosion and sedimentation of coastal areas, as well as cause inputs of excess sediments, nutrients, and contaminants into the water as discussed further in the "Discharges and Wastes" section above.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined that noise, lighting and visual impacts, and socioeconomic changes/drivers would not likely affect water quality because these IPFs do not directly interact with water. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Offshore habitat modification/space use would not likely affect water quality because few interactions occur with water quality and those interactions that do occur are generally limited in duration. Furthermore, many of the activities associated with this IPF are subject to a variety of State and Federal regulations that aim to minimize and mitigate impacts to water quality.

4.2.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.2.2-1 highlights the IPF categories associated with OCS oil- and gas-related activities that could potentially affect water quality in the GOM region. The pathways for these IPFs would be primarily the same as those identified for the non-OCS oil- and gas-related activities discussed in **Chapter 4.2.2.1** and would affect water quality by altering its physical and chemical characteristics.

The environmental fate of chemicals, nutrients, and other inputs depends on environmental factors, geochemical conditions, and various mechanisms that transport the constituents in the environment. Some natural transport mechanisms, such as advection by currents, dispersion, dissolution (dissolving), precipitation by chemical reaction, and adsorption (the adhesion of a chemical constituent onto the surface of a particle in the environment [e.g., clay]) reduce concentrations in water and redistribute constituents between the water and sediments. The following sections summarize the various types of effects that occur from routine OCS oil- and gas-related activities by IPF category. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

Air emissions and pollution from routine oil and gas operations may be a contributing factor to acidic deposition, acidification, and eutrophication in the Gulf of Mexico (Caldeira and Wickett 2003; Driscoll et al. 2003; Paerl et al. 2002; Vitousek et al. 1997; Wanninkhof et al. 2015). Routine oil and gas operations contribute to the emission of carbon dioxide (CO_2) and air pollution containing sulfur and nitrogen elements (e.g., sulfur dioxide [SO_2], nitrogen oxides [NO_x], and ammonia [NH_3]) into the atmosphere. Both CO_2 uptake and acidic deposition (wet + dry deposition) of sulfur and nitrogen can increase acidification in the GOM seawater by changing the pH value (Doney et al. 2007; Echeverria et al. 2020; Paerl et al. 2002; USEPA 2008; Wanninkhof et al. 2015). Also, acidic deposition can contribute to eutrophication (Glibert 2020; USEPA 2008). Additionally, CO_2 could indirectly change the temperature of the GOM seawater (refer to **Chapter 3.4**).

Discharges and Wastes (Chapter 2.2.1)

The Gulf Coast petrochemical industry (including offshore and onshore development, petroleum transport, and processing/refining of petroleum products) is the largest in the U.S. (U.S. Department of the Navy and NMFS 2010). The primary operational wastes and discharges generated during offshore oil and gas exploration and development are drilling fluids, drill cuttings, various waters (e.g., bilge, ballast, fire, and cooling), deck drainage, sanitary wastes, and domestic wastes. During production activities, additional waste streams include produced water, produced sand, and well-treatment, workover, and completion fluids. Produced water may contain inorganic and organic chemicals and radionuclides known as technologically enhanced naturally occurring radioactive materials (226Ra and 228Ra). The composition of the discharge can vary greatly in the amounts of organic, inorganic, and radioactive compounds.

In addition to those previously mentioned, other small discharges occur from numerous sources. These discharges may include desalination unit discharges, blowout preventer fluids, boiler blowdown discharges, excess cement slurry, several fluids used in subsea production, and uncontaminated freshwater and saltwater. Discharges are expected to be diluted and dispersed rapidly through mixing by currents.

Incidental vessel discharges are currently regulated by the USEPA and the Vessel Incidental Discharge Act, which establishes a new framework for the regulation of vessel incidental discharges under Section 312(p) of the CWA. On October 26, 2020, the USEPA, in coordination with the USCG, published for public comment a proposed rule under the Vessel Incidental Discharge Act (USEPA 2020l). The proposed rule would establish national standards of performance for marine pollution control devices for discharges incidental to the normal operation of primarily non-military and non-recreational vessels 79 ft (24 m) or greater in length into the waters of the United States or the waters of the contiguous zone. The specific discharge standards of performance would establish requirements for 20 separate discharges incidental to the normal operation of a vessel. These discharge-specific requirements are based on best available technology economically achievable, best conventional pollutant control technology, and best practicable technology currently available, including the use of best management practices, to prevent or reduce the discharge of pollutants into the waters of the United States or the waters of the contiguous zone. The proposed standards, once finalized and implemented through corresponding USCG regulations addressing implementation, compliance, and enforcement, would reduce the discharge of pollutants from vessels and streamline the current patchwork of Federal, State, and local vessel discharge requirements.

The discharge of any oil or oily mixtures is prohibited under the Water Pollution Control Act; however, discharges may occur in water farther than 12 nmi (14 mi; 22 km) from shore if the oil concentration is less than 15 ppm as outlined in 33 CFR § 151.10. Ballast water is not usually contaminated with oil; however, the same discharge criteria apply as for bilge water. All vessels with toilet facilities must have a marine sanitation device that complies with Section 312 of the CWA. The discharge of treated sanitary waste would still contribute small amounts of nutrients to the water. The volume of oceanic water and its circulation disperses, dilutes, and biodegrades anthropogenic contaminants. Compliance with applicable State-issued or Federal USCG regulations would be expected to prevent or minimize most impacts on receiving waters. The small amount of discharge associated with vessels into a large and dynamic waterbody may affect water quality locally and temporarily. BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report discusses the CWA and NPDES permitting in greater detail (BOEM 2020c).

Operational discharges from drilling exploration, development, and production wells, and from installing and operating production structures can potentially affect coastal and marine water quality. Operational discharges include drilling muds and fluids, cuttings, and produced water. Effects from drilling muds and cuttings associated with OCS oil- and gas-related activities are potentially significant if left unmitigated. 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.

Discharges can transport trace metals, hydrocarbons, and other suspended materials within several acres around the drilling location; however, they are regulated by the USEPA and would be released into the ocean only if NPDES permit requirements are met. Environmental effects of discharged muds and cuttings are often localized because of settling, mixing, and dilution. While the total volumes of drilling muds and cuttings discharged to the ocean during drilling operations are large, impacts to water quality are minimal since drilling operations are spaced over a few to several months. Periodic minor increases in turbidity, reflecting suspended particulate material concentrations in the upper water column during mud and cuttings discharges, also could affect water quality.

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 the USEPA's regulations for preventing unreasonable degradation of the receiving waters. BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report discusses the CWA and NPDES permitting in greater detail (BOEM 2020c). 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 2009).

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 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 milligram/kilogram mercury and 3.0 milligram/kilogram 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 potential toxic effects of water-based and synthetic-based fluid (SBF) drilling muds are discussed in **Chapter 2.2.1.1**. 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. A previous study of an SBF spill (Boland et al. 2004) 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 synthetic-based mud 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 cause minimal and brief bottom disturbance as discussed below.

Produced water may degrade water and sediment quality in the immediate vicinity of the discharge as it contains elevated concentrations of salts, petroleum hydrocarbons, metals, naturally occurring radioactive material (NORM), dissolved or suspended solids, produced solids, injected fluids, and additives – some of which are toxic and persist in the marine environment (DeLaune et al. 1999; Rabalais et al. 1998). Some hydrocarbon constituents are found above background levels in some fishes in the GOM, and routine discharges from oil and gas activities may play a role (Pulster et al. 2020).

Decommissioning may also release discharges that could affect water quality. Pipelines (which may be interpreted to include umbilicals and jumpers that service a subsea completion) decommissioned in place in accordance with 30 CFR § 250.1751. This includes flushing and filling with seawater unless BSEE's Regional Supervisor of Field Operations waives these requirements. The flushing that occurs during this process can potentially release contaminants into the environment. 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.

Bottom Disturbance (Chapter 2.3)

Bottom disturbances to the seafloor create turbidity and occur during anchoring and geological sampling, as well as 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). Pipeline installation is expected to cause local disturbance of the seafloor and cause sediments to become suspended in the near-bottom water column. Trenching for emplacement of pipelines disturbs an area of seafloor up to 2.5 ac (1.0 ha) per kilometer of pipeline (Cranswick 2001). Drilling disturbs the seafloor where the well infrastructure and borehole penetrate and where mud and drill cuttings are deposited. The highest cutting concentrations are usually in sediments within 328 ft (100 m) of the platform, but some cuttings may be found up to 1.2 mi (2 km) from the discharge point. Sediment displacement also occurs during the removal of pipelines and may increase as the existing pipeline infrastructure ages. Maintenance is required throughout the lifespan of OCS oil and gas infrastructure, which often uses submersibles and other equipment. These maintenance activities can result in disturbance of the seafloor.

Resuspended sediments may obstruct filter-feeding mechanisms and gills of fishes and sedentary invertebrates (refer to **Chapter 4.3.4**). These alterations of water quality are expected to be localized and active only during installation/removal activities. These bottom-disturbing activities impact water quality when sediments are resuspended, creating turbidity and resulting in a temporary changes to water and sediment chemistry. This includes a localized and temporal release of components such as metals or nutrients that were associated with the sediment.

Water quality impacts could occur during decommissioning activities from material dislodged from the piles during removal, and sediment resuspension and re-sedimentation during the removal of structures. Requirements for decommissioning are stated at 30 CFR § 250.1703. These activities include permanently plugging all wells, removing platforms and other facilities, decommissioning pipelines, and clearing the seafloor of all obstructions. The regulation at 30 CFR § 250.1750 allows pipelines 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. 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.

Coastal Land Use/Modification (Chapter 2.5)

The OCS oil- and gas-related activity may require construction of onshore infrastructure, such as ports and support facilities (repair and maintenance yards, crew services, and support sectors), construction facilities (platform fabrication yards, shipyards and shipbuilding yards, and pipecoating facilities and yards), transportation (pipelines and railroads), and processing facilities (natural gas processing, natural gas storage, LNG facilities, refineries, petrochemical plants, and waste management). Oil and gas activities such as tanker and barge transport, survey and support vessels, onshore support bases, and pipelines to shore and distribution points could impact coastal and estuarine habitats. Increased erosion from these activities could potentially cause an increase in turbidity.

Onshore support facilities could discharge into local wastewater treatment plants and waterways during routine operations and could consequently impact coastal water quality. Indirect impacts could also occur from non-point source runoff such as runoff from infrastructure that could contribute trace-metal pollutants and suspended sediments. Construction and modification of onshore structures will cause disturbances of the bottom and could release sediments, nutrients, and pollutants into nearshore waters. Activities associated with staging and construction of oil and gas structures would account for a moderate amount of shorter-term activity, while ongoing support activities would last throughout the lifecycle of development and production. Overall, coastal land use can indirectly affect water quality because it can result in increased erosion and sedimentation of coastal areas, as well as cause inputs of excess sediments, nutrients, and contaminants into the water, which were discussed in the “Discharges and Wastes” section above.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined noise, lighting and visual impacts, and socioeconomic changes/drivers are not likely to affect water quality because they do not directly interact with water. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Offshore habitat modifications/space use would not likely affect water quality because few interactions occur with water quality and those interactions that do occur are generally limited in duration. Further, BOEM-regulated oil and gas activities are subject to a variety of State and Federal regulations that aim to minimize and mitigate negative effects to water quality.

4.2.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.2.2-1 highlights the accidental events associated with oil and gas development on the OCS that could potentially affect water quality in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9)

Any oil and/or chemical spills are considered accidental and unauthorized events. Industry practices and government regulations minimize the risk of spills and ensure that industry and government entities would be prepared to respond should a spill occur. Despite these efforts, there is no way to guarantee that spills will not occur. The magnitude and severity of impacts from a spill on any resource would depend on the spill's location, size, depth, and duration. Other factors such as the chemical composition of the spill, meteorological conditions such as wind speed and direction, seasonal and environmental conditions, and the effectiveness of response activities will also affect the magnitude and severity of a spill. The aforementioned factors can have a substantial effect on weathering processes such as evaporation, emulsification, dispersion, dissolution, microbial degradation and oxidation, and transport of the spilled products. This will in turn determine how water quality will be impacted by a spill. Natural processes also can physically, chemically, and biologically contribute to the degradation of oil and other chemicals – all of which will have varying impacts on water quality.

Oil Spills

Oil spills have the greatest potential of all OCS oil- and gas-related activities to affect water quality. Oil spills, regardless of size and causal factor(s), may allow hydrocarbons to partition into the water column in a dissolved, emulsion, and/or particulate phase. Water quality can be impacted by the dissolution and dispersion of the petroleum constituents and other contaminants throughout the water column, including across the sea surface. A spill can also release natural gas and other components into the water column, which could reduce the dissolved oxygen levels due to microbial degradation (Kessler et al. 2011). Mitigation efforts for oil spills may include booming, burning, and the use of dispersants, which is discussed in the "Spill Response" section below.

As discussed in **Chapter 2.9**, BOEM analyzes the impacts from both small and large oil spills. Small spills (<1,000 bbl) are less likely 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. A large oil spill in coastal or marine waters could present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria. An additional concern in the GOM is that sunlight, specifically ultraviolet wavelengths, can dramatically increase the toxicity of spilled oil constituents to marine organisms (Alloy et al. 2016; Roberts et al. 2017). These effects could be significant depending on the duration of the release and the area impacted by the spill. A large oil spill at depth could introduce large quantities of oil into the water column, with chemically or mechanically dispersed and suspended oil droplets potentially creating a plume at depth (Driskell and Payne 2018). It could also cause large patches of sheen or oil on the sea surface. Additionally, temperature and oceanographic conditions can have a significant effect on weathering processes such as evaporation, emulsification, oxidation, and the transport of the spilled products. The level of impact would depend on the location, timing, and magnitude of the event, as well as the effectiveness of containment and cleanup activities. Refer to the *Catastrophic Spill Event Analysis* technical report (BOEM 2021d) for an assessment of potential impacts resulting from a catastrophic spill similar in nature to the *Deepwater Horizon* explosion and oil spill.

Drilling Fluid Spills

Chemical and synthetic-based drilling fluids are used in offshore oil and gas drilling and production activities, and may be accidentally spilled into the environment due to equipment failure, weather (i.e., wind, waves, and lightning), collisions, and human error. The WBF and SBF spills may result in elevated turbidity, which would likely 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. As discussed in **Chapter 2.9.1.2**, SBF has low toxicity, and the discharge of SBF is allowed to the extent that it adheres onto drill cuttings. The 2017 USEPA Region 4 and Region 6 NPDES permits allow for the discharge of cuttings wetted with SBF as long as the retained SBF amount is below a prescribed percentage, meets biodegradation and toxicity requirements, and is not contaminated with formation oil or PAHs. A spill of SBF may cause a temporary increase in biological oxygen demand and locally result in lowered dissolved oxygen in the water column. A spill of SBF could produce an oil sheen if formation oil is present in the fluid. Historically in the GOM, spills of SBF have typically not required mitigation because SBF sinks in water and seafloor cleanup is technically difficult, coupled with SBF having low toxicity and being naturally biodegradable.

Chemical and Waste Spills

Chemical spills are generally smaller in volume than spills of oil and drilling fluids. The effects are usually temporary and localized, primarily resulting from changing pH. From 2007 to 2014, small chemical spills occurred at an average annual volume of 15.9 bbl, while large chemical spills occurred at an average annual volume of 231.9 bbl (**Chapter 2.9.1.2**). These chemical spills normally dissolve in water and dissipate quickly through dilution, with minimal expected impacts to water quality.

Trash and Debris

Common marine debris from OCS oil- and gas-related facilities and vessels may include gloves, various plastics (from packaging, etc.), light bulbs and tubes, oil and gas containers, pipe-thread protectors, rope, and floats and buoys. Although plastics are resistant to degradation, they do gradually break down into smaller particles due to sunlight (photolysis) and mechanical wear (Law et al. 2010). Law et al. (2010) noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. Marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates (PHA), a bacterial carbon and energy source (Ong et al. 2017). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al. 2008).

The discharge of trash and debris is prohibited into the sea or navigable waters of the United States under the Water Pollution Control Act, unless processed by a comminutor and able to pass through a 25-mm (1-in) mesh screen. All other trash and debris must be returned to shore for proper disposal. Because the discharge of trash is prohibited, BOEM concludes that the environmental effects likely to occur as a result of trash and debris would be negligible. The BSEE has a marine trash and debris program (30 CFR § 250.300) that would also help control discharges of debris and trash.

Response Activities (Chapter 2.9.2)

Associated spill response and cleanup activities also could affect resource areas. Particularly, water quality could be impacted by response activities. This includes vessel discharges associated with deploying, operating, and retrieving skimmers and boom; *in-situ* burning to remove oil from the water surface; and the use of chemical dispersants applied both on the surface or injected near the release point during a subsurface release. 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. Burning and the use of dispersants would likely put additional hydrocarbons into the dissolved phase, impacting water quality. As these dissolved hydrocarbons extend down into the water column, additional exposure pathways via ingestion and gill respiration are possible, which may result in acute or chronic effects to other marine life.

Accidental OCS Oil- and Gas-Related Events Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the accidental OCS oil- and gas-related events described in **Chapter 2** and determined that vessel strikes and collisions are not likely to affect water quality and, therefore, would not likely be analyzed in detail in future NEPA analyses. Collisions between vessels, platforms, and/or helicopters can result in explosions, fires, and/or the release of fuel, oil, natural gas, or chemicals. The effects on water quality would depend on the type and amount of fuel or chemical composition of the product(s) released from a collision, which were evaluated as part of **Chapter 2.9.1**. Any fire occuring as a result of a collision would likely release CO_2, NO_x, PM, and possibly SO_2 into the atmosphere, some of which could be absorbed into the water column. Vessel collisions would not likely affect water quality, as the occurrence of vessel collisions in OCS waters is extremely low. Unintended releases from collisions are considered in the "Unintended Releases into the Environment" section above, and any other indirect pollutants released would likely occur in such low quantities that water quality would not be expected to be significantly affected. Therefore, strikes and collisions would not likely be analyzed in detail in future NEPA analyses outside of its potential to be a causal factor considered in **Chapter 2.9.1** and in the "Unintended Releases into the Environment" section above.

4.3 BIOLOGICAL RESOURCES AND HABITATS

This chapter provides a characterization of the habitats and biological resources of the GOM and an evaluation of the potential effects to these resources from the IPFs described in **Chapter 2**. The GOM in its entirety, including coastal zones, is identified as a large marine ecosystem under the jurisdiction of three countries, i.e., the United States (2/3 control), Mexico (1/3 control), and Cuba (marginal control). The biological components of the GOM's large marine ecosystem within U.S. jurisdiction are discussed in this chapter. These components are described within the context of three habitat regimes, i.e., coastal, pelagic, and benthic, as well as within the context of organism or community type, including fish and invertebrates, marine mammals, sea turtles, and birds. Organisms that do not fall into one of these categories are discussed in context of their relevant habitat(s). Most animal or plant types are discussed at a general level; however, specific species or groups are mentioned where relevant, such as those with protected status or that are commercially important. In these instances, common names are generally used. Appendix B of BOEM's Biological Environmental Background Report provides a list of common and scientific (or Latin) names of each species mentioned in this chapter (BOEM 2021b).

4.3.0 Definition of Effect for Biological Resources

An effect (positive or negative) on a biological resource (i.e., coastal, pelagic, and benthic communities and habitats; fish and invertebrates; birds; marine mammals; and sea turtles) is defined as the reasonable, scientifically supportable *potential* for an IPF to cause effects. Effects do not necessarily indicate past, present or future impacts.

For coastal, pelagic, and benthic communities and habitats, IPF categories with a reasonable, scientifically supportable *potential* for small and/or temporary positive or negative effects were shaded with either green (positive) or blue (negative) hashing in the pie figures in **Chapter 4.3**. The IPF categories with a reasonable, scientifically supportable *potential* to have long-term consequences to the habitat function or use by biota were shaded with either solid green (positive) or solid blue (negative) in the pie figures in **Chapter 4.3** and would likely be scoped from detailed analysis in future NEPA analyses for proposed GOM lease sales. The IPF categories not expected to result in observable effects to the habitats' function or associated biota were identified as "No Effects" in the pie figures and associated analyses in **Chapter 4.3** and, therefore, would likely be scoped from future NEPA analyses for proposed GOM lease sales.

For organismal biological resources (i.e., fish and invertebrates, birds, marine mammals, and sea turtles), the IPF categories with a reasonable, scientifically supportable *potential* to have effects at the population-level were identified as either “Potential for Negative Population-Level Effects” or “Potential for Positive Population-Level Effects” in the pie figures and associated analyses. The IPF categories with a reasonable, scientifically supportable *potential* to have consequences to individuals or small groups but would not have effects on the entire population were identified as either “Potential for Negative Effects to Individuals or Groups” or “Potential for Positive Effects to Individuals or Groups” in the pie figures and associated analyses in **Chapter 4.3** and would likely be scoped from detailed future NEPA analyses for proposed GOM lease sales. The IPF categories not expected to result in observable effects to the resource were identified as “No Effects” in the pie figures and associated analyses in **Chapter 4.3** and, therefore, would likely be scoped from detailed future NEPA analyses for proposed GOM lease sales.

Effects on a resource may exist even though lease stipulations, NTLs, and other guidance from BOEM may mitigate the effect the IPF has on the resource, which are discussed in this document. Identification of a *potential* for effects to a resource by an IPF does not indicate the impact determination for any subsequent NEPA analyses (e.g., negligible, minor, moderate, major) but rather provides an initial screening of what effects should be considered more closely in a subsequent NEPA analysis and which effects could likely be screened from future NEPA analyses.

The biological resources of coastal, pelagic, and benthic habitat and communities; fish and invertebrates; birds; marine mammals; and sea turtles are not affected by the socioeconomic changes and drivers IPF. This IPF category covers the extent to which activities (oil- and gas-related and cumulative factors) produce socioeconomic changes. Because these biological resources describe non-human organisms and habitats, this IPF does not apply. Without doubt, socioeconomic changes and drivers may indirectly have impacts on organisms and habitats. For example, the cost of oil may drive higher rates of exploration and production activities on the OCS, which in turn may cause more and higher rates of impacts to these biological resources. However, these cause and effect relationships are captured by the other IPF categories described in **Chapter 2**. The socioeconomic changes and drivers IPF is limited to potential effects on human elements of our society, including communities, governments, industries, and individuals.

4.3.1 Coastal Communities and Habitats

4.3.1.1 Resource Description

The GOM region comprises 1,630 mi (2,623 km) of coastline, spanning from the southern tip of Texas east to the Florida Keys (USEPA 2004); **Figure 4.3.1-1**). This coastline comprises more than 750 bays, estuaries, and sub-estuary systems (USEPA 2012a). Coastal habitats in the U.S. portion of the GOM include marshes (salt, brackish, and fresh), forested wetlands, estuaries, beaches, and dunes. Saltwater marshes, saltwater mangrove swamps, and nonvegetated areas (e.g., sand bars, mudflats, and shoals) are the most common GOM coastal habitats (Dahl and Stedman 2013). The primary physical oceanography factors that influence coastal environments are temperature, salinity, dissolved oxygen, chlorophyll content, nutrients, potential of hydrogen (pH), oxidation reduction potential, pathogens, transparency (i.e., water clarity, turbidity, and suspended matter), and contaminant concentrations (e.g., heavy metals, hydrocarbons, and other organic compounds). Refer to Chapter 3.2 of BOEM's Biological Environmental Background Report for a more detailed description of the GOM's coastal communities and habitats (BOEM 2021b).

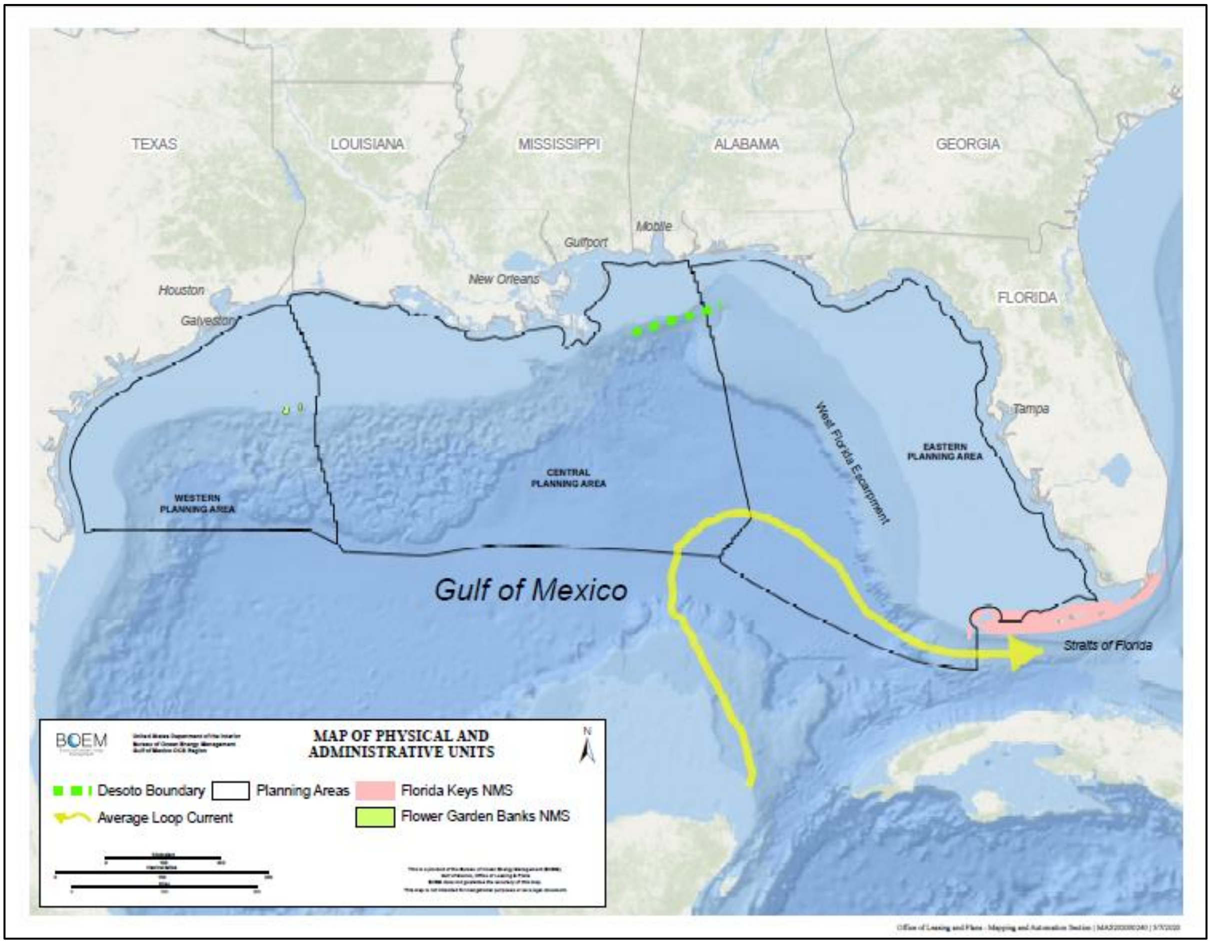


Figure 4.3.1-1. Physical and Administrative Boundaries in the U.S. Portion of the Gulf of Mexico.

These coastal and estuarine habitats provide critical nursery grounds and adult habitat for numerous species of birds, fish, and invertebrates, while seagrass beds provide foraging habitat for sea turtles and manatees. Most of the GOM coastal waters are designated as essential fish habitat (EFH; refer to **Chapter 4.3.4**). The coastal GOM waters are enriched by organic material exported from the estuaries and rivers that empty into the GOM and support high fish biomass. Many of the fishes and invertebrates found in mid- or near-shelf waters are dependent upon or opportunistically make use of estuaries at some point in their life cycle. For example, estuaries provide nursery habitat for Gulf menhaden, spotted sea trout, blue crab, brown shrimp, and gag. The eastern oyster is an example of a species that both benefits from the environmental conditions in estuarine habitat and serves as an important substrate. Critical habitat for the ESA-listed smalltooth sawfish occurs in the nearshore waters of the EPA. The ESA-listed Gulf sturgeon has designated critical habitat in select rivers and coasts of Louisiana, Mississippi, Alabama, and Florida. The coastal communities and habitats of the U.S. portion of the GOM provide key foraging, nesting, and resting areas for more than 400 species of birds (FWS 2013).

Wetlands occur along the coastal GOM areas, with the highest density occurring in Louisiana and southern Florida (Dahl and Stedman 2013). Coastal Louisiana contains about 37 percent of the estuarine herbaceous marshes in the conterminous U.S. and supports the largest commercial fishery in the lower 48 States. Coastal wetlands are complex systems characterized by high productivity that provide many essential functions. Wetland corridors provide habitat for a large and diverse group of resident plants, invertebrates, fishes, reptiles, birds, and mammals. Marsh environments are particularly vital nursery grounds for many economically important fish and shellfish juveniles. As "living filters," wetlands improve water quality by removing pollutants and nutrients, as well as trapping sediments. Furthermore, coastal wetlands provide direct human value by minimizing upland erosion, providing defense against storm surges and buffering against sea-level rise, thereby protecting property and infrastructure. Wetlands also support the tourism, hunting, and fishing sectors of the economy.

Mangrove swamp habitat, a type of coastal wetland, can be found from Texas to Florida along the U.S. portion of the GOM. Mangrove swamps are named after the dominant vegetation, the salt-tolerant mangrove tree. In the conterminous U.S., only three species of mangrove exist: red, black, and white mangroves. Mangroves provide habitat for a diversity of animals, including fish, oysters, shrimp, and other invertebrates, which subsequently support wading birds, pelicans, and the ESA-listed American crocodile. Mangroves serve as storm buffers and stabilize shorelines by functioning as wind breaks and through prop root baffling of wave action. Mangroves trap fine substrates and reduce turbidity by filtering upland runoff and trapping waterborne sediments and debris.

Submerged aquatic vegetation (SAV) is a vital component of coastal aquatic ecosystems, with at least 26 species of SAV growing in the U.S. portion of the GOM (Carter et al. 2011; Heck et al. 2011). Distribution and composition of the species present depend on an interrelationship among several environmental factors, including water temperature, depth, turbidity, salinity, turbulence, and substrate suitability (Kemp 1989; Onuf 1996; Short et al. 2001; 2007; 2015). The SAV provides several vital ecological functions, including foraging material for grazers such as nekton and waterfowl (**Chapter 4.3.2**), habitat for marine life, and essential nursery grounds for numerous commercially important fish and invertebrate species (**Chapter 4.3.4**). The SAV habitats are important in carbon sequestration, nutrient cycling, and sediment stabilization (Duarte et al. 2004; Frankovich et al. 2011; Heck Jr. et al. 2003; Orth et al. 2006). An estimated 500,000 ha (1.25 million ac) of SAV beds 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). Elevated nutrient concentrations, declining water quality, and sedimentation from natural and anthropogenic events are common and are a significant cause of seagrass declines worldwide (Carlson Jr. and Madley 2007; Orth et al. 2006; Waycott et al. 2009).

Barrier islands are present along more than half of the U.S. Gulf of Mexico coastline (BOEM 2015) and protect the mainland from shoreline erosion by reducing wave action (Morton 2003). Barrier islands serve as critical stopover areas for numerous migrating birds as well as important habitat for birds (**Chapter 4.3.5**). Barrier islands additionally provide habitat for sand-dwelling crustaceans (e.g., mole crabs, ghost shrimp, and clams) and burrowing small mammals (e.g., beach mice and rabbits) (Britton and Morton 1989). Beaches in the GOM also provide important nesting habitat for several species of sea turtles (**Chapter 4.3.7**), including Kemp's ridley, loggerhead, green, leatherback, and hawksbill (Valverde and Holzwart 2017). 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). The following four subspecies of beach mouse occupy restricted habitats in the mature coastal dunes: the Alabama beach mouse; the Perdido Key beach mouse; the Choctawhatchee beach mouse; and the St. Andrew beach mouse. Critical habitat for the four subspecies of beach mouse extend from Baldwin County, Alabama, to Gulf County, Florida. Habitat loss due to beachfront development and predation have the greatest impacts to beach mice.

The GOM shallow-water coral reefs occupy roughly 1,019 mi^2 (2,640 km^2) of the entire GOM (<0.2% of the area), with the largest distribution along the Florida coast, (Tunnell Jr. et al. 2007). Coral reefs provide key ecosystem functions, including coastal protection from storms and erosion, habitat, and spawning and nursery grounds for numerous fishes, as well as human ecosystem functions like tourism, fishing, and recreation, and even a source of new medicines. The ESA-protected corals in the GOM include elkhorn, staghorn, and boulder corals and the lobed and mountainous star corals. Critical habitat was designated for the elkhorn and staghorn coral species by NMFS in 2008 and includes four counties in Florida (i.e., Palm Beach, Broward, Miami-Dade, and Monroe Counties) (DOC and NOAA 2006).

Programmatic Concerns Influencing Coastal Communities and Habitats

Eutrophication and Hypoxia

Eutrophication can trigger harmful algal blooms, which can cause neurotoxic shellfish poisoning and respiratory problems in humans and other mammals (e.g., annual red tide events along the Mississippi River outlet). These blooms have occurred since the 19^{th} century and have increased in frequency and spread geographically (Van Dolah 2000). Harmful algal blooms may reduce SAV fitness and even cause mortality through light attenuation and decreased oxygen concentrations (Hauxwell et al. 2003). Increased turbidity and decreased light penetration from algal blooms may affect other benthic organisms such as corals (McManus and Polsenberg 2004).

Land Loss and Sea-Level Rise

Coastal land loss across the GOM Coast States is expected to continue over the next several decades. Coastal and estuarine habitats would likely continue to decline, particularly in Louisiana, due to high rates of relative sea-level rise and local subsidence. Erosion of shorelines, intensification of storms, and coastal flooding due to climate change are likely to continue to affect coastal communities in the GOM (refer to **Chapter 3.4**). Loss of wetland habitat would reduce the ability of these habitats to mitigate climate change impacts and absorb atmospheric carbon (Nahlik and Fennessy 2016). Any stressors that lead to the degradation or loss of key habitat areas for estuarine fish, shellfish, and birds would likely put additional stress on these species.

Natural and anthropogenic stressors have contributed to a long-term trend of wetland loss in the coastal GOM, and wetlands are converting to open water at staggering rates in this region (refer to **Chapter 2.1.2.5**). The GOM coastal region represents 99 percent of all intertidal, coastal wetland losses across the three coastal regions of the conterminous United States. These losses are attributed to the effects of severe coastal storms, natural and induced land subsidence, sea-level rise, the creation of canals and channels for oil and gas and other industries, and the construction of levees and other water management measures along the Mississippi River (refer to **Chapter 2.5.2**). In concert, these factors result in the conversion of marshland to open water at staggering rates. In some areas of the GOM, artificial hydrologic modifications and coastal development impede the ability of wetlands to migrate inland. This "coastal squeeze" (Doody 2004) contributes to an overall loss of intertidal coastal habitat in the region. Wetland loss across the Gulf Coast States is expected to continue (refer to **Chapter 2.5.2.2**). Coastal and estuarine habitat acreage would likely continue to decline, particularly in Louisiana, due to global sea-level rise and subsidence. Also, offshore hypoxia has persisted for years (varying in intensity and size) and is expected to remain for decades to come, with varying effects on the coastal ecosystem. The shoreline surrounding the Mississippi River Delta is also expected to continue to erode as agricultural, residential, and commercial development persists (Boesch et al. 1994; Day et al. 2000; 2001). Erosion of shorelines, storm intensification, and coastal flooding due to climate change may continue to affect coastal wetlands in the GOM. Any stressors that lead to the degradation or loss of key habitat areas for estuarine fish, shellfish, and birds would likely put additional stress on these species.

Major Storm Events

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, making these habitats more vulnerable to future hurricanes and wind-driven tidal or storm events. These stressors cause habitat loss for organisms such as beach mice, nesting sea turtles, and coastal birds. Refer to **Chapter 3.3** for more information on major storms and their potential to effect coastal habitats or further exacerbate other stressors.

All five ESA-listed shallow-water GOM corals are threatened by ocean warming, ocean acidification, unsustainable fisheries, and pollution (NMFS 2020c; 2020e; 2020h; 2020i; 2020l), as well as habitat destruction, turbidity, and sedimentation (Jones et al. 2015; Schutte et al. 2010).

Ocean Acidification

Approximately one-third of anthropogenic carbon dioxide air emissions are absorbed by the world's oceans, which causes ocean acidification (as reviewed in Doney et al. 2009). As atmospheric carbon dioxide concentrations rise, it is expected that the concentrations of carbon dioxide in ocean water would also increase, leading to lower pH values. This change in ocean chemistry has been shown to affect biological and ecological functions of marine calcifiers (Gattuso et al. 1998), compromise larval development (Kurihara 2008), and impair predator-prey interactions (Kroeker et al. 2014). Atmospheric deposition of nitrogen and sulfur compounds (e.g., nitrogen and sulfur oxides, and ammonia) can also lower the pH at the surface of ocean water, especially along the coast Doney et al. [2007]; refer to **Chapter 2.1**). Compared to other regions, the pH of the coastal GOM waters has not yet decreased significantly; it is expected that the GOM would not experience acidified coastal waters until after 2099 (Ekstrom et al. 2015). However, the eastern oyster is vulnerable to changes in pH (Beniash et al. 2010; Boulais et al. 2017; Tomanek et al. 2011). Hypoxia and riverine input, both major factors in the coastal waters of the GOM, exacerbate local ocean acidification (Ekstrom et al. 2015; Melzner et al. 2013) and may contribute to lower pH values in the GOM in the near future.

Invasive Species

Marine shipping has driven the spread of invasive species across the world's oceans, estuaries, and freshwater systems (Ruiz et al. 1997). Organisms may be introduced via a ship's ballast water exchange. In the last centuries, the rate of invasion has risen steadily despite increased awareness of this issue (International Maritime Organization 2017; Ruiz et al. 1997). As the volume of seaborne trade continues to increase, the risk of the introduction of invasive species also increases. Invasive species can cause enormous damage to biodiversity and disrupt ecosystems. The International Convention for the Control and Management of Ships' Ballast Water and Sediments, entered into force in September 2017, may slow the rate of introduction via ballast.

Other methods of introducing non-native species includes aquarium, pet, and fur trades; horticulture; aquaculture; agriculture; and recreation. The nutria, native to South America, was introduced to the Gulf Coast in the 1940s via the fur trade and now occurs in all five Gulf Coast States. These rodents graze on wetland vegetation and exacerbate ongoing erosion, land loss, and saltwater intrusion.

Marine Trash and Debris

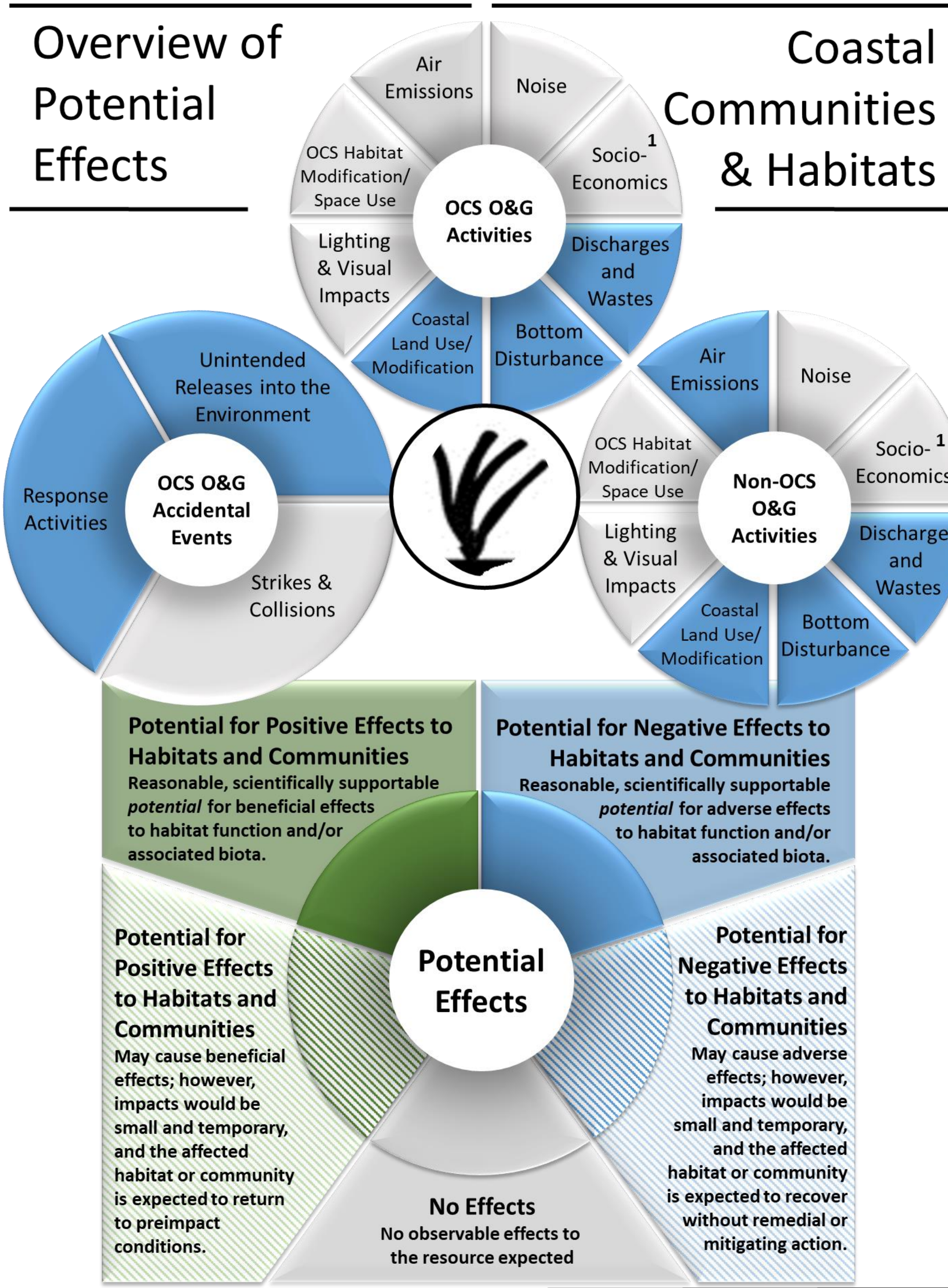
As discussed in **Chapter 3.5**, plastic debris and microplastics are by far the main components of marine litter, forming sometimes up to 95 percent of the waste that accumulates on shorelines, the sea surface, and the seafloor (Galgani et al. 2015). Common land-based sources are beachgoers, storm-water runoff, landfills, solid waste, rivers, floating structures, and ill-maintained garbage bins. To compound this problem, there is population influx along the coastal shorelines in or near the coastal communities and habitats discussed above. Common offshore sources include, but are not limited to, commercial and recreational fishing, shipping, military operations, and OCS oil- and gas-related activities. These factors, combined with the growing demand for manufactured and packaged goods, has led to increases in nonbiodegradable solid wastes in waterways. Some trash items, such as glass, pieces of steel, and drums with chemical or chemical residues, can pose a health threat to coastal habitats, particularly in highly populated areas.

4.3.1.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and coastal communities and habitats. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.1-2**. No IPF categories were identified to potentially have observable positive effects to coastal communities and habitats.

Figure 4.3.1-2 is intended to highlight the relevant IPF categories and potential effects that are analyzed in this chapter, as well as highlight the IPFs that are not likely to cause effects to coastal communities and habitats and, therefore, would not likely warrant further analysis in a NEPA analysis for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors including, but not limited to, location, frequency, and duration of the activities and resource; and the condition of the resource; as well as habitat type and feature-specific characteristics (e.g., associated communities). BOEM will use this preliminary identification and disclosure of the potential range of effects to coastal communities and habitats, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development in the Gulf of Mexico OCS. While this document does not make impact determinations, future NEPA analyses will include such determinations.



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.1-2. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Coastal Communities and Habitats. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.3.1.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.1-2 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect coastal communities and habitats in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Coastal habitats and communities may be affected by air emissions and pollution from fossil fuel combustion and agriculture. As discussed in **Chapter 2.1**, these anthropogenic activities release large amounts of nitrogen, sulfur, and carbon into the atmosphere. In the form of nitrogen, sulfur, and carbon oxides and ammonia, these chemicals can disrupt the chemistry of coastal soils and surface waters, leading to acidification and reduced pH. Coastal ocean acidification can affect coastal communities (e.g., oysters, corals, and zooplankton). In addition to altering local pH, atmospheric deposition of sulfur and nitrogen oxides enhance nutrient loads in coastal ecosystems, causing eutrophication and potentially leading to algae blooms (Paerl 1997). Atmospheric nitrogen deposition may account for up to 40 percent of new nitrogen inputs in coastal systems (Paerl et al. 2002). These impacts may be compounded by nutrient pollution (refer to the "Discharges and Wastes" section below).

Elevated concentrations of carbon dioxide in the atmosphere, including from anthropogenic sources, may act as a fertilizer and stimulate plant production, although the response is variable and influenced by local environmental factors. In coastal vegetation, increased carbon dioxide may enhance growth in C_3 type coastal vegetation (e.g., mangroves, brackish, and freshwater wetlands) by stimulating higher rates of photosynthesis as reviewed in (Kirwan and Megonigal 2013). In C_4 type dominated wetlands (e.g., *Spartina,* a dominant saltmarsh grass in the Gulf of Mexico), however, higher concentrations of carbon dioxide have little effect because their photosynthetic pathway already naturally concentrates CO_2. These findings are largely based on laboratory and microcosm experiments and it is difficult to predict long-term consequences of elevated carbon dioxide concentrations on coastal vegetation, especially given the complex interactions with accompanying consequences of elevated carbon dioxide, namely rising temperatures and sea levels.

Discharges and Wastes (Chapter 2.2.2)

Pollution in coastal and estuarine habitats is introduced directly or indirectly through runoff and riverine inputs. The Mississippi River has an enormous watershed of 1,245,000 mi^2 (3,220,000 km^2), totaling 41 percent of the conterminous United States. As it makes its way to the Gulf of Mexico, water pollutants from agricultural and urban runoff, as well as discrete point sources (e.g. industrial sites or sewage plants), enter the Mississippi River. These pollutants include toxins that directly harm the organisms that ingest them and can also have impacts up the food chain through biomagnification, the process in which chemicals are passed to higher trophic levels through predation. Therefore, although filter-feeding benthic organisms may be the first to encounter toxic chemicals, these compounds can also contaminate other coastal organisms such as predatory fish, sea turtles, marine mammals, and seabirds (Fry and Chumchal 2012; Mason and Porter 2009). Degraded water quality can negatively affect vegetation in wetlands and seagrass beds, which could lead to increased shoreline erosion and loss of habitat. Aside from toxic chemicals, excess nutrients in the water can have large-scale ecological consequences on the coastal and estuarine habitats of the GOM. In the Mississippi-Atchafalaya basin, high organic and nutrient loads cause eutrophication, which in turn leads to low-oxygen (hypoxic) conditions that kill or displace many species and lead to “dead zones” (Bianchi et al. 2010; Rabalais et al. 2002b). Coastal hypoxia has persisted for years in the GOM (with variations in intensity and size) and is expected to remain for decades to come, with varying effects on the coastal ecosystem (refer to **Chapters 3.3 and 4.3.1.1**).

Accidental oil spills from State oil and gas activity could have similar effects to coastal and estuarine habitats as those described in **Chapter 4.3.1.2.3** for spills as a result of OCS oil- and gas-related activities. **Chapter 2.2.2.10** discusses oil spills from non-OCS oil- and gas-related activities.

Bottom Disturbance (Chapter 2.3.2)

Dredging of coastal waterways and ports must continue to support more ship traffic and increasingly larger vessels (Merk 2015). Dredging may lead to increased erosion rates, removal of sediments, increased turbidity, land loss, and changes in salinity (Boesch et al. 1994; Onuf 1996; Wilber and Clarke 2001).

Past, current, and future State oil and gas activities in the GOM may continue to put pressure on coastal habitats and their associated fauna and flora into the future. These State energy activities would cause impacts to coastal and estuarine habitats similar to those outlined below for routine OCS oil- and gas-related activities (refer to **Chapter 4.3.1.2.2**). For example, pipeline installation for State energy production can disturb and/or destroy coastal communities and habitats.

Coastal Land Use/Modification (Chapter 2.5.2)

In all planning areas, coastal habitats are currently facing challenges due to the high human population density and presence of large ports along the coast. This area’s shoreline is also expected to continue to erode, as agricultural, residential, and commercial development persists (Boesch et al. 1994; Day et al. 2000; 2001).

The construction of residences, industrial centers, ports, and other infrastructure is expected to continue in the coming decades to match steadily increasing population growth on the coasts (Kildow et al. 2016; Sengupta et al. 2018). To support coastal residents and tourists, the construction of additional hotels, resorts, marinas, docks, seawalls, bridges, and roads is also expected to continue in the coming years (Kildow et al. 2016; Sengupta et al. 2018). Coastal construction can degrade or destroy coastal habitats and put species at risk (Huettmann and Czech 2006; Morrison et al. 2006). Direct habitat loss is particularly problematic for buffer species such as mangroves, which naturally protect the shoreline from storm damage and filter sediments from coastal runoff (Burge et al. 2014;

Marshall et al. 2011). Removing shoreline vegetation and replacing it with man-made structures (e.g., seawalls) exacerbates the risk of storm impacts on coastal communities and habitats.

Any onshore activities that alter the hydrology or change the estuarine flow can lead to saltwater intrusion, which can destroy freshwater marshes. The creation of canals or widening of existing canals, channels, and rivers destroys coastal and estuarine habitat and fragments available habitat for the organisms that depend upon them. Removal or degradation of fish nursery habitats can have cascading impacts on not just coastal ecosystems but on pelagic and benthic ecosystems as well (Parrish 1989; Serafy et al. 2015). Vessel traffic is expected to increase in the coming decades, which would contribute to erosion and land loss in coastal communities and habitats.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined that noise, lighting and visual impacts, socioeconomic changes and drivers (refer to **Chapter 4.0**), and offshore habitat modification/space use are not likely to affect coastal and estuarine habitats. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Artificial light sources on the Gulf Coast are prevalent and cumulatively impact the wildlife in coastal and marine habitats. Lighting from man-made infrastructure (e.g., street lights, hotel lights) near beaches with sea turtle nesting can disturb nesting females, disorient young hatchlings, and increase predation (Silva et al. 2017). In some areas, coastal lighting disorients birds and may cause them to collide with man-made structures or divert them from migration routes. Refer to **Chapter 4.3.7** (Sea Turtles) and **Chapter 4.3.5** (Birds) for more information on these effects.

Effects related to the physical alteration of these habitats were addressed in the coastal land use/modification section, and the effects related to the aesthetic and visual characteristics of these habitats are discussed further in **Chapter 4.4** (Social Factors). Therefore, this IPF category was not discussed in further detail in this chapter.

Noise is not expected to substantially impact coastal and estuarine habitats, largely because of the physics of sound propagation in shallow waters. In coastal areas, noise from onshore construction, pipeline trenching, or vessel traffic could occur, however, given that low-frequency sounds do not propagate well through shallow water (the “low-frequency” [Urick 1983]) and that invertebrates and most fish are primarily sensitive to particle motion, these effects would be highly localized. Effects to coastal and estuarine habitats are not expected from offshore habitat modification/space use because these activities do not overlap spatially with coastal communities and habitats. For a description of the potential cumulative effects from onshore habitat modification, refer to coastal land use/modification and **Chapter 4.3.1.1**.

4.3.1.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.1-2 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect coastal communities and habitats in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.1)

Most operational discharges, such as produced sands, oil-based or synthetic-based drilling muds and cuttings, along with fluids from well treatment, workover, and completion activities, occur offshore. These waste streams are either transported to shore or diluted and discharged during operations offshore in accordance with applicable NPDES permit requirements (refer to **Chapter 5.11**). In most cases, produced-water discharges from OCS wells are too distant to pose a threat to coastal and estuarine habitats. 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 vegetation and pollute soils. This would lead to habitat degradation and destruction.

All vessels in U.S. and international waters are required to adhere to the International Maritime Organization's regulations under the International Convention for the Prevention of Pollution from Ships (MARPOL) limiting discharges, avoiding release of oily water, and prohibiting disposal of solid wastes. Therefore, discharges from vessels are not expected to have measurable effects on coastal communities and habitats.

Ballast water often carries biological materials, including plants, animals, and microorganisms. The discharge of ballast water in coastal and estuarine habitats is the single largest source of introduced species. Federal laws and regulations exist to minimize the risk of introducing species through ballast water, including the National Invasive Species Act.

Bottom Disturbance (Chapter 2.3.1)

Pipelines

Many existing OCS pipelines make landfall on barrier island and wetland shorelines. Approximately 4,971 mi (8,000 km) of OCS oil- and gas-related pipelines cross marsh and upland habitat in Louisiana (Johnston et al. 2009). 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 kilometer of pipeline for the 1955-1978 time period (Baumann and Turner 1990). Baumann 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.

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 post-construction 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 protective of sensitive habitats, such as estuarine systems, beaches, and wetlands. 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. Currently, no new construction of flotation canals (the most harmful construction technique) is being allowed in vegetated areas (Johnston et al. 2009).

Typically, the installation of new pipelines that make landfall is rare. When pipelines do make landfall, there are mitigating measures from the present regulatory programs of Federal or State agencies that may be applied, including compensatory mitigation. Modern pipeline installation techniques are less destructive for wetlands than previous methods. Because of the regulations and new construction methods, and the limited projection for new pipeline landfalls, the damages of pipeline landfalls to coastal communities and habitats are minimized. The addition of new pipelines to distribution points could further stress coastal and estuarine habitats along the GOM, leading to erosion and loss. Installation of pipelines in or near wetland habitats could lead to the hydrologic alteration, disturbance, fragmentation, and loss of wetlands (Ko and Day 2004). Most impacts would be long term and could affect the biological communities, such as coastal bird species, that rely on these habitats for nesting and feeding. These vulnerabilities may be higher in the EPA, where existing infrastructure and pipelines are limited. Coastal land loss is already an issue of immense concern along the Gulf Coast, and pipeline installation could worsen this loss.

Dredging

Maintenance dredging of navigation channels and canals is routinely conducted, in part, to support OCS activities. Occasionally a channel could be dredged ahead of its normal maintenance schedule in order to accommodate the transport of large OCS platforms or other structures or vessels. Dredging on the OCS for beach nourishment is a BOEM-regulated activity. Dredging for sand and other marine minerals generally occurs at depths of 10-30 m (33-98 ft).

Beneficial use of dredged material can be used to enhance and create coastal wetlands after material has been tested for the presence of contaminants. As discussed in **Chapter 2.5.2.4**, the USACE's New Orleans District dredges an average of 78 million cubic yards of material annually during maintenance dredging of Federal navigation channels, with approximately 38 percent of that average used for beneficial use in the dredged materials program (USACE 2013). The USACE reported that, over the last 20 years, approximately 12,545 ha (31,000 ac) of wetlands were created with dredged materials, most of which are located on the Louisiana Coastal Area delta plain (USACE 2013). As a result of the tremendous wetland land loss in the Louisiana coastal region, the beneficial use of dredged material is expected to increase. Executive Order 11990 (*The White House 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 USACE'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 can also be detrimental to coastal and estuarine habitats and associated fish and wildlife that use them for nursery grounds and protection. These vulnerabilities may include increased erosion rates, removal of sediments, increased turbidity, land loss, and changes in salinity (Boesch et al. 1994; Onuf 1996; Wilber and Clarke 2001). The combined impacts of increased turbidity, physical removal, and burial from dredging activities would disturb and destroy seagrass beds (Erftemeijer and Lewis III 2006; Kenworthy and Fonseca 1996), such as those in the EPA. Many of these impacts are reduced through the use of modern dredging and disposal practices.

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land disturbance can impact coastal communities and habitats through the construction and operation of coastal infrastructure (i.e., construction facilities, support facilities, oil and gas transportation, and processing facilities), vessel traffic, navigation canals, and interactions. Coastal land disturbance could permanently alter coastal communities and habitats.

Onshore Construction

Various kinds of onshore facilities service OCS development. The GOM coastal communities and habitats would be further stressed with the addition of infrastructure (e.g., roads and onshore support bases) to support offshore activities (e.g., oil and gas), which could result in loss of ecosystem function, physical ecosystem structure, and functional and structural value loss, as well as loss of recreational opportunities and value. Construction and operations associated with onshore facilities would result in some removal of coastal habitat. It is possible that shore-based organisms, such as birds and alligators, could experience stress related to onshore construction. Sedimentation of nearby wetlands and streams would be another risk. Long-term habitat loss or alteration may result from onshore construction.

Onshore support activity may result in increased vehicular traffic, especially in the vicinity of the facilities. This would occur as a result of new roads and vehicles associated with construction and operation of the facility. Installation of roads in or near coastal and estuarine habitats could lead to the hydrologic alteration, disturbance, fragmentation, and loss of wetlands (Ko and Day 2004). Collisions between animals and vehicles or construction equipment might cause direct mortality. Limited disturbance may occur as a result of vehicles traveling over the onshore habitat.

Coastal habitats along the GOM are already impacted by and responding to the impacts from sea-level rise and land loss. Wetlands may be particularly vulnerable because development and infilling may remove or change the ecosystem function. Most impacts would be long term and could affect the biological communities, such as coastal bird species, that rely on these habitats for nesting and feeding. Coastal land disturbance can lead to turbidity, which can negatively impact important habitats such as oyster reefs and seagrass beds. Major construction projects that destroy oyster reefs and/or reduce water quality could have substantial impacts to the eastern oyster and the communities it supports. Many nesting and foraging coastal animals, including some ESA-listed bird and sea turtle species, may experience negative habitat impacts. These habitat losses would likely be localized but could lead to long-term impacts and shoreline loss.

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 USACE's 404 permit and State permitting programs. The high cost of wetland mitigation discourages industry from causing damage to wetlands when building onshore facilities.

Depending on the location of newly established infrastructure, special places (i.e., national and State parks and wildlife refuges, national marine sanctuaries, and national estuaries) could be at risk as well. The EPA, which has less onshore infrastructure to support offshore energy, may be more susceptible to these consequences. Mitigating measures could reduce impacts.

Navigation Channels and Vessel Traffic

Vessel activity (e.g., tankers, barges, support vessels, and seismic survey vessels) associated with OCS oil- and gas-related activities such as pipeline installation could increase wave erosion and habitat loss or degradation in coastal and estuarine habitats (Robb 2014). Coastal organisms and vegetation may be impacted by increased turbidity from the wake from vessels such as tankers, barges, survey vessels, and support vessels. In addition, increased OCS vessel traffic could increase shoreline erosion of coastal and estuarine habitats from wave activity, which could lead to loss or degradation of habitat in these areas. Vessel traffic is especially harmful to unprotected shorelines and may accelerate erosion in areas already affected by natural erosion processes. Because of these impacts, the many nesting and foraging coastal animals, including some ESA-listed bird and sea turtle species, may experience negative habitat impacts. Saltwater intrusion into coastal, freshwater habitats may also result from vessel traffic and/or the creation or maintenance of navigation channels.

Much of the service-vessel traffic associated with OCS oil- and gas-related activities uses the channels and canals along the Louisiana coast. 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 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. The vulnerability of coastal and estuarine habitats to vessel traffic depends, in part, upon the type of canal used. 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 due to erosion have slowed based on maintenance techniques. Port Fourchon, which currently services approximately 90 percent of all deepwater rigs and platforms in the GOM (Loren C. Scott and Associates Inc. 2014), 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. Ports that have navigation channels deep enough to accommodate deeper-draft vessels may expand their infrastructure for better accommodation of BOEM-regulated activities. For example, Port Fourchon has been substantially expanded over the years by deepening the existing channel and dredging additional new channels. Refer to the “Bottom Disturbance” section above for a discussion on dredging consequences.

One of the many consequences of coastal land disturbance is permanent habitat modification. Coastal landfall of pipelines can convert wetlands to open water and introduces hard substrates. The creation and maintenance of navigation canals also permanently modifies coastal habitats. The construction of onshore facilities and roads may convert natural habitat to a built environment or may infringe upon neighboring coastal and estuarine habitats. The construction of roads and navigation canals and the installation of pipelines through coastal and estuarine habitats may serve as obstacles to the movement and migration of coastal species. The construction of onshore facilities would permanently convert natural habitat; port expansion and construction would degrade and destroy coastal and estuarine habitats. Coastal and land-based habitat modification would lead to a fragmentation of usable habitat and displace coastal organisms. Vegetation and less mobile species would be killed. These habitat modifications from onshore and coastal activity may inhibit feeding and reproduction and lead to reduced fitness of individuals. Mortality is a reasonable consequence of habitat modification. For particularly sensitive groups, such as ESA-listed species, population-level impacts may occur.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that noise, air emissions, lighting and visual impacts, socio-economic changes and drivers (refer to **Chapter 4.0**), and offshore habitat modification/space use are not likely to affect coastal communities and habitats and, therefore, would likely be scoped out of future NEPA analyses of proposed GOM lease sales.

Noise (Chapter 2.4.1)

Noise is not expected to substantially impact coastal and estuarine habitats, largely because of the physics of sound propagation in shallow waters. In coastal areas, noise from onshore construction, pipeline trenching, or vessel traffic could occur. However, given the fact that low-frequency sounds do not propagate well through shallow water (the “low-frequency cutoff,” [Urick 1983]) and the fact that invertebrates and most fish are primarily sensitive to particle motion, these impacts are expected to be highly localized. It has been shown that some of the species that commonly occur in these areas, such as crabs, oysters, mussels, and shrimp, are capable of perceiving low-frequency sounds (e.g., Charifi et al. 2017; de Soto et al. 2013; Roberts et al. 2015). In addition, larval stages of some estuarine species may use acoustic cues to navigate towards appropriate settlement habitat or to initiate metamorphosis (Lillis et al. 2013; 2015; Stanley et al. 2015).

Although these animals may use natural acoustic cues for basic life functions, the particle motion signal from anthropogenic noise sources would propagate only a few wavelengths from the sound source (Kalmijn 1988; Popper and Hawkins 2018; Urick 1983). Therefore, the potential effects on these estuarine organisms is expected to be minimal.

Air Emissions and Pollution (Chapter 2.1.1)

The combustion of fossil fuels during operations as well as the consumption of the oil and gas derived from the OCS releases nitrogen, sulfur, and carbon compounds into the atmosphere (refer to **Chapter 2.1.1**). As discussed above for non-OCS oil- and gas-elated activities, emissions in the form of nitrogen, sulfur, and carbon oxides and ammonia have the potential to affect the pH of coastal waters and soils, disrupt nutrient budgets, and spur growth of coastal vegetation and algae through nutrient loading and enhanced carbon dioxide concentrations. As discussed in **Chapter 4.1**, however, OCS oil- and gas-related sources contribute a small percentage to the emissions received onshore near coastal habitats and communities. In addition, most of these sources are localized and would dissipate quickly. Therefore, BOEM expects that coastal communities and habitats will not be vulnerable to air emissions from routine OCS oil- and gas-related activities.

Lighting and Visual Impacts (Chapter 2.6.1)

Artificial light sources on the Gulf Coast are prevalent. It is unlikely that consequences of OCS oil- and gas-related light pollution can be teased apart from the background levels of light pollution along this industrialized coastline. Therefore, the threat posed by lighting and visual impacts to coastal and estuarine habitats is low. Beachfront lighting deters sea turtles from coming onto beaches to nest and disorients hatchlings (refer to **Chapter 4.3.7**). Lights attract birds and insects that forage and migrate at night, resulting in substantial mortality from collisions with structures in the vicinity of lights (refer to **Chapter 4.3.5**). Shore-based lighting may also affect predator-prey interactions of coastal fish species (Bolton et al. 2017); refer to **Chapter 4.3.4**.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Effects to coastal communities and habitats are not expected from offshore habitat modification because these communities and habitats do not occur offshore. For a description of the potential impacts from onshore habitat modification, refer to the Coastal Land Use/Modification section above.

4.3.1.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Activities Events

Figure 4.3.1-2 highlights the IPF categories of accidental events associated with OCS oil- and gas-related activities that could potentially affect coastal communities and habitats in the GOM region. Effects from these categories of IPFs would vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Both coastal and offshore oil spills can be caused by large tropical storm events, faulty equipment, or human error. The distance from shore 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 out to sea. This allows for the toxicity of spilled oil from offshore to be greatly reduced or eliminated by weathering and biodegradation before it reaches the coast (OSAT-2 2011). Nonetheless, accidental spills are reasonably foreseeable, and coastal and estuarine habitats may be vulnerable to these incidents. 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. 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, and pipeline accidents could result in high concentrations of oil directly contacting localized areas of wetland habitats (Fischel et al. 1989). Refer to the *Catastrophic Spill Event Analysis* technical report for an analysis of impacts from a low-probability, catastrophic spill event (BOEM 2021d) .

Coastal communities and habitats can be indirectly and directly impacted by releases into the environment (e.g., oil spills). These impacts are complex and can vary in intensity based on several interrelated factors, including oil type, time of year, and specific habitat characteristics, such as porosity. The NOAA created the Environmental Sensitivity Index (ESI) to assess the risk posed to coastal habitats in the event of a nearby oil spill. The ESI ranks shorelines according to their sensitivity to oil, the natural persistence of oil, and the expected ease of clean up after an oil spill. These factors affect the impacts of oil spills in coastal and estuarine areas. Based on the ESI, marshes, mangroves, and swamps are the most sensitive shoreline habitats to oiling as oil tends to persist in these areas and are difficult to clean (NOAA 2019d). The GOM shoreline is dominated by marshes and wetlands, making it highly sensitive to oil spills. Intertidal habitat vulnerability is generally highest for vegetated wetlands (Hayes et al. 1992; NOAA 2010a) as well as semipermeable substrates that have low wave energy and high tidal currents. Barrier island loss due to hurricanes and anthropogenic factors has reduced protection of wetlands from offshore oil spills, which has increased the potential for the oiling of coastal wetlands during an accidental event.

Oil that impacts wetlands or SAV would result in substantive injury to vegetation, plant mortality, and some permanent wetland loss. Oil that impacts beaches would thicken as its volatile components are degraded, and it forms tar balls or aggregations that incorporate sand, shell, and other materials. Completely submerged seagrasses are less susceptible to oil spills as they largely avoid direct contact with the oil pollutant (U.S. Navy 2018). Releases into the environment (e.g., spilled oil) could result in loss of ecosystem function, physical ecosystem structure, and functional and structural value loss, as well as loss of recreational opportunities and value. Depending on the location of the spill, protected areas (i.e., national parks, national wildlife refuges, national marine sanctuaries, and national estuaries) could be at risk as well.

The short-term effects of oil on wetland plants range from reduction in transpiration and carbon fixation to plant mortality. 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 and DeLaune 2015). Oil can indirectly affect animals that rely on SAV and wetlands during their lifecycles, especially benthic organisms that reside in the sediments and comprise an important component of the food web. Habitat degradation could persist and have long-term residual impacts on species' populations, community structure, and habitat function, resulting in loss of ecosystem function, value, and physical ecosystem structure. Depletion of marsh vegetation following a spill may increase and accelerate erosion, resulting in land loss (Alexander and Webb Jr. 1987; Fischel et al. 1989; McClenachan et al. 2013; Silliman et al. 2012; Turner et al. 2016). This could increase coastal vulnerability to storms and sea-level rise, potentially impacting tourism, recreation, and environmental value.

Mangroves, which occur on the coasts of Florida, Louisiana, and parts of Texas, are also highly vulnerable to oil spills (Swan et al. 1994; Duke et al. 1999; Duke and Burns 2003; Hoff and Michel 2014). Oil can coat breathing surfaces of the mangroves, which kills shorter plants and animals within days. Symptoms of chronic impacts from oil spills include death of trees with seedling regeneration, defoliation and canopy thinning, leaf yellowing, reduced height growth for surviving trees, and poor seedling establishment (Duke et al. 1997; Hoff and Michel 2014; Lewis et al. 2011). Toxic response deformities and morphological changes may also occur after oil exposure, including pneumatophore branching (Duke et al. 2005), reduced lenticel numbers (Böer 1993), and genetic mutations like variegated leaves and chlorophyll-deficient propagules (Duke and Watkinson 2002). These effects could result in loss of ecosystem function and structure, as well as loss of recreational opportunities and value.

While oil can completely foul wetland plants, it is the amount and type of oil, as well as the particular plant type that determines recovery. 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 (DeLaune et al. 1979; Lytle 1975; Webb et al. 1985). 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. Different species of plants respond differently to oiling (DeLaune and Wright 2011). Pezeshki and DeLaune (2015) 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. 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.

Oil has been found or estimated to persist for at least 17-20 years in low-energy environments like salt marshes (Baker et al. 1993; Burns et al. 1993; Irvine 2000; Teal et al. 1992). If thick oil is deposited on a 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); thus, 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 hydrocarbon degradation is higher in intertidal than in subtidal wetland soils. The same is true for submerged vegetation; 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 III 2006).

Trash and Debris

Trash and debris from OCS oil- and gas-related activities may pollute coastal and estuarine habitats. Fauna, such as birds, sea turtles, marine mammals, and fish, may become entangled in objects or may ingest them. As items degrade, they may further release contaminants in the environment including organic pollutants and microplastics.

Response Activities (Chapter 2.9.2)

Response activities in coastal habitats include boom placement adjacent to shorelines to prevent oil from reaching shorelines, barrier berms, flushing salt marshes with water, cutting and raking vegetation, raking heavy oil deposits from soil surfaces, and placing loose sorbent materials. The use of nearshore booming protection for beaches and wetlands could also help to reduce oiling of these resources, if done correctly. However, booms deployed adjacent to marsh shorelines can be lifted by wave action onto marsh vegetation, resulting in plant mortality under the displaced booms. After the *Deepwater Horizon* explosion and oil spill, the use of barriers such as booms and sand berms did not work as well as planned (Jones and Davis 2011; Martínez et al. 2012; Zengel and Michel 2013). 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 the species are only tolerant to certain salinities and light levels (Frazer et al. 2006; Kenworthy and Fonseca 1996; Zieman et al. 1984). Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts.

Oil-spill cleanup in coastal marshes remains an issue because wetlands and submerged vegetation can be extremely sensitive to the disturbances associated with cleanup activities. 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. Oiled marshes may incur secondary impacts associated with the cleanup process, such as trampled vegetation, accelerated erosion, and the burying or mixing of oil into marsh soils (Long and Vandermeulen 1983; Mendelssohn et al. 1993; Zengel et al. 2015). Associated foot and vehicular traffic may work oil farther into the sediment than would otherwise occur. Cleanup activities in marshes that may last years to decades following a spill may accelerate erosion rates and retard recovery rates. Some dominant freshwater marsh species (*Sagittaria lancifolia*) are tolerant to oil fouling and may recover without being cleaned (Lin and Mendelssohn 1996). For smaller oil spills, it may be prudent to allow wetland areas to recover naturally (Zengel et al. 2014). This is especially effective in marshes with adequate tides where natural tidal flushing can naturally reduce oil concentrations (Kiesling et al. 1988). In areas of thick oil deposits, however, a cleanup effort would result in greater recovery (Baker et al. 1993). Heavily oiled, untreated marsh areas showed negative effects on the vegetation, intertidal communities, and erosion tendency compared to the control (Beyer et al. 2016).

Oil-spill response may damage sand beaches. Sand beaches provide several key services as a habitat, including sediment storage and transport, wave dissipation and buffering during storms, scenic vistas and recreation, groundwater filtration, nutrient mineralization and recycling, maintenance of biodiversity and genetic resources, carbon transfer, and functional links between terrestrial and marine environments (Defeo and McLachlan 2005). Shoreline cleanup actions to address oiling of beaches can alter and/or diminish these services. Cleanup activities can require extensive and prolonged uses of mechanical and manual treatments. Most mechanical beach cleanup activities occur in the supratidal zone, where wrack commonly accumulates, which supports a community of up to 40 percent of intertidal species and supports important prey resources for higher trophic levels (Dugan et al. 2003). The intertidal zone comprises a much higher invertebrate biomass than the supratidal zone (Colombini and Chelazzi 2003; Janssen and Mulder 2005; Raffaelli et al. 1991). These intertidal species are considered tolerant to disturbances due to their adaptation to a dynamic environment. Despite their high tolerance, fauna can be directly and indirectly impacted by spill-response cleanup activities. Intertidal fauna are directly impacted by crushing, which can result in mortality, and desiccation during sediment shifting and removal. Intertidal fauna are indirectly impacted by response activities through alteration of the habitat and its suitability, reproduction disruption, and food supply removal (Michel et al. 2017).

Accidental Events Determined Not Likely to Cause Effects

BOEM evaluated the accidental events associated with OCS oil- and gas-related activities as described in **Chapter 2** and determined that collisions and strikes are not likely to affect coastal communities and habitats and, therefore, would likely be scoped out of future NEPA analyses of proposed GOM lease sales. Ship strikes to coastal and estuarine environments are not reasonably foreseeable. Should they occur, the damages would be similar to those discussed in the "Coastal Land Use/Modification" section in **Chapter 4.3.1.2.2**. If a vessel was to run aground in a coastal habitat, an accidental spill may occur as discussed in the "Unintended Releases into the Environment" section above.

4.3.2 Benthic Communities and Habitats

4.3.2.1 Resource Description

Benthic fauna inhabit the seafloor throughout the Gulf of Mexico at all water depths (**Figure 4.3.2-1**). The following information summarizes the benthic community resource description that is detailed in BOEM's Biological Environmental Background Report (BOEM 2021b). Benthic organisms interact with seafloor sediment through bioturbation, oxygenation, and cementation of the sediments. Microbial communities and, within the photic zone, microalgae, macroalgae, and rooted vegetation also inhabit the seafloor. All benthic communities are trophically linked and contribute significantly to global carbon cycling.

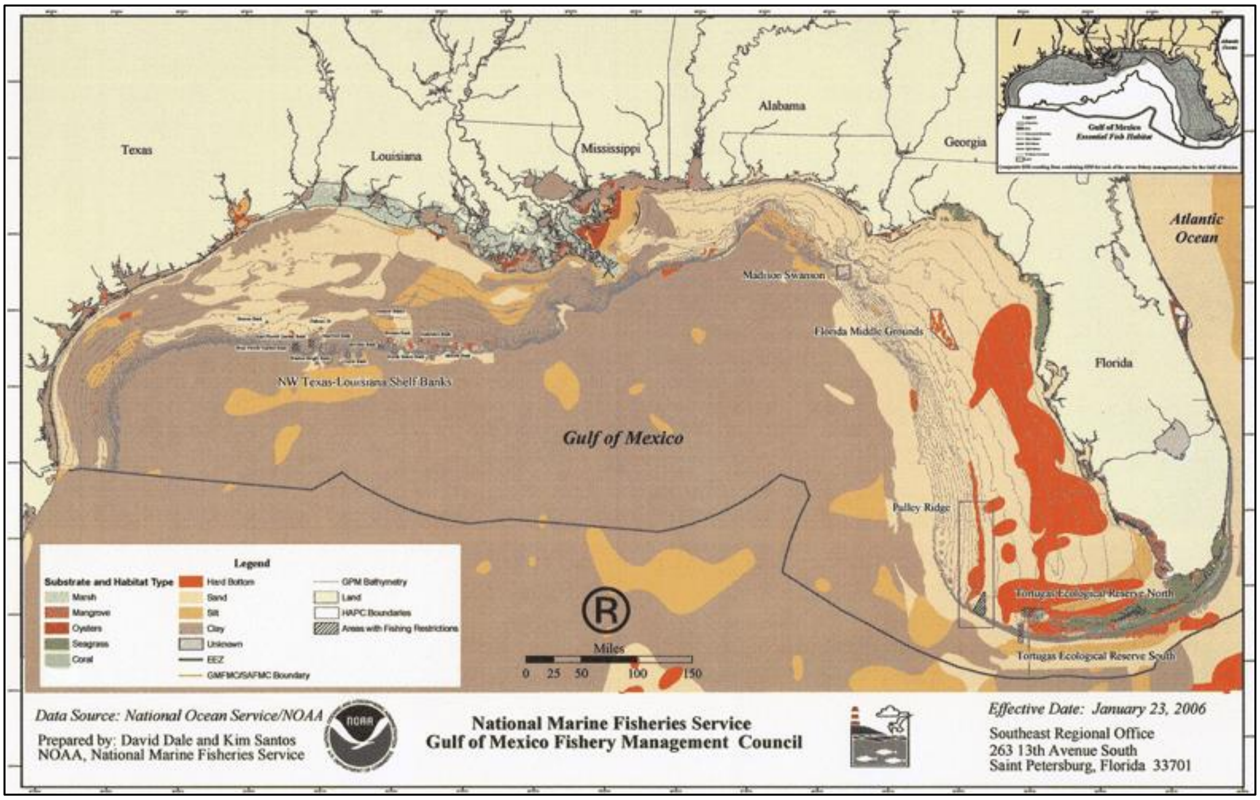


Figure 4.3.2-1. Benthic Habitat Distribution in the Gulf of Mexico (Rowe 2017) [modified from Gulf of Mexico Fishery Management Council 2004 and 2005]). This figure is licensed under the terms of the Creative Commons Attribution-NonCommercial 2.5 International License (http://creativecommons.org/licenses/by-nc/2.5/).

Documented benthic ecosystems in the Gulf of Mexico include muddy softbottom; oyster reefs; coral and sponge dominant banks (e.g., the Flower Garden Banks); hydrocarbon seeps along the continental margin; and marine canyons, escarpments, and seamounts on the abyssal plain (Briones 2004). Coastal benthic habitats are discussed in **Chapter 4.3.1**. Connectivity with areas adjacent to and within the Gulf of Mexico depends on pelagic larval transport by surface currents. Most Gulf of Mexico hardbottom benthic communities are diverse and characterized by high species richness and low abundance, while soft-bottom communities are characterized by low species richness and high abundance. Suspension feeders are generally most abundant in high-energy environments, and deposit feeders are most abundant in low-energy environments in areas with fine-grained, muddy sediments (Snelgrove 1999).

Within the photic zone, naturally occurring geological (exposed bedrock) or biogenic (authigenic carbonate relict reef) seafloor with measurable vertical relief serves as important habitat for a wide variety of sessile and mobile marine organisms in the Gulf of Mexico. Hardbottom habitats on the OCS large enough to play an important ecological role in the Gulf of Mexico, with high biomass, diversity, and abundance, are called topographic features or banks. These include the midshelf and shelf-edge banks (including the East and West Flower Garden Banks), South Texas banks, Alabama Pinnacle Trend, and Florida Middle Grounds. Encrusting algae and sessile invertebrates such as corals, sponges, sea fans, sea whips, hydroids, anemones, ascidians, and bryozoans may recruit to and colonize these hard substrates, creating “live bottom” (Cummins Jr. et al. 1962). Corals and large sponges function as structural architects adding complexity to the benthic habitat. This complex structure provides shelter to small fish and invertebrates, which in turn provide food for larger fishes, including many that form important commercial fisheries (Fraser and Sedberry 2008; Gallaway et al. 2009; Johnston et al. 2015; Nash et al. 2013; Szedlmayer and Lee 2004).

Hardbottom substrate is found throughout the deep waters of the Gulf of Mexico and is comprised of either exposed bedrock or relict authigenic carbonate coral reef (Brooks et al. 2016). Both hard- and soft-bodied corals colonize deepwater substrate. Associated sessile and mobile benthic megafauna include sponges, anemones, echinoderms, crustaceans, and demersal fishes. Field data suggest that the extent of deepwater, hardbottom habitat is large and that diversity of corals and sponges is high (Boland et al. 2017).

Cold seeps are areas of the ocean floor where high concentrations of oil or reduced chemicals, including methane, sulphide, hydrogen, and iron II, are expelled forming hydrocarbon or gas plumes. Hydrocarbon seep ecosystems are composed of mosaic habitats with a range of physio-chemical constraints for organisms including temperature, salinity, pH, oxygen, carbon dioxide, hydrogen sulfide, inorganic volatiles, hydrocarbon components, and heavy metals (Levin and Sibuet 2012). These habitats support chemosynthetic communities. Such communities on natural substrate typically occur in the Gulf of Mexico at water depths greater than 300 m (984 ft), at a temperature range of 13°C to 4°C (~55°F to 30°F), with seafloor currents from 5 to 10 cm/s (2 to 4 in/s), and in locations with moderate hydrocarbon flow. Gulf of Mexico seep communities tend to be large, up to several hundred meters across (MacDonald 1992). Typical chemosynthetic fauna in the Gulf of Mexico include chemoautotrophic bacteria, vestimentiferan tubeworms, mussels, epibenthic clams, and burrowing clams (MacDonald et al. 1990). Over 330 chemosynthetic communities are confirmed in the Gulf of Mexico at depths ranging from 290 m (952 ft) (Roberts et al. 1990) to 2,750 m (9,022 ft) in Alaminos Canyon (Roberts et al. 2010).

Environmental Factors

Climate change-related effects have the potential to alter baseline environmental conditions throughout the GOM. Benthic communities are potentially vulnerable to 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 in deep-sea organisms because of the additional energy expended in pH buffering. 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, leading to habitat modification. Changing climatic conditions that alter the frequency and/or severity of weather events could affect benthic communities through sedimentation and direct impact of deep wave action breaking and/or overturning benthos. Severe weather may cause bottom disturbance by the movement of abandoned fishing gear and other anthropogenic debris along the seafloor, which could scour, smother, crush, break, or kill benthic communities if they are struck.

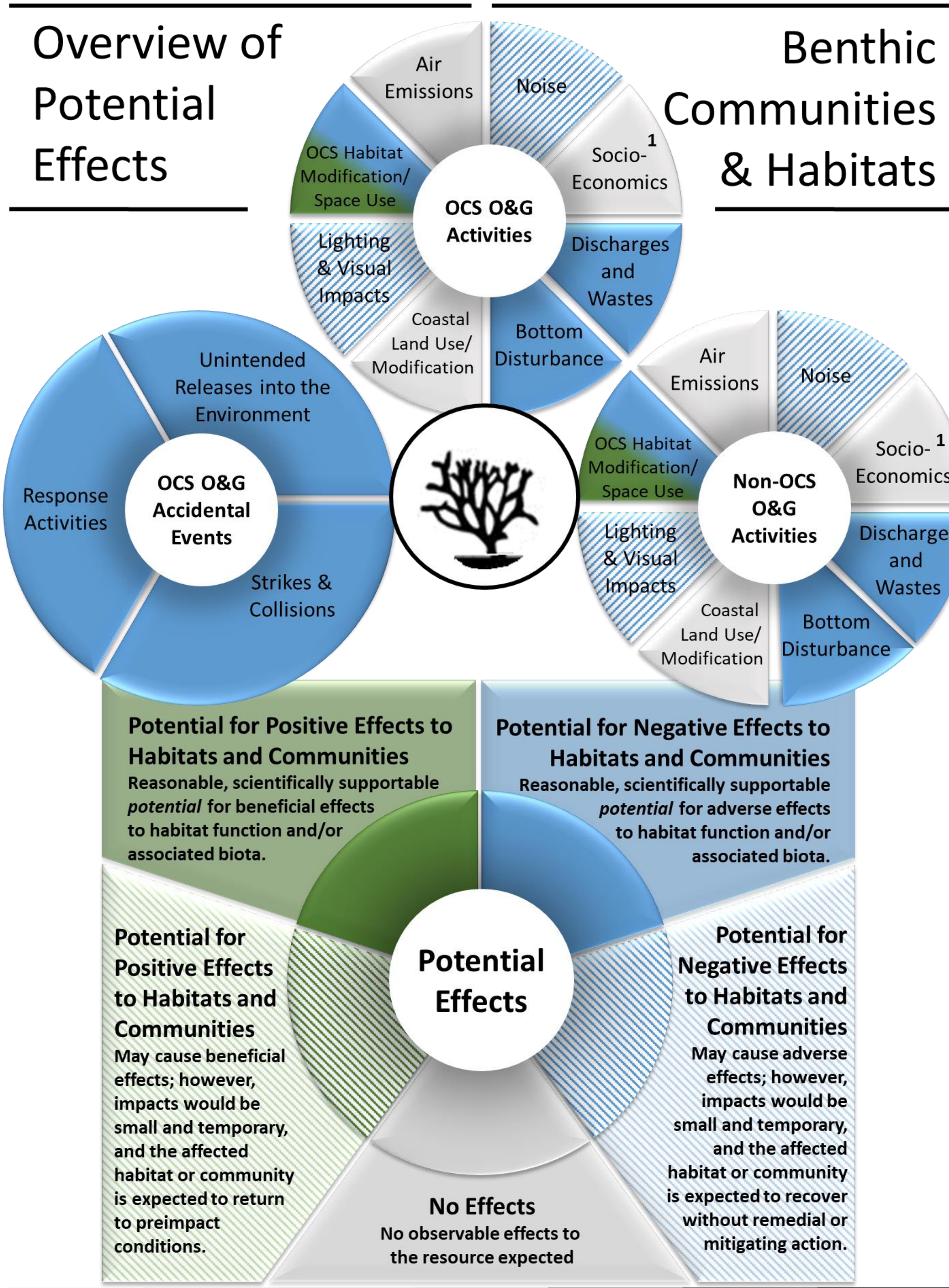
4.3.2.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and benthic communities and habitats. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.2-2**.

Figure 4.3.2-2 is intended to illustrate the relevant IPF categories and potential effects that are analyzed in this chapter, as well as the IPFs that are not likely to cause effects to benthic communities and habitats and, therefore, would likely be scoped out of future NEPA analyses of proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).

This discussion primarily focuses on the effects that could occur to the hardbottom benthic communities in the GOM. Although hardbottom habitats occur throughout the GOM, they are relatively rare compared with the soft bottoms that comprise approximately 90 percent of the OCS. A discussion of effects to soft bottom benthic communities is limited in detail here because localized effects to soft bottom benthic communities would not affect soft bottom benthic populations as a whole in the GOM.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and resource; and the distribution, condition, and scarcity of the resource, as well as habitat type and feature-specific characteristics (e.g., seafloor relief, rugosity, and associated community).



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.2-2. Potential Interactions between the Impact-Producing Factors Identified in **Chapter 2** and Benthic Communities and Habitats. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

BOEM will use this preliminary identification and disclosure of the potential range of effects to benthic communities and habitats, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

4.3.2.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.2-2 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect benthic communities and habitats in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.2)

The primary source of non-OCS oil- and gas-related effects of discharges and wastes to benthic communities is the influx of freshwater, toxic chemicals, nutrients, and anthropogenic debris from the Mississippi and Atchafalaya River Basins into northcentral GOM waters. The majority of these effects are likely to occur within the coastal zone. Discharges and wastes in the coastal zone can bury and/or smother benthic habitat and associated organisms, and the organisms can be exposed to toxins within the discharges. Benthic communities exposed to non-OCS oil- and gas-related discharges and wastes may suffer reduced survival, fecundity, and growth; reduced community abundance; and reduced species richness.

The Gulf of Mexico annually develops an extensive seasonal hypoxic zone on the OCS west of the Mississippi Delta during the late spring and summer. Hypoxic conditions are defined as water masses with dissolved oxygen concentrations lower than 2 mg/L (63 micromilliliters per liter). In 2019, this “dead zone” measured ~18,000 km^2 (6,952 mi^2), the eighth largest on record (NOAA 2019a). Hypoxic zones are caused by terrestrial runoff, nutrient-fed algal growth, and subsequent bacterial decomposition, resulting in near seafloor oxygen levels too low to sustain most marine life and causing habitat loss, sublethal stress, and/or death. The persistence of hypoxic zones leads to a metazoan community with anaerobic conditions that significantly change the benthic ecosystem. The extent of hypoxic zones varies over the course of their duration due to water column mixing by wind and storm events. In the Gulf of Mexico, the persistence of the hypoxic zone into the early fall depends on the breakdown of vertical stratification of the water column by winds from either tropical storms or cold fronts; they rarely persist into late fall or winter (Rabalais et al. 2002a).

Terrestrial floodwater containing freshwater, toxic chemicals, nutrients, and other anthropogenic debris from large hurricane events may impact midshelf and shelf edge topographic banks and features on the OCS. For example, poor water quality resulting from storm-driven freshwater runoff at the East and West Flower Garden Banks led corals to experience sublethal stress (Wright et al. 2019), potentially making these species less resilient and more susceptible to other stressors.

Oil and gas activities within State waters occur offshore Texas, Louisiana, Mississippi, and Alabama. The potential effects to benthic communities and habitats from oil spills resulting from State-permitted oil and gas activities include death as well as sublethal effects such as reduced feeding, reduced reproduction and growth, physical tissue damage, and altered behavior. These effects from State oil and gas activities are the same as those that could occur for OCS oil- and gas-related oil spills. Refer to **Chapter 4.3.2.2.2**, "Unintended Releases to the Environment," for a more detailed discussion of the effects of oil spills on benthic communities. Dredge material disposal from State oil and gas activities could smother benthic communities in or near a disposal site (Bishop et al. 2006). These effects are also the same as for OCS oil- and gas-related activities, which are discussed in more detail in **Chapter 4.3.2.2.2**, Discharges and Wastes.

Bottom Disturbance (Chapter 2.3.2)

The majority of non-OCS oil- and gas-related effects to benthic communities results from bottom-disturbing activities. These activities include artificial reef development, scuba diving, anchoring, and fishing pressure.

The placement of artificial reef development materials within the context of State artificial reef programs has the potential to cause bottom disturbance, including the crushing and/or burial of sessile organisms. As the purpose of artificial reef development is to create hard substrates and benthic habitat where it does not naturally exist, artificial reef development is not expected to affect hardbottom benthic habitat or communities as reefs are generally placed on soft bottom sediments located away from such features.

Most shallow-water hardbottom benthic features on the OCS are deep enough that recreational scuba diving activities are limited. Scuba diving activities may affect benthic habitats through crushing or fracturing by divers or dive boat anchors, or removal of organisms. In some areas where such diving does occur, activity is managed by other Federal agencies (e.g., the Flower Garden Banks National Marine Sanctuary), with regulations and management practices developed to protect benthic resources.

Many significant topographic features are found near established shipping fairways and anchorage areas, and are well-known fishing areas. Vessel anchoring at a topographic feature or bank may result in bottom disturbance, including crushing of hard substrates and structure-forming organisms including corals and sponges, burial of organisms, and scarring of the seafloor. Damage from anchoring on topographical features 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 and for fishing vessels within the McGrail Bank Coral Habitat Area of Particular Concern boundaries designated by NMFS and the Gulf of Mexico Fishery Management Council. The extent of effects from non-OCS oil- and gas-related anchoring activities on nonprotected topographic features is unknown.

The primary anthropogenic activities that may contribute to non-OCS oil- and gas-related effects to benthic communities are related to commercial fishing. Bottom-tending fishing gear of any type (e.g., trawls, traps, bottom-set longlines, and gillnets) can damage benthic communities by dislodging or crushing organisms attached to the bottom, with trawls representing the most serious threat in deep water (Hourigan 2014). Currently, the overall amount of fishing effort in 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 (Continental Shelf Associates Inc. 2003).

Bottom disturbance from oil and gas activities within State waters could affect benthic communities and habitats by crushing or smothering organisms from anchoring or structure and pipeline emplacement. These effects to benthic communities are the same as those that could occur for OCS oil- and gas-related oil spills. Refer to **Chapter 4.3.2.2.2** for a more detailed discussion of the effects of bottom disturbance on benthic communities.

Noise (Chapter 2.4.2)

Noise in the marine benthic environment may be propagated directly within seafloor sediments or indirectly through the water column. It is likely that acoustic vibration is important for mobile benthic species to navigate, communicate, and find food (Roberts and Elliott 2017). Sources of acoustic vibration within marine sediments related to the non-OCS oil- and gas-related activities include State oil and gas infrastructure construction and installation, explosive structure removal, vessel traffic, pile-driving, dredging, and sand borrowing activities. The effects of non-OCS oil- and gas-related noise to benthic communities are the same as those that could occur for OCS oil- and gas-related noise and can include altered behaviors as well as functional, fitness, and ecological stress. Refer to the “Noise” section in **Chapter 4.3.2.2.2** for a more detailed discussion of the effects of noise on benthic communities. Although noise may cause adverse effects to benthic organisms, these effects would be small and temporary, and recovery would occur without remedial or mitigating action.

Lighting and Visual Impacts (Chapter 2.6.2)

Components of artificial light spectrum have been documented reaching the seafloor (Tamir et al. 2017); however, direct effects to benthic organisms in the Gulf of Mexico have not been evaluated. Biological processes of benthic organisms that may be negatively affected by seafloor irradiance from non-OCS oil- and gas-related activities such as vessel lighting and State oil and gas platforms include circadian regulation, synchronization of coral spawning, recruitment and competition, vertical (diurnal) migration of demersal plankton, feeding patterns, and visual interactions (Tamir et al. 2017). Although artificial light may cause adverse effects to benthic organisms, these effects would be small and temporary, and recovery would occur without remedial or mitigating action.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Sand shoals represent significant sources of sand on the OCS for potential coastal beach nourishment and coastal stabilization projects. Mineral dredging can result in direct bottom disturbance and sediment suspension. The OCS sand borrowing can physically remove, crush, or kill benthic organisms in the borrow area as well as smother benthic communities surrounding the borrow site. There is little research on the potential effects to soft bottom benthic communities from sand dredging activities. Dubois et al. (2009) predict that sand extraction from significant sand shoals (e.g., Ship Shoal) in the northern Gulf of Mexico would cause a shift in species dominance to small, fast growing and reproducing species such as spionid polychaetes, which could, in turn, impact higher trophic levels. Mineral dredging activities are not expected to affect hardbottom benthic habitat or communities as dredging occurs in soft bottom sediments generally located away from such features.

The introduction of invasive species associated with benthic hardbottom habitat have the potential to cause habitat modification. Invasive lionfish (*Pterois volitans*) first arrived in the Gulf of Mexico in 2010 and currently inhabit the coasts of all five Gulf Coast States as well as artificial and natural reefs. Lionfish are generalist predators. As they grow, fish comprise a greater part of their diet (Dahl and Patterson III 2014). Their density, feeding patterns, growth rate, and lack of predators have the potential to significantly affect benthic communities, potentially leading to habitat modification. 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. An ulcerative skin disease impacting lionfish was first observed in late 2017 and 2018, and has resulted in an overall density decline of the species (Harris et al. 2020), which may mitigate their overall effect on benthic communities. The invasive Regal Demoiselle (*Neopomacentrus cyanomos*) has been recorded on the Flower Garden Banks (Johnston et al. 2020). Potential effects from its spread are currently unknown; however, they are unlikely to have any unusual ecological advantages over native species (Robertson et al. 2016).

Artificial reefs may enhance biological productivity and facilitate the conservation and/or restoration of benthic organisms by restricting access to other bottom-disturbing activities such as bottom trawling (Macreadie et al. 2011). Microalgae and nearly all invertebrate taxa (i.e., corals, anemones, hydroids, sponges, bivalves, mollusks, and polychaetes) have been observed on artificial reefs (summarized in Macreadie et al. 2011). Communities that develop on artificial substrate are often different than those on natural reefs (Burt et al. 2009). Over long distances, artificial reefs may act as “stepping stones” across areas with little to no natural hard substrate that act to increase connectivity with biogeographical consequences (summarized in Cordes et al. 2016). This may include increased genetic homogeneity and reduced opportunity for allopatric speciation (Macreadie et al. 2011).

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the non-OCS oil- and gas-related activities described in **Chapter 2** and determined that air emissions, coastal land disturbance, and socioeconomic factors are not likely to affect benthic communities and habitats. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.2)

Benthic habitats on the OCS are not expected to be vulnerable to air emissions from non-OCS oil- and gas-related activities activity because the emissions would be localized, would dissipate quickly, and are not expected to reach the seafloor. For potential effects to benthic habitats from ocean acidification, refer to the "Environmental Factors" section above in **Chapter 4.3.2.1**.

Coastal Land Use/Modification (Chapter 2.5.2)

Benthic habitats on the OCS are not expected to be vulnerable to coastal land disturbance due to their distance from the coast. Refer to **Chapter 4.3.1** for an analysis of coastal and estuarine benthic habitats and organisms, and their vulnerabilities to coastal land disturbance.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Benthic habitats on the OCS are not expected to be vulnerable to changes in socioeconomics as fluctuations in the economy should not affect seafloor habitats. Because commercial trawling in deep water is limited (refer to "Bottom Disturbance" above), any fluctuations in economic drivers and the associated commercial fishing industry are not likely to affect deepwater benthic communities. Therefore, the effects of socioeconomic factors on benthic communities were not analyzed.

4.3.2.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.2-2 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect benthic communities and habitats in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.1)

Discharges from OCS oil- and gas-related activities are managed through the U.S. Environmental Protection Agency's NPDES permitting process or MARPOL Annex V Treaty. Enforcement of the relevant laws and regulations is conducted by several Federal agencies including the USEPA, NOAA, BSEE, and U.S. Geological Survey. For the purpose of this analysis, compliance with these laws and regulations is assumed.

Drilling operations have the capacity to deposit up to 2,000 metric tons of combined muds and cuttings and drilling fluid onto the seafloor (Neff 2005). The spatial footprint of discharge varies with discharge volume, water depth, local hydrography, sediment particle size distribution, settlement rate, floc formation, and time (Neff 2005; Niu et al. 2009). Cuttings discharged at the sea surface tend to disperse in the water column and be distributed at low concentrations (Continental Shelf Associates Inc. 2004a). In deep water, most cuttings discharged at the sea surface are likely to be deposited within 250 m (820 ft) of the well (Continental Shelf Associates Inc. 2006) although ecological changes have been observed within 300 m (984 ft) and up to 1 to 2 km (0.6 to 1.2 mi) for especially sensitive species (summarized in Cordes et al. 2016). Cuttings shunted to the seafloor form sediment piles with a generally smaller surface area than those formed from sea-surface discharge (Neff 2005).

Operational discharges from drilling can bury and/or smother benthic habitat and associated organisms. Habitat and organisms most vulnerable to impacts from muds and cuttings are those in low-energy environments within a few hundred meters of the wellsite. Cuttings may form resistant mounds on which distinctive fauna characterized by mobile predators may develop (Lissner et al. 1991). The vulnerability of sessile organisms to impacts from drilling discharges is directly related to levels of suspended solids and the organisms' ability to clear particles from feeding and respiratory surfaces (Rogers 1990). Coverage with discharged sediments as low as 3 mm (0.12 in) can cause detectable impacts to infauna (Schaanning et al. 2008).

The chemical content of drilling muds and cuttings, and to a lesser extent produced waters, may contain hydrocarbons, trace metals including heavy metals, elemental sulphur, and radionuclides (Kendall and Rainey 1991; Trefry et al. 1995). Undiluted heavy metals and toxic compounds have the potential to be moderately toxic to benthic organisms (Continental Shelf Associates Inc. 2004b). Sediment infauna have shown effects from toxins at less than 100 m (330 ft) from discharge locations including reduced reproductive fitness, altered populations, and acute toxicity C (Carr et al. 1996; Chapman et al. 1991; Continental Shelf Associates Inc. 2004b; Continental Shelf Associates Inc. et al. 1989; Kennicutt II et al. 1996; Montagna and Harper Jr. 1996).

Produced waters dilute rapidly with distance from the source; impacts are generally only observed within very close proximity to the source (Gittings et al. 1993; Neff 2005). The exposure of warm-water coral species to drilling fluid may result in reduced viability, morphological changes, altered feeding behavior, altered physiology, or disruption to the pattern of polyp expansion (summarized in Freiwold et al. 2004).

Typically, dredge spoil materials from dredging for OCS oil- and gas-related activities are disposed at established dredge material disposal areas permitted by the USACE, USEPA, and relevant State agencies. Dredged sediments could smother benthic communities in or near a disposal site (Bishop et al. 2006). Benthic communities within permitted dredge spoil areas may suffer reduced survival, fecundity, and growth; reduced community abundance; and reduced species richness.

Historically, BOEM distances bottom-disturbing activity from sensitive hardbottom benthic seafloor features through stipulations attached to leases or mitigations attached as conditions of approval to permitted activities. The distancing requirements separate the heaviest concentration of discharges from the benthic habitat. In addition, for specific topographic features, variably sized concentric shunting zones are established surrounding the topographic feature 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. For more information on postlease seafloor reviews of permit applications, refer to **Chapter 5.10**. For more information on postlease mitigations applied as conditions of approvals to permits, refer to **Chapter 6**. For more information on lease stipulations, refer to **Chapter 7**.

Bottom Disturbance (Chapter 2.3.1)

The physical disturbance of the seafloor may result in the destruction of sessile benthic organisms and hardbottom and/or chemosynthetic habitat and soft sediment turbation. Factors that cause bottom disturbance may be temporary (e.g., anchoring) or more persistent within the environment (e.g., platform or pipeline installation). On average 8-12 anchors are used to hold OCS oil and gas platforms in place. The direct extent of the effects of infrastructure use and installation, including anchors and pipelines, is up to ~100 m (328 ft) from the footprint of the operation (Cordes et al. 2016; Ulfsnes et al. 2013). The spatial extent of anchor impacts to the seafloor is typically between 1.5 and 2.5 times the local water depth (Vryhoff Anchors BV 2010). Potential effects from bottom disturbance may include crushing of hard substrates and structure-forming organisms including corals and sponges, burial of organisms, and scarring of the seafloor. The spatial extent of the seafloor disturbance would depend on the specific activity, local environmental conditions and physical regime (e.g., water depth, bottom currents, light penetration, etc.), and local habitat and community composition, extent, and health. It is generally assumed that benthic communities associated with unconsolidated soft sediments will recover more quickly than those associated with hardbottom habitat (Dernie et al. 2003).

The type of hardbottom habitat (e.g., topographic features, pinnacles, low-relief features, cold seeps, brine pools, etc.), individual features' sizes and surface areas, distance between features, community structure, species richness, and organism density, among other attributes, coupled with the spatial scale and temporal duration of the bottom disturbance, influence the degree of impact and the ability of the local community to recover from the impact. For example, for patches of disturbed hardbottom habitat and organisms surrounded by unimpacted mature colonies of the same species, recolonization of the impacted area may occur relatively rapidly. If the disturbed patch is surrounded by solitary organisms, recovery may be slower and occur as a function of short-distance larval dispersal. Disturbed habitat that is isolated from undisturbed communities may take much longer to recover, with recolonization a function of long-range larval dispersal (Lissner et al. 1991). Anthropogenic bottom disturbance can cause loss of species diversity within benthic communities, particularly in the deep sea (summarized in Jones et al. 2006).

Regardless of duration, bottom disturbance causes at a minimum localized, temporary resuspension of sediment (Morgan et al. 2006) and increased turbidity. Some mobile invertebrates may be able to move to avoid the heaviest sediment displacement and highest suspended sediment loads, while sessile invertebrates (e.g., corals and sponges) cannot. In shallow water, sediment particles can reduce light available for photosynthesis. In corals, heavy, chronic sedimentation is associated with fewer species, less live coral, lower growth rates, greater abundance of branching forms, reduced recruitment, decreased calcification, decreased net productivity, and slower rates of reef accretion (Rogers 1990). Sedimentation damage to reefs can have cascade effects on reef-associated species (Rogers 1990).

Increased turbidity can reduce feeding efficiency and clogging of filter-feeder structures and decrease the success of larval settlement (summarized in (Lissner et al. 1991). The impact to filter feeders as a result of bottom disturbance and sediment suspension may result in preferential recolonization by epibenthic deposit feeders, resulting in an overall change of species composition (Jones et al. 2006). Sessile and mobile invertebrate species adapted to living in turbid environments, such as several tall and flexible gorgonian species, may be less affected by increased turbidity. Reduction in available geological or biogenic substrate may also have secondary ecological effects on organisms that use complex structural microhabitats to, for example, lay eggs (Etnoyer and Warrenchuk 2007; Shea et al. 2018).

Historically, BOEM distances bottom-disturbing activity from sensitive hardbottom benthic seafloor features through stipulations attached to leases or mitigations attached as conditions of approval to permitted activities. The distancing requirements separate the placement of anchors, structures, pipelines, and wells from the benthic habitat. For more information on postlease seafloor reviews of permit applications, refer to **Chapter 5.10**. For more information on postlease mitigations applied as conditions of approvals to permits, refer to **Chapter 6**. For more information on lease stipulations, refer to **Chapter 7**.

Noise (Chapter 2.4.1)

Noise in the marine benthic environment may be propagated directly, within seafloor sediments, or indirectly, through the water column. It is likely that acoustic vibration is important for mobile benthic species to navigate, communicate, and find food (Roberts and Elliott 2017). Sources of acoustic vibration within marine sediments related to the oil and gas industry include drilling, infrastructure construction and installation, explosive structure removal, pile-driving, and seismic and high-resolution geophysical surveys. Although noise may cause adverse effects to benthic organisms, these effects would be small and temporary, and recovery would occur without remedial or mitigating action.

The effect of noise on benthic habitats has not been studied in the Gulf of Mexico OCS or in deep water. However, laboratory analyses of the vulnerability of benthic marine invertebrates to both continuous and impulsive broadband noise has been conducted for several invertebrate species. Evidence indicates that marine intertidal hermit crabs (*Pagurus bernhardus L.*) (Roberts et al. 2016b), the venus clam (*Ruditapes philippinarum*), the Norway lobster (*Nephrops norvegicus*), and a species of brittlestar (*Amphiura filiformis*) (Solan et al. 2016) in response to sound propagation within sediments, can alter behaviors important to ecosystem functioning. This is likely due to mechanical particle motion as opposed to the pressure component of acoustic waves (Roberts et al. 2016b). Evidence also suggests that some organisms are capable of physiological and/or behavioral acclimation to variable acoustic impacts. Their capability to do so may be moderated by attributes at the level of the individual, including exposure history, environmental context, and physiological condition. Though species may persist within a soundscape, they may be subject to functional, fitness, and ecological stress (Solan et al. 2016) though it is still unclear whether these impacts are short- or long-term or have translatable community or population impacts (Roberts and Elliott 2017).

There is currently no evidence that shallow-water benthic communities are vulnerable to 3D seismic geophysical survey. A pre- and post-survey monitoring study of scleractinian corals at eight sites detected no effect to coral mortality, skeletal damage, or other visible signs of stress (Heyward et al. 2018). Differences in local environment, water depth, community structure, and potential survey parameters make it difficult to extrapolate these findings to the breadth of benthic habitats throughout the Gulf of Mexico.

Lighting and Visual Impacts (Chapter 2.6.1)

Components of artificial light spectrum have been documented reaching the seafloor (Tamir et al. 2017); however, direct effects to benthic organisms in the Gulf of Mexico have not been evaluated. Biological processes of benthic organisms that may be negatively impacted by seafloor irradiance from OCS oil- and gas-related activities such as vessel and platform lighting include circadian regulation, synchronization of coral spawning, recruitment and competition, vertical (diurnal) migration of demersal plankton, feeding patterns, and visual interactions (Tamir et al. 2017). Although artificial light may cause adverse effects to benthic organisms, these effects would be small and temporary, and recovery would occur without remedial or mitigating action.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Sessile benthic organisms commonly associated with OCS oil and gas structures are influenced by the presence of these structures. The presence, removal, and/or conversion of artificial hard substrate colonized by sessile invertebrates is likely to result in localized community changes, such as changes in species diversity in the local area (Schroeder and Love 2004). Larvae originating from productive coastal waters, carried by regional water movement, may colonize throughout the lifespan of the rig (Sink et al. 2010). Colonization and growth of these organisms likely represents biomass production (Macreadie et al. 2011). Oil and gas platforms off California are among the most productive fish habitat (secondary production) per unit area of seafloor of all marine ecosystems (Claisse et al. 2014). Spatial distribution of these organisms may shift over time because of the presence or removal of infrastructure in otherwise soft bottom-dominated areas. A change in a species' spatial distribution may have potential long-term effects related to dispersal and genetic connectivity to other populations of said species. Evidence of these types of changes has been documented for some shallow-water hermatypic species (Sammarco et al. 2012); however, parallel research in deep water is lacking.

At the end of their use-life, operators are required to remove platforms; however, as of April 2018, 532 decommissioned oil and gas platforms have been reefed on the Gulf of Mexico OCS. A typical four-leg platform jacket provides 0.81-1.2 ha (2-3 ac) of surficial hard substrate that may be colonized by benthic organisms (BSEE 2016). Reefed platforms may enhance biological productivity and facilitate the conservation and/or restoration of benthic organisms by restricting access to other bottom-disturbing activities such as bottom trawling (Macreadie et al. 2011). Microalgae and nearly all invertebrate taxa (i.e., corals, anemones, hydroids, sponges, bivalves, mollusks, and polychaetes) have been observed on artificial reefs (summarized in Macreadie et al. 2011). Communities that develop on artificial substrate are often different than those on natural reefs (Burt et al. 2009). Over long distances, both operating platforms and reefs may act as "stepping stones" across areas with little to no natural hard substrate that act to increase connectivity with biogeographical consequences (summarized in Cordes et al. 2016). This may include increased genetic homogeneity and reduced opportunity for allopatric speciation (Macreadie et al. 2011).

Offshore oil and gas platforms are also a known vector for the movement of non-native and invasive species (Bax et al. 2003; Simons et al. 2016). In the Gulf of Mexico, the most common introduced benthic species are the cup coral *Tubastraea* sp., mussels, and a diademnid ascidian. Mussels have the greatest impact through fouling, clogging, competition with indigenous species, and disease transfer. The ascidian smothered and overgrew other established (Sheehy and Vik 2010; Sink et al. 2010). *Tubastraea coccinea* has been reported on platforms along with indigenous coral species within 15 km (9.3 mi) of the Flower Garden Banks (Sammarco et al. 2004). *T. coccinea*, originally from the Pacific Ocean, is considered an invasive species in the Gulf of Mexico and prefers artificial to natural substrates; however, at this time, it does not appear to threaten natural coral communities (Kolian et al. 2017).

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that air emissions, coastal land disturbance, and socioeconomic factors are not likely to affect benthic communities and habitats. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.1)

Benthic habitats on the OCS are not expected to be vulnerable to air emissions from BOEM-regulated activity because the emissions would be localized, would dissipate quickly, and are not expected to reach the seafloor. There is no evidence that benthic organisms are directly vulnerable to atmospheric deposition.

Coastal Land Use/Modification (Chapter 2.5.1)

Benthic habitats on the OCS are not expected to be vulnerable to coastal land disturbance due to their distance from the coast. Refer to **Chapter 4.3.1** for an analysis of coastal and estuarine benthic habitats and organisms and their vulnerabilities to coastal land disturbance.

Socioeconomic Changes and Drivers (Chapter 2.8.2)

Benthic habitats on the OCS are not expected to be vulnerable to changes in socioeconomics as fluctuations in the economy should not effect seafloor habitats (refer to **Chapter 4.3.0**). Therefore, effects of socioeconomic factors on benthic communities were not analyzed.

4.3.2.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.2-2 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect benthic communities and habitats in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

The vulnerability of benthic habitats to an accidental release of oil or other contaminants from a surface vessel, well, pipeline, etc. would depend on the combination of several components: oil location (surface or subsurface); use of dispersants; if the oil is adsorbed to sediment particles; and certain spill-response activities.

Sublethal effects that may occur to benthic organisms exposed to oil or dispersants 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 exposed to oil 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. 2016) 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. 2016) that exceed probable exposure concentrations in the field.

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 were to come into contact with the benthic habitat and organisms, the impacts could be severe. Consequences may include mortality, loss of habitat, reduced biodiversity, reduced live bottom coverage, changes in community structure, and reduced reproductive success (Guzmán and Holst 1993; Negri and Heyward 2000; Reimer 1975; Silva et al. 2016). The extent and severity of impacts would depend on the location and weathering of the oil and the hydrographic characteristics of the area (Bright et al. 1978; Le Hénaff et al. 2012; McGrail 1982; Rezak et al. 1983). If dispersants are applied to a subsurface plume, any dispersed oil in the water column that comes into contact with corals may evoke short-term negative responses, including reduced feeding and photosynthesis or altered behavior (Cook and Knap 1983; Dodge et al. 1984; Ross and Hallock 2014; Wyers et al. 1986).

Chemosynthetic organisms are adapted to handle the limited amounts of hydrocarbons that are typical at slow-flowing seeps. It is possible that some deepwater coral species also have limited capabilities to endure oil exposure. Results from DeLeo et al. (2016) suggested that *Callogorgia delta*, a soft coral often associated with 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.

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). It is expected that the greatest amount of adsorbed oil particles would occur close to the spill, with the concentrations reducing over distance. If a spill does occur close to a benthic habitat, some of the organisms may become smothered by settling particles and/or other sediments and experience long-term exposure to hydrocarbons and/or oil-dispersant mixtures that could persist within the sediments (Fisher et al. 2014; Hsing et al. 2013; Valentine et al. 2014). Localized impacts may include reduced recruitment success, reduced growth, and reduced biological cover as a result of impaired recruitment (Kushmaro et al. 1997; Rogers 1990).

Response Activities (Chapter 2.9.2)

Benthic organisms are also vulnerable to spill cleanup/response activities. 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. 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.

Strikes and Collisions (Chapter 2.9.3)

It is expected that shallow-water hardbottom benthic habitats that are potentially vulnerable to accidental strikes from vessel traffic would occur only within the coastal zone and not on the OCS. A strike could cause breaking or fracturing of a hardbottom habitat, which could result in injury or death to those benthic species. In addition, vessel collissions could result in an oil spill, the effects of which are discussed in “Releases to the Environment” above. Refer to **Chapter 4.3.1** for an analysis of vulnerabilities to coastal and estuarine benthic habitats and organisms from accidental vessel collisions and strikes.

The OCS oil- and gas-related equipment could be inadvertently deposited or placed on benthic habitat. Accidental loss of equipment could occur during transfer operations between vessels and platforms, during vessel transit, during an “on deck” accident, because of a severe storm, or if a structure, drill, or anchor is unintentionally placed in the wrong location during operations. The vulnerability of benthic organisms from accidental placement of equipment on hardbottom habitat is largely the same as the effects discussed under routine OCS oil- and gas-related activities and could include crushing, breaking, compaction, and smothering of benthic communities. Accidental effects from bottom-disturbing equipment are expected to be infrequent and highly localized.

4.3.3 Pelagic Communities and Habitats

4.3.3.1 Resource Description

The pelagic habitats in the GOM are described in the following chapter, with a focus on associated planktonic communities. For more information on the larger biota that inhabit or utilize pelagic habitats, refer to **Chapter 4.3.4** for fish and invertebrates, **Chapter 4.3.5** for birds, **Chapter 4.3.6** for marine mammals, and **Chapter 4.3.7** for sea turtles. The pelagic zone (i.e., habitat) encompasses the entire water column from the surface of the water column down to the greatest depths (excluding the seafloor); pelagic communities include all swimming and floating organisms that reside in this water column. Although the pelagic zone is overwhelmingly large in extent and volume, the animals found within the various pelagic habitats are not randomly distributed (Hobday et al. 2011). The relationships of pelagic communities to pelagic habitat are complex and frequently tied to physical and chemical attributes that can vary seasonally and annually. Some pelagic habitats are more static and less susceptible to large-scale variations such as the deep-sea meso-, bathy-, and abyssopelagic zones. The pelagic zone is divided into two provinces: neritic and oceanic (**Figure 4.3.3-1**). Coastal and estuarine waters are considered part of the neritic province and span from the coast to the continental shelf break (water depths of 328-656 ft; 100-200 m). The oceanic province begins at the shelf break, continuing out into the open ocean.

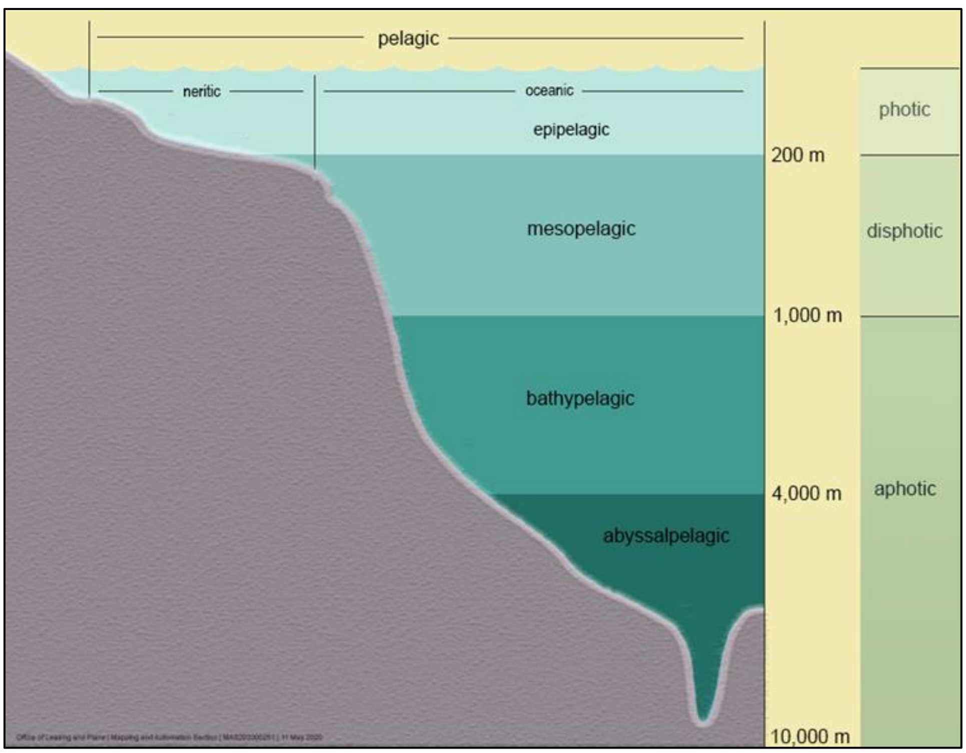


Figure 4.3.3-1. Oceanic Province Habitat Zones and Light Zones with Corresponding Depth Levels. The hadalpelagic zone is not depicted as not present in the Gulf of Mexico.

The neritic province encompasses all waters from the intertidal zone to the continental shelf break and contains only epipelagic waters (0-656 ft; 0-200 m). For this document, pelagic waters are considered to start at the 20-m (66-ft) isobath; therefore, not all of the neritic province is included in this analysis (refer to **Chapter 4.3.1**, Coastal Communities and Habitats). The neritic province is entirely penetrated by sunlight, which allows primary producers (e.g., phytoplankton) to photosynthesize. Phytoplankton also requires nutrients, which the neritic province receives from both land-based inputs (e.g., watersheds and associated outflows like major rivers, creeks, and groundwater) and deepwater, nutrient-rich upwelling events (**Chapter 2.2.2**). Wide temperature and salinity ranges occur throughout neritic waters, accommodating a variety of animal life. As a result, the neritic province is highly productive with high species richness and biodiversity supporting many commercial and recreational fisheries and ecotourism operations.

Further, neritic waters house some of the ocean's most complex habitats, including coral reefs, seagrass beds, and oyster reefs (refer to **Chapter 4.3.1** for more information on these coastal habitats). For more information on benthic habitats and associated communities in the neritic province, refer to **Chapter 4.3.2** for hard bottoms; for descriptions of the fauna that is commonly found utilizing these habitats, refer to **Chapter 4.3.4** for fish and invertebrate resources including EFH, **Chapter 4.3.5** for birds, **Chapter 4.3.6** for marine mammals, and **Chapter 4.3.7** for sea turtles.

The oceanic province includes all waters beyond the continental shelf. The oceanic province has different zones based on both sunlight (i.e., light zones) and habitat (i.e., oceanic province habitat zones). The three light zones of the oceanic province are the photic (with sunlight), disphotic (little to no light or perpetual twilight), and aphotic (no light) zones. The amount of sunlight, as well as water temperate and pressure, influence the organisms found within the different oceanic province subdivisions due to their mechanism for feeding (e.g., consumers, photosynthesizers, and decomposers). These influences result in a variety of unique adaptations such as bioluminescent lures (e.g., anglerfish). **Table 4.3.3-1** includes the water depths associated with these light zones as well as the oceanic habitat zones. There are five oceanic province habitat zones determined by depth; however, the depths and number of zones can change based on physiographic or ecological principles (Priede 2017). Generally, the different zones are the epipelagic, mesopelagic, bathypelagic, abyssopelagic, and hadalpelagic zone (Webb 2019). The GOM has no hadalpelagic waters; therefore, it will not be further discussed.

Table 4.3.3-1. Light Zone Water Depths Compared to Oceanic Province Habitat Zone Water Depths.

Light Zone	Water Depth (ft (m))	Oceanic Province Habitat Zone
Photic	0-656 (0-200)	Epipelagic
Disphotic	656-3,280 (200-1,000)	Mesopelagic
Aphotic	>3,280 (1,000)	Bathypelagic Abyssopelagic Hadalpelagic

Epipelagic Zone

The uppermost habitat zone in the oceanic province is the epipelagic zone. In the GOM, the temperatures of epipelagic sea-surface waters vary seasonally and can rise above 90°F (32°C) during the summer. This zone is entirely within the photic zone, allowing for photosynthesis by phytoplankton (e.g., diatoms) and other primary producers (e.g., autotrophic dinoflagellates). However, unlike the sunlit waters of the neritic province, oceanic epipelagic waters are generally nutrient poor. This can be attributed to the distance from shore (i.e., low nutrient input from land-based sources) and the photosynthetic organisms' rapid utilization of available nutrients (Webb 2019).

Consequently, primary producers in this oceanic province rely heavily on atmospheric deposition of nutrients, such as soil dust from deserts and other terrestrial habitats (Jickells and Moore 2015). Epipelagic species generally comprise the highest trophic level (Chen 2017) as either a tertiary consumer or an apex predator. Animals utilizing the epipelagic zone include marine mammals (**Chapter 4.3.6**), sea turtles (**Chapter 4.3.7**), birds (**Chapter 4.3.5**), and fish and invertebrates (**Chapter 4.3.4**).

***Sargassum* and Associated Communities**

There is a lack of natural structural habitat due to the oceanic province's depths and distance from shore. However, a unique floating habitat ubiquitous in the oceanic epipelagic zone in the GOM is *Sargassum (S. natans* and *S. fluitans*). *Sargassum* are pelagic species of free-floating, brown macroalgae that float in generally large mats, or "floating islands." These mats can be up to dozens of meters long as well as in diameter. *Sargassum* mats are not rigidly attached structures; thus, they can be broken up naturally by wave action as well as washed ashore (i.e., beached).

Sargassum provides an otherwise nonexistent essential habitat for several life functions for numerous species (**Table 4.3.3-2**). *Sargassum* is vital to several fish species as both nursery habitat and adult feeding grounds (refer to **Chapter 4.3.4.1** for more information). *Sargassum* habitat has been identified as potential foraging grounds for some marine mammals, particularly in frontal zones (Laffoley et al. 2011; Witherington et al. 2012). *Sargassum* is also designated as critical habitat by NMFS for the loggerhead sea turtle (refer to **Chapter 4.3.7** for more information; (DOC and NOAA 2014) and EFH by the South Atlantic Fishery Management Council for snappers, groupers, and coastal migratory pelagic fishes (DOC and NOAA 2003). During the first several years of sea turtles' lives in the Atlantic Ocean, juveniles rely on *Sargassum* mats as drift habitats for refuge from predators and sources of prey. The five sea turtle species that occur in the Atlantic have been recorded on the *Sargassum* mat in the Sargasso Sea, which originates in the GOM. Leatherback turtles use the Sargasso Sea as an important migration corridor during their annual migration (Inter-American Convention for the Protection and Conservation of Sea Turtles 2015). There is less information about habitat usage in the GOM. However, one study found that most of the observed sea turtles (representing four species) were within 3.3 ft (1 m) of a *Sargassum* mat, including both post-hatchlings and juveniles (Witherington et al. 2012). Pelagic seabirds (e.g., masked boobies, bridled terns, and black terns) also utilize *Sargassum* mats as foraging grounds and roosting sites (Haney 1986), with some species feeding directly on the algae and others on *Sargassum*-associated prey (Moser and Lee 2012).

Table 4.3.3-2. *Sargassum* Mats – Ecosystem Functions and Associated Animals.

Ecosystem Function	Associated Fauna
Nursery habitat	Billfish Jacks*† Dolphinfish Sea turtles Driftfish Swordfish** Filefish Triggerfish Flying fish Tunas
Feeding grounds for juvenile and adult commercially and recreationally valuable fish	Amberjacks Mackerels Billfish† Mahi-mahi Dolphinfish† Tunas† Jacks† Wahoo
Sole habitat	*Sargassum* swimming crab *Sargassum* nudibranch Slender *Sargassum* shrimp *Sargassum* frogfish

Sources: Dooley 1972; Lafolley et al. 2011; Witherington et al. 2012.
*Juvenile and sub-adults.
**Juveniles.
†*Sargassum* serves multiple functions.

Deep-Sea Zones (Mesopelagic, Bathypelagic, and Abyssopelagic)

Deep-sea pelagic habitat zones are defined here as those deeper than 656 ft (200 m). Deep-sea zones are some of the most stable environments in the ocean because of their vast depths, which may contribute to increased susceptibility to anthropogenic disturbances (Ashford et al. 2019; FAO 2020; Food and Agriculture Organization of the United Nations 2017). The deep-sea pelagic realm represents approximately 91 percent of the GOM's total volume and contains enormous taxonomical and functional diversity (Sutton et al. 2020). The deep-sea pelagic zone is one of the four "hyper-diverse" mid-water ecosystems in the World Ocean (Sutton et al. 2017; Sutton et al. 2020). Much of what is known about the GOM's deep-sea pelagic ecosystems has come from the collection of observations of meso- and bathypelagic organisms. No photosynthetic organisms live in the meso-, bathy-, and abyssopelagic because of the lack of sunlight. As such, many deep-sea organisms rely heavily on sinking organic matter from the epipelagic zone (i.e., marine snow) for energy.

In contrast, several mesopelagic fishes are active hunters, having highly sensitive, specially adapted eyes that allow them to see and hunt in low- to no-light zones (Priede 2017). Some deep-sea fish taxa have also developed very large mouths, hinged jaws, and expandable stomachs to take advantage of a variety of prey sizes. Additionally, fish and invertebrates in the deep sea have evolved the ability to emit light through bioluminescence (the biochemical emission of light) as a means of attracting prey, hunting prey without being seen (e.g., red bioluminescence in dragonfishes), avoiding predators, or communication (Douglas and Partridge 1997; Haddock et al. 2010). Diel vertical migration is a prominent and important behavioral adaptation of meso- and bathypelagic organisms to the shortage of food availability in deep-sea habitats. It represents the Earth's largest animal migration (Sutton 2013). Finally, cold temperatures and extreme water pressure effectively result in organisms with slow metabolisms that are long-lived and that exhibit "K" selected life history properties (e.g., low fecundity and low intrinsic rate of population recovery) (Pianka 1970; Priede 2017; Roberts 2002). Due to the challenges of living in an extreme habitat (e.g., low food availability, large migrations, and K-selected life history), organisms living in deep-sea pelagic habitats are highly adapted to those environments. Thus, pelagic habitats and communities are especially susceptible to perturbations in their environments and overexploitation.

Programmatic Concerns Influencing Pelagic Communities and Habitats

Climate Change

Climate change is a major environmental factor affecting pelagic habitats and communities in the GOM. Atmospheric temperature rise could lead to sea-surface temperature rise, altered wind and current patterns, increased freshwater inputs, and ocean acidification. Sea-surface temperature, sea-surface height anomalies, and wind speed have all gradually increased over 20 years. Still, primary productivity (expressed as chlorophyll-*a* concentrations) has shown no significant trends and has remained largely the same over the period (Muller-Karger et al. 2015). The long-term effects of rising sea-surface temperatures on pelagic plankton and larval fishes depend on species-specific factors. For example, model projections based on species-specific temperature tolerance of bluefin tuna (*Thunnus thynnus*) indicate that, as GOM water temperatures increase, spawn intensity decreases (Muhling et al. 2011). These could broadly affect planktonic organisms and the habitat suitability of pelagic waters.

Climate change impacts on *Sargassum* remain unknown as the habitat has a vast distribution. Increased temperatures could result in benefits to *Sargassum* by increasing the range where 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 improved larval survival. However, the growth rates could rise to a point where beach and shipping lanes fouling in the GOM and the Atlantic Ocean could create negative impacts on coastal communities. Additionally, water column stratification and changes in water current patterns could alter access to nutrients and move *Sargassum* mats into areas outside of its current range.

Ocean Acidification

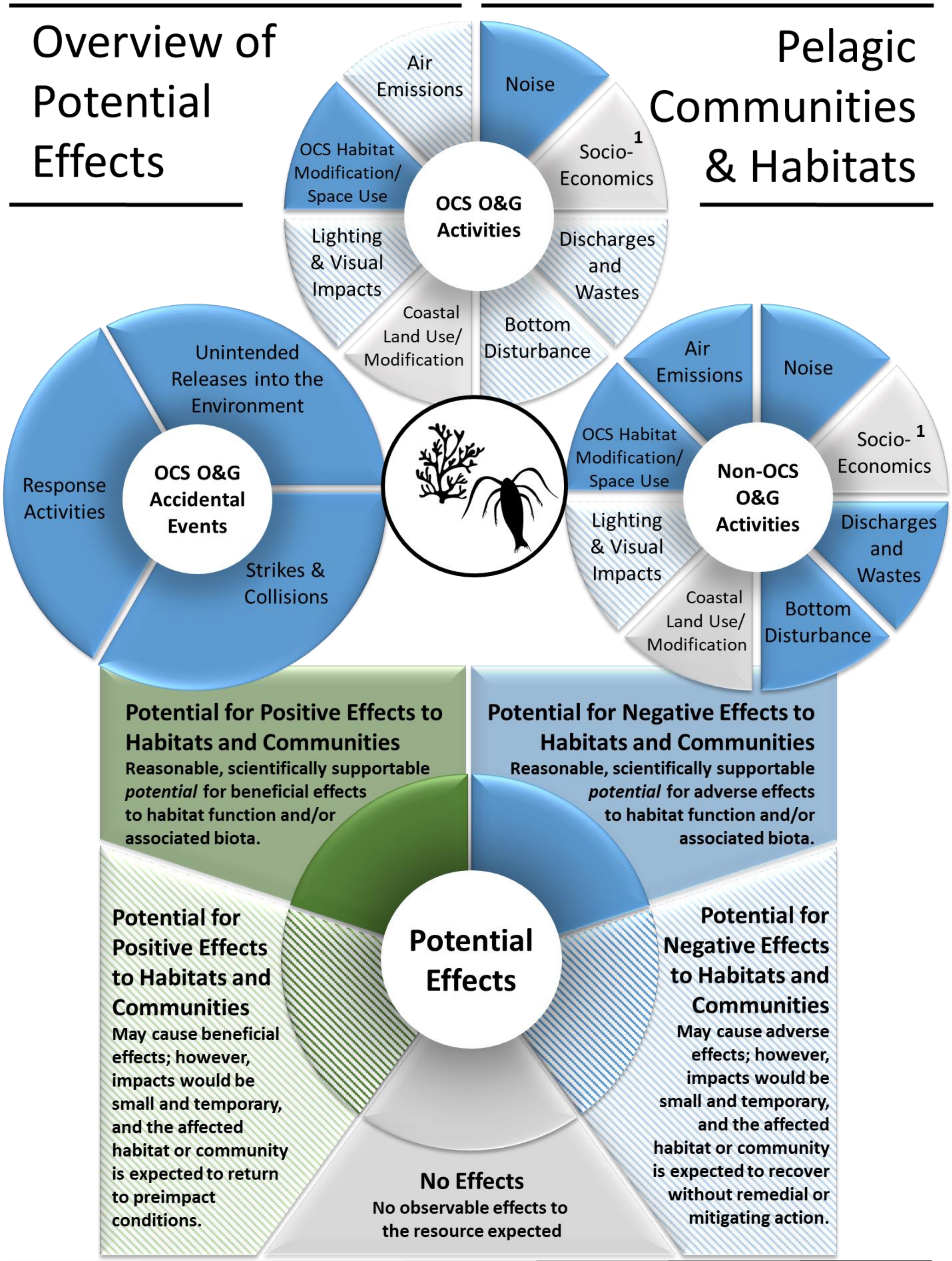
Ocean acidification and any related pH alteration in the pelagic environment has been documented to negatively affect the ability of planktonic organisms with calcium carbonate exoskeletons (e.g., crustaceans, foraminifera, and coccolithophores) to grow or maintain these structures (Fabry et al. 2008), leading to less prey biomass or lower prey quality at the base of the food web. These reductions could affect sensitive planktonic species from the organismal level to a larger population-level response. Additionally, ocean acidification could lead to alterations in carbon sequestration driven by these affected organisms. Carbon sequestration by planktonic organisms plays a crucial role in the large-scale ocean carbon cycles (Hays et al. 2005) and lead to larger-scale ecosystem responses. Organisms that colonize *Sargassum* could be impacted as pH levels fluctuate. Refer to **Chapter 4.3.4** for more information on how ocean acidification affects fish and invertebrates and **Chapter 3.4** for information on BOEM's efforts to assess ocean acidification and its impacts to the marine environment.

4.3.3.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and pelagic communities and habitats. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.3-2**. No IPF categories were identified to potentially have observable positive effects to pelagic communities and habitats.

Figure 4.3.3-2 is intended to highlight the relevant IPF categories and potential effects that are analyzed in this chapter, as well as highlight the IPFs that are not likely to cause population-level effects to pelagic communities and habitats and, therefore, would not likely warrant further analysis in a NEPA analysis for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities or resources, as well as the time of year and the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to pelagic communities and habitats, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.3-2. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Pelagic Communities and Habitats. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.3.3.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.3-2 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect pelagic communities and habitats in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

The relationships of pelagic communities to pelagic habitats are complex and frequently tied to physical and chemical attributes that vary seasonally and annually. These relationships can also be influenced by uncontrollable natural environmental events (e.g., tropical storms and freshwater inputs) and in some cases by the presence of anthropogenic structures and vessel activity, such as oil and gas infrastructure, maritime operations, military activities, commercial fishing, and recreational boating activities. These activities all contribute to the overall cumulative impact on pelagic habitats and communities. Most cumulative activities impact organisms in pelagic communities.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions and pollution from non-OCS oil- and gas-related activities may contribute to increased CO_2 uptake in pelagic waters, which is a factor of climate change, as well as acidic deposition, which is a factor of ocean acidification. Refer to the "Programmatic Concerns Influencing Pelagic Communities and Habitats" section in **Chapter 4.3.3.1** above for more information on the impacts of these environmental factors on pelagic habitats.

Discharges and Wastes (Chapter 2.2.2)

Pelagic habitats and communities would be exposed to discharges from permitted point sources (e.g., sewage treatment) and nonpoint sources (e.g., agricultural runoff, bilge, and gray water accidental releases), making the habitat less suitable. Cooling water used to cool machinery in LNG operations, seafood processing vessels, and existing State oil and gas production facilities can entrain and possibly kill large numbers of plankton, including larval fish and shrimp (Gallaway et al. 2007; USEPA 2006a). Operations requiring cooling water intake could occur throughout the GOM. The USEPA requires existing oil and gas operations, LNG vessels, and seafood processing vessels using over 2 million gallons of cooling water to use their best professional judgment to comply with Section 16(b) of the Clean Water Act (USEPA 2014). The amount of participating facilities and their locations might influence the level of impact on pelagic communities.

Eutrophication, often caused by non-point discharge and waste sources, has led to declining coastal water conditions in the GOM (**Chapter 3.3**) and could impact *Sargassum* and associated communities. Increased nutrient loading can lead to increased turbidity from plankton growth. On the other hand, increased nutrients could result in increased growth of *Sargassum*. A reduction in production could result in a decreased ability of *Sargassum* to sequester nutrients and carbon dioxide and to produce oxygen. In contrast, an increase in production could provide more habitat. The exact impact of declining water quality is currently unknown because *Sargassum* passively floats in and out of these waters, depending on oceanographic drivers. Further, much of the hypoxia and highly turbid waters occur nearshore where *Sargassum* typically does not reside or survive.

Eutrophication as a result of anthropogenic nutrients (e.g., runoff and industrial waste) also impacts pelagic habitats and communities at all trophic levels (Cloern 2001). Pelagic food webs can be affected when species abundance varies in response to the excess nutrient load, as well as possible harmful algal blooms. Higher trophic level species abundance can be reduced based on the extent of the bloom event, and commercially and recreationally important fishery pelagic species can be reduced as well (Vasas et al. 2007). Ecosystems have thresholds of nutrient loading, and when that threshold is passed, positive responses (e.g., increased fisheries production) no longer occur (Rabalais et al. 2002a). Further, when eutrophication occurs in the surface waters and hypoxia (i.e., oxygen deficiency) occurs in the bottom waters, fish stocks can shift (Rabalais et al. 2002a). Eutrophication impacts are not often localized and can have large-scale implications. Effects can include localized or temporary biodiversity loss, community structure shifts in pelagic and benthic systems, and habitat degradation (Nixon 1995; Rosenberg 1985, page 63). Hypoxia events can also lead to pelagic species displacement (Rabalais and Turner 2001b). As mentioned in **Chapter 4.3.3.1**, Saharan dust delivered to the eastern GOM carries iron, which has stimulated *Trichodesmium* blooms over the last 50 years (Lenes et al. 2001).

Bottom Disturbance (Chapter 2.3.2)

Pelagic organisms' (e.g., larval fish and zooplankton) feeding could be affected by increased turbidity from dredging, commercial fishing (e.g., bottom trawling), marine mining, marine construction, and scientific research. Turbidity is a reduction in water clarity due to the resuspension of seafloor particles. Turbidity in the water column can impact the planktonic communities of pelagic habitats. Suspended particles can reduce light penetration, making it more difficult for photosynthesis to occur (Grobbelaar 2009). This effect would likely happen in shallow, coastal waters where resuspension from bottom-disturbing activities could reach the photic zone (0-656 ft; 0-200 m). However, other studies have shown larval foraging success, and growth may benefit from resuspended nutrient-rich plumes (Gray et al. 2012; Wenger et al. 2014). Ichthyoplankton that cannot avoid turbidity can be exposed, with limited information suggesting that hatching success could be reduced or larval development delayed while other studies indicate that foraging success and growth may benefit (Gray et al. 2012; Wenger et al. 2014). For more information on bottom disturbance impacts on pelagic fish and invertebrates, marine mammals, and sea turtles, refer to **Chapters 4.3.4**, **4.3.6, and 4.3.7**, respectively.

Noise (Chapter 2.4.2)

Anthropogenic activities occurring in marine environments, such as shipping, military operations, commercial fishing, recreational boating, and underwater construction, potentially introduce abiotic noise into pelagic habitats, altering the ambient soundscape. A soundscape is the combination of biological, physical, and anthropogenic sounds in a seascape, which can temporally and spatially vary within a habitat. The physical structure of the habitat naturally impacts underwater soundscapes (e.g., bays, basins, and canyons), seafloor type (e.g., hard bottom and soft bottom), and intermittent geologic activity (e.g., underwater earthquakes, volcanoes, and mudslides). The daily movements of animals in and out of habitats in response to tidal and light cycles can alter the natural soundscape. Finally, seasonal changes can occur in response to weather patterns, tidal magnitudes, and local human activity (e.g., recreation, fishing, and shipping), which can alter the distribution and abundance of different organisms in an area. Anthropogenic sound sources could change the signature (i.e., original) soundscape of habitat, and the impacts of this depend on the type of sound produced (e.g., high-frequency and low-frequency), proximity to the source, and a variety of anatomical and behavioral factors that pertain to certain animal groups found in pelagic habitats. Soundscapes are essential to several biological functions, including communication, reproduction, predator avoidance, prey identification, and larval settlement in many marine organisms. As such, anthropogenic noise introduced into pelagic habitats may mask sounds needed for these critical behaviors. Refer to the following chapters for more information on the effects of noise on marine mammals (**Chapter 4.3.6.2**), sea turtles (**Chapter 4.3.7.2**), and fish and invertebrates (**Chapter 4.3.4.2**).

Lighting and Visual Impacts (Chapter 2.6.2)

Artificial lighting has the ability to attract some zooplankton (e.g., larval crustaceans and fish), potentially subjecting individuals to predation as well as altering the natural distribution in pelagic waters. Conversely, artificial lighting may increase individuals' ability to hunt (e.g., sight) for prey. Nighttime artificial lighting could interfere with biological functions of marine organisms that are synchronized with moon phases, including diurnal-based feeding patterns exhibited by pelagic organisms and demersal plankton (Tamir et al. 2017). Zooplankton diurnally vertically migrate through the water column to reduce predation risk based on light intensity (Cohen and Forward Jr. 2009; Gliwicz 1986), and artificial lighting may disturb this activity (Davies et al. 2014; Depledge et al. 2010; Moore et al. 2006). Lights on State oil and gas structures, LNG facilities, and moving or moored vessels contribute to the artificial lighting presence offshore. However, stationary structures (i.e., platforms) with a long-term presence are expected to have these effects on zooplankton communities. Because platforms light only a small volume of water around the structure, impacts to the pelagic habitat and communities are not expected to negatively affect habitat function or use by marine biota that would rise to a population level.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Anthropogenic Structures and Activities

Anthropogenic structures and activities may alter pelagic habitats and behaviors of organisms within pelagic ecosystems. State oil- and gas-related platforms, deepwater ports, military, and any future renewable energy-related infrastructure in the coastal northern GOM (e.g., platforms and monitoring stations) have similar impacts to the pelagic environment, as discussed in the "Offshore Habitat Modification/Space Use" section in **Chapter 4.3.3.2.2**. Anthropogenic activities (e.g., commercial shrimp trawling and recreational fishing) can alter the feeding behaviors of bottlenose dolphins (*Tursiops truncatus truncates*) (Lorenz 2015) and pelagic fishes (e.g., sharks, blackfin tuna

[*Thunnus atlanticus*], and yellowfin tuna [*Thunnus albacares*]), which are known to forage on the bycatch thrown overboard.

The OCS minerals program and OCS sand borrowing activities individually create short-term turbidity plumes. For more information on the impacts of turbidity on pelagic habitats and communities, refer to the “Bottom Disturbance” section above.

Vessel Traffic

Non-OCS oil- and gas-related vessels (e.g., recreation, commercial or recreational fishing, military use, shipping, or in support of non-OCS oil- and gas-related infrastructure) operating in pelagic waters may pose a risk to *Sargassum* habitats and their associated communities. For example, *Sargassum* mats are popular fishing locations amongst recreational and commercial fishers in offshore waters where they target adult, pelagic fish such as mahi-mahi, wahoo, and tripletail. This activity can cause direct damage to *Sargassum* from boat propellers as motorists propel through the mats (though unlikely due to potential propeller issues), as well as cause large mats to dislodge and break apart. Similarly, large shipping vessels can cause analogous damage when motoring through vast *Sargassum* mats, rather than moving around them. Because *Sargassum* is seasonally ubiquitous throughout the pelagic waters of the GOM and a lack of research exists investigating the effects of vessel traffic to these habitats and associated communities, the long-term impacts of these activities to *Sargassum* are unclear. Short-term impacts could include direct damage via laceration from propellers, as well as disturbance and displacement of organisms (Doyle and Franks 2015). Displacements are likely to be short term as the associated animals can actively swim back to the mats even if broken apart; however, the breaking up of *Sargassum* mats could potentially increase juvenile fish susceptibility to predation by adult predators (e.g., tunas). For more information on the effects of non-OCS oil- and gas-related vessel traffic on pelagic fish and invertebrates, birds, marine mammals, and sea turtles, refer to **Chapters 4.3.4.2.1, 4.3.5.2.1, 4.3.6.2.1, and 4.3.7.2.1**, respectively.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil- and gas-related activities and determined that coastal land use/modification and socioeconomic changes and drivers (refer to **Chapter 4.3.0**) are not likely to affect pelagic communities and habitats. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land use/modification occurs in coastal areas and is not expected to positively or negatively affect neritic or oceanic pelagic habitats. For more information on the effects of coastal land disturbance on coastal habitat and associated communities, refer to **Chapter 4.3.1**.

4.3.3.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.3-2 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect pelagic habitats and communities in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

All air emissions as a result of BOEM-regulated activities are permitted and regulated to a point that both onshore and offshore releases are unlikely to pose risk to pelagic communities and habitats. The Clean Air Act established the NAAQS for specified pollutants (42 U.S.C. §§ 7401 *et seq*.). As required by the OCSLA, BOEM assesses these in relation to oil and gas development projects, as well as volatile organic compounds to the extent that activities significantly affect the air quality of any State. BOEM-regulated activities release air emissions from sources related to drilling and production via vessels, flaring and venting, decommissioning, fugitive emissions, and oil spills.

Transport and dispersion processes via prevailing wind circulations immediately begin to circulate pollutants when released. Dispersion depends on several factors, including emission height, atmospheric stability, mixing height (i.e., the height above the surface through which vigorous vertical mixing occurs), exhaust gas temperature and velocity, and wind speed. The mixing height is important because it dictates the vertical space available for spreading the pollutants. Mixing height information in the GOM is scarce, but measurements near Panama City, Florida (Hsu et al. 1980) found that the mixing height can vary between 1,312 and 4,265 ft (400 and 1,300 m), with a mean of 2,953 ft (900 m). Heat flux calculations in the WPA (Barber et al. 1988; Han and Park 1988) indicate an upward flux year-round – highest during winter and lowest in summer.

Air emissions and pollution from OCS oil- and gas-related activities mostly occur above the sea surface but could indirectly affect pelagic waters through the absorption of CO_2. Emissions resulting from routine OCS oil- and gas-related activities are not anticipated to reach a level that would affect GOM pelagic habitat function or use by marine biota as these emissions are regulated and localized, and air pollution would dissipate quickly.

Discharges and Wastes (Chapter 2.2.1)

Elevated turbidity from routine discharges and wastes can reduce the amount of light available for photosynthesis by phytoplankton and could impair feeding opportunities for visual-foraging zooplankton (e.g., larval fish). Additionally, suspended material in the water can clog and damage appendages and feeding structures on some zooplankton species (Kjelland et al. 2015; Wilber and Clarke 2001). However, the impacts from this increased turbidity would be localized and short term due to dilution, thus not likely to cause a population-level impact on pelagic communities or habitat degradation to the GOM pelagic zone. Refer to **Chapters 4.3.7.2, 4.3.6.2, 4.3.4.2, and 4.3.5.2** for more information on the effects of discharges and wastes on water quality as well as pelagic sea turtles, marine mammals, fish and invertebrates, and birds, respectively.

Population-level effects to pelagic communities and negative effects to pelagic habitat function or use by marine biota would not be expected as all operational discharges and wastes are regulated. The USEPA and USCG regulate produced water, drilling muds, and cuttings' releases to keep contaminants below harmful levels. These, along with sanitary wastes, graywater, and miscellaneous discharges, are not expected to persist in the water column. Drilling muds released into the water column do not increase to high concentrations and only affect a small area of water (Neff 2005). Most mud cuttings settle rapidly to the seafloor and only around the drill site (area dependent on drilling depth and mud line cellar size). Impacts on water quality are localized and transient, thus unlikely to have lasting effects on pelagic habitats and associated communities. It is also assumed that operators on the OCS will adhere to additional BSEE regulations and BOEM guidance, as well as the USEPA (via the NPDES permits) and USCG regulations.

Bottom Disturbance (Chapter 2.3.1)

Bottom-disturbing activities can lead to resuspension of particulate matter and increased turbidity in the surrounding water column. Those effects on pelagic habitats and associated communities are discussed above. Turbidity from marine construction and seafloor activity related to OCS oil- and gas-related activities is expected to be a localized, temporary event and, therefore, would not affect the pelagic habitat's function over a long-term period. Otherwise, bottom disturbance from BOEM-regulated activity occurs on the seafloor, which is not considered pelagic habitat. For more information on the effects of bottom disturbance on benthic habitat and associated communities, refer to **Chapter 4.3.2**.

Noise (Chapter 2.4.1)

Several noise sources could potentially interact with pelagic habitats and associated communities in the GOM and are produced by either active acoustics (e.g., seismic surveying) or vessels and equipment. Noise has the potential to alter the soundscape in the pelagic zone (refer to the "Noise" section in **Chapter 4.3.3.2.1** above for more information about pelagic soundscapes). Little research has evaluated the physiological impacts of noise on eggs, zooplankton, and fish larvae that are a part of GOM pelagic communities.

Active Acoustics

The low-frequency underwater noise created by active acoustic noise sources (e.g., airguns) can affect the hearing and sound reception of organisms associated with pelagic habitats (McQueen et al. 2020). Seismic surveying could cause body malformations in planktonic organisms post-exposure (de Soto et al. 2013). Most of the work on noise impacts to plankton has been done on relatively small spatial scales (i.e., 10s of meters) and has shown minimal effects at these short distances (Booman et al. 1996; Dalen et al. 2007; Holliday et al. 1987; Kostyuchenko 1973; Pearson et al. 1994). McCauley et al. (2017) observed an elevated mortality rate in zooplankton after exposure to seismic airguns at larger distances (>3,280 ft; 1,000 m); however, Richardson et al. (2017) modeled that, despite a spike in the mortality rate, zooplankton would recover quickly due to rapid turnover, natural mixing, and high rates of reproduction. The impact zone from airgun surveying can overlap with pelagic habitats also occupied by marine mammals, sea turtles, fish and invertebrates, and diving seabirds. For more information on the impacts of active acoustics on these resources, refer to **Chapter 4.3.6.2** for marine mammals, **Chapter 4.3.7.2** for sea turtles, **Chapter 4.3.4.2** for fish and invertebrates, and **Chapter 4.3.5.2** for birds.

Vessel and Equipment Noise

Vessels (i.e., semisubmersibles, drillships, heavy lift vessels, and crew and supply vessels) contribute to anthropogenic noise in pelagic habitats. Other equipment noises could be added from construction activities (e.g., pile-driving), drilling, dredging, and decommissioning activities (e.g., explosives). These noise sources can impact the soundscape of pelagic habitats with the potential to impact the abundance and distribution of pelagic organisms throughout the GOM. These noise sources can also lead to direct and indirect impacts on pelagic organisms. For example, some fish larvae use acoustic signals to maintain group cohesion (Staaterman et al. 2014) or to navigate towards appropriate settlement habitat (Montgomery and Coombs 2011; Montgomery et al. 2006; Radford et al. 2011; Simpson et al. 2005). High-intensity decommissioning noises (e.g., explosives) possibly cause irreversible damage to the internal anatomy and physiology of planktonic organisms if they are close to the sound source (Govoni et al. 2003; Govoni et al. 2008), but most work on noise impacts to plankton has been done on a small scale (Bolle et al. 2012; Govoni et al. 2008). For more information on the impacts of vessel and equipment noise on these resources, refer to **Chapter 4.3.6.2** for marine mammals, **Chapter 4.3.7.2** for sea turtles, **Chapter 4.3.4.2** for fish and invertebrates, and **Chapter 4.3.5.2** for birds.

Lighting and Visual Impacts (Chapter 2.6.1)

Lighting as a result of OCS oil- and gas-related activities has effects on phototactic organisms (e.g., dinoflagellates) and can attract such organisms to sources of lights (e.g., platform lighting). This alteration of the natural light field could lead to a higher abundance of such organisms around offshore platforms and increased ability to see and hunt prey. One study found that the type of lighting used can affect the amount of light that can reach deeper in the water column. LED lighting with a stronger blue component was found to reach the highest depth (Tamir et al. 2017). The irradiance of lighting is also an important factor as some artificial lighting is equal to or exceeds the irradiance of a full moon. Nighttime light pollution caused by such artificial lighting could interfere with the biological functions of marine organisms that are synchronized with moon phases as discussed in the "Lighting and Visual Impacts" section in **Chapter 4.3.3.2.1** above. Negative impacts on the planktonic community in pelagic habitats could have cascading effects on the food web. Further, the consumption of phytoplankton by the migrating zooplankton higher in the water column and the subsequent defecation of fecal pellets lower in the water column (Cohen and Forward Jr. 2009; Hays 2003) is a major carbon cycle pathway in marine environments (Davies et al. 2014). Despite the possible effects of artificial lighting, routine OCS oil- and gas-related activities are not anticipated to affect GOM pelagic habitat function or use by marine biota. The OCS oil- and gas-related lighting is not expected to reach a level that could cause widespread habitat degradation to pelagic habitats.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

The emplacement of platforms for BOEM-regulated activities in GOM pelagic habitats has long-term impacts as they remain in the water column for up to several decades. During this time, platforms can become ecologically important artificial reefs and support higher biodiversity than surrounding open waters. This habitat alteration exists in a habitat that would otherwise have no vertical structures, aside from natural topographic highs (e.g., coral reefs, pinnacles). In areas where the water bottom is mostly soft sediment, installed platforms create the opportunity for hard bottom habitats to exist. These structures can attract pelagic species of sea turtles, marine mammals, and seabirds likely by providing foraging opportunities (Gitschlag et al. 1997; Lohoefener et al. 1990; Ronconi et al. 2014; Todd et al. 2020). Refer to **Chapters 4.3.7.2**, **4.3.6.2, and 4.3.5.2**, respectively, for more information on offshore habitat modification impacts on these resources.

Fish and invertebrates are also attracted to structural habitats. The large-scale introduction of platforms in the pelagic GOM waters has created a network of artificial reefs that attract and enhance the production of pelagic species of fish (Franks 1999; Franks et al. 2015; Gallaway et al. 2019). One study found indirect evidence of the potential spawning, nursery, and recruitment habitat provided by platforms (Shaw et al. 2002). Moreover, the predominant taxa of post-larval and juvenile fishes collected down current of platforms are primarily represented by pelagic species and pre-settlement stages of soft-bottom taxa, which may be taking advantage of the high zooplankton and ichthyofauna concentrations near the platforms (Shaw et al. 2002). These organisms are likely attracted to the light field or the structure provided by the platforms in an otherwise barren underwater landscape as discussed in the "Offshore Habitat Modification/Space Use" section in **Chapter 4.3.3.2.1** above.

Drill spudding, offshore infrastructure emplacement, and structure or pipeline removal individually create short-term turbidity plumes and have similar impacts to the pelagic habitat and communities as the activities described in **Chapter 4.3.3.2.1**. A reduction in phytoplankton would cascade into a decline of the zooplankton that feeds on them. This can have downstream effects on fish and invertebrate species (Fiksen et al. 2002). Turbidity effects would occur in the bottom waters surrounding the activity area. (BOEM 2011).

Vessel traffic in pelagic waters could also affect pelagic communities. Vessels transiting through the area may increase local circulation and turbulence (e.g., ship wake), which could cause mortality or injury to some planktonic organisms nearby. This is not likely to have substantial impacts, as the abundances of planktonic organisms are naturally high and variable. Further, the effects of ship wake would be localized and small scale in nature. Vessel traffic can also impact larger pelagic organisms; refer to **Chapters 4.3.6**, **4.3.7**, **4.3.5, and 4.3.4** for more information on the impact on marine mammals, sea turtles, birds, and fish and invertebrates, respectively.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that coastal land use/modification and socioeconomic changes and drivers are not likely to affect pelagic communities and habitats.

Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land disturbance from OCS oil- and gas-related activities occurs in coastal areas and waters that do not overlap geographically with pelagic habitats and communities and, therefore, would not be expected to affect pelagic communities and habitats. For more information on the effects of coastal land disturbance on coastal habitat and associated communities, refer to **Chapter 4.3.1**.

4.3.3.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.3-2 highlights the IPF categories of accidental events associated with OCS oil- and gas-related activities on the OCS that could potentially affect pelagic habitats and communities in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

Accidental events can occur on the Gulf of Mexico OCS from BOEM-regulated activities. These include oil and chemical spills, oil-spill response, accidental collisions, vessel strikes, and marine trash and debris. Pelagic habitat and associated communities are affected by oil and chemical spills and oil-spill response. The pelagic habitat itself is not vulnerable to accidental collisions or vessel strikes; instead, marine organisms in the pelagic communities could be affected. For more information about these effects, refer to **Chapter 4.3.6.2.3** for marine mammals, **Chapter 4.3.7.2.3** for sea turtles, **Chapter 4.3.4.2.3** for fish and invertebrates, and **Chapter 4.3.5.2.3** for birds.

Unintended Releases into the Environment (Chapter 2.9.1)

All marine trash and debris from OCS oil- and gas-related activities are regulated. However, the accidental release of marine debris could occur. Losses of large quantities of debris are rare, but losses of smaller pieces might happen. Floating debris is subject to the same oceanographic processes that influence and move *Sargassum* mats, which can lead to marine trash and debris rafting together with *Sargassum*. This may have little impact on the plants themselves but can impact the associated organisms. Given the lack of stationary GOM gyres, marine trash and debris are not expected to remain long enough in contact with the mats to undergo degradation. Some could be advected within the Gulf Stream and carried to the mid-Atlantic, where it could undergo degradation.

Accidental surface releases of oil from platforms or vessels or seafloor releases from pipelines or wellheads could affect pelagic habitats. Habitat quality, as well as local ecosystem functions, would be temporally reduced. Impacts from accidental small spills are expected to be short-term due to dilution and hydrocarbon breakdown. Upper water column and sea-surface spilled oil could enter the epipelagic food web and reduce zooplankton that grazes on phytoplankton, causing phytoplankton blooms and subsequent effects (Fisher et al. 2016). This could have indirect impacts on fish and invertebrates, marine mammals, sea turtles, and birds.

Response Activities (Chapter 2.9.2)

Burning, skimming, and chemical dispersants or coagulants can affect pelagic habitats and associated communities, including *Sargassum*, sea turtles, marine mammals, and sea-surface fishes (e.g., flying fishes). Burning could kill pelagic biota in the activity area. Skimming could remove pelagic biota from the activity area or trap them in oiled water (BOEM 2011). These cleanup processes could also trap and destroy patches of *Sargassum*; however, these patches would likely already by destroyed by oil contamination even if the response activities were absent.

Though unlikely to be used on smaller spills, dispersants could also affect pelagic habitats and associated communities in the water column. Chemicals used during an oil-spill response are toxic, though less toxic than spilled oil (Hemmer et al. 2011; National Research Council 2005b) , and their toxicity varies by dispersant type as well as varying levels of toxicity among species (CDC 2010; Fingas 2017). There is controversy about whether the combination of oil and dispersants is more toxic than oil alone (Fingas 2017; Holland-Bartels and Kolak 2011; National Research Council 2005b). Post-*Deepwater Horizon*, many lab-based studies sought to determine the toxicity of oil, dispersed oil, and dispersants. However, due to a lack of consistency in the media preparation, exposure procedures, and chemical analyses (National Research Council 2005b), researchers have been unable to determine a comprehensive conclusion on the toxicity of oil and dispersants. The National Academy of Sciences published guidance on how to address these inconsistencies in future research to address the controversy over the toxicity of chemically dispersed oils (National Academies of Sciences, Engineering, and Medicine 2020). Dispersants blend with oil, thus mimicking impacts of an oiled area and increasing the areal extent of oil dispersion and subsequent exposure of pelagic communities (BOEM 2011; National Academies of Sciences, Engineering, and Medicine 2020).

Strikes and Collisions (Chapter 2.9.3)

Vessel strikes could occur with *Sargassum* mats and associated communities. *Sargassum* would either encounter the vessel hull or the propulsion systems, possibly resulting in breaking up the mat into smaller pieces, death of the *Sargassum* plants, or dislodging or death of epiphytic organisms or organisms living near the mats. If individual plants are broken into moderately sized pieces, it is expected that the plants would continue to grow as multiple separate entities. Organisms that survived dislodgement from the mat are expected to return to the mat once the vessel passes.

4.3.4 Fish and Invertebrates

4.3.4.1 Resource Description

The GOM has a taxonomically and ecologically diverse assemblage of fish and invertebrates due to its unique geologic, oceanographic, and hydrographic features as discussed in **Chapter 3**. Felder and Camp (2009) reported that the GOM has a total of 1,541 fish species in 736 genera, 237 families, and 45 orders. Fifty-one of these species are sharks and 42 are comprised of rays and skates (Ward and Tunnell Jr. 2017). The GOM invertebrate assemblages are represented by over 13,000 species in 46 phyla (Felder and Camp 2009) and include recreationally and commercially valuable shellfish such as eastern oyster, blue crab, penaeid shrimp, spiny lobster, and stone crab.

Additionally, the number of described species for both GOM fish and invertebrates continues to increase over time due to ongoing exploration of deep-sea ecosystems.

Like fish found along the U.S. Atlantic Coast from Cape Hatteras, North Carolina to Cape Canaveral, Florida, fish in the northern GOM are generally temperate (Carolinian) (Sherman et al. 1991). Conversely, the southerly waters of the continental shelf contain tropical fish species, which can be found occupying hard bottom habitats (e.g., natural banks and artificial reefs). These species likely originated from the southern, tropical waters of the GOM and beyond, and were carried north via the Loop Current. Many of these tropical fishes and invertebrates, along with other endemic species, are year-round residents in the northern GOM. Other large, pelagic species found in the northern GOM (e.g., whale sharks, giant manta ray, and bluefin tuna) occur seasonally and are highly migratory. However, continued satellite tagging efforts in the northern GOM have indicated that some adult highly migratory species (e.g., blue marlin and yellowfin tuna) exhibit more residency than previously assumed (Kraus et al. 2011; Weng et al. 2009).

Fish and invertebrates in the GOM can vary spatiotemporally due to ontogenetic (i.e., development from egg to adult) shifts in habitat use. For example, movements can include cross-shelf migrations of larvae, juveniles, and adults to and from estuarine and coastal waters (e.g., Gulf menhaden and penaeid shrimp). For others, habitat shifts are predominantly food-driven, resulting in vertical migrations through the water column in search of prey — a behavior commonly observed in deep-sea fish and invertebrates (Flock and Hopkins 1992; Hopkins and Baird 1985; Salvanes and Kristoffersen 2001). For highly migratory species, seasonal shifts in habitat use are correlated to reproduction and food availability. Less mobile species can include those attached to or primarily living in the benthos as adults and juveniles (e.g., sponges, corals, oysters, and tilefish), and their larval stages are the only time when these animals are highly mobile. During this period, egg and larvae movements are driven by coastal and oceanic currents (e.g., the Loop Current and associated spin-off eddies), topography, and wind, but they are not randomly distributed. For example, in the north-central GOM, adjacent to Mississippi River plume waters, the larvae of billfish and swordfish (Rooker et al. 2012), as well as phytoplankton, copepods, and other pelagic fish larvae (Dagg and Whitledge 1991; Govoni 1997; Lohrenz et al. 1990) are found in higher densities within frontal zones proximal to the Loop Current (refer to **Chapter 3.3**). Further, variability in the survival of pelagic eggs and larvae during transport are thought to be important determinants of future year-class strength in adult fish and invertebrate populations (Doherty and Fowler 1994).

The GOM also includes deep-sea meso-, bathy-, and abyssopelagic habitats and their associated species of fishes and invertebrates (refer to **Table 4.3.4-1** and Chapter 4, Fish and Invertebrate Resources, of BOEM’s Biological Environmental Background Report [BOEM 2021b]). Many organisms living within the meso- and bathypelagic zone exhibit diel vertical migration behaviors, where they swim up into surface waters at night to feed. This behavior has far-reaching ecological implications because these organisms become available prey for epipelagic marine mammals, seabirds, and fishes. Conversely, species like swordfish and oceanic marine mammals (i.e., dolphins and toothed whales) dive to these habitats during the day to feed on deep-sea cephalopods (e.g., squids and octopus) and fish (e.g., lanternfish). Knowledge of abyssopelagic assemblages and community structure in the GOM is very limited. In general, abyssopelagic waters (>13,000 ft; 3,962 m) can be characterized as energy-poor, resulting in an exponential decrease in animal biomass compared to shallower water habitats (e.g., coastal waters). There is currently no active oil and gas production taking place in abyssopelagic areas of the GOM.

Table 4.3.4-1. Examples of Fish and Invertebrate Taxa and Species Based on Water Depths. (Knowledge of abyssopelagic assemblages and community structure in the GOM is very limited and, therefore, was not included.)

Water Column Zone	Water Depth	Associated Fishes	Associated Invertebrates
Epipelagic	Surface – to 656 ft (200 m)	halfbeaks, flying fishes, early life stage driftfishes, yellowfin tuna, bluefin tuna, mahi mahi, swordfish, marlin, sailfish, giant manta ray, oceanic white tip shark, short fin mako shark, whale sharks	crustaceans (e.g., copepods), squids, chaetognaths, polychaete worms, pelagic octopus, gelatinous organisms (e.g., tunicates and ctenophores), pteropods
Mesopelagic	656-3,281 ft (200-1,000 m)	lanternfishes, bristlemouths, hachetfishes, dragonfishes, Atlantic angel shark, six gill sharks	crustaceans (e.g., amphipods, copepods, decapod shrimps, and ostracods), squids, pelagic octopus, gelatinous organisms (e.g., tunicates, cnidarians), pteropod and heteropod mollusks
Bathypelagic	>3,281 ft (1,000 m)	lanternfishes, bristlemouths, hachetfishes, anglerfish, dragonfishes, smooth-heads, fangtooths, whalefishes, cookie cutter shark, sleeper shark	crustaceans (e.g., decapod shrimps, *Lophogastrida* spp., mysids, amphipods, copepods, and ostracods), squids, gelatinous organisms (e.g., tunicates and cnidarians)

4.3.4.1.1 Commercial and Recreational Fishery Species

Federally managed fishery resources within the program areas include 183 species managed under six Fishery Management Plans (FMPs). Species are grouped as corals (142), reef fish (31), shrimp (4), coastal migratory pelagic fish (3), red drum (1), spiny lobster (1), and stone crab (1). Coastal migratory pelagic fish species (e.g., herrings, mullets, mackerels, jacks, cobia, and coastal sharks) are jointly managed by the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council. In addition to these FMPs, 39 highly migratory species (e.g., oceanic sharks, tunas, billfishes, and swordfish) occurring in the GOM are managed by NMFS' Office of Sustainable Fisheries, Highly Migratory Species Management Unit.

The reef fish management unit consists of 31 species represented by six families, primarily snappers and groupers. In the northern GOM, red, grey, and vermillion snappers are the primary snapper species targeted both recreationally and commercially, and for groupers, the species primarily captured include red, gag, scamp, black, and yellowedge groupers. The remaining reef fish families include nine species of tilefish, jacks, triggerfish, and wrasses. Out of these, the most sought-after species are the greater amberjack, grey triggerfish, hogfish, and tilefish (i.e., golden and blueline).

Red drum is managed within their own FMP and is an estuarine-dependent fish that represents a widely popular and lucrative recreational fishery throughout the GOM (refer to **Chapter 4.4.3**). Four species of penaeid shrimp (i.e., brown shrimp, white shrimp, pink shrimp, and royal red shrimp) are managed under the GOM shrimp FMP and are some of the most valuable GOM commercial fisheries. Lastly, spiny lobsters and stone crab are each managed under their own FMP and are primarily found and regulated in the southeastern GOM along the southwestern coast of Florida, including the Florida Straits.

In addition to federally managed species, the Gulf Coast States (Florida, Alabama, Mississippi, Louisiana, and Texas) each manage coastal fisheries within their State waters. State-managed species include economically valuable fish (e.g., southern flounder, black and red drum, spotted seatrout, Gulf menhaden, and Atlantic croaker) and shellfish (e.g., penaeid shrimp, eastern oyster, and blue crab).

Essential Fish Habitat

Portions of the ranges and associated habitats of the federally managed species above have been recognized by Congress as "those waters necessary for spawning, breeding, feeding or growth to maturity" (16 U.S.C. §§ 1801 *et seq.*). As such, these habitats have been designated as EFH and are given additional protection through the Magnuson Stevens Fishery Conservation and Management Act (as amended through January 12, 2007). To date, there are EFH designations for red drum, reef fish (32 species), coastal migratory pelagic fishes (3 species), stony coral, black coral, shrimps (4 species), spiny lobster, and highly migratory species (48 species). Collectively, the spatial extent of EFH designations in the GOM covers extensive areas, effectively encompassing all coastal estuaries and large portions of nearshore and offshore waters. Refer to Chapter 4.4.3.1 of BOEM's Biological Environmental Background Report for more information on EFH, the process by which it is designated, and currently managed species (BOEM 2021b).

4.3.4.1.2 Threatened and Endangered Species

Several fish and invertebrate species occurring in the coastal and marine habitats of the GOM are listed as threatened or endangered under the ESA. Threatened species include the Gulf sturgeon, Nassau grouper, oceanic whitetip shark, giant manta ray, and several species of coral. The coral species listed under the ESA are discussed in Chapter 4.1 of BOEM's Biological Environmental Background Report (BOEM 2021b). The smalltooth sawfish is the only endangered fish listed in the GOM to date. Refer to Chapter 4.4.3.2 of BOEM's Biological Environmental Background Report for descriptions and more information on currently listed species in the GOM.

4.3.4.1.3 Programmatic Concerns Influencing Fish and Invertebrates

Fish and invertebrates in the GOM are subject to a variety of programmatic stressors, both natural and anthropogenic factors, which cumulatively affect individuals and populations or act synergistically with the IPFs discussed below and potentially worsen the effects described below.

Major Storm Events

Major storm events (e.g., hurricanes) can affect fish and invertebrate assemblages and community structure in estuarine habitats. The downstream effects to fish and invertebrates largely depend on the characteristics of individual storms (Greening et al. 2006). For example, slow-moving storms that produce a lot of rainfall appear to have more substantial impacts than do fast-moving storms with higher winds (Paerl et al. 2006). Heavy rainfall from storms can lead to changes in estuarine salinity regimes and may cause hypoxia events in some cases (Stevens et al. 2006). The literature generally shows that salinity changes and subsequent hypoxia due to major storms result in acute, short-term effects to organisms with rapid recovery and evidence of long-term resiliency (Greening et al. 2006; Stevens et al. 2006). For example, eastern oyster populations in the Apalachicola Bay system impacted by two hurricanes in 1985 exhibited a high degree of resiliency with full recovery of populations observed within a 12-month period (Livingston et al. 1999). Similarly, fish assemblages decreased dramatically after the passing of a Category 4 hurricane in Charlotte Harbor, Florida, but recovered within 1 month (Stevens et al. 2006). Although there is evidence of general resiliency in fish and invertebrate assemblages in the GOM to the effects of hurricanes, biological sensitivity indices created by Christensen et al. (1997) indicate that sensitivities to subsequent changes in salinity are species-specific and vary between estuaries. The biological responses of species to temporally irregular disturbances (i.e., major storms) is also highly dependent on the timing of the event relative to the natural history of the population (e.g., spawning season and life phase) (Livingston et al. 1999).

Land Loss and Sea-Level Rise

The continued loss of coastal land and estuarine habitats (e.g., wetlands and mangroves) due to sea-level rise and major storms (refer to the “Major Storm Events” section above) can be problematic for fish and invertebrates that utilize these habitats. This is particularly true for species whose juveniles rely on estuarine habitats as nursery grounds (e.g., red drum, blue crab, speckled trout, Gulf menhaden, and penaeid shrimp). Many adult fish also utilize these habitats as feeding grounds and as shelter from predators. In contrast, Fujiwara et al. (2019) found that the effects of sea-level rise for 150 species of GOM fish and invertebrates will result in increased occupancy probability for 90 species and decreases for 33 (remaining species neither increase or decrease). Increases in species diversity was shown across the coast of Texas, likely due to the range expansion of many tropical species (Fujiwara et al. 2019).

Climate Change

Global climate change has resulted in rising temperatures in the world’s oceans, including the GOM. This is particularly the case in coastal waters, which it is problematic for organisms such as shallow-water corals (refer to **Chapter 4.3.2**, Benthic Communities and Habitats). Impacts to coastal habitats (e.g., coral reefs) have indirect effects to fish and invertebrates that rely on and utilize these habitats for foraging, reproduction, shelter, and cleaning stations (e.g., sharks and rays). Further, warming waters are expected to increase the proliferation of pathogens and subsequent disease in marine organisms. This can occur through changes in the distribution and abundance of their hosts, direct changes in the ecology of hosts and/or pathogens, and the extension of geographical range of pathogens (Marcogliese 2008).

In addition to warming waters, excess CO_2 in the atmosphere is absorbed by the oceans, reducing ocean pH (i.e., ocean acidification) and carbonate ion concentrations, as well as altering the levels of calcium carbonite saturation. Experimental evidence suggests that changes in these levels will result in impairing corals, calcareous phytoplankton, as well as larval mollusks and echinoderms from maintaining their calcium carbonite skeletons (Hoegh-Guldberg et al. 2017; Orr et al. 2005), which could have impacts that extend up the food chain.

Invasive Species

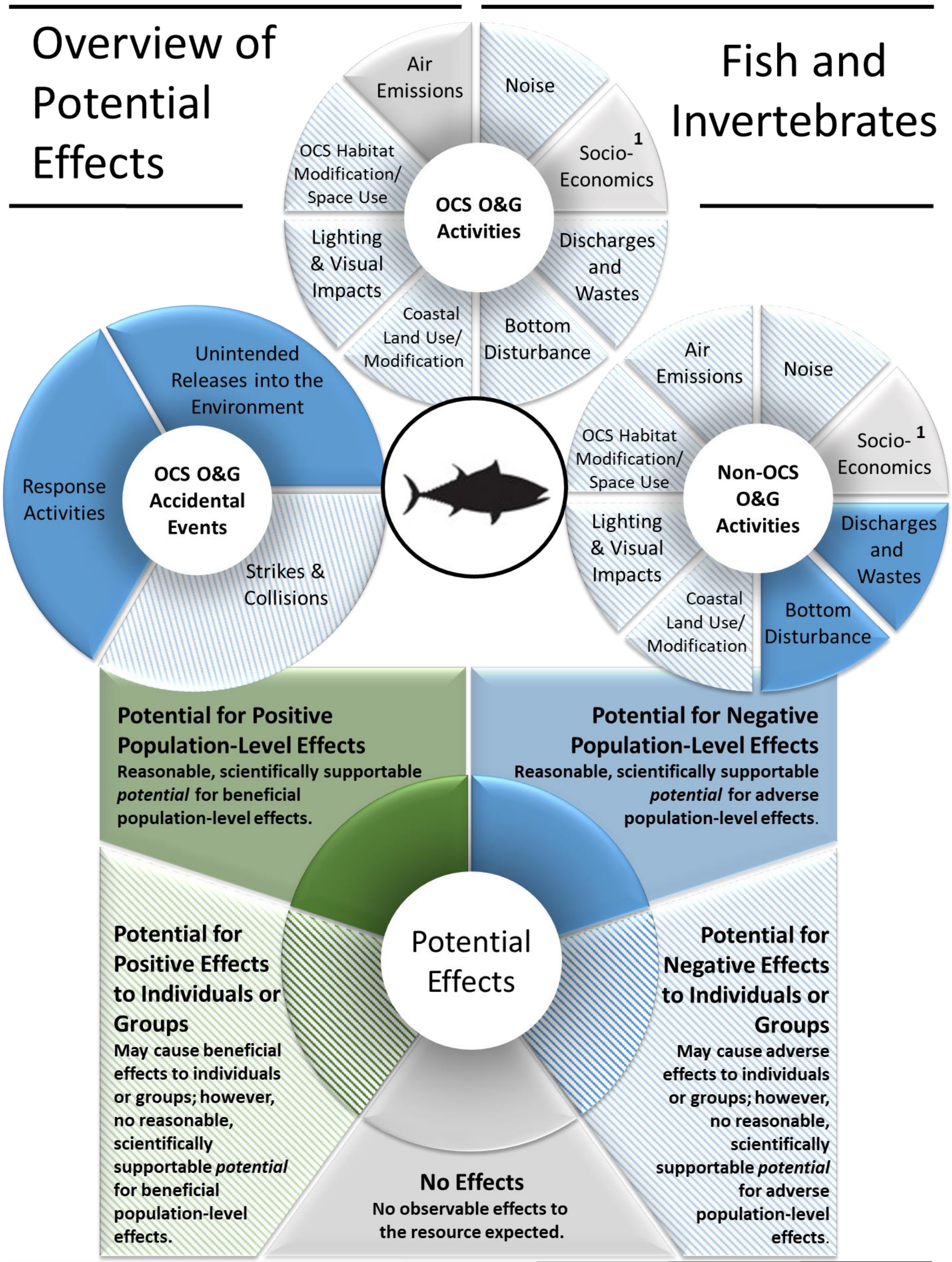
The introduction of nonnative species into the GOM is well documented and includes both aquatic fish and invertebrates (e.g., Asian tiger shrimp and lionfish), which threaten ecosystems through competition, habitat displacement, and/or predation of endemic species. Climate change and subsequent warming of coastal and oceanic waters are expected to affect the distribution of parasites, pathogens, and invasive species, intensifying their proliferation and expanding their ranges (Marcogliese 2008).

4.3.4.2 Description of Potential Effects

BOEM’s interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and fish and invertebrates. Direct effects occur via commercial and recreational fishing (**Chapter 4.4.3**), bottom-disturbing activities (e.g., the emplacement of artificial reefs; **Chapter 2.3**), and underwater noise produced from anthropogenic sources such as vessel traffic and underwater construction (**Chapter 2.4**). Fish and invertebrates are also indirectly affected by coastal land use/modification (**Chapter 2.5**) and discharges and wastes from various sources (e.g., river discharge) (**Chapter 2.2**).

The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.4-1**. No IPF categories were identified to potentially have observable positive effects to fish and invertebrates.

Figure 4.3.4-1 is intended to highlight the relevant IPF categories and potential effects that are analyzed in this chapter, as well as highlight the IPFs that are not likely to cause effects to fish and invertebrates and, therefore, would likely be scoped out of future NEPA analyses for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM’s Biological Environmental Background Report (BOEM 2021b).



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.4-1. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Fish and Invertebrates. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to fish and invertebrates, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

4.3.4.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.4-1 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect fish and invertebrates in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions from anthropogenic activities may contribute to climate change-induced effects such as increased CO_2 uptake in the GOM, which may have downstream effects to fish and invertebrates. Adverse effects from non-OCS oil- and gas-related air emissions and pollution would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects. **Chapter 2.1.2** provides emissions estimates for onshore and offshore emissions sources not related to OCS oil- and gas-related activities; however, the degree to which these contribute and influence CO_2 uptake and other processes is not well understood. Refer to **Chapter 4.3.4.1.3** for more information on the impacts of programmatic issues such as climate change to fish and invertebrates.

Discharges and Wastes (Chapter 2.2.2)

Discharges and wastes can come from a variety of non-OCS oil- and gas-related sources, which collectively impair coastal waters on a Gulf-wide scale. The most profound of which is the influx of freshwater, chemicals, and other materials (e.g., plastics) from the Mississippi and Atchafalaya River Basins into northcentral GOM waters. Other large bays in the GOM also receive discharges and wastes from upland waters, albeit with smaller footprints (e.g., Galveston Bay, Texas, and Mobile Bay, Alabama). These waters carry an abundance of nutrients (e.g., nitrogen and phosphorus) from point and nonpoint sources of pollution from approximately 41 percent of the contiguous United States. These inputs can cause decreases in salinity and light penetration, as well as increases in phytoplankton production, turbidity, and organic material load (Bianchi et al. 2013). The excess of nutrients has resulted in a more widespread hypoxic zone in the northcentral GOM, which occurs during the summer and which has deleterious effects primarily for nonmobile benthic organisms. Free-swimming pelagic organisms are generally less susceptible to hypoxia than benthic organisms because they can detect and actively avoid hypoxic waters (Howell and Simpson 1994). Additionally, these inputs can assist in the proliferation of toxic dinoflagellates, which have been known to cause "red tide" events along the Gulf Coast and elsewhere. Red tide events can result in mass mortalities of fishes and invertebrates and are a substantial cumulative stressor to coastal marine and estuarine habitats.

Chemical waste-product inputs from accidental discharges or nonpoint sources in upland areas can result in the release of pollutants such as cyanide, zinc, lead, copper, cadmium, PAHs, PCBs, persistent organic pollutants, and mercury from river basins to coastal habitats in the GOM. Although the volumes of pollutants have likely been diluted when they reach coastal waters, they can persist and accumulate in soft sediments. Pollutants can then be transferred to higher trophic levels via benthic and pelagic pathways (Chen et al. 2009). For example, apex predators like sharks are particularly susceptible to the biomagnification of pollutants such as PAHs, PCBs, and persistent organic pollutants (Cullen et al. 2019; Weijs et al. 2015). Similarly, tunas are a well-known taxa of apex predator that are susceptible to the biomagnification of mercury. However, the long-term, sublethal effects of this accumulation to populations are unknown.

Releases of trash and debris, specifically plastics, from river basins into the GOM is commonplace, and the persistence of plastic is long-lasting. Plastics entering coastal and oceanic waters eventually breakdown into microplastics, making them available for consumption by small suspension- and filter-feeding organisms (e.g., copepods and herrings). Documented negative effects from ingestion of microplastics include changes in feeding behavior and physiological processes (e.g., growth, survival) (Cole et al. 2015; 2016). However, a meta-analysis of the scientific literature investigating the effects of microplastic exposure on consumption (and feeding), growth, reproduction, and survival of fish and aquatic invertebrates revealed that many of the studies showed neutral effects and inter-species variation (Foley et al. 2018). The most consistent effect was a reduction in consumption of natural prey when microplastics were present, as well as examples of within taxa negative effects to growth, reproduction, and survival (Foley et al. 2018).

Other non-OCS oil- and gas-related discharges and wastes affecting fish and invertebrates occur primarily within coastal habitats (e.g., wetlands, bays, and estuaries) and include stormwater runoff from upland and coastal development, watershed modification (e.g., channelization), and the discharge of grey water from vessels. Upland activities can introduce contaminants or pollutants from agricultural runoff, wastewater discharges, and municipal discharges resulting in the degradation of water quality, which can negatively affect wetlands and seagrasses (**Chapter 4.3.1**, Communities and Habitats). Degradation to seagrass habitats could negatively affect fish and invertebrate communities occupying these habitats and using them as nursery grounds. For example, juvenile reef fishes and invertebrates, such as spiny lobster and blue crabs, are known to use seagrass beds as nursery habitat and foraging grounds (Bortone and Williams 1986; Flaherty-Walla et al. 2017; Handley et al. 2007). Additionally, permitted discharges of bilge can result in the introduction of invasive species (refer to **Chapter 4.3.4.1.3**).

The introduction of discharges and wastes into the GOM from the aforementioned sources work synergistically to degrade marine and estuarine waters by causing widespread hypoxic zones, introducing pollutants (e.g., chemicals and heavy metals, plastics) into aquatic food webs, inducing toxic algal blooms (e.g., red tide), and introducing invasive species. These stressors and their subsequent effects occur throughout the GOM on a scale that is large enough to reasonably impact populations of fish and invertebrates (**Chapter 2.3.2**, Bottom Disturbance).

While the long-term, cumulative impacts of bottom trawling (commercial shrimp fishery) and oyster dredging gear to fish and invertebrate resources in the GOM are unclear, the use of both types of gear causes bottom disturbance, altering the structure and composition of benthic and epibenthic communities (Watling and Norse 2008). In soft-sediment habitats, infauna (i.e., annelid and echiuran worms, bivalve mollusks, and amphipod crustaceans) and epifauna (i.e., shrimps, crabs, and some fishes), as well as their burrows and tubes can be displaced, injured, damaged, and/or buried (Sparks-McConkey and Watling 2001; Watling and Norse 1998). Exposure of infauna caused by the bottom trawling and dredging gear can also increase the risk of predation by mobile, epibenthic predators, which live on or just above the seafloor (Kaiser and Spencer 1994). The effects to biodiversity are the most pronounced in environments that experience less natural disturbance (e.g., continental shelf and slope waters), where storm-wave damage is less prevalent and biological processes such as growth tend to be slower in both fish and invertebrates (Roberts 2002; Watling and Norse 1998). For example, unlike shallow-water penaeid shrimp, royal red shrimp captured via bottom trawl gear along the continental shelf of the northern GOM (range extending between 180 and 730 m [591 and 2,395 ft]) live for several years and can be found living amongst long-lived, cold-water corals (e.g., *Lophelia* spp.) (Stiles et al. 2007).

Temporary disturbance of sediments and related increases in turbidity from other non-OCS oil- and gas-related activities (e.g., sand mining, sediment dredging and disposal, anchoring, and marine transportation) can cause a variety of detrimental or beneficial species-specific effects in fish and invertebrates. For some species, detrimental effects of increases in turbidity include negative impacts to egg and larval development, alarm and fleeing responses, reduced oxygen availability, decreased feeding efficiency, and increased predation (Johnson 2018; Wilber and Clarke 2001). Benefits of increases in turbidity include enhanced growth rates in adult and larvae due to increases in food availability, increased feeding efficiency, and enhanced predator avoidance (Johnson 2018; Wilber and Clarke 2001). The total concentration of suspended sediments in the water column, duration of exposure, and the availability of habitat allowing for avoidance largely determine the potential effects of turbidity to fish and invertebrates.

Other bottom-disturbing activities (e.g., propeller scarring and anchoring) can cause damage to submerged aquatic vegetation, which can have negative consequences for fish and invertebrate assemblages associating with these habitats. Propeller scarring occurs when vessels ride over seagrass in shallow water, and engine propellers come into direct contact with the seafloor. Although seagrasses can recover from propeller scarring, the process is slow, species dependent, and affected by prevailing winds and currents (Burfeind and Stunz 2005).

Noise (Chapter 2.4.2)

Underwater noise is introduced into GOM waters though a variety of non-OCS oil- and gas- related activities, including recreational boating activities, commercial fishing vessels, cruise ships, cargo vessels, military activities, dredging operations, and in-water construction, which may synergistically interact to affect fish and invertebrates. These sounds can be continuous (e.g., constant sounds of vessel traffic near busy ports) or pulsed (e.g., pile-driving) and cumulatively add anthropogenic inputs to the natural underwater soundscape.

Vessel traffic is recognized as a major contributor to anthropogenic ocean noise, primarily in the low-frequency bands from below 30 to 500 Hz, which is likely to be detected by most fish species (Popper et al. 2019). Vessel traffic is considered a continuous sound source and is particularly prevalent in and around major shipping ports, commercial and recreational fishing harbors, and coastal tourism towns along the Gulf Coast. Low-frequency, continuous sound sources may result in masking, whereby the background noise levels increase the threshold in which a sound can be detected. Masking can impact any fish species that use sound for several possible reasons, including communication, finding or attracting mates, detecting prey and predators, orientation and migration, and habitat selection (Popper et al. 2019). Pulsed sounds generated from in-water construction activities (e.g., pile-driving) can result in behavioral responses, impaired hearing, and even physiological damage in fish. Data for marine invertebrate responses to anthropogenically produced sounds have indicated both behavioral responses and the potential of physiological injury to both adults and embryos (André et al. 2011; de Soto 2016; Nedelec et al. 2014; Solan et al. 2016).

Masking of important biologically relevant sounds has the potential to increase predation, reduce foraging success, and reduce reproductive success; however, proximity to the source, signal characteristics, received peak pressures relative to the static pressure, cumulative sound exposure, species, and the receiver's prior experience all influence the level of impact on individuals (Popper et al. 2014b; 2019). Further, 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 (Hawkins and Popper 2018; Popper and Fay 1993; 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. Additionally, 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.

Most studies focusing on the effects of sound exposure to fish and invertebrates have been conducted in laboratories, so do not accurately represent the acoustics in natural aquatic environments and the ability of mobile species to leave the activity area (Popper et al. 2019). Data have supported that increased stress levels occur in fish and invertebrates with limited or no mobility in the vicinity of busy harbors with continuous background noise (e.g., coral reef fishes); however, any long-term, sublethal effects are still unclear. Adverse effects from non-OCS oil- and gas-related noise would likely be temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects. For more detailed information regarding the vulnerabilities of fish and invertebrates to underwater sound, refer to Chapter 4.5.1 of BOEM's Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

Coastal development, which includes beachfront construction of homes, hotels, restaurants, harbors, and roads, is a substantial contributor to coastal land use/modification not associated with OCS oil- and gas-related activities. These developments can indirectly affect fish and invertebrates through modification and/or loss of preferred habitat (refer to **Chapter 4.3.1**, Coastal Communities and Habitats), as well as from water quality degradation associated with runoff, which can degrade submerged aquatic vegetation, as discussed in the "Discharges and Wastes" section above). However, adverse effects from non-OCS oil- and gas-related coastal land use/modification would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects.

Lighting and Visual Impacts (Chapter 2.6.2)

Artificial lighting from non-OCS oil- and gas-related activities largely include dock lighting at night. Privately owned homes, public fishing piers, restaurants, and industry-related infrastructure (e.g., shipping and commercial fishery docks) all emit light at night into coastal waters. This creates conditions that would not naturally occur, and the effects to fish and invertebrates are not well understood. Limited research has suggested alterations in predator-prey interactions, potentially creating unnatural top-down regulations of fish populations in coastal urbanized areas (Becker et al. 2013). For example, under artificial lighting, predators can visually hunt prey that would normally be resting and taking refuge under the cover of darkness. Other research has indicated that sessile marine invertebrate assemblages illuminated at night are more vulnerable to predation (Bolton et al. 2017; Davies et al. 2015). Further, it is possible that unanticipated effects such as sub-optimal settlement site selection of invertebrate larvae can occur, increasing post-settlement mortality (Davies et al. 2015). The cumulative impacts of lighting would likely be more pronounced in heavily developed coastal towns; however, potential impacts to populations, if any, are not well understood. Non-OCS oil- and gas-related lighting and visual impacts would likely are not expected to cause population-level effects.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

The emplacement of artificial reef structures in the GOM is a common and wide-spread practice, resulting in both inshore and offshore habitat modifications. Offshore artificial reefs are typically created from recycled materials such as ships and decommissioned oil and gas structures, as well as concrete reef balls and pyramids. These structure emplacements may impact the distribution of species in an area (Carr and Hixon 1997; Gallaway et al. 2009; Shipp and Bortone 2009), and it is generally assumed that artificial structures serve as both fish-attracting and production-enhancing devices (i.e., producing an increase in the total population), depending upon the species (Carr and Hixon 1997; Gallaway et al. 2020; Gallaway et al. 2009; Shipp and Bortone 2009). The resulting assemblages frequently include commercially and recreationally valuable coastal and oceanic fishes. A typical objective of entities who emplace artificial reefs in offshore waters is the enhancement of fishery production and the creation of recreational fishing opportunities (refer to **Chapter 4.4.3**, Recreational Fishing, for a more detailed discussion), which may subject some fishes to locally increased fishing pressure (Addis et al. 2013; Dance et al. 2011).

Commercial and recreational fishing directly affects the abundances of fish and invertebrates in the GOM, although improvements in fishery management techniques and science have been able to improve stock levels for many commercially and recreationally valuable species. To date, grey triggerfish and greater amberjack stocks are the only federally managed fisheries in the GOM currently experiencing overfishing (NMFS 2020f). However, several gear types such as long-lines (surface and bottom) and trawls (bottom and midwater) can result in the bycatch and mortality of many species that are important both ecologically as predators and/or prey and socioeconomically (e.g., juvenile red snapper, Atlantic croaker, and bluefin tuna). This can result in potential damages to future year-classes, reduce prey availability, and damage benthic habitat for many GOM fish and invertebrate species. Adverse effects from non-OCS oil- and gas-related offshore habitat modification/space use would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects. However, it is likely that a combination of factors including overfishing, bycatch in fishing gear, and other anthropogenic factors (e.g., climate change) contribute to declines in populations (Diamond et al. 2000).

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil- and gas-related activities and determined that socioeconomic changes and drivers are not likely to affect fish and invertebrates for the reasons discussed in **Chapter 4.3.0**. Therefore, socioeconomic changes and drivers were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

4.3.4.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.4-1 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect fish and invertebrates in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.1)

Routine discharges and wastes associated with OCS oil- and gas-related activities in the GOM include sanitary wastes, gray water, cooling water, and miscellaneous discharges (e.g., bilge, ballast, and fire water; and deck drainage), as well as drilling muds and cuttings. Sources of these discharges are vessels (i.e., support, service/construction, seismic, and drilling) and platforms. The USEPA and USCG administer regulations and permits that are designed to keep contaminants in operational discharges and wastes below harmful levels (refer to **Chapter 2.2**). Once the contaminants are discharged into the water column, they are not expected to persist for long, particularly when considering the depths at which OCS oil- and gas-related activities occur along the continental shelf and beyond where they are exposed to strong currents, wind, and wave action.

Current evidence has shown that any observed effects of drilling wastes, as well as produced water, are local and generally confined to the water column and seabed between 1,000 and 2,000 m (3,281 and 6,562 ft) from the source and that widespread impacts to fish and invertebrate communities and populations are generally low (Bakke et al. 2013). The discharge of drilling fluids and cuttings offshore may contribute to localized, temporary marine environmental degradation (Neff 2005), particularly when shunted to the seafloor. For example, drilling muds and cuttings shunted to the seafloor can cause turbidity in the water column and sedimentation on the seabed, which can be problematic for species with limited to no mobility (e.g., corals and sponges) (refer to **Chapter 4.3.2**, Benthic Communities and Habitats). For mobile fish and invertebrates, time restrictions in place for drilling operations may allow for avoidance of large discharge plumes, although territorial reef fish and low-mobility invertebrates may be displaced from impacted habitats. Adverse effects from OCS oil- and gas-related discharges and wastes would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects. For more information, refer to Chapter 4.5.2 of BOEM's Biological Environmental Background Report (BOEM 2021b).

Bottom Disturbance (Chapter 2.3.1)

Anchoring, drilling, trenching, jetting, pipe-laying, dredging, 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. Cuttings discharged at the surface tend to disperse in the water column and are distributed at low concentrations (Continental Shelf Associates Inc. 2004a). In deep water, cuttings discharged at the sea surface may spread 1,000 m (3,280 ft) from the source, with most of the sediment deposited within 250 m (820 ft) of the well (Continental Shelf Associates Inc. 2006). Cuttings shunted to the seafloor form piles concentrated within a smaller area than that affected by sediments discharged at the sea surface (Neff 2005). Infrastructure emplacement (i.e., pipelines, platforms, and subsea systems) can also displace large volumes of sediment, resulting in increased turbidity and sedimentation.

Fish and invertebrates exposed to increases in turbidity and sedimentation may exhibit species-specific behaviors, including reduced or enhanced feeding efficiency, decreased or increased predator avoidance, and behavioral responses (Benfield and Minello 1996; Chesney et al. 2000; De Robertis et al. 2003; Jönsson et al. 2013; Lunt and Smee 2014; Minello et al. 1987). Mobile fish and invertebrates are expected to avoid the heaviest sedimentation and highest suspended sediment loads within 10 m (33 ft) of a disturbance. Sessile marine invertebrates (e.g., corals and sponges) may be affected by bottom-disturbing activities (refer to **Chapter 4.3.2**, Benthic Habitats and Communities). Ichthyoplankton cannot avoid sediment plumes at or near the surface and may be exposed for longer durations than adults. However, evidence suggesting that increased turbidity may reduce hatching success or delay larval development is limited and other studies have shown that larval foraging success and growth may benefit from nutrient-rich plumes (Gray et al. 2012; Wenger et al. 2014). Coastal fish and invertebrate species adapted to turbid environments (e.g., shallow bays, estuaries, and coastal habitats) may be less vulnerable and highly adapted to increased turbidity in the water column than species inhabiting less turbid environments. Adverse effects from OCS oil- and gas-related bottom disturbance would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects. For more information regarding the effects of bottom-disturbing activities to fish and invertebrates in the GOM, refer to Chapter 4.5.3 of BOEM's Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.1)

All routine OCS oil- and gas-related activities (e.g., seismic surveys, vessel traffic, propeller cavitation, and rotating machinery) have an element of sound generation, which can stimulate a behavioral response, mask biologically important signals, cause temporary or permanent hearing loss (Popper et al. 2005), or cause physiological injury resulting in mortality (de Soto 2016; Popper et al. 2014b). Masking of important biologically relevant sounds has the potential to increase predation, reduce foraging success, and reduce reproductive success; however, proximity to the source, signal characteristics, received peak pressures relative to the static pressure, cumulative sound exposure, species, and the receiver's prior experience all influence the level of impact on individuals (Popper et al. 2014b; 2019). Further, 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 (Hastings and Popper 2005; Popper and Fay 1993; 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. Additionally, 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; Popper et al. 2019). These factors are of particular importance when considering the use of data and results produced by various studies. For example, the recent study by McCauley et al. (2017) was conducted in shallow waters near Tasmania, Australia, and the methods used differ significantly from and are not representative of OCS seismic survey activities. While the study is informative, care should be taken in interpreting the study results.

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 fish and invertebrate resources. 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 fish 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, life-stage, experience, and motivation are very important factors and indicating that habituation may occur (Engås et al. 1996; Løkkeborg et al. 2012; Popper et al. 2014b). 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. 2014b). 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 is not likely. For eggs and larvae, the literature generally states that mortality or changes in pathology could occur when they are located within 0-5 m (0-16 ft) of an airgun blast, with detrimental effects occurring closer to the source. At distances of more than 10 m (33 ft), detrimental effects to fish eggs were detected only at very low levels (Turnpenny and Nedwell 1994); however, effects may be species-specific. For example, dungeness crab larvae exposed to airgun blasts at 1-, 3-, and 10-m (3-, 10-, and 33-ft) distances from an airgun array did not show differences in survival rates compared to control groups (Pearson et al. 1994).

Electromechanical sources, such as towed transmitters used to search for hydrocarbons in deep water, use extremely low frequencies (electromagnetic fields <300 Hz). As such, the estimated impact of an operator's methods on fishery resources that are highly dependent on electromagnetic sensory capabilities (e.g., sharks, rays, and skates) would be negligible as the operational frequency of the electromagnetic emissions are very low and the potential exposure times are short (Buchanan et al. 2011).

Routine vessel traffic associated with OCS oil- and gas-related activities to and from offshore facilities introduces sound into the aquatic environment. However, OCS oil- and gas-related vessel traffic generally occurs in deep, offshore waters and is widely dispersed. Additionally, the majority of bottom sediments in the northern GOM, where many OCS oil- and gas-related activities occur, are comprised of soft muds and clays that absorb sound. Negative impacts associated with noise from vessel traffic has been primarily observed in shallow, coastal habitats to fish and invertebrates with limited to no mobility that are continuously subjected to the sound source (refer to the "Noise" section in **Chapter 4.3.4.2.1**). Any negative effects of sound from OCS oil- and gas-related vessel activity in shallow waters would be localized and limited to a small number of channels leading to onshore facilities. Any potential negative impacts of OCS oil- and gas-related vessel noise to fish and invertebrates (e.g., masking) would be short term and is not expected to have population-level effects.

For explosive severance (e.g., platform decommissioning), the resulting rapid oscillation in the pressure waveform associated with detonation can cause fish and invertebrate mortality. These pressure waves cause rapid contraction and overextension of the swim bladder in fish, which can be problematic for the majority of managed species in the GOM (e.g., snappers, groupers, tilefishes, jacks, triggerfishes, wrasses, cobia (a coastal pelagic migratory fish), and bluefish (a species that is not managed but is taken by fishers). Fish mortalities that occur as a result of platform decommissioning can impact the number and age structure of fishes in localized communities. However, studies of the associated mortality for several recreationally and commercially important fishes with swim bladders (e.g., red snapper, greater amberjack, vermillion snapper, grey triggerfish, and cobia) have indicated that the level of explosive severance activity in the GOM does not significantly alter stock levels (Gallaway et al. 2020; Gitschlag et al. 2001). Although these studies were limited and cannot be directly applied to all species or habitats, it is reasonable to assume that other represented fish stocks would respond similarly. Fish without or with less developed swim bladders are generally more resistant to underwater blasts (Goertner et al. 1994) and include protected species such as the Gulf sturgeon, which have a swim bladder but no hearing specializations. Sawfish are a protected species of elasmobranch present in the GOM that do not have a swim bladder. Managed fish species without swim bladders include mackerels (e.g., Spanish, king, and cero) and some tunas (e.g., skipjack and little tunny). Dolphinfish, which also do not have a swim bladder, are not managed but are taken in commercial and recreational fisheries. Impacts to sessile benthic organisms (e.g., barnacles and bivalves) and 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. For more information regarding the effects of sound to fish and invertebrates from BOEM' routine OCS oil- and gas-related activities, refer to Chapter 4.5.1 of BOEM's Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land disturbance from routine OCS oil- and gas-related activity can indirectly impact fish and invertebrate resources and include navigation canal dredging, vessel traffic, and the construction of new onshore facilities and pipeline landfalls. The creation of new pipeline landfalls has decreased significantly since the 1970s, and coastal infrastructure is confined to a few locations in the northern GOM. Vessel traffic and maintenance dredging of canals leading to onshore processing facilities can cause increased turbidity in the water column and sedimentation of benthic organisms; however, the effects are expected to be minimal as the majority of fish and invertebrate assemblages occupying coastal habitats in the northern GOM are adapted to living in turbid environments and would be less vulnerable than organisms in other regions. Any new construction and routine vessel traffic to and from onshore processing facilities can also introduce sound into the underwater soundscape, but any negative effects from continuous sound exposure from vessel traffic leading to onshore facilities would be localized and are not expected to result in population-level impacts, as discussed in the "Noise" section above. Nonpoint sources of pollution from onshore facilities could also occur, particularly as run-off from paved surfaces during a heavy rain event, although the total contribution would be localized and de minimus compared to cumulative run-off received from other sources (e.g., river outflows and coastal developments) (refer to **Chapter 2.2**).

Lighting and Visual Impacts (Chapter 2.6.1)

As discussed in Chapter 4.5.7 of BOEM's Biological Environmental Background Report (BOEM 2021b), BOEM's onshore facilities, docked vessels, and offshore oil- and gas-related structures (e.g., standing platforms, drillships, tension-leg platforms, etc.) emit artificial lighting at night.

Research on the effects of artificial light to fishes and invertebrates is limited. Artificial light at night emitted from analogous anthropogenic infrastructure (e.g., floating restaurants and piers) has been shown to alter predator-prey interactions, potentially creating unnatural top-down regulations of fish populations in coastal, urbanized areas (Becker et al. 2013). In offshore waters, similar relationships have been observed, indicating that larval, juvenile, and adult piscivores (e.g., jacks and mackerels) take advantage of the attraction of prey (both planktonic organisms and small planktivorous fishes) to artificial lighting from OCS oil- and gas-related infrastructure (Keenan et al. 2007). Conversely, fishes observed using SONAR under shore-based infrastructure have been shown to be more abundant and relatively sedentary under no-light conditions, indicating their natural use of these structures for shelter during the night (Bolton et al. 2017). Unnaturally introduced light at night has also been shown to indirectly affect assemblages of sessile invertebrates by increasing the amount of predation during a time when these organisms likely perform essential activities such as spawning, settlement, and feeding under reduced predation pressure (Bolton et al. 2017; Davies et al. 2015). Further, artificial light illuminating shallow benthic communities at night may give rise to unanticipated effects such as sub-optimal settlement site selection and consequent increases in post-settlement mortality in sessile marine invertebrates (Davies et al. 2015). However, the long-term consequences of these effects are not well understood, and population-level impacts have not been observed.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Routine OCS oil- and gas-related activities that cause offshore habitat modifications include infrastructure installations (e.g., platforms, pipelines, and subsea systems). Although structure emplacements are temporary, the operational life is long term (usually years to sometimes multiple decades) and may impact the distribution of species in an area (Carr and Hixon 1997; Gallaway et al. 2009; Shipp and Bortone 2009), creating vertical, hard-substrate in a region dominated by soft sediments. These structures act as de facto reefs, allowing for the settlement of encrusting invertebrates, which then attracts higher trophic-level organisms. It is generally assumed that artificial structures serve as both fish-attracting and production-enhancing devices (i.e., producing an increase in the total population), depending upon the species (Carr and Hixon 1997; Gallaway et al. 2020; Gallaway et al. 2009; Shipp and Bortone 2009). The resulting assemblages frequently include commercially and recreationally valuable coastal and oceanic species. 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 (Addis et al. 2013; Dance et al. 2011). However, the removal of infrastructure also impacts fish and invertebrates associated with the substrate. Structure removal is necessary to restore the pelagic and benthic habitat to its natural state, 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, fish, and invertebrates (Schroeder and Love 2004).

Some structures may be converted to artificial reefs via the Rigs-to-Reef program (refer to **Chapter 2.3.2.4**). 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. Community diversity would change due to the reduced vertical presence in the water column, but some associated fish species would be expected to continue using 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 could impact any associated benthic communities if not properly avoided (refer to **Chapter 4.3.2**, Benthic Habitats and Communities).

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 Jr. et al. 2001). A follow-up story 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 Jr. et al. (2001) and Shaw et al. (2002) found highest taxonomic richness and diversity at mid-shelf platforms. Results indicated that the distribution of larval and juvenile life stages is influenced by across-shelf gradients of increasing depth, like 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 that the predominant factors influencing the distribution of larvae and juvenile life stages are environmental conditions and the distribution of adult conspecifics. Adverse effects from OCS oil- and gas-related discharges and wastes would likely be small and temporary, affecting only individuals to small groups of fish and invertebrates and thus, not expected to cause population-level effects.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that air emissions and pollution, as well as socioeconomic changes and drivers (refer to **Chapter 4.3.0**), are not likely to affect fish and invertebrates, as discussed below. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.1)

Due to steady vertical and horizontal air motion throughout the GOM region (Wang and Angell 1999), which rapidly disperse any pollutants from routine OCS oil- and gas-related activities, direct effects to fish and invertebrates are not expected. Indirectly, however, emissions from OCS oil- and gas-related activities may contribute to climate change-induced effects such as increased CO_2 uptake in the GOM, which may have downstream effects to fish and invertebrates. **Chapter 2.1.1** provides emissions estimates for routine OCS oil- and gas-related sources; however, the degree to which these contribute and influence CO_2 uptake and other processes is not well understood. Refer to **Chapter 4.3.4.1.3** for more information on the impacts of programmatic issues such as climate change to fish and invertebrates.

4.3.4.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.4-1 highlights the IPF categories of accidental events associated with OCS oil- and gas-related activities that could potentially affect fish and invertebrates in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Oil Spills

Fish and invertebrates may be vulnerable to the accidental release of oil in the environment. An oil spill in open waters of the OCS proximal to mobile adult fish would likely be sublethal; potential effects could be reduced because adult fish can avoid adverse conditions, metabolize hydrocarbons, and excrete metabolites and parent compounds (Lee et al. 1972; Snyder et al. 2019). However, long-term exposure to concentrated volumes of contaminants could result in a higher incidence of chronic sublethal effects (Baguley et al. 2015; Millemann et al. 2015; Murawski et al. 2014; Snyder et al. 2015). This can occur through the interaction of fish and invertebrates with PAH-contaminated water and sediments, which can occur by a variety of routes including respiration, ingestion of food, sediment, detritus, and absorption through the skin (Logan 2007). Oil floating on the surface could directly contact and coat the eggs and larvae of fish and invertebrates found at or near the surface. Eggs and larvae would be unable to avoid spills, and affected individuals may be at risk of death, delayed development, abnormalities, endocrine disruption, or other effects, resulting in decreased fitness and reduced survival rates (Fucik et al. 1995; Incardona et al. 2014; Mager et al. 2014); however, these effects would largely depend on the concentrations and duration of exposure. In general, early life stages of fish are more sensitive to acute oil exposure than adults, but some research indicates embryos, depending on their developmental stage, would be less sensitive to acute exposure than larval stages (Fucik et al. 1995).

Spills reaching nursery habitat or overlapping spatiotemporally with a spawning event have the greatest potential for affecting the early life stages of fish and invertebrates, particularly in shallow waters. Fish and invertebrates inhabiting shallow-water habitats (e.g., estuaries, coral reefs, and shorelines) are at increased risk because they can receive higher oil loading per unit volume of seawater than those in deeper offshore water (IT Corporation 1993). However, much of the OCS oil- and gas-related activity occurs far offshore. As such, interactions of released oil with currents, waves, and other physiological processes would allow for the toxicity of spilled oil to be greatly reduced or eliminated by weathering and biodegradation before it reaches coastal habitats (OSAT-2 2011). Nonetheless, accidental spills are reasonably foreseeable and fish and invertebrates occupying coastal and estuarine habitats may be vulnerable to these incidents.

Marine Trash and Debris

Routine OCS oil- and gas-related activities, such as vessel operations, are required to be proactive against the loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. All discharge of trash and debris from offshore platforms and all ships within 500 m (1,640 ft) of such platforms is prohibited (33 CFR §§ 151.51-77) except for food wastes discharged more than 19 km (12 mi) from shore that is passed through a comminutor (a machine that breaks up solids) and that can pass through a 25-mm (1-in) mesh screen. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste. However, it is still possible to have accidental release of trash and debris into the marine environment, specifically plastic waste, which has documented impacts to fish and invertebrates.

The negative effects of microplastics to copepod feeding, fecundity, and survival have been documented in previous laboratory-based toxicological studies (Cole et al. 2015; Cole et al. 2016). Many larval fish species in the ocean are also being found with microplastics in their systems (Gove et al. 2019), which has been found to induce sublethal effects on growth and behavior in laboratory-based studies (Pannetier et al. 2020). Foley et al. (2018) conducted a meta-analysis of the scientific literature investigating the effects of microplastic exposure on consumption (and feeding), growth, reproduction, and survival of fish and aquatic invertebrates. The analysis revealed that many of the studies showed neutral effects and inter-species variation. Generally, the most consistent effect was a reduction in consumption of natural prey when microplastics were present. There were also examples of within taxa negative effects to growth, reproduction, and survival (Foley et al. 2018).

Response Activities (Chapter 2.9.2)

The use of chemical dispersants may be used during oil spills. Oil-spill dispersants may be applied to break down surface oil into smaller oil droplets, making them easier to ingest by oil-eating microbes. Unfortunately, this process may also increase the water solubility of petroleum hydrocarbons, which makes them more bioavailable for uptake by fish and invertebrates (Wolfe et al. 2001). For example, Laramore et al. (2016) found that larval pink shrimp exposed to oil alone and oil treated with dispersants experienced greater negative impacts to the dispersant, and the impacts differed between larval stages with zoea being the most sensitive. Similarly, eastern oysters exposed to dispersants experienced some negative effects to immunological and physiological functions, which could result in serious health implications (e.g., increased parasitism and decreased growth) (Jasperse et al. 2018). In contrast, the effects of chemical dispersants on the larvae of blue crabs was laboratory tested, and only the larvae exposed to the highest treatment levels experienced significant increases in mortality (Anderson Lively and McKenzie 2014). Fish exposed to dispersants were found to have higher concentrations of PAHs versus fish exposed to crude oil without dispersants (Ramachandran et al. 2004). Overall, research has suggested that dispersed oil may be more toxic to fish and invertebrates than exposure to crude oil alone; however, life-stage, exposure levels, duration, and geographic extent dictate the impacts to individuals, and the long-term effects are not well understood.

Strikes and Collisions (Chapter 2.9.3)

Accidental strikes by oil and gas vessels operating in the OCS would likely not affect most fish and invertebrates because many can actively avoid oncoming ships. Larval fish and invertebrates with limited mobility may experience highly localized and minimal mortalities, but most would only be temporarily displaced. However, there is the potential for oil- and gas-related vessels to strike large, surface-feeding fish such as whale sharks (Ramírez-Macías et al. 2012; Schoeman et al. 2020). During the spring and summer, some whale sharks travel to the north-central GOM where they have been observed feeding at the surface in aggregations of 16 to 100 individuals (Chen 2017; Hoffmayer et al. 2007; McKinney et al. 2017). These aggregations occur near existing oil and gas infrastructure on the OCS, which potentially makes them vulnerable to ship strikes (**Figure 4.3.4-2**). No data currently exist indicating that vessel strikes to whales sharks have occurred in the north-central GOM; however, whale sharks are negatively buoyant and may sink quickly if a mortality occurred due to a vessel strike (Speed et al. 2008), possibly allowing a vessel strike to go unnoticed. Whale shark feeding aggregations near the Mexican state of Quintana Roo in the southern GOM have had documented vessel strikes by ecotourism vessels during surface feeding. This suggests that, depending on motivation, some behaviors may increase potential interactions with surface vessels due to a reduced avoidance/flight response. As such, whale sharks may experience increased seasonal vulnerability to accidental strikes in the north-central GOM by OCS oil- and gas-related vessel activity.

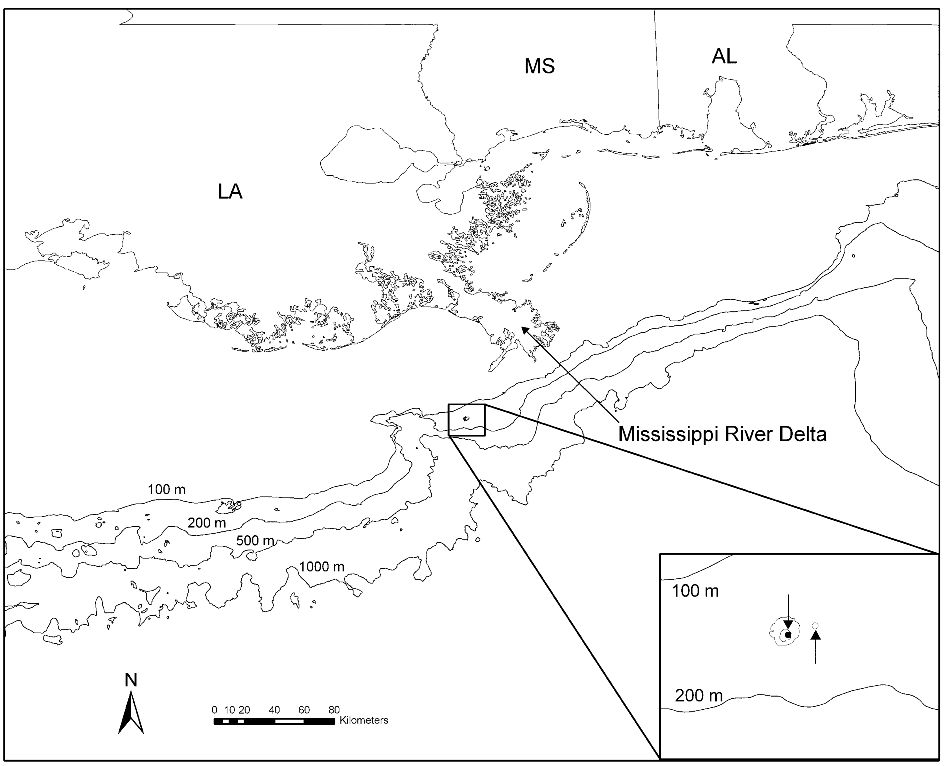


Figure 4.3.4-2. Location of a Whale Shark Feeding Aggregation as Reported in Hoffmayer et al. (2007) during June 2006 in the North-central Gulf of Mexico. The inset map depicts the location of the aggregation sighted (closed circle), and control sites (open circle) show where zooplankton samples were taken. The study site was located in surface waters 78 m (256 ft) above the eastern edge of the crest of a topographic high, the base of which is located at 100-m (328-ft) water depth. (Reprinted by permission of Dr. Mark Peterson on May 5, 2020, whose permission is required for further use.)

4.3.5 Birds

4.3.5.1 Resource Description

Several bird groups utilize the U.S. Gulf of Mexico environment, as the area serves multiple habitat and life staging purposes. Birds from six distinct taxonomic and ecological groups are represented within the GOM region, including passerines (i.e., Passeriformes), raptors (i.e., Falconiformes, Accipitriformes), seabirds (i.e., Charadriiformes, Pelecaniformes, Procellariiformes, Gaviiformes, Podicipediformes), waterfowl (i.e., Anseriformes, Gaviiformes), shorebirds (i.e., Charadriiformes), and wading or marsh birds (i.e., Ciconiiformes, Gruiformes). For more information about these bird groups, refer to Chapter 3.8 of BOEM's Biological Environmental Background Report (BOEM 2021b). Seven ESA-listed species of birds are distributed across the GOM region, either year-round or migratory, with a strong seasonal component, and include the Cape Sable seaside sparrow, Mississippi sandhill crane, piping plover, rufa red knot, roseate tern, whooping crane, and wood stork. These species are considered and analyzed in consultations with the U.S. Fish and Wildlife Service.

Several hundred species of birds rely on the marine (i.e., pelagic waters) and coastal habitats (i.e., beaches, mudflats, salt marshes, coastal wetlands, and embayments) in the GOM region (Dahl and Stedman 2013), which are discussed further in **Chapter 4.3.1**. Both resident and migratory bird species are found in the GOM. Resident species are present throughout the year and do not migrate. Many passerines, or songbirds, breed and winter within the Gulf Coast States and can be found in the coastal area and offshore during the trans-Gulf migration in the fall and spring. Other bird species, mainly seabirds, live primarily offshore, except during their breeding season. These pelagic birds, including shearwaters, storm-petrels, boobies, gannets, jaegers, gulls, and terns (Duncan and Harvard 1980), rely on offshore waters for food and rest at stop-over sites. The remaining species found in the GOM region are located within coastal and inshore habitats. Species reliant on inshore habitats are not likely to be impacted by the same IPFs that coastal and marine birds encounter.

Species abundance in the GOM varies seasonally due to migration and breeding timings. Abundance can also be driven by mesoscale features, such as the Mississippi River freshwater plume and oceanic fronts and eddies (Bost et al. 2009; Ribic et al. 1997; Scales et al. 2014) (refer to Chapter 3.0 of BOEM's Biological Environmental Background Report [2021b]). Seabirds have a K-selected life history strategy, which means they are species that produce few offspring but invest high amounts of parental care. As such, seabird population levels can be impacted by natural climate cycles (Paleczny 2012) and anthropogenic activities. For example, commercial fisheries may overexploit prey, which can negatively impact seabird abundances (Furness and Tasker 2000; Paleczny 2012). Nutritional conditions of prey are essential to seabird reproductive success and population dynamics as well (Lamb 2016).

Migration

Migratory birds are any species that migrate and live or reproduce in multiple, separate places at least once during their annual life cycle. Migrations can expand beyond local, State, Federal, and international borders. As such, migratory birds and their nests are protected under the Migratory Bird Treaty Act (MBTA), enforced by the FWS, which prohibits the take, possession, importation, exportation, sale, purchase, barter, or offer of any migratory bird or their parts, nests, or eggs unless federally permitted (DOI and FWS 2013). On December 22, 2017, the DOI released M-Opinion 37050, which states that the MBTA does not prohibit the incidental take of migratory birds and their active nest contents (Office of the Solicitor 2017); however, this reinterpretation was recently overturned by a Federal district court (Caproni 2020). More information on the MBTA can be found in BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c).

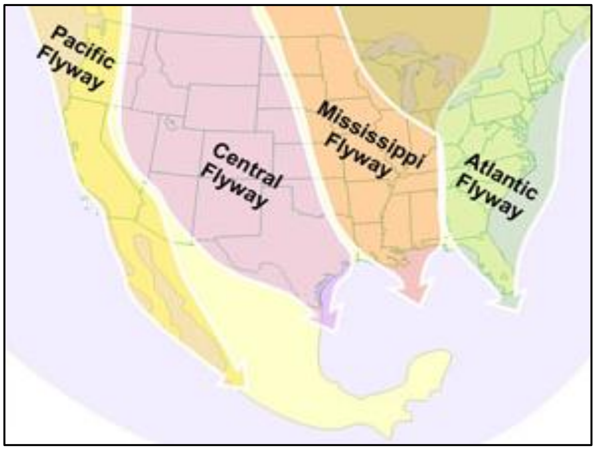


Figure 4.3.5-1. North American Migratory Birds Follow Migratory Routes, or "Flyways." There are four major flyways in North America: the Pacific, Central, Mississippi, and Atlantic Flyway (FWS 2013).

The GOM is an essential area for migratory birds, as three of the four major flyways (**Figure 4.3.5-1**) occur within the Gulf of Mexico (the Central, Mississippi, and Atlantic Flyways). Areas of these Flyways are used by hundreds of millions of migratory birds, many of whom converge within the diverse coastal and terrestrial habitats in the northern GOM, which is an important area for migratory species that travel in large numbers in the spring and fall (Russell 2005). Roughly 40 percent of all North American migrating waterfowl and shorebirds use the Mississippi Flyway (FWS 2013), which runs through the peninsula of southern Ontario to the mouth of the Mississippi River followed by a short distance across the GOM. During this highly energetic period, stop-over sites are critical to migratory birds. These areas provide resting and feeding opportunities (Brown et al. 2001; McWilliams and Karasov 2005). Stop-over sites can also serve as temporary shelters from inclement weather. Adequate stop-over sites allow migratory birds to arrive in good health (Helmers 1992).

ESA-Listed (Threatened or Endangered) Species

Currently, seven listed bird species occur in the GOM: Cape Sable seaside sparrow (DOI and FWS 1967), Mississippi sandhill crane (DOI et al. 1973), piping plover (DOI and FWS 1985), rufa red knot (DOI and FWS 2014), roseate tern (DOI and FWS 1987), whooping crane (DOI and FWS 2011), and wood stork (DOI and FWS 2012). Listed species are considered and analyzed in consultations with the FWS. Five of these species (i.e., the Mississippi sandhill crane, piping plover, rufa red knot, whooping crane, and wood stork) are found in or adjacent to the WPA and CPA, where there are higher levels of OCS oil- and gas-related activities. Two of the listed species are found exclusively in Florida (i.e., the Cape Sable seaside sparrow and roseate tern), where they are less likely to be affected by BOEM-regulated activities. However, a bird's susceptibility to these effects could increase in the EPA if the moratorium established by the Gulf of Mexico Energy Security Act of 2006 was to expire (currently scheduled for June 2022) and subsequent oil and gas leasing were to occur in these previously unavailable areas.

Other listed species also occur in the coastal GOM. Still, they are not explored further in this document, as they rely more on terrestrial habitats or are not commonly documented in the northern GOM. Refer to Appendix A of BOEM's Biological Environmental Background Report for a list of these species (BOEM 2021b). The latest biological opinion (BiOp) issued by the FWS determined that the proposed BOEM oil and gas program (10-year period starting April 2018) is not likely to jeopardize the continued existence of the listed bird species and their designated critical habitat (FWS 2018).

The FWS also lists species as candidate species (DOI and FWS 2006) when it has enough information on their biological status and threats to propose them as ESA-listed, but for which other higher priority listing activities preclude the development of a proposed listing regulation. These species do not receive statutory protection under the ESA. Currently, there are several candidate bird species identified in the northern GOM (FWS 2020a), including the golden-winged warbler, black-capped petrel, eastern black rail, and the saltmarsh sparrow. For more information on these species and their status, refer to Chapter 3.8 of BOEM's Biological Environmental Background Report (BOEM 2021b). Three species (i.e., Florida sandhill crane, smooth-billed ani, and southeastern snowy plover) were proposed for listing but were found not to warrant an ESA listing.

Programmatic Issues and Environmental Factors Influencing Birds

There are numerous anthropogenic avian mortality sources, including collisions and predation by domestic cats. Collisions with human-made structures are one of the highest-ranked threats to birds worldwide when observing the numbers of individuals killed (Loss et al. 2014a). There are currently no GOM regional estimates for annual mortality rates for vehicle or building bird strikes as well as predation by cats. National estimated annual mortality from vehicle bird strikes is at 62-275 million birds per year (Loss et al. 2014b), building bird strikes is 599 million birds per year (Loss et al. 2014a), and predation by free-ranging domestic cats is 1.4-3.7 billion birds per year (Loss et al. 2013). Cat predation mainly impacts small birds (e.g., passerines). As these are national rates, the mortality rates are expected to be less in the northern GOM.

Emerging infectious diseases (e.g., West Nile virus) currently present a challenge to native species conservation. Emerging diseases are considered those that experience a recent incident or impact increase, or have recently spread to a new host population or region (Lederberg et al. 1992; Smolinski et al. 2003). Emerging wildlife diseases have been commonly linked to anthropogenic environmental changes (Daszak et al. 2001; Schrag and Wiener 1995). Bird species have so far experienced complex population response to West Nile virus (LaDeau et al. 2007) which was introduced to North America in 1999 (McLean 2006). Seven out of 20 (35%) selected avian species from across North America that were potential hosts to the virus exhibited changes attributed to West Nile virus at the population level. Only two of these species recovered to pre-virus levels by 2005 based on 26 years of data (LaDeau et al. 2007). However, this likely underestimates the impacts to birds as recruitment, and immigration can hide population declines (Ward et al. 2010a). These continental estimates can be qualitatively extrapolated to other species in the northern GOM, where West Nile virus and potentially other infectious diseases would be expected to have severe impacts on avian populations. George et al. (2015) study demonstrated how widespread and long-term effects from the West Nile virus and other emerging diseases can be on naïve landbird populations. There have been few large-scale studies to evaluate infectious and non-infectious emerging diseases in birds (Friend et al. 2001; Newman et al. 2007). However, one 30-year study of necropsy data of aquatic North American birds found that infectious diseases are a significant cause of bird mortality in the U.S., particularly for nearshore and coastal birds (Newman et al. 2007).

Climate change and ocean acidification are also expected to impact marine and coastal birds. Though climate change impacts on birds are difficult to predict; they are expected to influence bird's ecology through changes in habitat ranges (Mustin et al. 2007), increased risk of predation and competition, exposure to different prey and parasites, shifts in seasonal events (e.g., breeding and migration), changes to local food webs, and habitat alterations (Butler and Taylor 2005; Liebezeit et al. 2012; Tillmann and Siemann 2011; Wauchope et al. 2017; Wormworth and Mallon 2006).

The influence of climate change on birds is difficult to predict due to the complexity of predicting climate-induced ecological impacts (Mustin et al. 2007). Climate change is likely to impact a wide range of aspects of a bird's ecology, and the question remains as to whether species can shift to new habitat ranges (Mustin et al. 2007) as range contractions are expected to occur more frequently than range expansions. Shifts in bird species' ranges can disrupt ecological communities of birds and interdependent plants and animals. Range shifts could lead to increased exposure of some birds to different prey species, parasites, predators, or competitors. Species could be forced into areas less suitable for habitation. Impacts on birds could also include shifts in the timing of important seasonal events (e.g., breeding and migration), which could, in turn, force birds' lifecycles out of synchrony with prey sources (i.e., plants and insects). Alterations of the timing and magnitude of biological productivity could force bird populations to seek new levels and distribution of prey items in response to all seasonal timing and range shifts, possibly triggering effects to local food webs. Additionally, habitat alterations (e.g., loss of sea ice or freshwater habitats drying up) could impact various stages of development (Butler and Taylor 2005; Liebezeit et al. 2012; Tillmann and Siemann 2011; Wauchope et al. 2017; Wormworth and Mallon 2006). The potential effects of coastal and offshore habitat alteration, which can be worsened by climate change, are discussed further in **Chapters 4.3.1-4.3.3**.

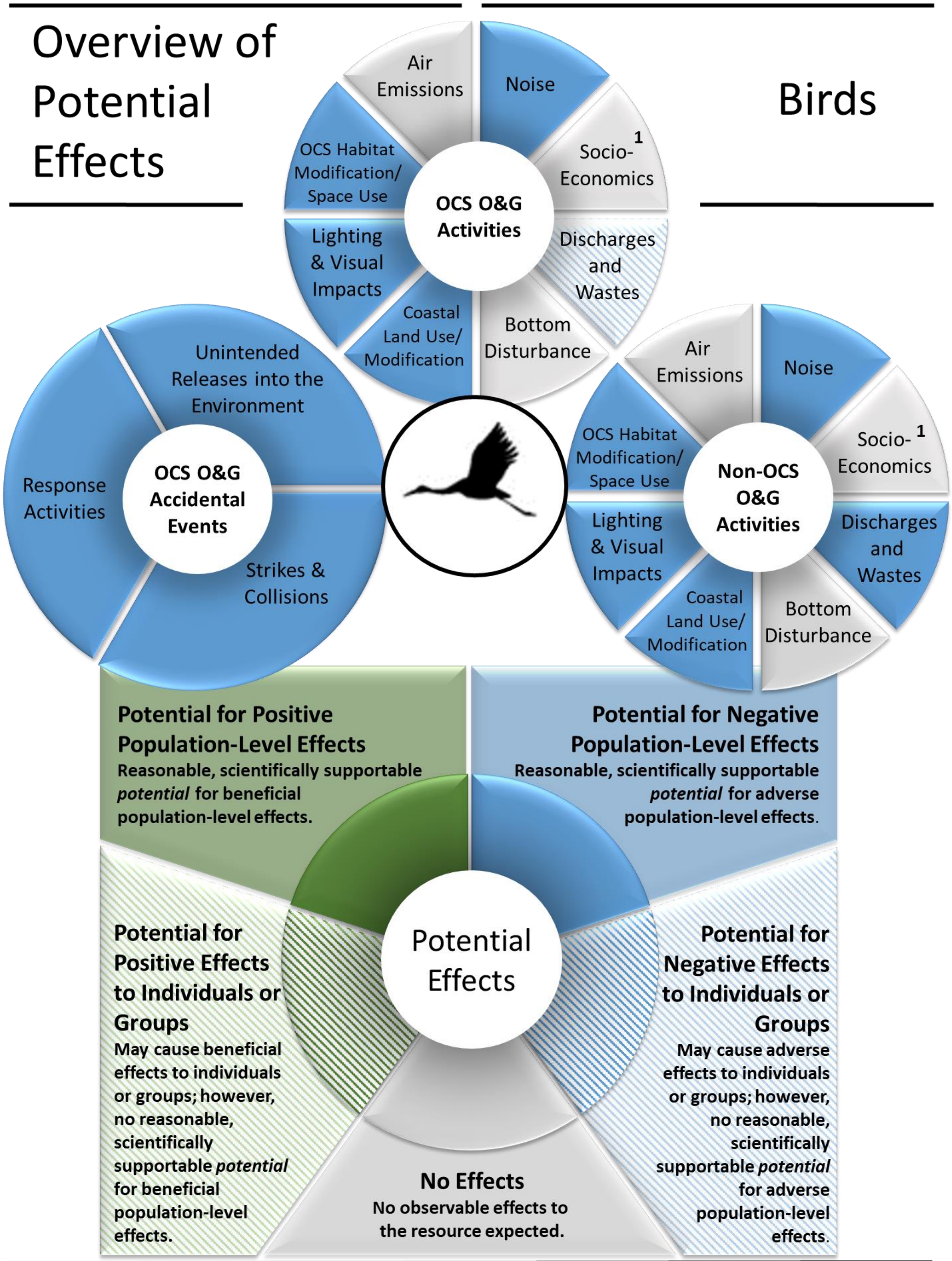
Ocean acidification (refer to **Chapter 3.4.4**) can also alter food web dynamics. Ocean acidification alters pH levels, which can affect sensitive planktonic species at the organismal level up to a population-level response due to food web dynamic changes, which can lead to impacts on marine and coastal birds. If climate change is not curtailed, biodiversity vital to the ecosystems that support all bird life could decline (McDaniel and Borton 2002). Global environmental change may also increase the frequency and intensity of hurricanes, which can increase the risk of accidental oil spills at Gulf of Mexico OCS oil and gas facilities (refer to **Chapter 4.3.5** for more information on accidental spills effects on birds) and possibly worsen damage to important breeding and wintering habitats in the northern GOM.

4.3.5.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and birds. **Figure 4.3.5-2** provides a synopsis of the IPF categories that currently affect or have the potential to affect birds in the Gulf of Mexico OCS. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.5-2**. No IPF categories were identified to potentially have observable positive effects to birds.

Figure 4.3.5-2 is intended to highlight the relevant IPF categories and potential effects that are analyzed in this chapter, as well as highlight the IPFs that are not likely to cause effects to birds and, therefore, would likely not be analyzed in detail in future NEPA analyses for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and resource; time of year; and species distribution and health. BOEM will use this preliminary identification and disclosure of the potential range of effects to birds, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.5-2. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Birds. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.3.5.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.5-2 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect birds in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below. All seasonal habitats in the area of potential impacts that are used during the life cycle of the species are considered in BOEM's analyses.

Discharges and Wastes (Chapter 2.2.2)

The USEPA regulates certain discharges (e.g., bilge or ballast water from ships and industrial discharges into the coastal atmosphere). Agricultural nutrient and pesticide run-off also occur in the GOM. Pollutants are expected to be safely disposed of or diluted to below harmful levels to birds. The discard of trash and debris from non-OCS oil- and gas-related sources (e.g., State oil- and gas-related activities, recreational fishing boats, and land-based sources) is prohibited. However, unknown quantities of plastics and other materials are discarded despite regulation and subsequently lost in the marine environment. Plastics and other trash and debris remain a threat to birds. Many species consume plastic debris, both intentionally and incidentally, through prey sources. Birds can also become trapped or entangled in discarded fishing lines or nets and commercial fishermen's gear. Seabird bycatch numbers in the GOM by pelagic and bottom longline fisheries indicate negligible impacts on seabird populations (Hale et al. 2011). Seabirds are known to feed on discarded fishery bycatch, which can be both beneficial (i.e., increased foraging opportunities) and detrimental (i.e., increased collision or entanglement risk).

Nutrient contributions to the GOM via the Mississippi River watershed cause seasonal population explosions of phytoplankton, which decompose to create a hypoxic or anoxic "dead zone" over the continental shelf (refer to **Chapter 3.3.2** for more information). Hypoxic zones can decimate coastal waterbirds' aquatic prey sources (refer to **Chapter 4.3.4**). However, no massive phytoplankton blooms have been reported to produce massive mortality to coastal and marine birds in the zone. Birds can move away from impacted areas to find sufficient food, and the effects from these blooms would be short term.

Noise (Chapter 2.4.2)

Several noise sources could potentially interact with coastal and marine birds in the GOM and are either considered active acoustics (e.g., seismic surveys) or produced from vessels and equipment. Noise has the potential to mask communication, displace birds from important breeding or foraging areas, disturb predator-prey interactions, and cause noise-induced threshold shifts (Crowell 2016). Vocalizations are essential to seabirds in-air; it is currently unknown if seabirds utilize vocalizations for communication or navigation underwater. Birds are known to have a relatively restricted hearing range for airborne noise, with acute sensitivity occurring in the range of 1 to 5 kHz (Dooling and Popper 2007). Less is known about the auditory hearing range of birds underwater; however, some studies suggest their greatest hearing sensitivity underwater ranges from 1 to 3 kHz (Crowell et al. 2015; Hansen et al. 2017; McGrew 2019).

Military activities, including training overflights, occur in designated areas offshore that also serve as seabird habitat. The U.S. Air Force and U.S. Navy conduct most military operations in the GOM in areas federally designated for training, research, testing, and evaluation activities. A study found that weapons testing noises had no significant effects on bald eagle activity or reproduction (Brown et al. 1999). Aircraft noise can also affect birds, but studies have shown that bird exposure to frequent, low-level military jet aircraft and simulated mid- to high-altitude sonic booms resulted in some short-term behavioral responses with little effect on reproductive success (Ellis et al. 1991).

Coastal Land Use/Modification (Chapter 2.5.2)

Ongoing and projected wetland loss results in the loss of essential habitats for coastal and marine birds. Wetlands serve as vital breeding and nesting grounds for adult birds and rearing grounds for juveniles. These habitats provide drinking water and feeding, resting, shelter, and community opportunities for several species of birds. Historical wetland loss due to Mississippi River hydromodification would be somewhat improved by wetland creation from Atchafalaya River sediments and coastal restoration and hurricane protection programs. Louisiana's Master Plan (refer to **Chapter 2.5.2.5**), which was partly designed for maximizing coastal wetlands, would also likely increase habitat for four selected waterbird species and neotropical birds over the next 50 years. These predictions are based on Habitat Suitability Index models and were controlled for other non-habitat environmental variables (Nyman et al. 2013). Vessels traveling through navigable waters can cause wetland habitat loss due to erosion of banks from the vessel wake.

Important coastal and marine bird habitats can also be impacted by urbanization. Habitat (e.g., wetland) loss, alteration, and fragmentation associated with building, factory, and road construction are mitigated by USACE and State wetland permitting regulations to keep from harming sensitive bird habitat. A primary policy goal is "no net loss" of wetlands, but it has not been fully reached so far. Ward et al. (2010b) indicated that urbanization might alter wetland hydrology rather than outright destroy wetlands, which may cause an abundance reduction of wetland birds. Protection or active management of wetland hydrology regimes can help avoid these impacts (Ward et al. 2010b).

Sea-level rise directly impacts coastal habitats, therefore indirectly affecting birds through habitat loss. For more information on sea-level rise impacts on coastal habitats, refer to **Chapter 4.3.1**.

Lighting and Visual Impacts (Chapter 2.6.2)

Lighting can impact birds and, in the GOM region, State oil and gas platforms provide sources of artificial lighting in State waters. Many seabird species, including petrels, shearwaters, pelicans, gulls, terns, and skimmers, are attracted to vessels due to light attraction at night (Black 2005; Montevecchi 2006; Wiese and Jones 2001), which can lead to vessel strikes (refer to **Chapter 2.9.3**). Lights attract seabirds and migrating land birds, drawing them to onshore and offshore facilities and other infrastructure and equipment (e.g., vessels). Species and age can influence the susceptibility of birds to lighting impacts (Montevecchi 2006). Nocturnal seabirds are more likely to have more rods in their retinas, more rhodopsin, and larger eyes (McNeil et al. 1993), and thus are likely more impacted by artificial lighting. Smaller planktivorous nocturnal species are also likely attracted to, and subsequently influenced by, artificial lighting at night (Bretagnolle 1990; Imber 1975), especially those that feed on bioluminescent prey (Montevecchi 2006). Fledgling storm-petrels, petrels, and shearwaters may be more attracted to artificial light than their adult counterparts due to their environmental inexperience or their reliance on bioluminescent prey (Imber 1975). Attraction to artificial lighting could impose energetic costs to individual birds as well as collision risk with the structures, which could result in injury or mortality. For more information for bird collisions with offshore platforms, refer to **Chapter 2.7**.

Artificial lighting at night can disorient birds, especially offshore migrators. Poor weather conditions (e.g., fog, precipitation, and low cloud cover) can further increase birds' attraction to lighting, especially at dusk or during a full moon (Miles et al. 2010; Rodríguez and Rodríguez 2009). Large aggregations of nocturnal migrants can be attracted to artificial lighting. Disoriented birds can circle the light source for hours, leading to exhaustion, depleted fat reserves, and starvation (Longcore and Rich 2004; Montevecchi 2006; Ronconi et al. 2015), as well as a changed migration route, risk of collision with each other (Longcore and Rich 2004; Montevecchi 2006), and increased susceptibility to predation (Longcore and Rich 2004). Alternatively, artificial lighting can create foraging opportunities for birds (Burke et al. 2012), but this could have downstream adverse effects such as changes in migration routes and increased energy expenditure due to circling behaviors around the light source.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Nonconsumptive recreation that can impact birds includes recreational boating, 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, with varying degrees of response for different species. Birds that leave the area may not have other available habitats of equal value for feeding, nesting, roosting, or sleeping. Stress and ejection from the habitat on a large scale may cause sublethal decreases in reproductive productivity (i.e., fecundity), which in turn can result in population decline that may exceed population decline from mortality. Most recreational boats are subject to strict speed and wake restrictions, which reduces the chance of vessel strikes and impacts on coastlines. Disturbances of an area can be regular, but effects would be benign and short term.

The States, FWS, and Canadian provinces in each flyway (**Figure 4.3.5-1**), which are used by migratory birds that travel south through the GOM region, regulate consumptive recreation (i.e., hunting game birds). The total mortality of hunted species does not usually increase because of hunting, but instead remains the same because the overall carrying capacity of a species is not altered. Some game bird species have experienced population-level impacts from hunting-related mortalities, but further mitigations could reduce this.

State oil- and gas-related activities include the presence of platforms in State waters that are traveled by migrants in the spring and fall, which can lead to collisions and nocturnal circulations. For more detailed information on the collision risk posed by OCS platforms on birds, refer to **Chapter 2.8.1**.

Military activities, including sonic booms, occur in designated areas offshore that also serve as seabird habitat. The most significant impacts on birds would come from sonic booms, which can cause a short-term behavioral change (e.g., flushing and cessation of feeding). Regarding explosives, one study analyzed a western grebe mortality event in California where 70 individuals died as a result of a military underwater detonation (Danil and St. Leger 2011), which is sometimes used in decommissioning practices.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined that air emissions, bottom disturbance, and socioeconomic changes and drivers (refer to **Chapter 4.3.0**) are not likely to affect birds. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.2)

Transport and dispersion processes via prevailing wind circulations immediately begin to circulate pollutants when released. Dispersion depends on several factors, including emission height, atmospheric stability, mixing height (i.e., the height above the surface through which vigorous vertical mixing occurs), exhaust gas temperature and velocity, and wind speed. The mixing height is essential to dispersion of pollutants because it dictates the vertical space available for spreading the pollutants.

Due to the atmospheric processes on air pollutant transport, stack height, exit gas velocity from the stack, the distance of the marine species from the sources, and temporary vessel activity, coastal and marine birds are not expected to be affected by air emissions and pollution. Further, air emissions from offshore activities (e.g., vessel traffic and sand-borrowing) would be localized. Air pollution is expected to dissipate quickly.

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbance is not expected to impact birds given the limited footprint of disturbance and the widespread existence of benthic feeding grounds throughout the northern GOM. Overall, bottom disturbance is not expected to pose risks to marine and coastal birds as they do not inhabit the seafloor beyond quick, infrequent foraging trips mostly in inshore or coastal waters.

4.3.5.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.5-2 highlights the IPF categories associated with routine OCS oil and gas development that could potentially affect birds in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

Discharges and Wastes (Chapter 2.2.1)

All operational discharges and wastes are regulated. The USEPA and USCG regulate produced water, drilling muds, and cuttings releases to keep contaminants below harmful levels. These, along with sanitary wastes, gray water, and miscellaneous discharges, are not expected to persist in the water column. Oil sheens from produced waters could potentially contribute to seabird mortality if the sheen contacts the birds' feathers at sea (Fraser et al. 2006). Further, oil can compromise the feather structure, possibly leading to hypothermia and starvation, especially in colder waters (Wiese and Ryan 2003). Currently, no studies have evaluated the possible attraction of seabirds to the plumes of discharged produced waters. Drilling muds released into the water column do not increase to high concentrations and only affect a small area of water (Neff 2005). Most mud cuttings settle rapidly to the seafloor and only around the drill site (area dependent on drilling depth and mud line cellar size), which could lead to temporary loss of benthic foraging habitat (Neff et al. 2000). Impacts on water quality are localized and transient; therefore, they are unlikely to affect foraging and roosting activities by seabirds.

It is also assumed that operators on the OCS will adhere to additional BSEE regulations and BOEM guidance, as well as the USEPA (via the NPDES permits) and USCG regulations. For instance, the USCG and USEPA regulations require operators to be proactive in avoiding accidental loss of solid waste items. This requires developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions (e.g., covering outside trash bins) to prevent accidental loss of solid waste. It is prohibited to discharge trash and debris (33 CFR §§ 151.51-77) unless it is passed through a comminutor (i.e., a machine that breaks up solids) and ultimately passes through a 25-mm (1-in) mesh screen. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste. Therefore, significant amounts of trash and debris are not expected to be released into the marine environment. Further, rigid equipment is expected to be used in G&G operations, preventing entanglement in marine trash and debris. Adverse effects from OCS oil- and gas-related discharges and wastes would likely be small and temporary, affecting only individuals to small groups of birds and thus, not expected to cause population-level adverse effects.

Noise (Chapter 2.4.1)

Vessel and equipment noise make up most of the sounds produced by BOEM-regulated activities, including vessel traffic, drilling, trenching, production, offshore and onshore construction, and explosive platform decommissioning and removal noise. Most of these produced sounds are short term and below diving birds' hearing ranges. Therefore, they would have only transient effects on most birds. Diving seabirds would be the most likely group to interact with the underwater sound sources (e.g., drilling, trenching, and production). Seabirds' various feeding methods (e.g., surface feeding, pursuit diving, and plunge diving) can influence their possibility of exposure to equipment noise. Migratory seabirds would also have a higher chance of interacting with the offshore noises. Anticipated impacts on birds exposed to these sound sources include localized disturbance, temporary displacement, and masking of bird vocalization and communication. Other birds at high risk of effects (e.g., displacement and disturbance) from drilling and production noises are those that are attracted to offshore structures for resting or foraging opportunities (Baird 1990; Montevecchi 2006; Russell 2005; Tasker et al. 1986). Aircraft noise can also affect birds (refer to **Chapter 4.3.5.1**, Noise) (Ellis et al. 1991). If disturbance were to occur, birds have shown the ability to return to pre-disturbance behavior within 5 minutes (Komenda-Zehnder et al. 2003). Vessels and helicopters could cause disturbance to breeding birds and possibly decrease nesting success if the traffic occurs too close to a breeding colony. Some BOEM-regulated activities may require daily roundtrips from a shore base to an offshore worksite. These would likely occur at an already established port. Therefore, birds are not expected to roost near these areas. Those that continue to roost or nest in areas adjacent to shore bases have likely adapted to vessel traffic noise.

Platform Decommissioning

As birds are attracted to platforms, there is the potential for individuals to be present during platform decommissioning and removal activities. Decommissioning involves dismantling the above-platform structures, sometimes with the use of underwater explosives, to collapse the platform. Explosives have the potential to cause barotrauma and possibly the death of one or more individuals if they are present during the activity. However, most of the birds using the platform would have likely left the area during the dismantling process before the use of the explosives. Underwater detonations may occasionally harm deep-diving birds if they were diving in the immediate vicinity during the explosion.

Active Acoustics

The low-frequency underwater noise created by airguns and subbottom profilers would fall within the underwater hearing range of birds, while noise created by other survey equipment (e.g., side-scan sonar and echosounders) would not. Some seabirds and waterfowl rest on the water's surface or make short and shallow dives. Others (e.g., long-tailed duck and common loon) dive deeper (up to 197 ft [60 m]) and spend more time submerged. Airgun array pulses are directional, so only diving birds would encounter active acoustics. Any exposure to seismic noise would be for a short period. Diving seabirds (e.g., grebes, loons, cormorants, and sea ducks) would be the most likely group to interact with this noise source (Turnpenny and Nedwell 1994), especially those that forage via plunge-diving. Surveys conducted during migration periods may increase the chance of affecting diving seabirds. Energetic cost or loss of foraging opportunities (i.e., disturbance and displacement) of diving seabirds are the likeliest impacts of seismic surveying and may last for a day at most. The effects of underwater seismic survey airguns on diving seabirds are not well studied, but two studies observed no mortality events or distribution or abundance changes (Lacroix et al. 2003; Stemp 1985).

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land disturbance can impact birds, mainly if occurring in key bird habitats. Extensive onshore infrastructure (e.g., construction facilities, service bases, waste disposal facilities, and processing facilities) exists to support BOEM-regulated activities, and a background description of this coastal infrastructure can be found in **Chapter 2.5.1**. As discussed in Chapter 4.5 of BOEM's Biological Environmental Background Report (BOEM 2021b), new construction or expansion of onshore facilities, temporary and permanent roads, and pipeline landfalls can permanently alter local coastal and estuarine habitats. These effects would be long term (i.e., decades) and would affect those bird species that rely on them for nesting and feeding habitats. The presence of pipeline landfalls and roads during production would also result in a long-term disturbance.

Habitat loss as a result of coastal land disturbance could lead to the permanent displacement of birds. Construction may also increase the suspension of sediments in the coastal water column and decrease the local water quality. Birds' ability to locate prey could be compromised, and any degradation of local fish or invertebrates could reduce the quality of their prey. Mitigation in the form of careful placement (e.g., avoiding important bird nesting habitats) of facilities could minimize the effects of coastal land disturbance on local colonial or nesting bird species. Consultation with Federal agencies regarding bird species covered by the ESA or the MBTA could further mitigate these effects. Refer to BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report for more information on ESA and MBTA (BOEM 2020c).

Lighting and Visual Impacts (Chapter 2.6.1)

As discussed in **Chapter 4.3.5.2.1**, Lighting and Visual Impacts, artificial lighting (e.g., platform lighting) can impact birds in several ways. Birds are also attracted to flares used on offshore platforms (Montevecchi 2006; Poot et al. 2008; Ronconi et al. 2015; Russell 2005). Migrating birds were even attracted to a nocturnal gas-flaring event despite an installed anti-collision lighting system (Day et al. 2005; 2015). Attraction to gas flaring varies among species, with long-tailed ducks being the most represented taxa (Day et al. 2015). Several early studies on the effects of gas flares on birds reported no mortality events or injury to birds (Hope Jones 1980; Sage 1979; Wallis 1981). However, one study suggests that incinerations from colliding with gas flares may be killing more birds than previously thought (Bjorge 1987). A 2013 gas flare event was estimated to have killed 7,500 migrating passerines at a Canadian platform (Canadian Broadcasting Corporation 2013; Smith 2015a). Bourne (1979) estimated that annual mortality rates from interactions with gas flar}es are a few hundred birds per platform.

Mitigating measures could minimize the effects of artificial lighting on birds. For example, lease stipulations imposed by BOEM require the minimization of light pollution using techniques such as down-shielding lights, using the minimum necessary amount of lighting, and using LED or low-energy lights, which lead to less lighting overall. Consultation with Federal agencies regarding bird species covered by the ESA or the MBTA could further mitigate these effects.

Offshore Habitat Modification/Space Use (Chapter 2.8.1)

The placement of oil and gas platforms and associated offshore equipment has the potential to affect seabirds found in the GOM. Infrastructure emplacement can cause temporary and long-term disturbance via avoidance or attraction (Baird 1990; Montevecchi 2006; Russell 2005; Tasker et al. 1986). Although attraction is documented more, platforms can displace birds from previously suitable foraging habitats. Consequences from displacement are likely small unless the affected areas previously supported high concentrations or productivity due to physiographic features (e.g., shelf breaks) (Hedd et al. 2011). Avoidance behaviors could also subject birds to higher energetic demands (Masden et al. 2010), but this is difficult to predict since avoidance of platforms has not been extensively studied. Consultation with Federal agencies regarding bird species covered by the ESA or the MBTA could mitigate these effects.

Bird attraction to platforms can be attributed to increased foraging opportunities (Ortego 1978), oceanographic drivers (Castro et al. 2002; Fedoryako 1989), roosting refuge, and artificial lighting, which can all be species specific and seasonal (Burke et al. 2012). Other influencing factors include environmental (e.g., moon phases, tides, and ocean temperature) (Rodríguez and Rodríguez 2009), anthropogenic (e.g., humans on the platforms, and fishing vessels) (Votier et al. 2010), spatial dynamics (e.g., proximity to other platforms, nesting colonies, and shelf breaks) (Burke et al. 2005; Russell 2005; Tasker et al. 1986), and temporal variables (e.g., time of day and year, and breeding cycles) (Hüppop et al. 2016). "Spudding" events documented a 6- to 7-fold increase in bird density (Baird 1990). One study found that seabird density was seven times higher within 1,640 ft (500 m) of an offshore oil platform than the surrounding areas, which is likely due to increased food availability and roosting opportunities (Tasker et al. 1986). Platforms can serve as artificial reefs supporting biodiverse communities, including seabird prey (i.e., fish), and localized feeding events in masked boobies have been demonstrated (Duffy 1975; Ortego 1978). Offshore platforms can continue operating for several decades until production is complete. Spatially, they cover a relatively small area compared to the total pelagic habitat available to seabirds. However, the platform or infrastructure's location influences its interaction potential with seabirds. For example, if a platform occurs within a common feeding route of a breeding colony, a higher frequency of interaction(s) with that platform could occur. Decommissioned platforms that are subsequently used for the Rigs-to-Reefs program (refer to **Chapter 2.3.2.4**) could provide foraging habitats for birds in a similar fashion as that of operational platforms.

Offshore infrastructure can lead to collision events with seabirds migrating, roosting, or foraging in the area, especially for birds attracted to the platforms. **Figure 4.3.5-3** displays the overlap of two commonly used trans-Gulf bird migration routes and offshore oil and gas platforms. However, collision risk to birds from oil and gas platforms is poorly studied. Based on observations on a research platform in the North Sea (~28 mi [45 km] offshore), researchers conservatively estimated that hundreds of thousands of nocturnally migrating birds could die from colliding with a platform (Hüppop et al. 2016); other studies estimate up to six million annual collision mortalities (Bruinzeel and van Belle 2010; Bruinzeel et al. 2009). A multi-year, standardized survey on GOM platforms found that nocturnal collisions of migratory birds are a significant source of mortality during fall migration; they estimated that the nearly 4,000 platforms might cause roughly 200,000 annual collision deaths (Russell 2005). Direct platform mortality rates may be regional, species-specific, or seasonal (Burke et al. 2012; Ronconi et al. 2015). Underwater infrastructure also poses a potential effect on diving seabirds, which could collide, or become entangled, with the infrastructure while foraging.

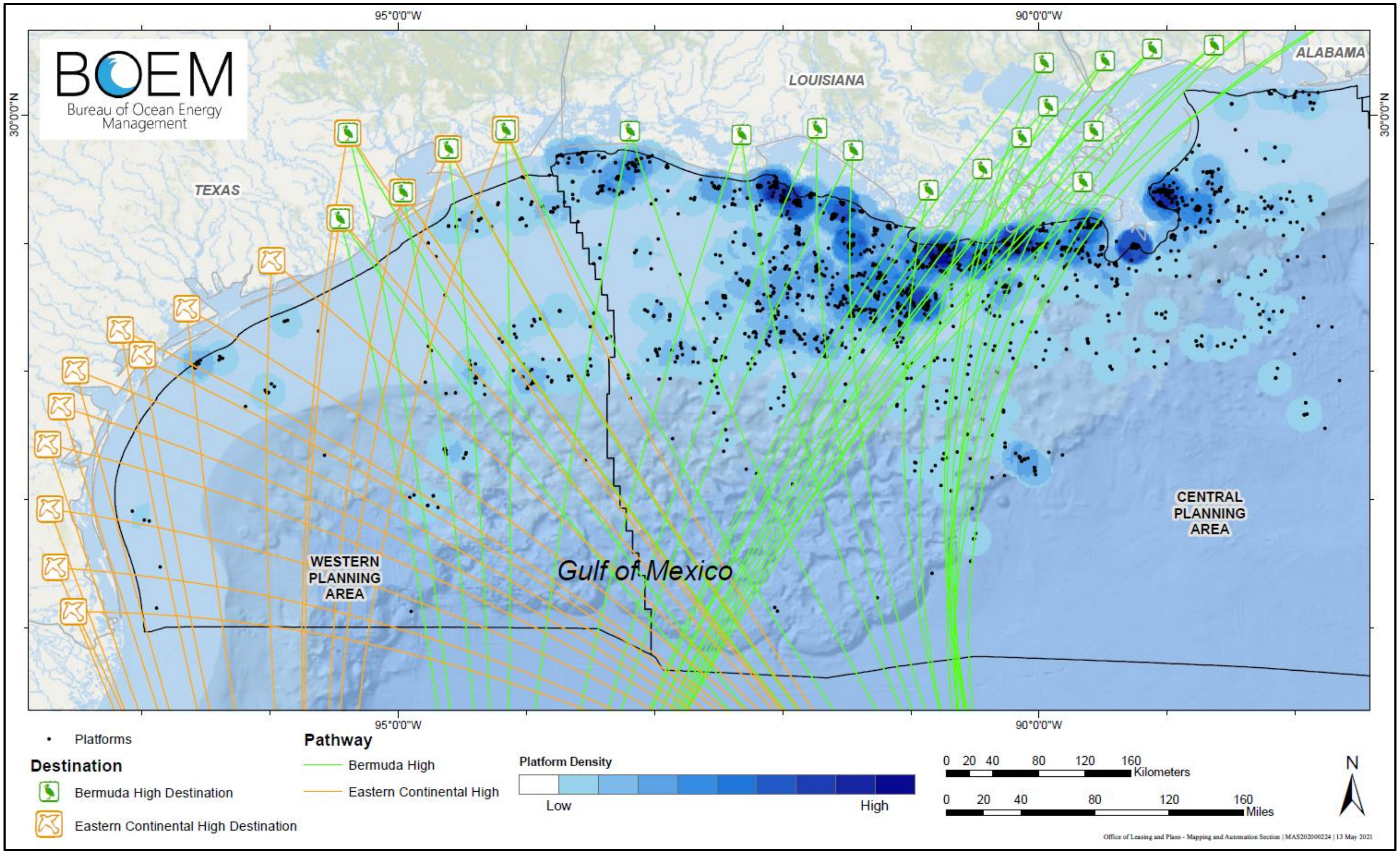


Figure 4.3.5-3. Platform Density and Spring Migration Routes for Trans-Gulf Migratory Birds.

Offshore oil and gas platforms create a structural presence in the GOM that otherwise would not exist or serve as habitats for birds, resulting in complex direct and indirect effects on birds. Many species opportunistically utilize these spaces for roosting and resting sites (Burke et al. 2012). Migratory birds have also been documented to stop at platforms to rest and recover from fatigue (Russell 2005); however, stop-over behavior may be detrimental as birds will still expend energy reserves while at the platforms (Hope Jones 1980) and could be increasing their exposure to predators (e.g., falcons) (Russell 2005). Traditional landbirds have also been sighted at GOM platforms.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that discharges and wastes, bottom disturbance, air emissions, and socioeconomic changes and drivers (refer to **Chapter 4.3.0**) are not likely to affect birds. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.1)

All air emissions and pollution as a result of OCS oil- and gas-related activities are permitted and regulated to the point that both onshore and offshore releases are unlikely to pose a risk to birds. The CAA established the NAAQS for specified pollutants (42 U.S.C. §§ 7401 *et seq*.). As required by the OCSLA, BOEM assesses these concerning oil and gas development projects as well as VOCs to the extent that activities significantly affect the air quality of any State. The OCS oil- and gas-related activities release air emissions from sources related to drilling and production via vessels, flaring (refer to **Chapter 2.6.1** for light attraction via flaring) and venting, decommissioning, fugitive emissions, and oil spills. Many OCS oil- and gas-related activities are transitory, as are most marine and coastal GOM birds, which may reduce interaction opportunities.

Transport and dispersion processes via prevailing wind circulations immediately begin to circulate pollutants when released. Dispersion depends on several factors, including emission height, atmospheric stability, mixing height (i.e., the height above the surface through which vigorous vertical mixing occurs), exhaust gas temperature and velocity, and wind speed. The mixing height is important to dispersion of pollutants because it dictates the vertical space available for spreading the pollutants.

Mixing height information in the GOM is scarce, but measurements near Panama City, Florida (Hsu et al. 1980), found that the mixing height can vary between 1,312 and 4,265 ft (400 and 1,300 m), with a mean of 2,953 ft (900 m). Heat flux calculations in the WPA (Barber et al. 1988; Han and Park 1988) indicate an upward flux year-round – highest during winter and lowest in summer.

Due to the atmospheric processes on air pollutant transport, stack height, exit gas velocity from the stack, the distance of the marine species from the sources, and temporary vessel activity, coastal and marine birds are not expected to be affected by air emissions. Further, air emissions would be localized, and air pollution would dissipate quickly upward in the air at considerable distances.

Bottom Disturbance (Chapter 2.3.1)

Pipeline trenching could result in the temporary displacement of some marine birds and some potential loss of benthic foraging habitat. Impacts would be greatest along the line of the trenching activity, but after the trenching process is complete, birds are expected to return to the area. Bottom disturbance offshore is not likely to significantly impact diving seabirds given the limited footprint of disturbance and the widespread availability of similar feeding grounds (i.e., offshore pelagic waters). Overall, bottom disturbance is not expected to pose risks to marine and coastal birds as they do not inhabit the seafloor beyond quick, infrequent foraging trips mostly in inshore or coastal waters.

4.3.5.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.5-2 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect birds in the GOM region. The effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Emergency air emissions, such as a hydrogen sulfide leak from a pipeline, can affect birds. Exposed birds or flocks can experience various toxic effects. This exposure would likely be limited to an individual or an individual flock passing through the area.

The effects of an oil spill on birds depend on many variables, including the spill location, spill size, oil characteristics, weather events, oceanographic conditions, and time of year, as well as the behavior and physiology of the birds. Repeated exposure to oil spills can also be a factor in determining the level of impact on birds. An accidental oil spill could occur in offshore waters or coastal, nearshore areas, determining which bird species would be affected and the extent of such effect (Castege et al. 2007; Wiese and Jones 2001). A nearshore accidental oil spill could directly or indirectly impact shorebirds, waterfowl, and coastal seabirds. Important coastal habitats for birds could also be affected (**Chapter 4.3.1**), which could lead to birds experiencing nesting and foraging habitat loss and displacement. Oiling can take a greater toll in shallower waters, wetlands, bay and gulf intertidal shorelines, beaches, and dunes as bird diversity and abundance may be high, and hydrocarbon accumulation and persistence can also be high in these habitats. This may be especially true for barrier islands, as they support many breeding and wintering waterbirds, and are important migratory stop-overs (Curtiss and Pierce 2016; Selman et al. 2016).

Direct impacts to birds that encounter accidentally spilled oil include tissue and organ damage from ingested or inhaled oil as well as interference with food detection, predator avoidance, homing of migratory species, disease resistance, growth rates, reproduction, and respiration. Birds can ingest and inhale spilled oil while feeding on oiled benthic, planktonic, or pelagic prey; grooming (i.e., preening) oiled plumage; or drinking hydrocarbons in water. The ingestion or inhalation to the extent of toxic oiling can kill birds. Oiled plumage can cause loss of insulation, the ability to fly, and buoyancy, which can all result in mortality. If the oiling occurs during incubation, contaminated plumage can transfer oil to the eggshells and can result in embryo mortality (Leighton 1993). Feather fouling can reduce a bird's flight ability, which can lead to longer flight times, decreased migration speeds, and increased energy costs. This can cause late arrivals to wintering grounds, breeding grounds, or stopover sites, which may have downstream effects on the bird (Perez et al. 2017). Exposure to sublethal levels of oil can result in oxidative injury (e.g., muscle fatigue, decreased energy availability for metabolic processes, and adverse reproductive impacts), negative impacts on plasma and liver metabolome (as demonstrated in double-crested cormorants), and liver hypertrophy and energy homeostasis changes (as demonstrated in seaside sparrows) (Albers 2006; Bonisoli-Alquati et al. 2020; Bursian et al. 2017; Dean et al. 2017; Dorr et al. 2019; Fallon et al. 2018; Harr et al. 2017a; 2017b; Miller et al. 1978; Peakall et al. 1989; Xu et al. 2016; 2017).

Some oiled birds can be rehabilitated post-contamination. Others may sustain injuries or die after the oiling event. Birds whose prey are aquatic or who rely on oceanic waters for foraging are more susceptible to oiling events. Migrants who pass through the GOM and residents of the GOM are also more susceptible to a spill in the area. Long-lived seabirds may also experience impacts longer, and impacts may also be delayed. For example, first-time breeders would have a delayed reduction in recruitment, which would not occur until years after oil exposure (Dunnet et al. 1982). Researchers have found that focusing rehabilitation practices on moderate to heavily oiled birds may enhance their long-term survival, but this would depend on the bird group, foraging behavior, and level of oil exposure (Horak et al. 2020). Gulls affected by sublethal external oiling may be good candidates for rescue and rehabilitation (Dannemiller et al. 2019).

Seabirds may need longer periods to recover from oil-spill impacts due to their unique population ecology, particularly their small clutch sizes, deferred maturity, and low adult mortality rates (Furness and Monaghan 1987). Long-term impacts can also occur when local colonies or flocks experience extirpation, causing species richness losses. Long-term effects can also occur if oil persists up to years in seafloor sediments, becoming resuspended in the water column or contacting prey organisms or diving seabirds. Resuspended oil can also be transferred to other areas, increasing the probability of exposure to birds. The level of impact would depend on habitat affected (e.g., shallower waters), local abundance of birds affected, and the persistence of oil in the area. Other effects include raptors and scavenging birds ingesting oil while foraging, which can lead to vomiting, diarrhea, and hemorrhaging. Even a small oil or fuel spill could have a large effect on ESA-listed species. The effectiveness of the containment and cleanup activities also influences the degree of impact that oil or chemical spills have on birds.

Response Activities (Chapter 2.9.2)

Dispersants are used in spill responses to move oil from the water surface into the water column, but they are also toxic. The dispersant Corexit 9500 was found to significantly decrease hatching success in mallard eggs when compared to the control results (Wooten et al. 2012). Finch et al. (2012) also found that mallard eggs exposed to weathered crude oil had less toxicity than when treated with a high dispersant-to-oil ratio but not when compared to those treated with a low ratio.

These studies demonstrated that the level of toxicity of dispersed, weathered oil could be less than levels with high dispersant usage.

Depending on the volume and spatial extent of a spill, the subsequent cleanup and response efforts in coastal habitats and beaches can be a large-scale activity. Large-scale response can require a large amount of personnel that could potentially disturb nesting birds. Proper training of response personnel is a critical component to reducing the likelihood of these types of effects. Non-nesting shorebirds could experience decreased fitness from lost access to breeding and/or foraging grounds. For example, shorebirds impacted by the *Deepwater Horizon* oil-spill cleanup may have experienced reduced fitness later when arriving at their northern breeding grounds (Henkel et al. 2014). More information on very large, catastrophic events similar to the *Deepwater Horizon* oil spill and the impacts of events of this size can be found in BOEM's *Catastrophic Spill Event Analysis* (BOEM 2021d).

Oil-spill response and cleanup activities can affect birds' prey and their coastal habitats. The birds could experience fewer foraging opportunities and lower quality food availability (**Chapter 4.3.4**). Birds could also face habitat loss of foraging, breeding, wintering, and roosting grounds (**Chapter 4.3.1**). Overall, few studies have been done to study the effects of beach cleanup activities on marine and coastal birds. Mechanical equipment and increased human activity could disturb and negatively affect local populations. Nesting and foraging areas could be damaged, the breeding activities could be prevented or altered, and displacement could occur.

Strikes and Collisions (Chapter 2.9.3)

Accidental Vessel Strike

Some birds will follow ships as a foraging strategy, though this is more common with commercial and recreational fishing vessels. In the open ocean, vessels are more easily detected from long distances and can attract birds to investigate. Many seabird species are also attracted to the vessel's lights at night (refer to **Chapter 4.8.7**). These instances can increase the chance of a subsequent vessel strike, most particularly light-induced attraction to vessels at night (Black 2005).

Just like with platforms, BOEM has historically directed vessels to have down-shielded lighting to minimize attraction and subsequent strikes. Vessel speed can also influence the chance of collision. For example, some seabirds that are attracted to vessels or dive near a seismic survey vessel have a low potential for collision or entanglement as the vessels are moving relatively slowly (4-6 kn; 5-7 mph), and the surveying gear (e.g., hydrophone streamers) is towed 3-11.5 ft (1-3.5 m) below the surface. Further, no empirical evidence suggests that marine and coastal birds could become entangled in seismic survey gear. Shorebirds, including the piping plover and rufa red knot (ESA-listed species), are not known to be attracted to vessels. They may fly at lower altitudes during inclement weather conditions during their migrations across the GOM, which may increase the potential for vessel strikes. Loons and other low-flying waterfowl could also be susceptible to vessel collisions if vessel traffic occurs near federally designated important bird areas.

Accidental Aircraft Strike

Low-flying aircraft (e.g., helicopters) can disturb birds, including those resting or foraging on the water surface or those in flight. Birds can respond to flying aircraft by flushing into flight or rapidly changing their flight speed or direction. These behavioral responses to the aircraft can result in strikes. However, the potential for bird collisions with aircraft decreases at speeds greater than 81 kn (93 mph) (Efroymson et al. 2000). Additionally, the Federal Aviation Administration recommends that aircraft fly at least 2,000 ft (610 m) above the ground when passing over noise-sensitive areas (i.e., national parks, national wildlife refuges, waterfowl protection areas, and wilderness areas), which decreases the chances of behavioral responses and subsequent collisions from the higher density of birds in those areas (Kaulia 2004).

Accidental Collisions

The likelihood of a vessel collision is low, and the chance of a fuel spill from a vessel collision is even smaller. Still, accidental collision events that could result in the release of diesel or other fuel sources could affect birds. Diesel and other fuels that would likely be used by vessels on the OCS are light and would float on the surface for several days. These releases would likely disperse and weather, and volatile components would quickly evaporate. The location of the collision event and resultant spill event helps determine the level of potential impact. If an incident occurs within or near a federally designated Important Bird Area, there could be a greater potential for impact on birds. For more information about the direct and indirect effects of accidental chemical releases on birds, refer to the "Unintended Releases into the Environment" section above.

4.3.6 Marine Mammals

4.3.6.1 Resource Description

The U.S. Gulf of Mexico marine mammal community is diverse and distributed throughout the northern Gulf of Mexico waters. The GOM's marine mammals include members of the taxonomic order Cetacea, including suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia (i.e., manatee). Twenty-one species of cetaceans and one species of Sirenia regularly occur in the GOM and are identified in the NMFS Stock Assessment Reports (Hayes et al. 2018; 2019). Habitat-based cetacean density models are found in Roberts et al. (2016a). Two cetacean species, the sperm whale (**Figure 4.3.6-1**) and the Rice's whale[3] (**Figure 4.3.6-2**), regularly occur in the GOM and are listed as endangered under the ESA. The West Indian manatee is listed as threatened under the ESA and has designated critical habitat in northeastern Florida (DOI and FWS 1976). Further, 19 of the 20 toothed cetaceans (including beaked whales and dolphins) that regularly occur in the GOM are not ESA-listed. Despite being non-listed,

[3] On August 23, 2021, NMFS published a direct final rule in the *Federal Register* (84 FR 15446), "Endangered and Threatened Wildlife and Plants; Technical Corrections for the Bryde's Whale (Gulf of Mexico Subspecies)." The NMFS revises its common name to Rice's whale, the scientific name to Balaenoptera ricei, and the description of the listed entity to the entire species. The changes to the taxonomic classification and nomenclature do not affect the species' listing status under the ESA or any protections and requirements arising from its listing. This rule became effective on October 22, 2021.

the MMPA protects all marine mammals, ESA-listed or not. The NMFS is charged with protecting all cetaceans, while manatees are under the jurisdiction of the FWS. More information on the description of marine mammals can be found in the 2020 NMFS BiOp (NMFS 2020b) and BOEM's Biological Environmental Background Report (BOEM 2021b).

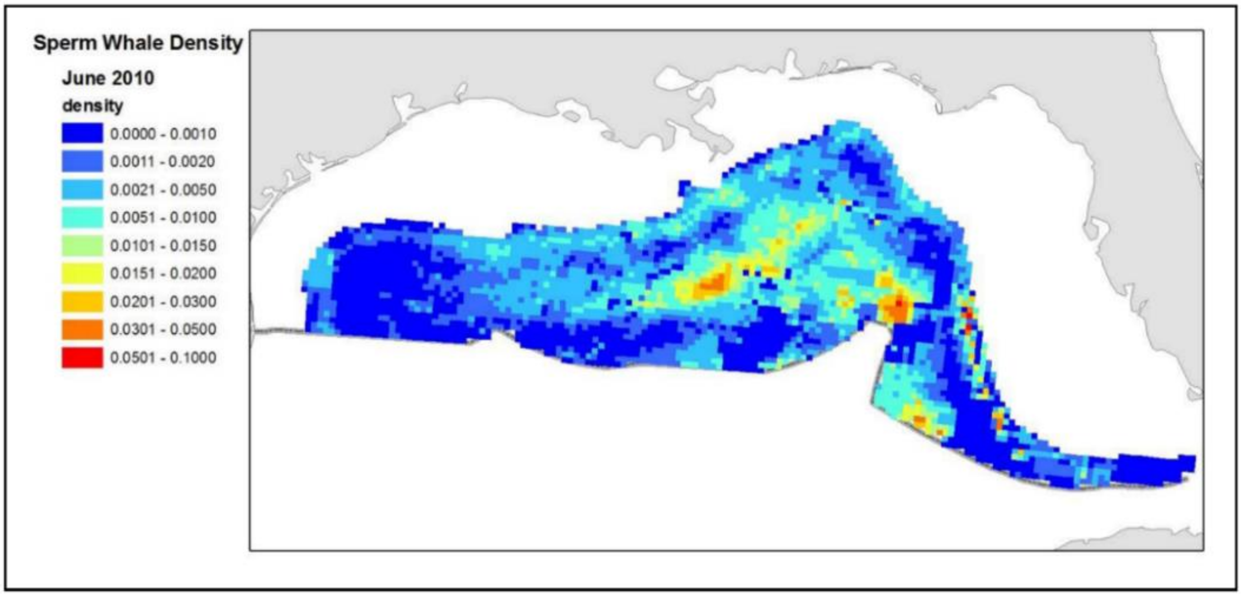


Figure 4.3.6-1. Predicted Sperm Whale Density from a Habitat Model based on Vessel Data Collected during 2003-2009 (Garrison et al. 2018).

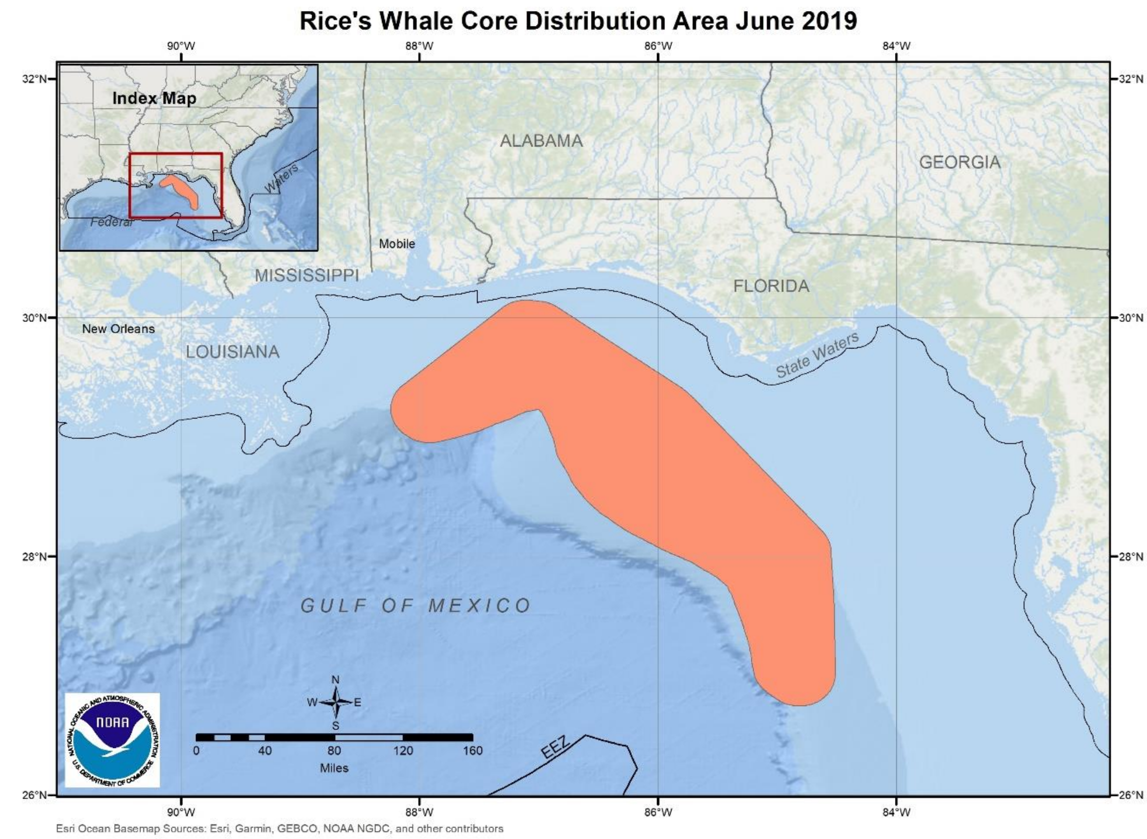


Figure 4.3.6-2. Rice's Whale Core Distribution Area (https://www.fisheries.noaa.gov/resource/map/rices-whale-core-distribution-area-map-gis-data).

Most marine mammal distributions widely vary across the northern GOM with little known about each species' breeding and calving grounds, as well as any general patterns of movement. Several species (e.g., Rice's whale, sperm whale, and bottlenose dolphin) have presumed year-round resident populations in the (Ferguson et al. 2015). 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 (**Chapter 3.3**). Marine mammals may focus their foraging efforts on these abundant nutrient-rich prey locations to improve overall feeding efficiency and reduce overall energy costs (Bailey and Thompson 2010). In addition, marine mammals may forage under *Sargassum* mats due to the abundance of small fishes that typically assemble there (Casazza and Ross 2008; Dooley 1972). Other than factors influencing feeding behaviors, very little is known generally about other factors that may influence marine mammal distribution in the northern GOM.

Species Not Analyzed in Detail

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 document (Hayes et al. 2018; 2019; Mullin and Fulling 2004; Würsig et al. 2000). These species include the following: the blue whale, North Atlantic right whale, and Sowerby's beaked whale (all considered extralimital in the GOM); and the humpback whale, fin whale, sei whale, and minke whale (all considered rare occasional migrants in the GOM) (Hayes et al. 2018; 2019; Mullin and Fulling 2004; Würsig et al. 2000). BOEM did not consider these species in this analysis as they are uncommon in the GOM and are not included in the most recent NMFS Gulf of Mexico Stock Assessment Reports. Nonetheless, they are still protected under the MMPA and ESA, and BOEM mitigations for marine mammals would still apply to these species, as applicable.

Unusual Mortality Events

Under the MMPA, an unusual mortality event (UME) is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." A list of active and closed UMEs with updated information can be found at the following website, and information is generally updated regularly: https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events. The 2018 to 2019 Southwest Florida Bottlenose Dolphin UME was issued in July 2018 due to an elevation in bottlenose dolphin mortalities. Southwest Florida has been experiencing an ongoing severe red tide event (**Chapter 3.3**) since November 2017. The results from several necropsies showed positive results for the red tide toxin (i.e., brevetoxin), indicating that this UME is related to the bloom (NMFS 2020a). Investigation is ongoing.

Hearing and Vocalization

Marine mammals can detect acoustic pressure, and different mammalian families have distinct hearing capabilities (**Figure 4.3.6-3**). Rice's whales are classified within the low-frequency cetacean functional marine mammal hearing group (7 Hz to 22 kHz), while the sperm whale is classified within the mid-frequency cetacean functional hearing group (150 Hz to 160 kHz), though hearing group designations are changing per species (Southall et al. 2007, 2019). Marine mammals produce sounds for a variety of natural behaviors over a range of acoustic frequencies (Greene Jr. and Moore 1995). Some cetaceans have sophisticated mechanisms for beam-forming and sound localization, which they utilize for hunting prey. Fully aquatic mammals (e.g., cetaceans and sirenians) have additional adaptations. Toothed whales use higher frequency echolocation clicks to navigate and track prey, as well as a variety of whistle types during social interactions (Greene Jr. and Moore 1995). Baleen whales produce low-frequency reproductive and social calls that can travel great distances, even across ocean basins (Clark and Gagnon 2002).

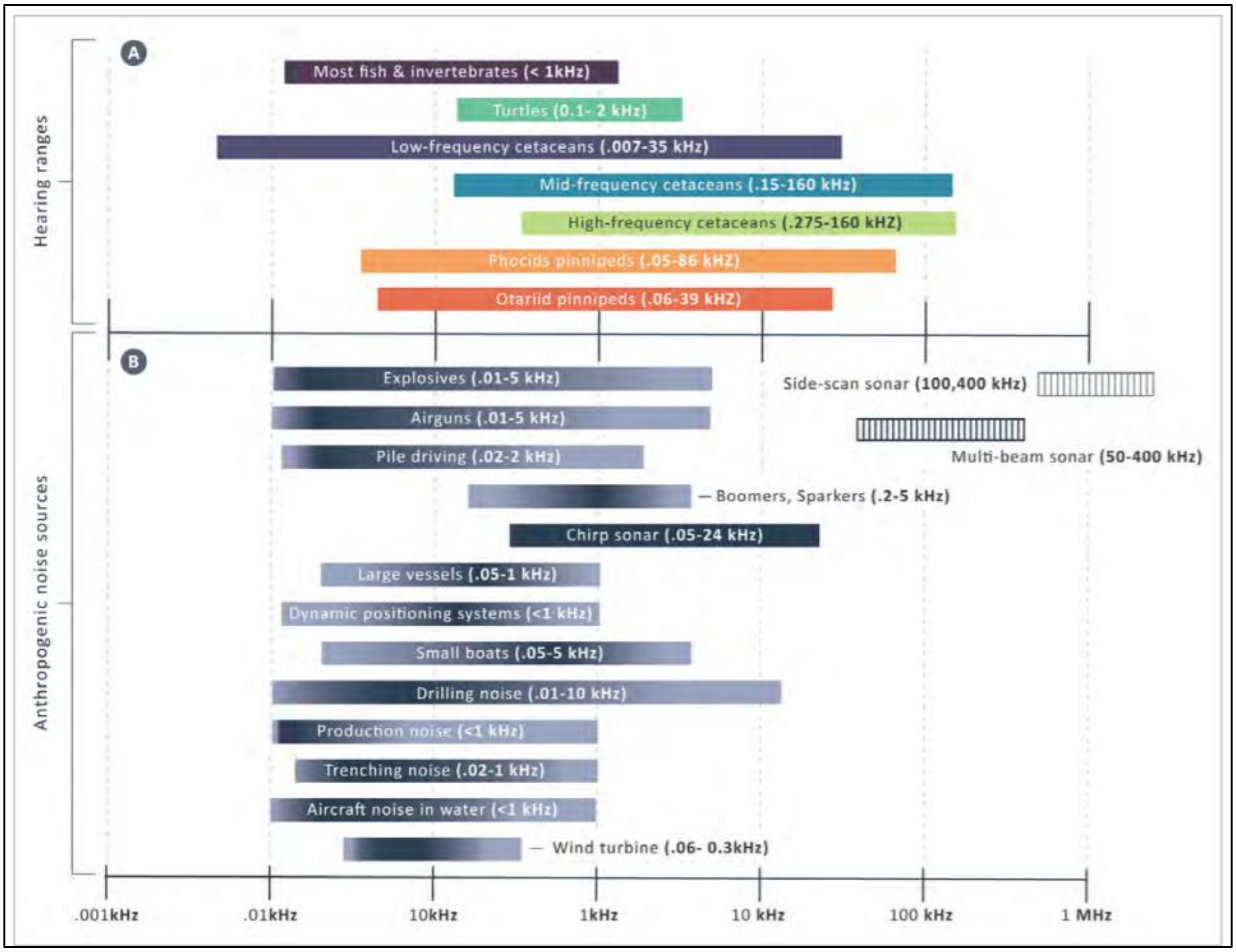


Figure 4.3.6-3. (A) Approximate Hearing Ranges of Marine Species; (B) Frequency Ranges of Various Anthropogenic Sources. These ranges represent approximately 90% of the acoustic energy, and color shading roughly corresponds to the dominant energy band of each source. Dashed lines represent broadband sonars to depict the multi-frequency nature of these sounds. The frequency axis of both plots shows kHz in a logarithmic scale. Sources: Popper et al. (2014b), Greene Jr. and Moore (1995), and NMFS (2018a).

Climate Change Influences to Marine Mammals

Climate change has the potential to influence or act synergistically with ongoing or future stressors to modify effects (positive or negative) to marine mammals, some species more than others depending on the geographic location and season. Broadly, possible impacts include temperature and rainfall changes; rising sea levels; and changes to ocean conditions, such as ocean circulation patterns and storm frequency (IPCC 2014), which are discussed programmatically in **Chapter 3.4** and more specifically with respect to marine mammals below.

These changes may affect marine GOM ecosystems by increasing the vertical stratification of the water column, shifting prey distribution, impacting competition, and generally impacting species' ranges (Learmonth et al. 2006). Such modifications could result in ecosystem regime shifts as the productivity of the regional ecosystem undergoes various downstream changes related to nutrient inputs and coastal ocean processes .

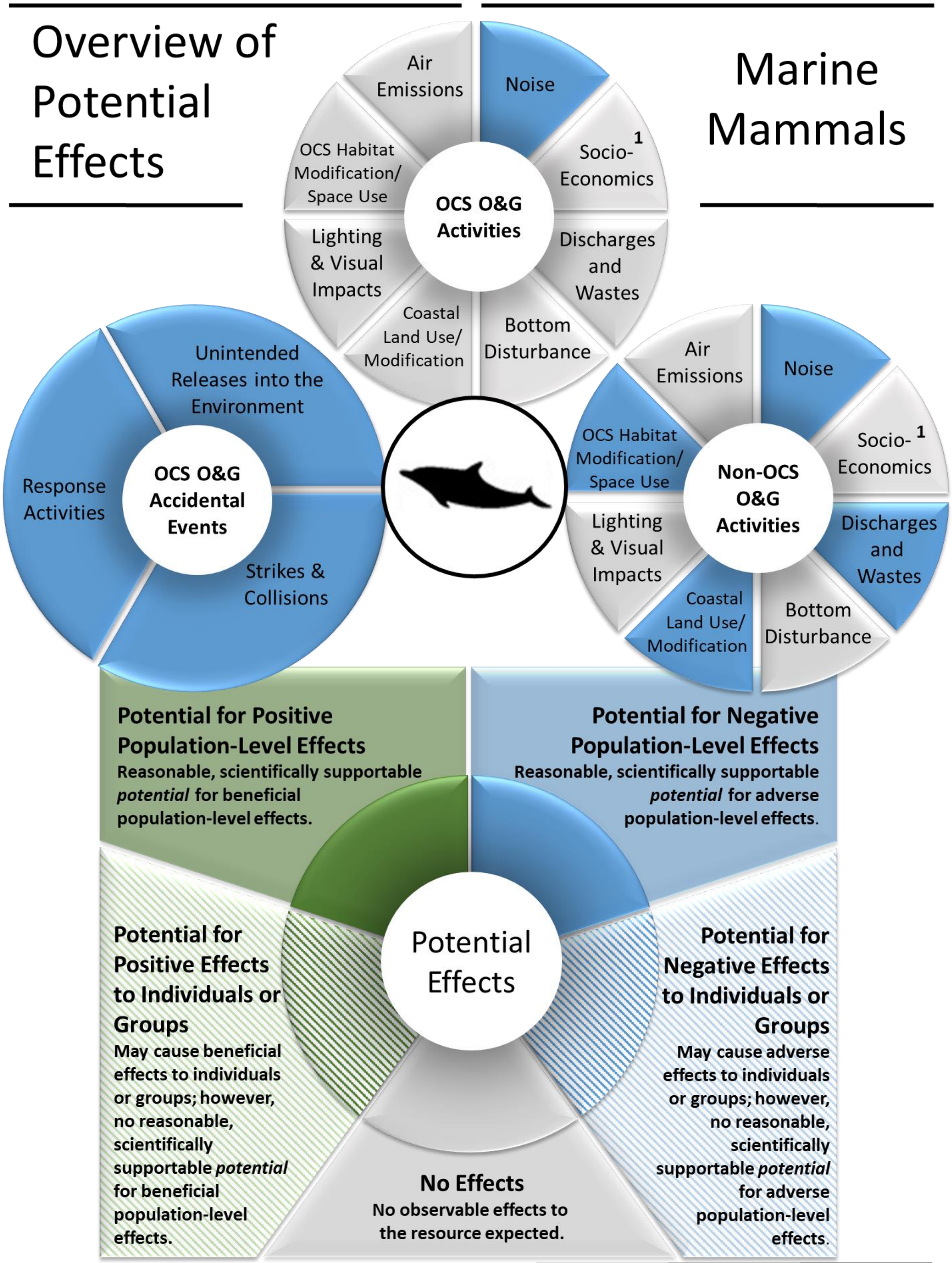
Warming ocean and coastal temperatures can push species to the edge of their optimal temperature ranges. The collective range shifts by individual species could result in broad changes to marine ecosystems, with unpredictable consequences (Doney et al. 2012; Karnauskas et al. 2015). A poleward shift in certain species' ranges is predicted. Warming waters can affect the timing of annual events such as plankton blooms (important food source for baleen whales [e.g., Rice's whale]), migration, and reproduction in some species, potentially disrupting predator-prey relationships, with cascading effects throughout the food web (Ullah et al. 2018).

There is also some research suggesting that ocean acidification from rising carbon dioxide levels could potentially decrease sound absorption in oceans, thereby causing amplified levels of ambient noise (Gazioğlu et al. 2015). Further, increased sea-surface temperatures likely enhance the magnitude and frequency of harmful algal blooms and their associated toxins (O'Neil et al. 2012). Several uncertainties exist on how climate change impacts marine mammals (Evans and Bjørge 2013; Silber et al. 2017), though it is assumed that range shifts (e.g., in response to shifting prey distribution or expansion of breeding grounds), timing of important biological activities (e.g., breeding), and regional abundance changes could occur (Learmonth et al. 2006). While some effects are anticipated, the precise impacts of global climate change on the GOM cannot currently be predicted or parsed out from every global activity.

4.3.6.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and marine mammals. **Figure 4.3.6-4** provides a synopsis of the IPF categories that could currently affect or have the potential to affect marine mammals in the Gulf of Mexico OCS. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.6-4**.

Figure 4.3.6-4 is intended to illustrate the relevant IPF categories and potential effects that are analyzed in this chapter, as well as the IPFs that are not likely to cause effects to marine mammals and, therefore, would likely be scoped out of future NEPA analyses for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

Figure 4.3.6-4. Potential Interactions Between the Iimpact-Producing Factors Identified in **Chapter 2** and Marine Mammals. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and resource; and the species' distribution and health. BOEM will use this preliminary identification and disclosure of the potential range of effects to marine mammals, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

4.3.6.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.6-4 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect marine mammals in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent and are discussed below.

Discharges and Wastes (Chapter 2.2.2)

In the U.S., about 80 percent of marine debris washes into the oceans from land-based sources and 20 percent is from ocean sources (The Maritime Executive 2018; USEPA 2017d). Discharges and wastes have the potential to modify suitable habitat for marine mammals (Morton 2003). Plastics have been found inside deceased marine mammals (Gregory 2009). Marine debris affects marine habitats and marine life worldwide, primarily through entanglement or ingestion (e.g., choking) (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality of marine mammals. Entanglement can also result in drowning. Marine debris ingestion can lead to intestinal blockage, which could impact feeding ability and lead to injury or death. Chapter 4.7.9.2 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b). The harmful algal blooms, including brown and red tides, occur almost every year in GOM waters (**Chapter 3.3**). The harmful algal blooms could kill, displace, or cause respiratory or reproductive issues in marine mammals (Fire et al. 2008; Rosel et al. 2016). Bottlenose dolphins and manatees are most at risk from nearshore discharges and wastes. For instance, the propensity of manatees to aggregate at industrial and municipal outfalls may expose them to high concentrations of contaminants (Stavros et al. 2008). 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). Chapter 4.7.9.2 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Noise (Chapter 2.4.2)

Marine mammals in the GOM planning areas are vulnerable to several non-OCS oil- and gas-related noise sources, including dredging, construction, mineral exploration in offshore areas, geophysical (seismic) surveys, sonars, ocean research activities, commercial and recreational vessels, aircraft, commercial sonar, military activities, in-water construction activities, and other human activities (refer to **Chapter 2.4.2**). The potential for noise impacts from OCS oil- and gas-related sources on marine mammals is highly variable and influenced by many factors, such as the health of the exposed individual and the existing soundscape (Greene Jr. and Moore 1995; Nowacek et al. 2007; Southall et al. 2007; 2019). Furthermore, the same sound source can propagate differently depending on the physical environment. Sound propagation through a particular environment depends on a variety of factors, including physical and oceanographic 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) (Greene Jr. and Moore 1995; Southall et al. 2007; 2019).

Vessel traffic is a major contributor to anthropogenic ocean noise, primarily in the low-frequency bands (10-100 Hz) (Erbe et al. 2019). Over the last few decades, low-frequency ambient ocean noise has increased substantially due to a steady increase in shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009; McKenna et al. 2012; National Research Council 2003d). Faster, larger ships generally create more noise and lower-frequency sounds (less than 1 kHz), while smaller craft produce sounds in the mid frequencies (1-5 kHz).

The biological significance of behavioral responses to underwater noise and the population consequences of those responses are not fully understood (National Research Council 2005a; Southall et al. 2007; Southall et al. 2019). Mounting evidence indicates that noise in the marine environment could interfere with communication in marine mammals, a phenomenon called acoustic masking (Clark et al. 2009; Erbe et al. 2016). In addition to acoustic masking, elevated ocean noise levels can increase stress in marine mammals, which may lead to lower reproductive output and increased susceptibility to disease (Kight and Swaddle 2011). The increased noise level may steadily erode marine mammals' abilities to communicate and find food and mates (Clark et al. 2009). Chapter 4.7.1 of BOEM’s Biological Environmental Background Report contains additional information (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

The construction of residential areas, industrial centers, ports, hotels, resorts, marinas, docks, seawalls, bridges, and roads and other infrastructure occurs along the Gulf Coast (Kildow et al. 2016; Sengupta et al. 2018). Expansions of ports and dredging of port areas accommodate increased shipping and increasingly larger vessels (Merk 2015). An increase in built infrastructure, especially during the construction process (though short-term), may affect habitat utilized by coastal marine mammals (e.g., coastal dolphins and manatees). Coastal construction can degrade or destroy coastal habitats and degrade water quality by increased sedimentation and pollutant runoff, affecting coastal marine mammals if ingested.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Offshore habitat degradation can occur from a variety of anthropogenic activities. For instance, beach-going, wildlife viewing, fishing, boating, sailing, diving, historic sightseeing, and cruise ship traffic could degrade and/or change the oceanic landscape and thereby preferred marine mammal habitats. Physical features, including canyons, used by marine mammals could be degraded indirectly by these activities. Habitat degradation could persist and have long-term residual impacts on community structure and habitat function (Morton 2003). Anthropogenic events can cause the loss of core and/or preferred habitat if habitat becomes unsuitable (Morton 2003).

Fisheries Interactions

Commercial fishery interactions are a threat to marine mammals because the marine mammals may be injured or killed by commercial fishing gear. Fishing line and gear, which is managed by NMFS, that is not disposed of properly can pose entanglement and ingestion risks to marine mammals (Wells et al. 1998). Entanglement can decrease the individual's swimming ability, disrupt feeding, cause life-threatening injuries, or result in death. Marine mammals are most often found entangled in net fragments and monofilament line from commercial and recreational fishing boats, as well as discarded strapping bands and ropes from a variety of vessels. Fisheries bycatch of marine mammals has also occurred in the GOM, such as from pelagic longline fisheries and shrimp trawl fisheries (Benaka et al. 2016). Chapter 3.6.5.2 of BOEM’s Biological Environmental Background Report contains additional information (BOEM 2021b).

Strikes and Collisions

Vessel strikes from non-OCS oil- and gas-related activities have caused injuries and fatalities for several large whale species (Constantine et al. 2015; Laist et al. 2001). Vessel speed and size influence the strike risk. The following vessel types are associated with accidental whale strikes (listed in descending order): tanker/cargo vessels; whale watch vessels; passenger liners; ferries; naval vessels; recreational vessels; USCG vessels; fishing vessels; research vessels; dredges; and pilot boats (Laist et al. 2001). Deep-diving whales (e.g., sperm whale) may be more vulnerable to vessel strikes given the longer surface period required to recover from extended deep dives (Laist et al. 2001). The Rice's whales spend 90 percent of their time within 39 ft (12 m) of the ocean’s surface (Constantine et al. 2015), which could make them vulnerable to strikes by large ships. Manatees are slow-moving and are often struck by smaller boats (FWS 2001). Vessel activity along the northern GOM coast could put both manatees and Rice’s whales at risk, especially in the EPA, where Rice's whales typically reside (**Figure 4.3.6-2**) and manatees undertake seasonal movements along the northern Gulf Coast. Chapter 3.6.5.4 of BOEM’s Biological Environmental Background Report contains additional information (BOEM 2021b).

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil- and gas-related development and determined that air emissions, bottom disturbance, lighting and visual impacts, and socioeconomic changes and drivers (refer to

Chapter 4.3.0) are not likely to affect marine mammals. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions and pollution can contribute to climate change and ocean acidification; however, additional research is neeed to fully understand these interactions, as current scientific knowledge is limited (Gazioğlu et al. 2015). Once anthropogenic emissions are released into the atmosphere, transport and dispersion processes begin circulating the emissions. Due to the atmospheric processes on air pollutant transport, stack height above any infrastructure, exit gas velocity from the stack, distance of the marine mammals from the sources, and temporary vessel activity, marine mammals are not vulnerable to air emissions. Overall, marine mammals are not expected to be vulnerable to onshore or offshore air emissions because emissions would be localized and air pollution would dissipate quickly.

Natural sources of air pollution include subsurface seeps of crude oil, bacterial processes, and mud volcanoes (**Chapter 2.1.2**). Gulf of Mexico seeps are highly variable in composition and volume but do include gases and volatiles. Wilson et al. (2019a) estimated VOC emissions from natural seeps to be approximately 13,597 tons of VOC/year, with about 40 percent eventually finding its way to the surface. Bacterial process sources include plankton producing dimethylsulfide and sediment bacteria producing methane. Releases from mud volcanoes often contain CH_4 and CO_2; however, approximately 80 percent of CH_4 emitted by mud volcanoes is consumed by biologic organisms (Reeburgh 2007). Additionally, N_2O, a potent GHG, is produced in hypoxic coastal zones by deepwater bacteria. Emissions from all of these natural processes, however, are episodic according to prevailing environmental conditions, making it difficult to assess temporal variances throughout the year. Given the temporal variance and eposidic nature of these events, coupled with the transient nature of marine mammals, these emissions are not expected to have meaningful effects to marine mammals.

Bottom Disturbance (Chapter 2.3.2)

State-regulated drilling would be localized, and impacts are not expected to occur outside of the immediate area. Infrastructure emplacement, pipeline trenching, and structure removal would be localized and typically temporary, and habitat loss is not expected. Also, bottom-disturbing activities associated with military operations, sand borrowing, and commercial fisheries would be localized and temporary. The ESA-listed whale species in the GOM do not use benthic or seafloor habitats to any discernable extent. If bottom activities were to take place in benthic habitats of coastal, inland waters used by the Florida manatee, impacts would be localized and temporary. Adverse modification of critical habitat would not be legally authorized under the ESA. Further, it is assumed that care in the timing of activities and siting of onshore and State-regulated, military, or commercial infrastructure, particularly with regard to ESA-listed species, would be applied. Therefore, bottom disturbance from such activities is not expected to have any detectable effect on marine mammals in the GOM.

Lighting and Visual Impacts (Chapter 2.6.2)

Migratory, feeding, and breeding behaviors of cetaceans are not substantially impacted by artificial light since they depend on acoustic rather than visual cues. Marine mammals are not expected to be impacted by lighting or visual impacts since infrastructure above the water is not expected to be in the visible range of marine mammals.

4.3.6.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.6-4 highlights the IPF categories associated with routine OCS oil- and gas-related development that could potentially affect marine mammals in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent and are discussed below.

Noise (Chapter 2.4.1)

Noise sources from OCS oil- and gas-related activities that marine mammals could be vulnerable to include active acoustic sources, vessels, drilling, production, trenching, construction, and platform decommissioning (including use of explosives) (**Figure 4.3.6-3** and **Chapter 2.4.1**). Acoustic sources are described by their sound characteristics and are generally divided into impulsive noise and nonimpulsive noise for the regulatory process. Impulsive noises (e.g., seismic surveys and pile driving) 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., drilling) and includes continuous anthropogenic noise (e.g., vessel noise).

As with all OCS-related sources, the potential for noise impacts from OCS oil- and gas-related sound sources on marine mammals is highly variable and influenced by many variables such as health of the exposed individual and the existing soundscape (Greene Jr. and Moore 1995; Nowacek et al. 2007; Southall et al. 2007; 2019). Furthermore, the same sound source can propagate differently depending on the physical environment. Sound propagation through a particular environment depends on a variety of factors, including physical and oceanographic 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) (Greene Jr. and Moore 1995; Southall et al. 2007; 2019).

Marine mammal responses to sound exposure from oil- and gas-related activities may include lethal or nonlethal injury, temporary hearing impairment, behavioral harassment and stress, or no apparent response (Nowacek et al. 2007). Most observations have been limited to short-term behavioral responses, which have included temporary cessation of feeding, resting, or social interactions; however, habitat abandonment can lead to more long-term effects. Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds (Parks 2012). Masking can reduce the range of communication, particularly long-range communication. This could have a variety of implications for marine mammals, including, though not limited to, inability to avoid predators and to reproduce successfully (Marine Mammal Commission 2007). Chapter 3.6.5.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that discharges and wastes, bottom disturbance, coastal land use/modification, air emissions, socioeconomic changes and drivers (refer to **Chapter 4.3.0**), and lighting and visual impacts are not likely to affect marine mammals. Therefore, these IPFs were excluded from detailed analysis for the reasons below and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.1)

Air emissions would arise from drilling, production, and pipeline installation with associated vessel support, G&G survey vessels, flaring and venting, decommissioning, and fugitive emissions. Most activity within the OCS is transitory, as would be any marine mammal, though activities may be recurring and certain facilities may remain for several years. Additionally, emissions are occurring above the air-water interface, which is outside of the commonly used habitat of marine mammals in the GOM.

Once pollutants are released into the atmosphere, transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing wind circulations, which can vary depending on the time of year. Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed. The mixing height is the height above the surface through which vigorous vertical mixing occurs. The mixing height is important because it dictates the vertical space available for spreading the pollutants. Although mixing height information throughout the Gulf of Mexico is scarce, measurements near Panama City, Florida (Hsu et al. 1980), show that the mixing height can vary between 1,312 and 4,265 ft (400 and 1,300 m), with a mean of 2,953 ft (900 m). Heat flux calculations in the WPA (Barber et al. 1988; Han and Park 1988) indicate an upward flux year-round – highest during winter and lowest in summer.

Due to the atmospheric processes on air pollutant transport, stack height, exit gas velocity from the stack, distance of the marine species from the sources, and temporary vessel activity, marine mammals are likely not vulnerable to air emissions (Barber et al. 1988; Han and Park 1988; Hsu et al. 1980). Because of the combination of 2,953-ft (900-m) mixing height and upward flux of discharged regulated pollutants year-round from stacks, the contribution of routine activities to the air-water interface is either insignificant (negligible) or unlikely to occur (and are therefore discountable). Overall, marine mammals are not expected to be affected by onshore or offshore air emissions because emissions would be localized and air pollution would dissipate quickly upward in the air at considerable distances.

Discharges and Wastes (Chapter 2.2.1)

Drilling fluids, drill cuttings, and produced-water discharges contribute heavy metals and other substances, in particular petroleum hydrocarbons, that may be toxic or detrimental (e.g., increase oxygen demand and sediment) to the surrounding environment. Heavy metals include barium and trace amounts of chromium, copper, cadmium, mercury, lead, and zinc. Several hundred chemical compounds could be part of a total petroleum hydrocarbon mixture, including PAHs, benzene, toluene, ethylbenzene, and xylene. The composition of the mixture depends on the source, age, and environmental conditions. Toxicity data for some chemical compounds used for development and production are summarized in (Boehm et al. 2001a; 2001b).

As discussed in **Chapter 2.2**, the USEPA regulates discharges through the issuance of NPDES permits under the CWA and subsequent provisions (33 U.S.C. §§ 1251 *et seq*.). Under this authority, the USEPA has established effluent limitations, toxicity testing requirements, and monitoring requirements for the various discharges that operators must comply with to ensure the health of GOM waters. It is assumed that compliance with the USEPA and USCG regulations, which are designed to keep contaminants below harmful levels for public health and welfare, would prevent impacts from produced water, drilling muds, and cuttings.

Data from different oceans around the world, however, show that heavy metal and PAH concentrations are present in marine mammal tissues and organs, as well as in the milk of lactating cetaceans. While these tissue levels provide strong evidence of exposures to these pollutants, in consultation with NMFS, both BOEM and NMFS were not able to reliably estimate the contributions of OCS oil and gas pollutant loadings to pollutant accumulations in marine species (NMFS 2020b). This is because there are many known and unknown pollutant sources discharging into Gulf of Mexico waters, and these species are long lived and travel widely within and outside the GOM over their lifetimes. Furthermore, the USEPA toxicity tests evaluate survival growth and fertility under ideal laboratory conditions such that effects are not influenced by real world factors like predation, competition, disease, other stressors in the field, and fluctuations in natural water quality parameters. However, in the natural environment, effects on swimming speed and predator detection or evasion influence survival. In addition, toxicity test durations may not be long enough to accurately detect lags in responses that may occur (e.g., delayed mortality, metabolism to more toxic form, and cascading effects). Also, full lifecycle and generational tests are not typically conducted, so important effects that may not manifest at the exposed life stage or that have generational influences may not be detected.

BOEM believes that the regulated discharges described in **Chapter 2.2** will be insignificant based on the following: (1) discharges must meet permit requirements for acceptable toxicity levels that do not cause harm to tested sensitive species (as described above) and other restrictions set forth in the permit, which, according to the USEPA's biological evaluation, are intended to protect all aquatic life, including protected species and prevent unreasonable degradation of the marine environment; (2) discharges are expected to quickly dilute and disperse in the vast receiving waters; (3) restrictions will limit many chemicals and nutrients from entering the receiving waters (i.e., no free oil, no floating solids, no garbage, no foam, phosphate free soap and detergents, and sanitary waste treated with chlorine); (4) the standard use of curbs, drip pans, and other pollution prevention equipment on offshore structures; (5) toxicity limits are required for facilities intending to discharge drilling fluids, drill cuttings, and/or produced waters to the sea; and (6) based on the USEPA, BOEM, and bioaccumulation studies cited previously, there have been no reported significant adverse environmental impacts, including no bioaccumulation resulting from routine OCS oil- and gas-related activities in the GOM, and no adverse effects to NMFS' protected resources have been reported (NMFS 2020b).

Most discharges associated with OCS oil- and gas-related activities are localized, temporary, and not expected to persist in the water column. Therefore, these discharges are unlikely to affect foraging or other activities by marine mammals. Because of the USEPA's regulation, most of the routinely discharged chemicals are not expected to result in exposure intensities that would result in detectable adverse effects to marine mammals because they are diluted and dispersed when released in offshore areas (Kennicutt II 1995). In addition, it is assumed that BSEE, the USCG, and the USEPA regulations, and BOEM guidance will be applied and strictly followed for avoiding accidental loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions (e.g., covering outside trash bins) to prevent accidental loss of solid waste. It is prohibited to discharge trash and debris (33 CFR §§ 151.51-77) unless it is passed through a comminutor (a machine that breaks up solids) and ultimately passes through a 25-mm (1-in) mesh screen.

Bottom Disturbance (Chapter 2.3.1)

The ESA-listed whale species in the GOM do not use benthic or seafloor habitats to any discernable extent. The benthic habitats used by the Florida manatee are in coastal, inland waters, which would not be within typical locations for OCS oil- and gas-related activities. BOEM-regulated drilling would be localized, and effects are not expected to occur outside of the immediate area. In addition, infrastructure emplacement, pipeline trenching, and structure removal would also be localized and temporary, and no significant habitat loss would be expected. Adverse modification of critical habitat would not be legally authorized under the ESA. Further, it is assumed that care in the timing of activities and siting of infrastructure, particularly with regard to ESA-listed species, would be applied. Therefore, bottom disturbance is not expected to have any detectable effect on marine mammals in the GOM planning areas.

Coastal Land Use/Modification (Chapter 2.5.1)

It is assumed that careful planning would be applied to avoid coastal land disturbance in areas utilized by the Florida manatee, which are mainly located in the EPA where very few OCS oil- and gas-related activities would be likely to occur. Adverse modification of critical habitat of any marine species would not likely be legally authorized under the ESA or MMPA. Coastal land disturbance would not affect cetaceans since they strictly utilize pelagic waters. Also, marine mammals are not expected to be affected by a pipeline landfall due to the unlikely potential for it to occur in the WPA and CPA and because cetaceans utilize pelagic waters. Onshore construction is not within the OCS and would be outside of BOEM or BSEE's regulatory authority. In addition, any activity would be under other regulatory authorizations (e.g., the USACE and Federal Energy Regulatory Commission).

Lighting and Visual Impacts (Chapter 2.6.1)

Migratory, feeding, and breeding behaviors of cetaceans are not affected by artificial light since they depend on acoustic rather than visual cues. Marine mammals are not expected to be impacted by lighting or visual impacts since infrastructure is above the water and is not expected to be in the visible range of and/or an attractant source for marine mammals.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

It is assumed that care in planning and siting of infrastructure, particularly with regard to ESA-listed species, would be applied to avoid long-term marine mammal habitat modification. Adverse modification of critical habitat would not be legally authorized under the ESA or MMPA. The ESA-listed whale species in the GOM do not use benthic or seafloor habitats to any discernable extent. The benthic habitats used by the Florida manatee are in coastal, inland waters, which would not be within typical locations for OCS oil- and gas-related activities. BOEM-regulated drilling would be localized, and effects are not expected to occur outside of the immediate area. Infrastructure emplacement, pipeline trenching, and structure removal would be localized and temporary, and no significant habitat loss would be expected.

4.3.6.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.6-4 highlights the IPF categories of accidental events associated with oil- and gas-related development on the OCS that could potentially affect marine mammals in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, and are discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Marine debris affects marine mammals, primarily through entanglement or ingestion (e.g., choking) (Gall and Thompson 2015). Entanglement in marine debris could lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality (e.g., drowning) of marine mammals. Marine debris ingestion can lead to intestinal blockage, which could impact feeding ability and lead to injury or death. There are little data on marine debris in the GOM; therefore, it is difficult to determine the extent of the problem and its impacts on marine mammal populations. Chapter 4.7.9 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Effluent limit violations and accidental discharges have the potential to release chemicals in larger-than-approved regulated volumes or concentrations. In such accidents, negative effects from exposures at harmful levels during the discharge and as it dissipates could occur in organisms within the immediate area. If the discharge contained persistent and bioaccumulative pollutants, longer-term effects are possible over a broader area through dietary exposure and bioaccummulation.

In the event of an accidental oil 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 (not considered in this example as catastrophic) at the exact moment it occurs is low due to the wide-ranging movement of marine mammal species and their tendency to avoid being in close proximity to drilling activities that would be active prior to a loss of well control event, along with the low probability of a loss of well control actually occuring.

There are relatively few studies assessing the physiological impacts of oil spills on marine mammals because laboratory experiments present ethical concerns. The impacts of an oil spill on marine mammals depend on many variables, including the oil spill location and size, oil characteristics, meteorological and oceanographic conditions, time of year, and impacted habitat types, as well as the behavior and physiology of the affected marine mammals (Johnson and Ziccardi 2006; Sullivan et al. 2019; Ziccardi et al. 2015). Further, these factors would determine which species would be affected and the extent of the affect. Several factors increase the probability of marine mammal/oil spill contact, including the following: (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 (natural seeps or otherwise); and (3) some spills are larger, increasing the area of potential impact. Generally, a small spill (10-49 bbl) would be expected to disperse quickly in the open ocean and would not be likely to contact more than a few, if any, individual marine mammals.

Effects of spilled oil on marine mammals are discussed by Geraci (1990); Geraci and St. Aubin (1980; 1982; 1985) and Lee and Anderson (2005). Marine mammals could be affected through various pathways, including direct surface contact, inhalation of fuel or its volatile components, or ingestion (via direct ingestion or by the ingestion of contaminated prey). These pathways could affect marine mammals by leading to mortality, decreased health, reproductive fitness, and longevity, as well as increased vulnerability to disease. The oil from a spill can adversely affect marine mammals by causing soft-tissue irritation, 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. An oil spill may physiologically stress an animal (Geraci and St. Aubin 1980), causing increased vulnerability to disease, parasitism, environmental contaminants, and/or predation. A small spill would likely not result in mortality or life-threatening injury of individual marine mammals, or the long-term displacement of marine mammals from preferred feeding, breeding, or calving areas.

Spill Response (Chapter 2.9.2)

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.). The increased human presence in the water after an oil spill (e.g., vessels) would likely add to changes in behavior and/or distribution, thereby potentially stressing affected marine mammals further, possibly making them more vulnerable to various physiologic and toxic effects of spilled oil. In addition, the large number of response vessels could increase the risk of vessel strikes (refer to the "Strikes and Collisions" section below). Vessel noise would increase as a result of increased vessel activity and could result in immediate behavioral changes in some individuals (refer to the "Noise" section in **Chapter 4.3.6.2.2**).

Dispersant application to the affected area could occur, depending on the spill size and location. Little is known about the impacts of oil dispersants on cetaceans, except that removing oil from the surface would reduce the risk of oil contact and render it less likely to adhere to the skin or other body surfaces (Neff 1990). 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). Impacts from dispersants are unknown though they may be irritants to tissues and sensitive membranes (National Research Council 2005a) and could cause non-lethal injury such as tissue irritation, inhalation, long-term exposure through bioaccumulation, and potential shifts in distribution from some habitats.

The use of skimmers, booms, and *in-situ* burns may also be used and can also impact marine mammals. Skimmers could capture and/or entrain individuals. In both skimming and controlled burning activities, the use of trained observers is common. The low probability of marine mammals being in the vicinity of oil-spill response activity due to their wide-ranging behavior reduces the likelihood of impacts to marine mammals. Chapter 4.7.9.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Strikes and Collisions (Chapter 2.9.3)

BOEM and BSEE vessel traffic in the GOM primarily occurs near major ports, such as Port Fourchon, Louisiana, and Houston, Texas. Many marine mammal species are vulnerable to vessel strikes, which can result in injury or death (Laist et al. 2001; Pace 2011; Van Waerebeek et al. 2007; Vanderlaan and Taggart 2007). Most reports of vessel strikes with marine mammals involve large whales, though collisions with smaller species also occur (Van Waerebeek et al. 2007). Laist et al. (2001) compiled data and found that most severe and lethal whale injuries involve large ships (greater than 262 ft [80 m]) at higher speeds; 89 percent of ship strike records show that vessels were moving at speeds greater than 16 mph (14 kn). They also concluded that the majority of strikes appear to have occurred over or near the continental shelf, and the whales were usually not seen beforehand or seen too late to be avoided (Laist et al. 2001). Seismic operations with towed gear generally are conducted at relatively slow speeds of 4-6 kn (5-7 mph), with a maximum speed less than 8 kn (9 mph), though small crew change or support vessels move faster. (Vanderlaan and Taggart 2007) Chapter 4.7.9.3 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b). Since the implementation of the vessel strike NTL through previous ESA consultations and associated reporting requirements, there have been no documented vessel strikes on marine mammals by OCS oil- and gas-related vessels.

4.3.7 Sea Turtles

This chapter provides (1) a summary overview of the current baseline and affected environment as it pertains to sea turtles in the GOM, (2) natural and human-induced influences to sea turtles, and (3) an assessment of the potential effects to sea turtles from the IPFs described in **Chapter 2**. The effects analysis also identifies which IPF categories are not likely to affect sea turtles and why.

4.3.7.1 Resource Description

Five ESA-listed sea turtles occur in the GOM, i.e., the loggerhead turtle, green turtle, hawksbill turtle, Kemp's ridley turtle, and leatherback turtle. The Northwest Atlantic Ocean Distinct Population Segment of loggerhead turtle and the North Atlantic Distinct Population Segment of green turtle are ESA-listed as threatened (DOC and NOAA 2014). Hawksbill turtles, Kemp's ridley turtles, leatherback turtles (proposed threatened as Northwest Atlantic Distinct Population Segment), and breeding populations of green sea turtles in Florida are ESA-listed as endangered. Floating *Sargassum* patches in the CPA and WPA are federally designated under the ESA as critical habitat for loggerhead turtles (**Figure 4.3.7-1**) (**Chapter 4.3.3**). The FWS and NMFS share jurisdiction for sea turtles. The FWS has responsibility for monitoring and managing sea turtles (i.e., nesting turtles, eggs, and hatchlings) on beaches, and NMFS has jurisdiction for sea turtles in the marine environment. More information on the description of sea turtles can be found in the 2018 FWS Biological Opinion (FWS 2018; NMFS 2020b), and BOEM's Biological Environmental Background Report (BOEM 2021b).

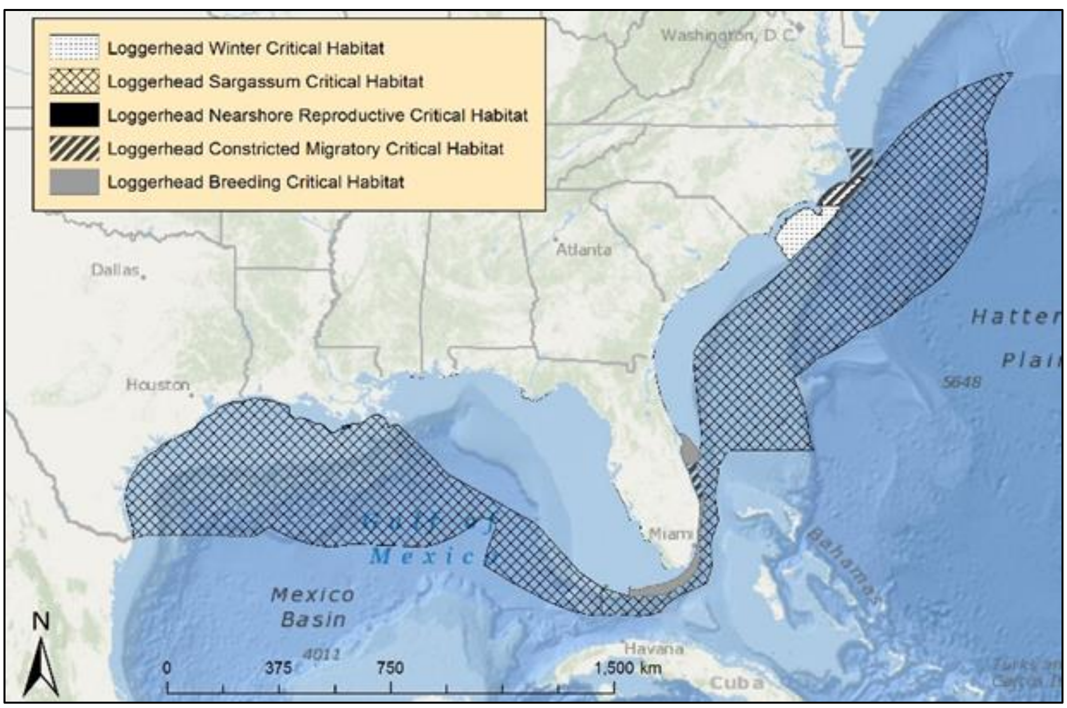


Figure 4.3.7-1. Loggerhead Turtle Critical Habitat for the Northwest Atlantic Ocean Distinct Population Segment of Loggerhead Turtles (NMFS 2018b).

Loggerhead, green, hawksbill, Kemp's ridley, and leatherback turtles are all highly migratory. Individual animals migrate into nearshore waters as well as other areas of the North Atlantic Ocean, GOM, and Caribbean Sea (**Chapters 4.3.1 and 4.3.3**). Important marine habitats for sea turtles in the Gulf of Mexico OCS include nesting beaches, estuaries and embayments, nearshore hard substrate areas, and the Gulf Stream (Valverde and Holzwart 2017). Barrier islands and mainland beaches in the GOM also provide important nesting habitat for sea turtles (Valverde and Holzwart 2017). These species rely on coastal and pelagic waters for foraging needs (Bjorndal 1997; Collard 1990; Fritts et al. 1983a; Fritts et al. 1983b; Godley et al. 2008; NMFS and FWS 2015). For instance, seagrass beds provide foraging habitat for sea turtles (Ward and Tunnell Jr. 2017). *Sargassum* mats provide food and protection from predation for juvenile sea turtles (Casazza and Ross 2008; Dooley 1972). The hatchlings of loggerhead, green, Kemp's ridley, and hawksbill sea turtles are thought to find *Sargassum* rafts when seeking frontal zones (predictable mesoscale [tens to hundreds of kilometers] regions of persistent frontal activity, i.e., the Gulf Stream), then utilizing the habitat as foraging grounds and protection during their pelagic "lost years" (juvenile years in which turtle sightings are scarce) (Carr 1987; Coston-Clements et al. 1991; Putman and Mansfield 2015; Witherington et al. 2012). Most sea turtle species move geographically, either seasonally or between nesting activities.

Sea Turtle Hearing

Sea turtle ears resemble those of most reptiles, though they have a few underwater specializations (Popper et al. 2014b). They have no outer ear; the opening of their ear is covered by thick skin with a fatty layer underneath. As in marine mammals, this fatty layer helps conduct sound to the middle and inner ear. 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). Sea turtles may be sensitive to acoustic pressure. There is relatively little data on sea turtle hearing, though the current understanding is that their underwater hearing range is generally constrained to frequencies less than 2 kHz, with a narrower frequency range in air (Bartol et al. 1999; Piniak et al. 2012; Popper et al. 2014b). A few preliminary investigations using adult green, loggerhead, and Kemp's ridley turtles suggest that they are most sensitive to low-frequency sounds (Bartol et al. 1999; Lenhardt et al. 1983; Ridgway et al. 1969). Sea turtles likely use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al. 1983). Compared to most fish and marine mammals, they have relatively low hearing sensitivity (Martin et al. 2012; Popper et al. 2014b). Overall, little is known about the extent to which sea turtles use their auditory environment. Refer to Chapter 3.6 of BOEM's Biological Environmental Background Report for more information on sea turtle hearing and other life history traits (BOEM 2021b).

Programmatic Concerns Influencing Sea Turtles

Environmental factors that may affect sea turtles in the GOM include climate change and disease. These factors may act synergistically to affect sea turtles or can further worsen the effects from some of the IPF categories discussed further below. Further, these factors may affect some species and life stages more than others depending on the geographic location and season.

Climate Change

High-intensity storms, coupled with higher sea levels, could increase coastal flooding and erosion, and degrade coastal habitats (**Chapters 3.3 and 3.4**), which may affect nesting sea turtles, especially on barrier islands (Morton 2003). While some effects are anticipated, the precise impacts of global climate change on the GOM cannot currently be predicted. Chapter 3.6.6.5 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

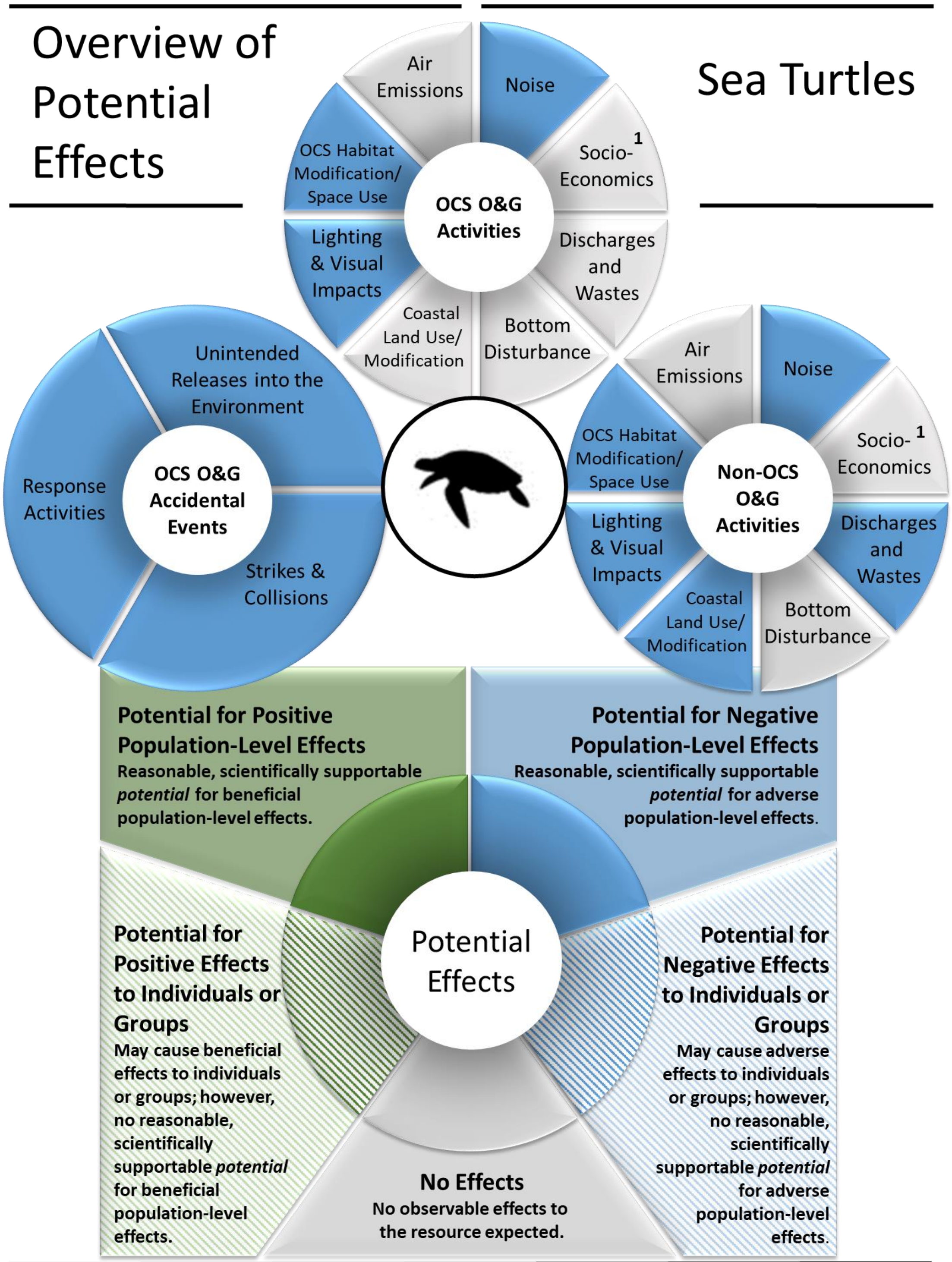
Disease

Sea turtles are affected by pathogens and disease, which may be secondary infections following other stressors, such as entanglement injury or nutritional deficiencies. Some of these diseases include species-specific fibropapillomatosis; viral, bacterial, and mycotic (fungal) infections; parasites (internal or external); and other environmental health problems (e.g., hypothermic stunning). Fibropapillomatosis is characterized by the presence of internal and external tumors that can grow large enough to disrupt swimming, vision, feeding, and predator evasion (Herbst 1994; Van Houtan et al. 2014). Its precise cause(s) is unknown (NMFS and FWS 2007; 2013). Other stressors, such as increased ocean noise levels, could increase susceptibility to disease (Kight and Swaddle 2011). Further, climate change may act additively or synergistically with marine diseases. Host-pathogen relationships are sensitive to environmental conditions; thus, climate change could increase the risk of disease (Burge et al. 2014). Chapter 3.6.6.6 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

4.3.7.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and sea turtles. The reasonable, scientifically supportable *potential* effects from each IPF associated with routine OCS oil- and gas-related activities, accidental OCS oil- and gas-related events, and all other non-OCS oil- and gas-related activities is shaded according to the possible effects identified in **Figure 4.3.7-2**. No IPF categories were identified to potentially have observable positive effects to sea turtles.

Figure 4.3.7-2 is intended to highlight the relevant IPF categories and potential effects that are analyzed in this chapter, as well as highlight the IPFs that are not likely to cause effects to sea turtles and, therefore, would not likely warrant further analysis in a NEPA analysis for proposed oil and gas leasing on the Gulf of Mexico OCS. A more in-depth analysis of these effects can be found in BOEM's Biological Environmental Background Report (BOEM 2021b).



1. As discussed in **Chapter 4.3.0**, the socioeconomic changes and drivers IPF is limited to potential effects to human elements of our society and therefore, does not apply to biological resources.

*Figure 4.3.7-2. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Sea Turtles. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and resource; and/or the current condition of the resource or environment. BOEM will use this preliminary identification and disclosure of the potential range of effects to sea turtles, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

4.3.7.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.3.7-2 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect sea turtles in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, and are discussed below.

Noise (Chapter 2.4.2)

Sea turtles in the GOM planning areas are exposed to several sources of anthropogenic noise including maritime activities, dredging, construction, mineral exploration in offshore areas, non-BOEM-regulated geophysical and geological surveys, sonars, and ocean research activities. These could be produced by commercial and recreational vessels, aircraft, commercial sonar, military activities, in-water construction activities, and other human activities. Vessel traffic is recognized as a major contributor to anthropogenic ocean noise, primarily in the low-frequency bands between 5 and 500 Hz. Marine vessel traffic adds noise to the marine environment, mostly from propeller cavitation. Over the last few decades, low-frequency ambient ocean noise has increased substantially due to a steady increase in shipping as vessels have become more numerous and of larger tonnage (Hildebrand 2009; McKenna et al. 2012). Faster, larger ships generally create more noise and lower-frequency sounds (less than 1 kHz), while smaller craft produce sounds in the mid frequencies (1-5 kHz). There is growing concern over these increases in anthropogenic sound in the GOM and the types of potential effects to sea turtles.

Few studies have examined the role that acoustic cues play in the ecology of sea turtles (Mrosovsky 1972; Nunny et al. 2005; Samuel et al. 2005), and little is known about the extent to which the turtles depend upon their auditory environment. Mounting evidence indicates that noise in the marine environment could interfere with communication in sea turtles, a phenomenon called acoustic masking (Clark et al. 2009; Erbe et al. 2016). In addition to acoustic masking, elevated ocean noise levels could increase stress in marine species, which in turn could lower reproductive output and increase susceptibility to disease (Kight and Swaddle 2011). The impacts of increasing ambient noise would be expected to occur in the category of behavioral responses and possibly masking effects, rather than death, injury, or threshold shifts (i.e., temporary or permanent hearing loss). Avoidance responses to seismic signals have been observed (e.g., DeRuiter and Larbi Doukara 2012; Lenhardt 1994; McCauley et al. 2000b; Moein et al. 1994; Suedel et al. 2019; Weir 2007); therefore, it is known that sea turtles can detect, respond to, and avoid low-frequency sound. Sea turtles appear to be low-frequency specialists, and thus the potential masking noises could fall within at least 50-1,000 Hz. However, there are no quantitative data demonstrating masking effects for sea turtles, and no noise exposure criteria have been developed for them officially by NOAA, though Popper et al. (2014a) established general acoustic thresholds. Chapter 3.6.6.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Discharges and Wastes (Chapter 2.2.2)

In the U.S., about 80 percent of marine debris washes into the oceans from land-based sources and 20 percent is from ocean sources (USEPA 2017d). Pollution, including point and nonpoint discharges of metals and organic compounds, could degrade water quality, and, contaminants in sediment can be re-suspended into the water column by anthropogenic activities or storms. In addition, plastics have been found inside deceased sea turtles (Gregory 2009; Schuyler et al. 2016). Marine debris affects marine habitats and marine life worldwide, primarily through entanglement or ingestion (e.g., choking) (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality of sea turtles. Entanglement could also result in drowning. Marine debris ingestion can lead to intestinal blockage, which could impact feeding ability and lead to injury or death. Chapter 3.6.6.3 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

Coastal development, such as beach reclamation and dredging activities (Kildow et al. 2016; Sengupta et al. 2018), may degrade or destroy coastal sea turtle habitats. The construction of residential areas, industrial centers, ports, hotels, resorts, marinas, docks, seawalls, bridges, and roads and other infrastructure that occurs along the Gulf Coast (Kildow et al. 2016; Sengupta et al. 2018) may also degrade or destroy coastal sea turtle habitats. Expansions of ports and dredging of port areas accommodate increased shipping and increasingly larger vessels (Merk 2015). Coastal development can result in the displacement of nesting sea turtles (Harewood and Horrocks 2008). An increase in infrastructure, especially during the construction process, may affect sea turtle nesting habitat. Coastal construction could degrade or destroy coastal habitats and put sea turtles at risk, especially since sea turtles are slow to reach sexual maturity. Thus, they may be vulnerable to any coastal construction that disrupts egg-laying (Harewood and Horrocks 2008). Coastal construction could indirectly degrade water quality by increased sedimentation, pollutant runoff, and potential discharges from construction vehicles. Coastal development that leads to permanent alteration of nesting habitats, or even short-term disturbance during nesting periods, could have impacts on sea turtles.

Lighting and Visual Impacts (Chapter 2.6.2)

Increasing coastal development, including artificial lighting from beachfront properties and other buildings, could threaten nesting success and hatchling survival (Harewood and Horrocks 2008; Silva et al. 2017). Lighting (e.g., street lights and hotel lights) from human-made infrastructure near beaches used for sea turtle nesting could disorient young hatchlings and increase predation (Silva et al. 2017). Beachfront lighting has the potential to attract and disorient hatchlings when they emerge from the nest, leading them away from the water and towards roads and buildings where they may die from exposure, predators, or vehicles, or become trapped by obstacles. Chapter 3.6.6.2 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Offshore habitat modification from the sources identified in **Chapter 2.7.1** could degrade habitats via pollution and/or bottom or land disturbance. Pollution has the potential to modify suitable habitat for sea turtles (Morton 2003). Bottom or land disturbance could also destroy submerged aquatic vegetation habitat that sea turtles depend on for feeding and breeding. Habitat degradation could persist and have long-term residual impacts on community structure and habitat function (Morton 2003). Anthropogenic events could cause temporary or permanent shifts in species' ranges and the loss of core and/or preferred habitat, if habitat becomes unsuitable (Morton 2003).

Fisheries Interactions

Commercial fishing operations, such as shrimp trawl fisheries, often use equipment that may threaten sea turtles through entanglement or ingestion (Valverde and Holzwart 2017). Similar to commercial fishing, recreational fishing also results in increased marine traffic and resource consumption. Fishing line and gear that is not disposed of properly can create hazards to sea turtles and are outside BOEM/BSEE's regulatory authority. Sea turtle bycatch occurs in the GOM, especially for the longline fishery, and can be driven by turtle density, fishing intensity, or both (Lewison et al. 2014). Turtles may be accidentally caught and killed in finfish trawls, seines, gill nets, weirs, traps, longlines, and driftnets (Brady and Boreman 1993; Epperly et al. 2007; Jenkins 2012).

To reduce fishery impacts to sea 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 entrapments/entanglements. Since implementing the required use of turtle excluder devices throughout the shrimp fishing industry, gear improvements continue to be introduced nearly annually. 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 minimal commercial gillnetting takes place in southeast waters. Mortality rates have decreased since the implementation of these regulations, but because turtles mature slowly, populations are still recovering (Valverde and Holzwart 2017; Jenkins 2012). Chapter 3.6.6.3 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Strikes and Collisions

Vessel traffic in the GOM primarily occurs near major ports, such as Port Fourchon, Louisiana, and Houston, Texas. Vessel strikes are a poorly studied threat to sea turtles, though they are known to result in injury and mortality (Work et al. 2010). Several species, such as loggerheads, are known to bask at the surface for long periods. Although sea turtles can move somewhat rapidly, they are still vulnerable to strikes from vessels that are moving at more than 4 km/hr (2.5 mph), which is common in open water (Hazel et al. 2007; Work et al. 2010). Both live and dead sea turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007). Chapter 3.6.6.4 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil- and gas-related development and determined bottom disturbance, air emissions, and socioeconomic changes and drivers (refer to **Chapter 4.3.0**) are not likely to affect sea turtles. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air Emissions and Pollution (Chapter 2.1.2)

Once pollutants are released into the atmosphere, transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing wind circulations, which can vary depending on the time of year. Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed.

Due to the atmospheric processes on air pollutant transport, stack height, exit gas velocity from the stack, distance of sea turtles from the sources, and temporary nature of vessel activity, sea turtles are not vulnerable to air emissions. Because of the combination of a 2,953-ft (900-m) mixing height and upward flux of discharged regulated pollutants year-round from stacks, the contribution of non-OCS oil- and gas-related events to the air-water interface are either insignificant or unlikely to occur (and are therefore discountable). Overall, sea turtles are not expected to be vulnerable to air emissions because emissions would be localized, and air pollution would dissipate quickly, upward in the air at considerable distances.

Bottom Disturbance (Chapter 2.3.2)

Green, Kemp's ridley, and loggerhead turtles use soft bottom benthic habitats for foraging. Hawksbill turtles feed in coral and hard bottom areas, which are generally avoided. State-regulated infrastructure emplacement, pipeline trenching, and structure removal would be localized and temporary, and habitat loss is not expected. It is assumed that careful timing of activities and siting of onshore and State-regulated infrastructure, particularly with regard to ESA-listed species, would be applied.

4.3.7.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.3.7-2 highlights the IPF categories associated with routine OCS oil- and gas-related development that could potentially affect sea turtles in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent and are discussed below.

Noise (Chapter 2.4.1)

Noise sources that sea turtles could be vulnerable to include active acoustic sources from seismic surveys, vessels, drilling, production, trenching, construction, and platform removal (including use of explosive decommissioning) (**Figure 4.3.6-3**). Sea turtles could be vulnerable to noise from marine seismic surveys and the use of explosives in all GOM planning areas, though minimally so in the EPA (Nelms et al. 2016). It is generally accepted that sea turtles can detect sounds between 100 Hz and 2 kHz, although there is relatively little data on sea turtles' hearing sensitivity (Bartol and Musick 2003; Popper et al. 2014b). Results from the limited behavioral studies that have been conducted on sea turtles have yielded mixed results (Nelms et al., 2016). Behavioral disturbance or masking of salient acoustic cues could be more widespread, though little is known about noise levels that induce such changes in sea turtles (McCauley et al. 2000a; 2000b; Moein et al. 1994; Suedel et al. 2019).

Since sea turtles appear to be particularly sensitive to low-frequency sounds, they are likely to hear much of the low-frequency and high-intensity anthropogenic noise in the ocean, such as vessel traffic and offshore oil and gas exploration activities (e.g., seismic surveys and drilling) (**Figure 4.3.6-3**). Noise impacts could include behavioral changes, acoustic masking, fitness effects, or mortality. Limited data exist on the noise levels that induce behavioral changes in sea turtles (McCauley et al. 2000a; 2000b; Moein et al. 1994; Suedel et al. 2019). Once detected, some sounds may elicit a behavioral response, including temporary changes in habitat selection to avoid areas of higher sound levels or changes in diving behavior. Chapter 4.6.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Lighting and Visual Impacts (Chapter 2.6.1)

Ports, support facilities, construction facilities, transportation infrastructure, and processing facilities emit light onshore, which could impact sea turtles. Depending on the location of onshore facilities in relation to nesting beaches, lighting could disorient nesting sea turtles and hatchlings. Upon hatching, sea turtles use natural light cues to orient themselves and advance toward the ocean (Witherington and Martin 2003). Additional onshore lighting can confuse hatchling turtles when they emerge from their nests. Artificial light sources (or light pollution) on land might draw hatchlings away from the ocean, resulting in high mortality due to dehydration and predation (Silva et al. 2017; Witherington and Martin 2003). Offshore (or OCS) lighting is not expected to affect free-swimming juveniles or adults and would be located too far away to disorient hatchlings. Chapter 4.6.7 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Several activities, including drilling, coastal and offshore infrastructure emplacement, and decommissioning, could alter coastal and/or estuarine habitats (**Chapter 4.3.1**). Adverse modification of critical habitat, such as that for loggerheads, would not be legally authorized under the ESA. Coastal construction could degrade or destroy coastal habitats and put species at risk. The addition of roads, onshore support bases, and pipelines to distribution points could further stress coastal and estuarine habitats, leading to erosion and subsequent land loss. Since sea turtles are slow to reach sexual maturity, they may be vulnerable to any coastal construction that leads to permanent alteration of nesting habitats (i.e., beach) and/or disrupts egg-laying or nesting success. Offshore habitat modification could destroy submerged aquatic vegetation habitat that sea turtles depend on for feeding and breeding. Further, it could disrupt or destroy submerged coastal habitats, such as seagrass beds, which are a key food source for sea turtles. These losses would likely be localized, though they could lead to long-term impacts and shoreline loss.

Vessel traffic (e.g., tankers, barges, support vessels, and seismic survey vessels) within estuaries can result in habitat loss or degradation, and environmental contamination (Robb 2014). Coastal organisms and vegetation may be impacted by increased turbidity from the wake (though speed restrictions are required) from vessels. The OCS vessel traffic could increase shoreline erosion of coastal and estuarine habitats from wave activity, which could lead to loss or degradation of habitat in these areas. Thus, nesting or foraging sea turtles may be vulnerable to these impacts. Chapter 4.6.5 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine oil- and gas-related activities described in **Chapter 2** and determined that discharges and wastes, bottom disturbance, coastal land disturbance, socioeconomic changes and drivers (refer to **Chapter 4.3.0**), and air emissions are not likely to affect sea turtles. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Discharges and Wastes (Chapter 2.2.1)

The USEPA- and USCG-administered regulations, which are designed to keep contaminants below harmful levels for public health and welfare, would prevent impacts from produced water, drilling muds, and cuttings. These discharges are not expected to persist in the water column. Due to the localized and transient nature of the water quality impacts, these discharges are unlikely to affect foraging or other activities by sea turtles. Operational discharges are diluted and dispersed when released in offshore areas, and they are not expected to directly or indirectly affect any sea turtle species. Therefore, drilling discharges are not likely to have any detectable effect on sea turtles. In addition, it is assumed that BSEE, USCG, and USEPA regulations, and BOEM guidance will be applied and strictly followed by oil and gas operators.

Bottom Disturbance (Chapter 2.3.1)

Although many sea turtles forage in benthic areas, this tends to occur in nearshore areas (e.g., seagrass beds) and outside the areas where most OCS oil- and gas-related activities occur. Green, Kemp's ridley, and loggerhead turtles use soft bottom benthic habitats for foraging. Hawksbill turtles feed in coral and hard bottom areas, which would be avoided. Farther offshore where drilling is more likely, sea turtles generally spend time closer to the surface and feed on other prey (e.g., jellyfish). Drilling would be localized and impacts are not expected to occur outside of the immediate area, nor is habitat loss expected (Neff 2005). In addition, infrastructure emplacement, pipeline trenching, and structure removal would be localized and typically temporary, and habitat loss is not expected. It is assumed that timing of activities and siting of infrastructure would be conducted in compliance with any applicable consultation requirements, particularly regarding ESA-listed species, to minimize or reduce the potential for significant effects.

Coastal Land Use/Modification (Chapter 2.5.1)

Adverse modification of critical habitat, such as that for loggerheads, would not be legally authorized under the ESA. Therefore, since onshore construction would not occur on nesting beaches, nesting sea turtles and hatchlings are not expected to be vulnerable to coastal land disturbance from OCS oil- and gas-related activities. Onshore construction is not within the OCS and would be outside of BOEM or BSEE's regulatory authority. In addition, any activity would be under other regulatory authorizations (e.g., the USACE and Federal Energy Regulatory Commission).

Air Emissions and Pollution (Chapter 2.1.1)

Once pollutants are released into the atmosphere, transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing wind circulations, which can vary depending on the time of year. Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed.

Due to the atmospheric processes on air pollutant transport, stack height, exit gas velocity from the stack, distance of sea turtles from the sources, and temporary vessel activity, sea turtles are not vulnerable to air emissions. Because of the combination of a 2,953-ft (900-m) mixing height and upward flux of discharged regulated pollutants year-round from stacks, the contribution of routine events and accidental events (flaring or venting) to the air-water interface are either insignificant or unlikely to occur (and are therefore discountable). Overall, sea turtles are not expected to be vulnerable to onshore or offshore air emissions because emissions would be localized and air pollution would dissipate quickly, upward in the air at considerable distances.

4.3.7.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.3.7-2 highlights the IPF categories of accidental events associated with OCS oil- and gas-related activities that could potentially affect sea turtles in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent and are discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Marine debris affects marine habitats and marine life worldwide, primarily through entanglement or ingestion (e.g., choking) (Gall and Thompson 2015). Entanglement in marine debris could lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and/or mortality (e.g., drowning) of sea turtles. Marine debris ingestion could lead to intestinal blockage, which can impact feeding ability and lead to injury or death. Data on marine debris in some locations of the GOM is largely lacking; therefore, it is difficult to draw conclusions as to the precise extent of the problem and its impacts on sea turtle populations. Chapter 4.6.8.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

It is assumed that BSEE, USCG, and USEPA regulations, and BOEM guidance will be applied and strictly followed by oil and gas operators, which would minimize unintended releases of trash and debris. For instance, the USCG and USEPA regulations require operators to become proactive in avoiding accidental loss of solid-waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. It is prohibited to discharge trash and debris (33 CFR §§ 151.51-77) unless it is passed through a comminutor (a machine that breaks up solids) and ultimately pass through a 25-mm (1-in) mesh screen. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste.

The potential impacts of an oil spill could vary depending on the spill magnitude, frequency, timing, location, and the meteorological and oceanographic conditions at the time (National Research Council 2003c). Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior, indiscriminate feeding in convergence zones, inhalation of large volumes of air before dives (Milton et al. 2010; NOAA 2010c), and affinity to the *Sargassum* community for food and cover (Witherington et al. 2012). In general, a small spill (10-49 bbl) would be expected to disperse quickly in the open ocean and would not be likely to contact more than a few individual sea turtles. Oil could affect sea turtles through various pathways, including direct contact, inhalation of the fuel and its volatile components, and ingestion directly or indirectly through the consumption of fouled prey species (Geraci and St. Aubin 1987). Direct exposure of sensitive tissues (e.g., eyes, nares, and other mucous membranes) and soft tissues to diesel fuel may produce irritation and inflammation, and can adhere to turtle skin or shells (Lutcavage et al. 1995; Overton et al. 1983; Van Vleet and Pauly 1987). Sea turtles surfacing within or near an oil spill would be expected to inhale petroleum vapors, potentially causing respiratory stress. Ingested oil, particularly the lighter fractions, can be acutely toxic to sea turtles. The effects of contact with spilled oil could include mortality and decreased health, reproductive fitness, and longevity, as well as increased vulnerability to disease and contamination of prey species. A small spill would be unlikely to result in mortality or the life-threatening injury of individual sea turtles, or the long-term displacement of sea turtles from preferred feeding, breeding, or nesting habitats, while a large spill could be more likely to result in these effects. Chapter 4.6.8.1 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Response Activities (Chapter 2.9.2)

Spill-response features that may impact sea turtles include artificial lighting from night operations, booms, machine activity, human activity, increased vessel traffic, equipment on beaches and in intertidal areas, and changed beach landscape and composition. Spill-response activities could adversely affect sea turtle habitat and cause temporary displacement from suitable habitat. The strategy for cleanup operations varies depending on the season (Fritts and McGehee 1982). Spill-response activities could cause an increase in vessel traffic, and thus, an increased possibility for vessel strikes. Little is known about the effects of dispersants on sea turtles and, in the absence of direct testing, impacts are difficult to predict. Dispersants may affect multiple organ systems and interfere with digestion, excretion, respiration, and/or salt-gland function. The impacts to sea turtles from 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 habitat (NOAA 2010b; 2010c).

Depending on to the nature of the response activities, impacts could include a short-term behavioral change of sea turtles in the immediate affected area. Spill-response impacts include interrupted or deterred nesting behavior, crushed nests, entanglement in booms, and increased hatchling mortality due to predation from the increased time required to reach the water, assuming no outside intervention (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. Chapter 4.6.8.2 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

Strikes and Collisions (Chapter 2.9.3)

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, and orientation, which makes them vulnerable to vessel strikes (Lutcavage et al. 1997). Post-hatchlings, which generally reside at or near the sea surface (sometimes associated with *Sargassum*), could be more vulnerable to vessel strike compared to subadult and adult turtles, which spend more time submerged and at depth. Sea turtles located in shallower waters have shorter surface intervals, whereas turtles occurring in deeper waters have longer surface intervals.

Sea turtles are known to startle at the presence of boats and ships, causing immediate additional metabolic expenditure. There is little data available concerning potential sea turtle impacts from vessel strikes due to a lack of studies and/or challenges with detecting such impacts (Nelms et al. 2016). Nonetheless, vessel strike from all types of vessels is known to result in sea turtle injury and mortality in the GOM (Lutcavage et al. 1997; Nelms et al. 2016; Work et al. 2010). Sea turtles occur in all GOM planning areas and could experience increased risk of strike from vessels that support oil and gas activities on the OCS. If a sea turtle is struck by a vessel, effects could include serious injury, and/or minor, nonlethal injury, with the associated response depending on the size and speed of the vessel. There have been no documented sea turtle collisions with OCS oil- and gas-related vessels in the GOM; however, collisions with small or submerged sea turtles may go undetected. Chapter 4.6.8.4 of BOEM's Biological Environmental Background Report contains additional information (BOEM 2021b).

4.4 SOCIAL AND ECONOMIC FACTORS

4.4.1 Land Use and Coastal Infrastructure

4.4.1.1 Resource Description

Land use encompasses six general categories: transportation, recreation, agriculture, residential and commercial or industrial uses. Coastal infrastructure, for the purposes of BOEM's analysis, refers specifically to onshore oil- and gas-related infrastructure that provides support for offshore OCS oil- and gas-related activities. As opposed to land use, this type of coastal infrastructure serves as both an impact-producing factor *for* other resources (refer to **Chapter 2**) and also as a resource that is impacted *by* routine OCS oil- and gas-related activities, accidental activities, and non-OCS oil- and gas-related activities as these coastal infrastructure types support other interests that are unrelated to OCS oil- and gas-related activities, such as State oil and gas activities, commercial entities, and recreational uses. The following description of land use and coastal infrastructure is based on this distinction with descriptions of land uses in the GOM region and coastal infrastructure related to OCS oil- and gas-related activities.

For consideration of potential effects to land use and coastal infrastructure, the area of analysis for BOEM environmental impact assessments in the Gulf of Mexico region includes the Gulf Coast States, i.e., 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 (refer to **Figure 4.4.1-1**). Refer to **Chapter 2.5** for additional information on BOEM-identified EIAs. 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.

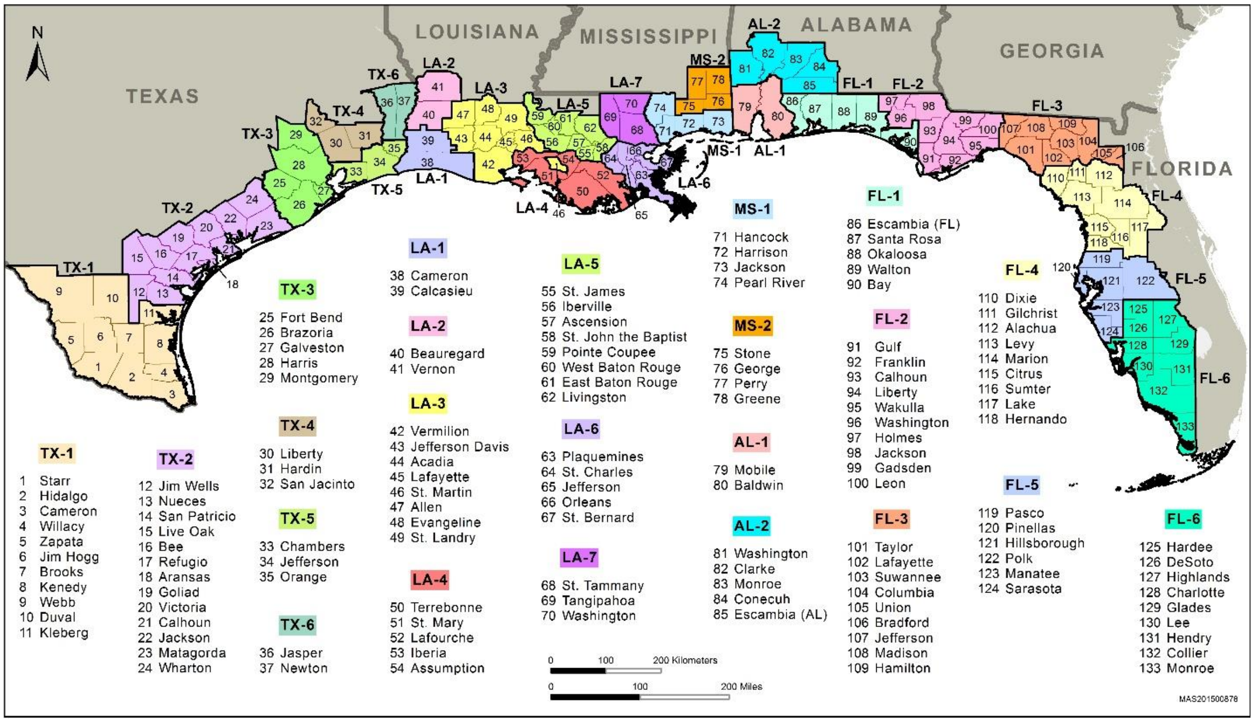


*Figure 4.4.1-1. BOEM's Economic Impact Areas (reprint of **Figure 2.5-1**).*

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 the coastal zone 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.

The GOM 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 GOM 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 1900s. 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 manufacturing 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 more recently 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 10-15 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 (Greater Lafourche Port Commission 2020). The LOOP has received and transferred over 12 billion barrels of crude oil since its beginning (LOOP LLC 2021). The LOOP is the only U.S. deepwater port that is able to offload very large crude carriers and ultra-large crude carriers (LOOP LLC 2020).

Coastal Mississippi is characterized by bays, deltas, marshland, and waterways. Two-thirds of this coast is devoted to State-chartered gambling barges 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—Hancock, Harrison, and Jackson—are timberlands (Petterson et al. 2008). Jackson County has a strong industrial base and designated industrial parks. Pascagoula, in Jackson County, is home to Ingalls Shipbuilding, which is an 800-ac (324-ha) shipyard that employs 11,500 people, and the Chevron Pascagoula Refinery located in the Bayou Casotte Industrial Park (Chevron Corporation 2020; Ingalls Shipbuilding 2020). 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 2020). After recovering from Hurricane Katrina damages, the Port of Gulfport went through a phase of expansion and 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 2020).

Southwestern Alabama's coastline is comprised of Mobile and Baldwin Counties, which oppose each other across Mobile Bay. 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 have 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, 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 1990s 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-1930s 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 covers more than 50 ac (20 ha) and provides logistics facilities, including laydown, working areas, and warehouses. Primary services range from bulk cargo to vessel maintenance, repair, and overhaul services (The Port of Pensacola 2020). Port Panama City served as an onshore support base for exploratory drilling in the GOM during the 1980s 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 2020).

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 (Economic Research Service 2008). The varied land-use patterns along the Gulf Coast are displayed in **Figure 4.4.1-2**.

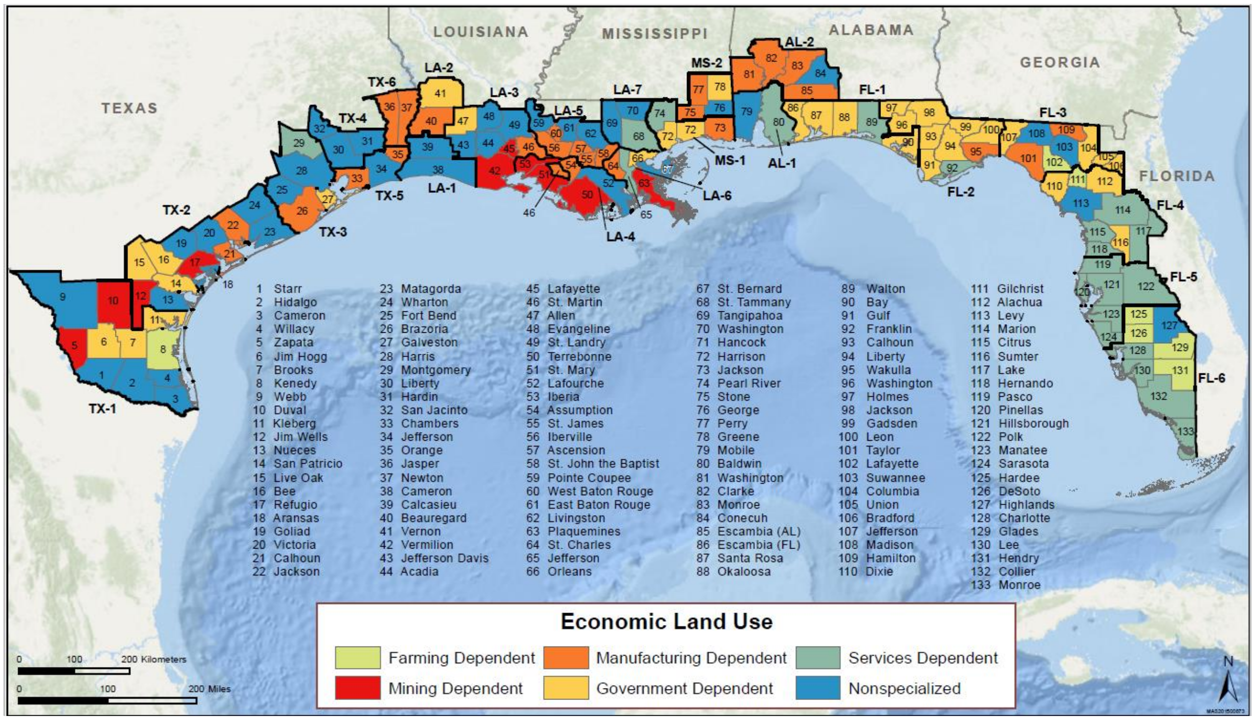


Figure 4.4.1-2. Economic Land Use (Source: Economic Research Service 2008).

Figure 4.4.1-3 illustrates the analysis area's key infrastructure. Major cities in the analysis area include Houston, Texas; Baton Rouge and New Orleans, Louisiana; and Mobile, Alabama. Other important cities in the analysis area include Corpus Christi, Galveston, Port Arthur, and Beaumont, Texas; Lake Charles and Lafayette, Louisiana; and Pascagoula, Mississippi. Several international and regional airports are located throughout the analysis area. One major interstate (I-10) traverses the area along the inner margin of the coastal zone while six interstate highways access the area longitudinally. There are numerous highways into and across the analysis area. These highways provide access to major ports, airports, rail stations, public transit facilities, and border crossings. The area's railroad configuration is similar to the highway system.

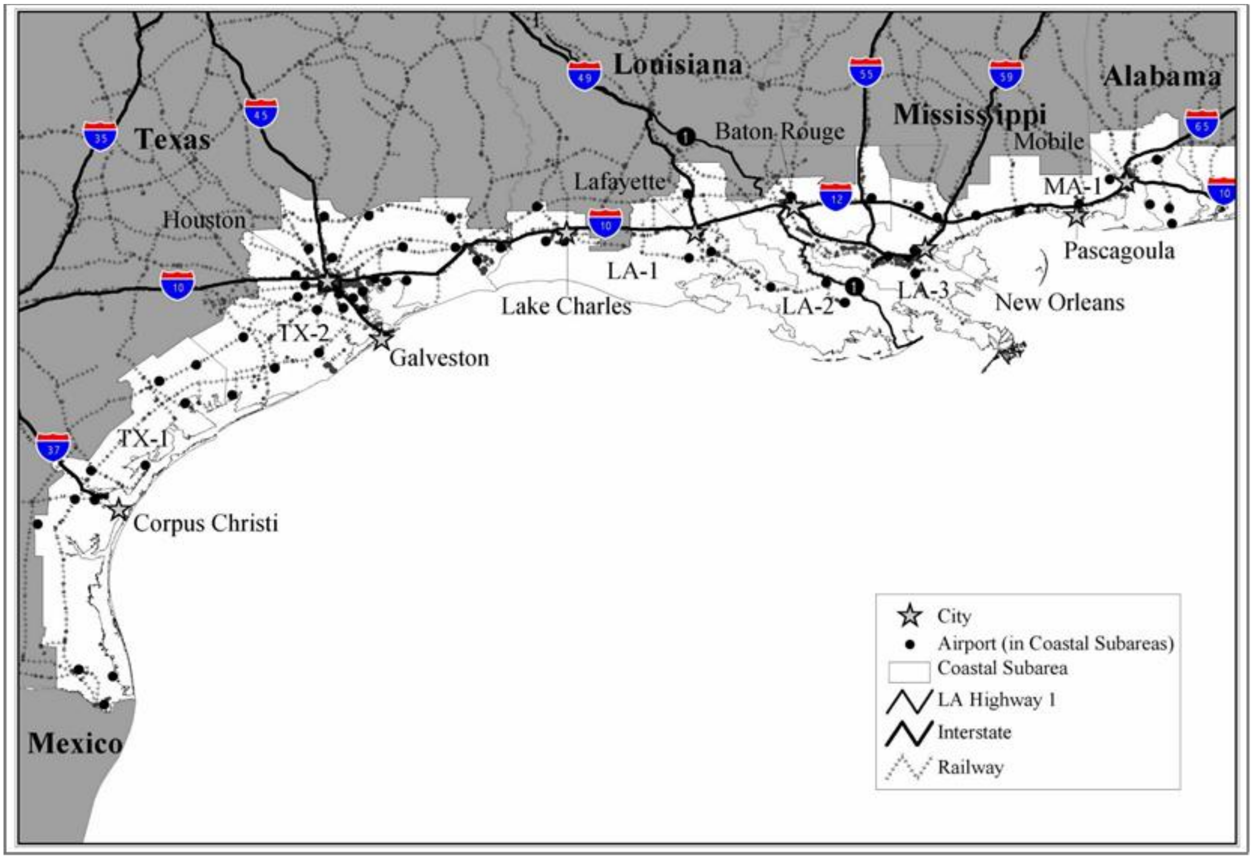


Figure 4.4.1-3. Interstates, Airports, and Railways in the Gulf of Mexico Region.

Recreational land use is prevalent in the GOM coastal region and has evolved over many decades to become increasingly developed. The U.S. coastline along the Gulf of Mexico runs from Brownsville, Texas, and the southern tip of Padre Island, north, east, and south to the Dry Tortugas off Key West, Florida. It encompasses the confluence with the sea of the Mobile and Mississippi Rivers, which have two of the largest delta systems in the United States. The shorefront of the northern Gulf of Mexico is diverse. In addition to homes, condominiums, and some industry, this coastline supports one of the major recreational regions of the United States, particularly for marine fishing and beach activities, both of which are viewed as public assets. There is a diversity of natural and developed landscapes and seascapes, including coastal beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes. Some lands are publicly owned and administered, such as national and State seashores, parks, beaches, and wildlife lands, as well as designated preservation areas, such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, research reserves, and scenic rivers. Gulf Coast residents and tourists from throughout the Nation, as well as from foreign countries, use these resources extensively and intensively for recreational activity. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, also serve as primary-interest areas. Locating, identifying, and observing coastal and marine birds, is a recreational activity of great interest and importance all along the Gulf Coast. A detailed discussion of tourism and recreational resources is provided in **Chapter 4.4.5**.

OCS Oil- and Gas-Related Coastal Infrastructure

The onshore OCS oil- and gas-related coastal infrastructure is extensive, covers a wide-ranging area with extensive transportation systems, supports development, and consists of thousands of large and small companies. These companies cover every facet of coastal and offshore industry activity, including, but not limited to, platform fabrication, shipbuilding and repair, pipelines, pipe coating, service bases, ports, waste disposal facilities, natural gas storage, gas processing plants, service vessels, heliports, terminals, refineries, and petrochemical plants. For analysis purposes, these infrastructure types are organized into the following categories: construction facilities; support facilities; transportation and processing facilities.

Unless otherwise indicated, the following information is directly from BOEM's three OCS Gulf of Mexico Fact Books: (1) *OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (The Louis Berger Group Inc. 2004); (2) *Fact Book: Offshore Oil and Gas Industry Support Sectors* (Dismukes 2010); and (3) *OCS-Related Infrastructure Fact Book; Volume I: Post-Hurricane Impact Assessment* (Dismukes 2011) and *Volume II: Communities in the Gulf of Mexico* (Kaplan et al. 2011b).

Construction Facilities

The major players among construction facilities in the coastal GOM include platform fabrication yards, shipbuilding and shipyards, and pipe-coating plants and yards. 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. This can complicate effects analysis because of the difficulty inherent in trying to separate the effects 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 more detail on construction facilities as an IPF, refer to **Chapter 2.5.1.1** (Construction Facilities).

Platform Fabrication Yards

Facilities where platforms (and drilling rigs) are fabricated are called platform fabrication yards. Most platforms are fabricated onshore and then towed to an offshore location for installation. Production operations at fabrication yards include the cutting and welding of steel components and the construction of living quarters and other structures, as well as the assembly of platform components, to support both exploration and production activities.

Fabrication yards build drilling rigs for offshore exploration. Early drilling rigs consisted of a derrick fitted to a barge and towed to a drilling site. Today, four common types of offshore drilling rigs include submersibles, jackups, drill ships, and semisubmersibles. Submersibles are one of the earliest forms of offshore drilling rigs used, especially in shallow coastal zones or inland waters. Submersibles are towed to shallow-water locations then ballasted to the seabed by flooding them with water. Jackups are quite mobile and common. A jackup lowers long metal legs to the seafloor and then the hull is jacked-up above the water's surface. Jackups can be used normally in water up to 525 ft (160 m) in depth. Drill ships are more advanced drilling structures that are floating marine craft with a derrick on top and a moon pool in the center of the hull for drilling operations. They are anchored and/or positioned with computers and GPS systems that continually correct the ship's drift. Drill ships are often used to drill wildcat wells in deep waters. Semisubmersibles can be used for production as well as drilling activities. These structures are supported by columns sitting on hulls or pontoons, which are ballasted with water below the ocean surface to provide stability in rough, deep waters. Refer to **Chapter 1.3.3.2** (Exploration) for more information on rigs used in OCS oil and gas exploration.

When an oil and/or gas discovery occurs, an exploratory drilling rig will be either replaced with, or converted to, a production platform assembled at the site using a barge equipped with heavy lift cranes. Often in deepwater areas, drilling and production occur on the same structure (such as semisubmersibles). **Figures 4.4.1-4 and 4.4.1-5** illustrate the various types of platforms used in production and development. Depending on the size of the field discovered, the water depth, and the distance from shore, platforms will vary in size, shape, and type, ranging from fixed platforms in shallow water all the way to subsea systems and floating production, storage and offloading systems (FPSOs) in deeper waters. Refer to **Chapter 1.3.3.4.1** (Offshore Production Platforms) for more information on infrastructure used in hydrocarbon production.

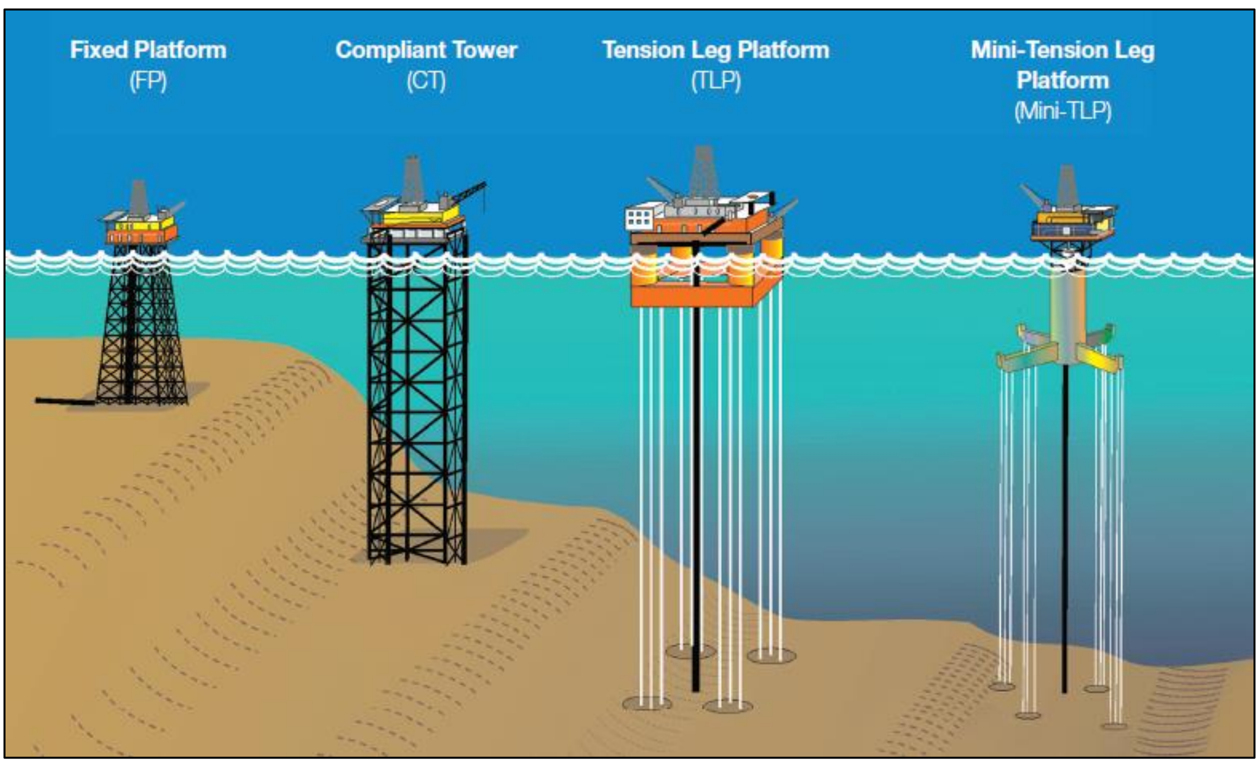


Figure 4.4.1-4. Production Facilities Commonly Used in Shallow to Moderately Deep Waters (reprint of ***Figure 1.3.3-4****).*

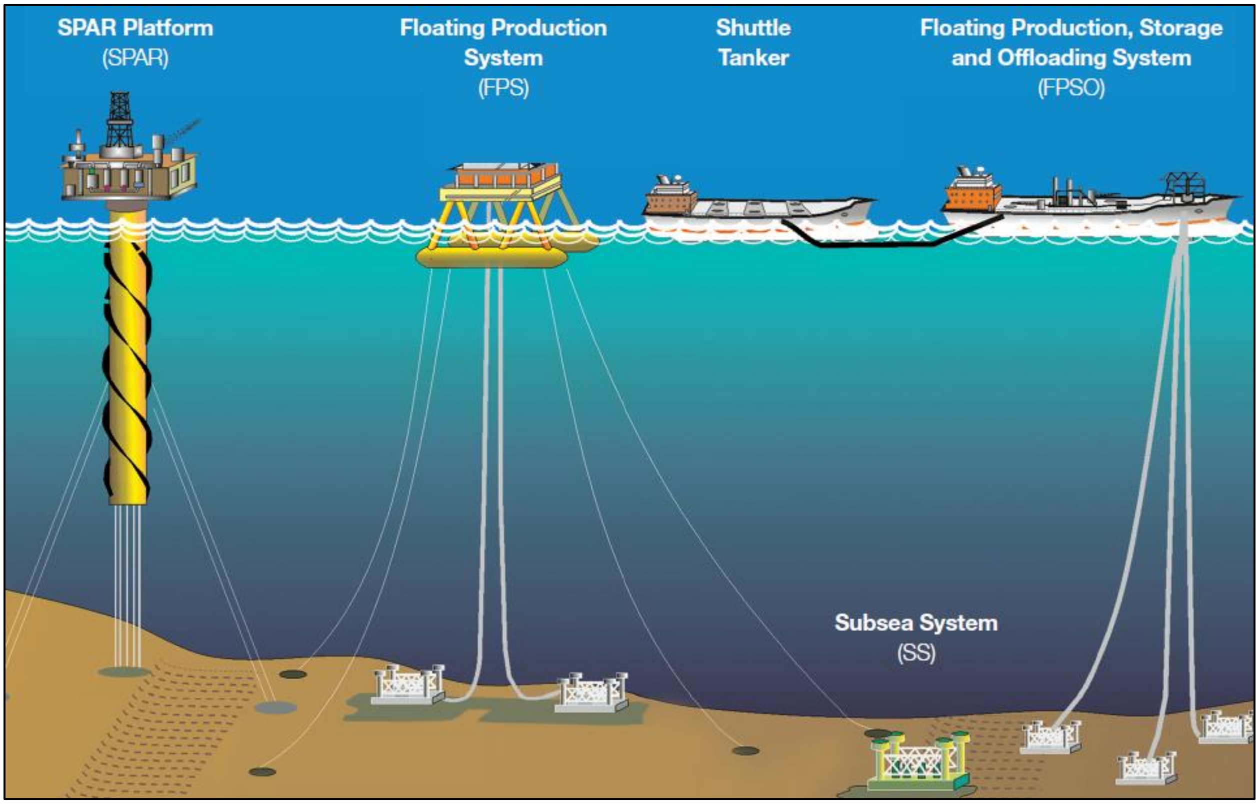


*Figure 4.4.1-5. Production Facilities More Commonly Used in Deep to Ultra-Deep Waters (reprint of **Figure 1.3.3-5**).*

A fixed platform is the most common production system in GOM shallow waters. Fixed platform fabrication can be subdivided into two major tasks: jacket fabrication and deck fabrication. The jacket is constructed by welding together steel plates and tubes to form a tower-like skeletal structure. Because the height of a jacket is several hundred feet, jackets are made lying horizontally on skid runners. Once the jacket is completed, it is pulled over, maintaining the same horizontal position, to a barge that transports it to an offshore location where the jacket is installed. Along with the jacket is the construction of smaller ancillary structures such as pile guides, boat landings, walkways, buoyancy tanks, handrails, etc. These structures are attached to the jacket while it is still in a horizontal position.

The deck is fabricated separately from the jacket. A typical deck is a flat platform supported by several vertical columns (deck legs). The deck provides the necessary surface to place production equipment, living quarters, and various storage facilities. Once the deck fabrication is completed, it is loaded onto a barge and transported to the site of the platform, where it is lifted by derrick barges and attached to the already installed jacket.

A compliant tower is similar to a fixed platform, but the underwater section is not a jacket. It is a narrow, flexible tower that can move (or is compliant) around in the horizontal position, allowing for a limited range of motion created by winds and wave action. Compliant towers are typically installed in water depths from 1,000 ft up to 2,000 ft (305 to 610 m), but they can be installed in water depths up to 3,000 ft (914 m). Some have an upper jacket with buoyant sections and mooring lines to the seafloor to stabilize it.

Based upon the semisubmersible technology, tension and mini-tension leg platforms (TLPs) are floating structures. A TLP is a ship-based type of structure that is towed to its location and anchored to the seabed with vertical, taut steel cables or solid pipes. The TLPs are distinguished from free-floating platforms in that wellheads can be placed on the TLP's deck.

The SPAR platforms are designed to facilitate deepwater production in potentially up to 10,000 ft (3,038 m) in water depth. The SPARs consist of a large vertical hull, moored to the ocean floor with up to 20 lines. Production equipment and living quarters are located on the top of the hull.

A floating production system is a variation of a semisubmersible and is kept stationary either by anchoring with wire ropes and chains or by the use of rotating thrusters, which self-propel the semisubmersible unit. Floating production systems are suited for deepwater production in depths up to 7,500 ft (2,286 m).

A subsea system consists of a single subsea well or several producing wells connected (tied back) to either a nearby platform or a distant production facility (e.g., TLP and SPAR) through a pipeline, umbilical, and manifold system. Subsea systems have proven to be the most utilized form of development system in use for deepwater projects, especially in ultra-deepwater, where water depths exceed 5,000 ft (1,524 m).

Originally developed for North Sea applications, an FPSO system consists of a large vessel housing production equipment to collect and store oil produced from several subsea wells. Eventually the oil is offloaded to a shuttle tanker for transportation to markets for refining and distribution. The FPSO systems are particularly useful in development of remote (or frontier) oil fields where pipeline infrastructure is not available. The FPSOs are not vulnerable to hurricane activity because they can disconnect from their subsea wells and return to shore in advance of a hurricane.

Given the large size of offshore platforms, fabrication yards necessarily span several hundred acres, as they must facilitate large construction projects and maintain an inventory of construction components such as metal pipes and beams, as well as a sizable amount of heavy construction equipment such as cranes and welding equipment. Most fabrication yards have large open spaces for jacket assembly as well as a number of covered warehouses and shops for storing materials and for supporting operations in inclement weather. The principle materials and supplies used in the fabrication business are standard steel shapes, steel plate, welding gases, fuel oil, gasoline, coatings, and paints. Like other industrial construction-oriented industries, the platform fabrication industry is vulnerable to primary commodity price increases with increases in both steel delivery times and price per ton.

The location of platform fabrication yards is tied to the availability of a navigable channel sufficiently large enough to allow the towing of bulky and long structures, such as offshore drilling and production platforms. Thus, platform fabrication yards are located either directly along the Gulf Coast or inland, along large navigable channels such as the Intracoastal Waterway. These waterways, which facilitate or limit movement into and out of the yard, can impact the size and scope of various projects that can be developed at a given location. Despite a large number of platform fabrication yards along the Gulf Coast, only a few facilities can handle large-scale fabrication. High capital costs restrict many companies from becoming full-service offshore construction companies, so many simply specialize in certain types of activities. Therefore, these smaller, more specialized fabrication yards work almost exclusively as subcontractors for competitors on larger jobs.

Shipbuilding and Shipyards

There are several kinds of shipyards throughout the Gulf Coast region that build and repair all manner of vessels, many of which are not related to OCS oil- and gas-related activities. Generally, the shipbuilding and repair industry encompasses the sector responsible for building ships, barges, and other large vessels, whether self-propelled or towed by other craft. These marine vessels are perhaps the most important means of transporting equipment and personnel from onshore bases and ports to offshore drilling and production structures. Facilities dedicated to constructing and repairing these various types of marine vessels also receive orders for marine vessels and ship repairs from a wide range of industries that can include commercial shipping companies, passenger and cruise companies, ferry companies, petrochemical companies, commercial fishing companies, and towing and tugboat companies. The primary vessels that shipbuilding yards provide to the oil and gas industry are known as “offshore service vessels” (OSVs). These vessels transport a wide range of personnel and equipment, ranging from pipes to wrenches to computers, fuel, and drinking water.

Shipyards are often categorized into a few basic subdivisions, characterizing either the type of operation (shipbuilding or ship repairing), the type of ship (commercial or military), or the shipbuilding or repairing capacity of the vessels being constructed or repaired (first-tier or second-tier). Ships themselves are often classified by their basic dimensions, weight (displacement), load-carrying capacity (deadweight), or their intended service. Shipbuilding activities in the U.S., and particularly along the GOM, can vary considerably depending upon the primary markets that these shipyards serve (i.e., commercial or military).

Like platform fabrication, almost all shipyard facilities lack the capability to construct or repair vessels under cover; most of the shipbuilding and repair work is done outdoors and near some major body of water such as a river or deep channel. For the most part, shipyards are designed to facilitate the flow of materials and assemblies. Also like platform fabrication yards, growth and expansion of the facility is piecemeal and depends on technology and the availability of land and waterfront property.

In addition to construction, shipyards also conduct repairs. For some, a large quantity of their business comes from servicing OSVs, which are the boats that work solely to provide services to the offshore oil and gas industry. The OSVs primarily serve exploration and development drilling rigs, and production facilities and support offshore and subsea maintenance activities. Besides transporting deck cargo, OSVs also transport liquid mud, potable and drilling water, diesel fuel, dry bulk cement and personnel between shore bases and offshore rigs and facilities.

Pipe-coating Plants and Yards

Pipe-coating plants generally do not manufacture or supply pipe. They receive the manufactured pipe by rail or water at either their plant or pipe yard depending on their inventory capabilities. At the plant, pipes that transport oil and gas are coated on the exterior with metallic, inorganic, and organic materials to protect from corrosion and abrasion. Pipes may also be coated on the inside to protect against corrosion from the fluids being transported or to improve the flow. In addition to corrosion protection, many pipes that will be used offshore are also coated with a layer of concrete to increase the weight of the line to ensure it stays on the seabed.

Significant threats to pipeline integrity often include third-party damage, geological activity, and corrosion. The most common threat, external corrosion, is recognized as the main deterioration mechanism that can reduce the structural integrity of buried pipelines. In fact, corrosion ranks only second to human error as a cause of pipeline failure. Because coatings are the first line of defense in protecting pipelines against corrosion, they must be well bonded, continuous, and resist the effects of their environments. Pipe coating has emerged as an industry because it is a cost-effective means of extending the life of a pipeline.

Pipeline corrosion coating can be applied either before the pipe is delivered (yard applied) or after the pipe lengths are welded together and suspended above the trench. When pipe lengths are coated and wrapped at a coating yard before being delivered to the job site, a short distance at each end of each length of pipe is left bare so the joints can be welded together. When field welding is complete, coating and wrapping material is applied to the bare pipe sections. Pipe-coating yards store 40-ft (12-m) segments of coated pipe until it is needed offshore. It is transported by barge to offshore locations for laying.

The levels of activity experienced by pipe-coating companies depend on the requirement for new pipeline infrastructure, which is driven by investment in energy supply. The strongest trends in energy supply that affect demand are energy prices, world economic growth, advances in technologies, and future public policy decisions. Much of the pipe coating that takes place is done by companies that also produce the pipes themselves. If the coating company is a separate entity, it is often located near a pipe facility.

The pipe-coating industry is dependent on the oil and gas market. Pipe coatings have evolved from simple coal-tar applications to more sophisticated fusion-bonded epoxies and polypropylene coatings. Companies continue to try new, cost-effective methods and materials in the battle against corrosion and extreme environmental effects. Sometimes the new methods involve using multiple types or layers of protection, and at other times, innovative processes use new materials. The advantages and disadvantages, particularly costs, of each type of coating needs to be taken into account in the development of different coating products.

Support Facilities

The major support facilities in the coastal GOM 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, and underwater contractors (i.e., 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. For more detail on support facilities as an IPF, refer to **Chapter 2.5.1.2** (Support Facilities and Transportation).

Service Bases and Ports

A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel that are needed at offshore work sites. A service base may also be referred to as a supply base and may be associated with a port. Although a service base may primarily serve the OCS planning area and the EIA in which it is located, it may also provide significant services for the other OCS planning areas and EIAs. **Figure 4.4.1-6** shows the primary service bases the industry currently uses to service the OCS. These facilities are identified from exploration and development plans received by BOEM. **Table 4.4.1-1** lists the OCS oil- and gas-related services bases according to EIA. The ports of Fourchon, Cameron, Venice, and Morgan City, Louisiana, are the primary service bases for Gulf of Mexico mobile rigs. Other major platform service bases include Intracoastal City, Louisiana; Pascagoula, Mississippi; and Mobile, Alabama.

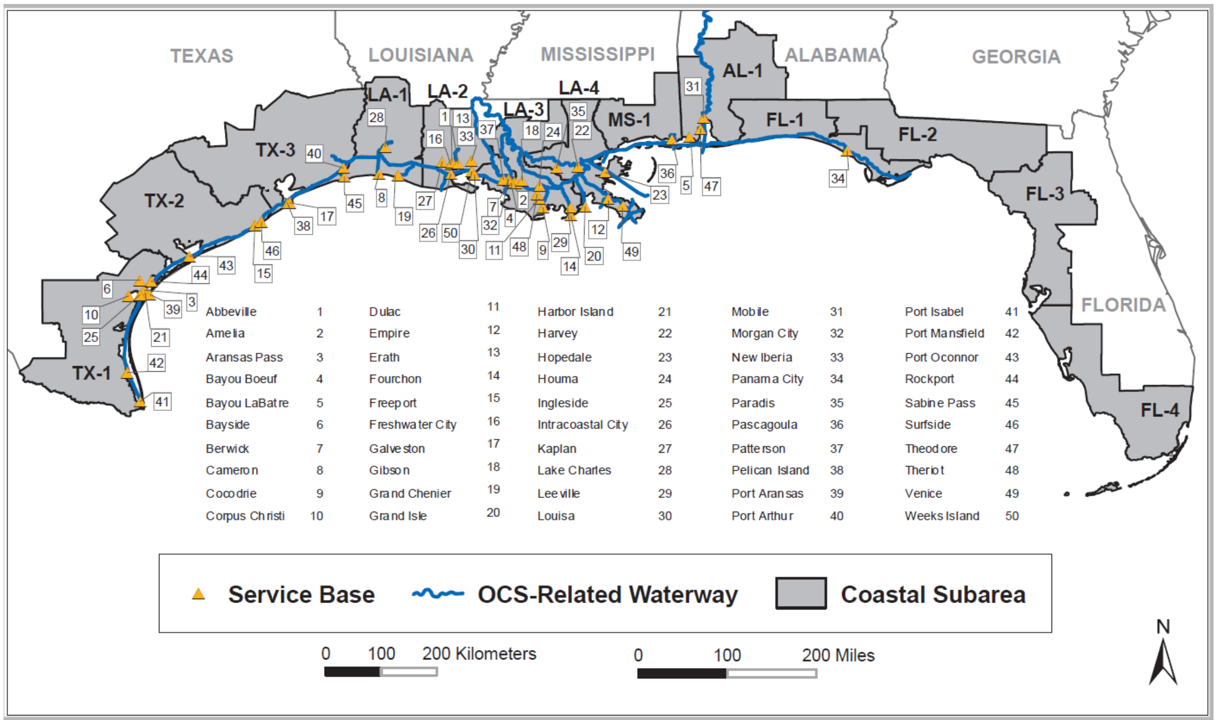


Figure 4.4.1-6. OCS Oil- and Gas-Related Service Bases and Waterways.

Table 4.4.1-1. OCS Oil- and Gas-Related Service Bases.

EIA	Service Base	
Texas TX-1	Aransas Pass (Nueces) Corpus Christi (Nueces) Ingleside (San Patricio) Port Isabel (Cameron) Rockport (Aransas)	Bayside (Aransas) Harbor Island (Nueces) Port Aransas (Nueces) Port Mansfield (Willacy)
Texas TX-2	Freeport (Brazoria)	Port O'Connor (Calhoun)
Texas TX-3	Galveston (Galveston) Port Arthur (Jefferson) Surfside (Harris)	Pelican Island (Galveston) Sabine Pass (Jefferson)
Louisiana LA-1	Cameron (Cameron) Lake Charles (Calcasieu)	Grand Chenier (Cameron)
Louisiana LA-2	Abbeville (Vermilion) Freshwater City (Vermilion) Kaplan (Vermilion) Weeks Island (Iberia)	Erath (Vermilion) Intracoastal City (Vermilion) New Iberia (Iberia)
Louisiana LA-3	Amelia (St. Mary) Berwick (St. Mary) Dulac (Terrebonne) Gibson (Terrebonne) Leeville (Lafourche) Morgan City (St. Mary) Theriot (Terrebonne)	Bayou Boeuf (St Mary) Cocodrie (Terrebonne) Fourchon (Lafourche) Houma (Terrebonne) Louisa (St. Mary) Patterson (St. Mary)

Louisiana LA-4	Empire (Plaquemines) Harvey (Jefferson) Paradis (St. Charles)	Grand Isle (Jefferson) Hopedale (St. Bernard) Venice (Plaquemines
Mississippi MS-1	Pascagoula (Jackson)	
Alabama AL-1	Bayou LaBatre (Mobile) Theodore (Mobile)	Mobile (Mobile)
Florida FL-1	Panama City (Bay)	
Florida FL-2	NA	
Florida FL-3	NA	
Florida FL-4	NA	

EIA = economic impact area; NA = information is not available.
The county or parish in which the service base is located is noted in parentheses.
Source: Dismukes 2011.

This extensive network of supply ports includes a wide variety of shore-side operations from intermodal transfer to manufacturing. Their distinguishing features show great variation in size, ownership, and functional characteristics. Basically, two types of ports provide this supply base. Private ports operate as dedicated terminals to support the operation of an individual company. They often integrate both fabrication and offshore transport into their activities. Public ports lease space to individual business ventures and derive benefit through leases, fees charged, and jobs created. These benefits spread throughout the entire area and are viewed as economic development impacts. Thus, the public ports play a dual role by functioning as offshore supply points and as industrial or economic development districts. An efficient network of ports lowers costs associated with oil and gas production and significantly boosts the well-being of citizens of the adjacent communities.

Waste Disposal Facilities

A variety of different types of wastes are generated by offshore oil and gas exploration and production activities along the GOM. Some wastes are common to any manufacturing or industrial operation (e.g., garbage, sanitary waste [toilets] and domestic waste [sinks and showers]), while others are unique to the oil and gas industry (e.g., drill fluids and produced water). Most waste must be transported to shore-based facilities for storage and disposal. The different physical and chemical characters of these wastes make certain management methods preferable over others.

The infrastructure network needed to manage the spectrum of waste generated by OCS exploration and production activities and returned to land for management can be divided into three categories:

(1) transfer facilities at ports, where the waste is transferred from supply boats to another transportation mode, either barge or truck, toward a final point of disposition;

(2) special-purpose, oil-field waste management facilities, which are dedicated to handling particular types of oil-field waste; and

(3) generic waste management facilities, which receive waste from a broad spectrum of American industry, of which waste generated in the oil field is only a small part.

The capacity of a waste facility has two dimensions. The first is the throughput capacity over a given period of time. In the short term, a waste facility can face limits to the volume of waste it accepts either from permit conditions or from physical limitations to the site, such as unloading bays, traffic conditions, or equipment capacity. Life-of-site capacity is also a limiting factor for disposal facilities. Limitations of storage space or, in the case of an injection well, service life of the well make it necessary to consider what must happen after existing facilities have exhausted their capacity.

Federal regulations govern what may be discharged in GOM waters and set different standards in different parts of the Gulf Coast. State regulations governing reporting and manifesting requirements may vary somewhat, but Federal law has, for the most part, preempted the field of waste transportation regulation. Dockside facilities that serve as transfer points from water to land modes of transportation are regulated by both USCG and State regulations covering the management of oil-field wastes.

Once at a waste management facility, regulations regarding storage, processing, and disposal vary depending on the type of waste. Most would fall under the oil and gas waste exemption of Subtitle C of the Resource Conservation and Recovery Act and would be subject only to State regulations regarding the disposal of oil-field wastes. State laws governing hazardous wastes are allowed to be more restrictive than Federal law, but no material differences exist between State and Federal law in Texas, Louisiana, Mississippi, or Alabama. For the most part, the wastes generated by oil-field activities, called nonhazardous oil-field waste, are exempt from hazardous waste regulation by Federal law because they are produced from the exploration, development, or production of hydrocarbons and thus fall under what is generally referred to as the oil and gas waste exemption found in 40 CFR part 261.

Waste fluids and solids containing naturally occurring radioactive material are subject to State regulations that require special handling and disposal techniques. There are currently no Federal regulations governing naturally occurring radioactive material. The States' special handling and disposal requirements for naturally occurring radioactive material generally result in the segregation of these materials from non-hazardous oil-field wastes and in substantially higher disposal costs when managed by commercial disposal firms.

The USEPA has established a hierarchy of waste management methods that it deems preferentially protective of the environment. For those technologies applicable to oil and gas production waste, the following general waste management techniques are described in order of the USEPA's preference:

- *Recycle/Reuse*—When usable components such as oil or drilling mud can be recovered from a waste, these components are not discarded and do not burden the environment with impacts from either manufacturing or disposal.
- *Treatment/Detoxification*—When a waste cannot be recycled or reused, it can sometimes be treated to remove or detoxify a particular constituent prior to disposal. Neutralization of pH or the removal of sulfides are examples of technologies that are used with oil and gas wastes.
- *Thermal Treatment/Incineration*—Wastes with organic content can be burned, resulting in a relatively small amount of residual ash that is incorporated into a product or sent to disposal. This technology results in air emissions, but the residuals are generally free of organic constituents.
- *Subsurface Land Disposal*—This technology places waste below usable drinking water resources and is viewed as superior to landfilling because of the low potential for waste migration. Injection wells and salt cavern disposal are examples of this type of technology.
- *Surface Land Disposal/Treatment*—This type of technology involves the placement of wastes into a landfill or onto a land farm. Although well-designed and constructed landfills minimize the potential for waste migration, generators remain concerned about migration of contaminants into water resources and avoid it whenever practical. The USEPA classifies surface land disposal as the least desirable disposal method.

Several waste management methods are used to handle the spectrum of wastes generated by OCS activity, and most types of wastes lend themselves to more than one method of management. Each option has a different set of environmental impacts, regulatory constraints, costs, and capacity limitations. The most common waste management methods are recycling of drilling wastes, offshore marine discharge, subsurface injection, salt cavern disposal, land application, and landfilling.

Natural Gas Storage Facilities

There are three main types of underground natural gas storage facilities: depleted reservoirs in oil and/or gas fields; aquifers; and salt cavern formations. Each type of storage facility has its own physical characteristics that include porosity, permeability, and retention capability. Each type of storage facility also has its own economic characteristics that include capacity development costs, location, deliverability rates, and cycling capability.

Most of the natural gas storage facilities in the GOM region are salt caverns. Salt caverns have certain cost benefits since they have lower base or “cushion gas” requirements than reservoirs and aquifers. Cushion gas is the term used to describe the minimum amount of gas that is needed in an underground storage facility to maintain operating pressures and, in the case of salt, maintain cavern integrity. In today’s markets, facilities that have large cushion gas requirements can be more expensive since they tie up large amounts of highly valued gas in limited revenue-generating activities. Thus, salt has an advantage relative to other types of underground storage since it typically requires considerably less cushion gas. However, salt's advantage over reservoir storage has to be balanced against its increased initial capital development cost. Reservoir storage is much cheaper on a capacity-developed basis.

Depleted reservoirs are simply geological formations that have stopped economic production of natural gas. These formations make excellent storage facilities since they are typically developed from known formations with a natural gas production history. In addition, quite often, these formations will have surface facilities on site that can be used or converted to gas storage service. Depleted reservoirs tend to be the most economical of the three main storage types both in development and operation. The Gulf Coast has a mix of depleted reservoir and salt cavern storage. In fact, the overwhelming majority of all salt cavern storage facilities operating in the U.S. are located along the GOM.

Processing Facilities

The major forms of processing facilities in the coastal GOM 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. For more detail on processing facilities as an IPF, refer to **Chapter 2.5.1.3** (Processing Facilities).

Gas Processing Plants

All natural gas is processed in some manner to remove unwanted water vapor, solids, and/or other contaminants that would interfere with pipeline transportation or marketing of the gas. After raw gas is brought to the earth's surface, it is processed at a gas processing plant to remove impurities. Typical contaminants include water, H_2S, carbon dioxide, nitrogen, and helium. Centrally located to serve different fields, natural gas processing plants have two main purposes: (1) remove the impurities from the gas; and (2) separate the gas into its useful components for eventual distribution to consumers. After processing, gas is then moved into a pipeline system for transportation to an area where it is sold.

Natural gas, as it is produced from a reservoir rock, is typically a mixture of light hydrocarbon gases, impurities, and liquid hydrocarbons. Natural gas processing removes the impurities and separates the light hydrocarbon mixture into its useful components.

The quality and quantity of components in natural gas varies widely by the field, reservoir, or location from which the natural gas is produced. Although there really is no "typical" make-up of natural gas, it is primarily composed of methane (the lightest hydrocarbon component) and ethane.

In general, there are four types of natural gas – wet, dry, sweet, and sour. Wet gas contains some of the heavier hydrocarbon molecules and water vapor. When the gas reaches the earth's surface, a certain amount of liquid is formed. The water has no value; however, the remaining portion of the wet gas may contain five or more gallons of recoverable hydrocarbons per thousand cubic feet. If the gas does not contain enough of the heavier hydrocarbon molecules to form a liquid at the surface, it is a dry gas. Sweet gas has very low concentrations of sulfur compounds, while sour gas contains excessive amounts of sulfur and an offensive odor. Sour gas can be harmful to breathe or even fatal.

The natural gas processing business includes a wide range of company types, such as fully integrated oil companies, intrastate pipeline companies, major interstate pipeline companies and their nonregulated affiliates, and independent processors. Each company type has varying levels of financial and personnel resources. Competition in the market generally revolves around price, service, and location.

Liquified Natural Gas Facilities

Liquefied natural gas (LNG) is natural gas converted to liquid form by cooling it to a temperature of -256°F (-124°C), the point at which gas becomes liquid. This simple process allows natural gas to be transported from an area of abundance to an area where it is needed. Once the LNG arrives at its destination, it is either stored as a liquid or converted back to natural gas and delivered to end-users. Liquefying gas is not a new process or technology; it is simply a process by which the physical properties of natural gas, primarily methane, are altered in order to transport the commodity from markets where it is abundant to those more limited in supply (Dismukes 2008).

The wide variety of pipeline systems and delivery markets makes the GOM attractive for LNG developers. In Texas, numerous large interstate pipelines parallel the Gulf Coast shoreline en-route to Louisiana and downstream markets. This allows LNG projects to tie into multiple interstate pipeline systems, with much shorter pipeline construction needs. The capital cost savings could help to mitigate the potential for Gulf Coast prices to trade at discounts to Louisiana. An LNG regasification facility can take advantage of this diverse pipeline system to move natural gas much like producers do today.

Onshore natural gas production has increased to the extent that LNG facilities along the GOM are seeking and receiving approval to export natural gas to foreign countries. There are 10 existing LNG import/export terminals in the GOM region—4 in Texas, 5 in Louisiana, and 1 in Mississippi (FERC 2020c; 2020g). There are six proposed LNG export terminals in the GOM region—two in Texas and four in Louisiana (FERC 2020d). There are 19 facilities with export approval that are not yet built—9 in Texas, 9 in Louisiana, and 1 in Mississippi (FERC 2020b).

Refineries

Petroleum refineries have emerged over the past 100 years as a variety of different manufacturing units designed to produce physical and chemical changes to turn crude oil into petroleum products. In the early days of petroleum refineries, the process was quite simple and consisted of heating crude oil at various temperatures to extract what at that time was its most important refined product, kerosene. Today, the process includes various types of heating, distilling, and catalytic conversions. A modern refinery will break down crude into a large number of components. Refineries vary in size, sophistication, and cost depending on their location, the types of crude they refine, and the products they manufacture. Because crude oil is not homogeneous (i.e., varying in color, viscosity, sulfur content, and mineral content), oil produced from different fields or geographic areas have different quality characteristics that give rise to different economic values.

Crude oil is refined into enumerable products and combinations of products, some of the more important being motor gasoline, diesel fuel, jet fuel, and heating fuel. Some of the refined byproducts from crude oil also serve as important feedstocks for the development of synthetic fabric for cloths, detergents, and dry-cleaning solvents, as well as chemical bases for cosmetics and pharmaceutical products and various plastic products from toys to building materials.

The U.S. Department of Energy's Energy Information Administration updates national energy projections annually, including refinery capacity. Most of the GOM region's refineries are located in Texas and Louisiana. Texas contains 30 operable refineries, with an operating capacity of over 5.7 MMbbl/day, which is over 31 percent of the total U.S. capacity. Louisiana contains 17 operable refineries, with an operational capacity of over 3.4 MMbbl/day, which is over 18 percent of the total U.S. capacity (Energy Information Administration 2020e). There has been a trend toward constructing simple refineries instead of complex refineries. In the United States, the last complex refinery started operating in 1977 in Garyville, Louisiana. In the GOM analysis area, a new simple refinery was constructed in 2017 in Channelview, Texas (Energy Information Administration 2020b).

Petrochemical Plants

The chemical industry converts raw materials (i.e., oil, natural gas, air, water, metals, and minerals) into more than 70,000 different products. After natural gas is processed and crude oil is refined, the non-fuel components are typically used as a feedstock, forming the production basis for what is known as "petrochemicals." Petroleum is composed mostly of hydrogen and carbon compounds (called hydrocarbons). It also contains nitrogen and sulfur, and all four of these ingredients are valuable in the manufacturing of chemicals.

The petrochemical industry is somewhat amorphous and can be difficult to define, particularly around the boundaries. The upstream side of the business is typically defined by the production and primary use of crude oil and natural gas by-products. As one moves downstream, the introduction of industries and facilities that combine petrochemical manufacturing and other organic chemistry-based industries such as plastics, synthetic fibers, agricultural chemicals, paints and resins, and pharmaceuticals are usually included. Quite often, companies owning and operating facilities in this industry are petroleum companies who have broadened their interests into chemicals, chemical companies who buy petroleum raw materials, and joint ventures between chemical and petroleum companies. For instance, Shell, ExxonMobil, and Occidental Petroleum have chemical/petrochemical operations. In fact, co-location of chemical and refining operations creates efficiencies and synergies that keep many of these facilities operational in an otherwise mature high-cost environment that defines North American and European operations.

Petrochemical plants are usually located in areas with close proximity to raw materials (petroleum-based inputs) and multiple transportation routes, including rail, road, and water. In many instances, such as development along the GOM, chemical plants arise because of their close proximity to other plants, which can often be their best customers. It is common for large integrated oil and gas companies that own refineries to have nearby chemical plant affiliates to take advantage of particular waste streams.

Laid out like industrial parks, most petrochemical complexes include plants that manufacture any combination of primary, intermediate, and end-use chemical products. Changes in market conditions and technologies are often reflected over time as input and product slates are changed. In general, petrochemical plants attempt to run in an “optimized” fashion by attaining the cheapest manufacturing costs and producing the largest level of output while taking advantage of any and all co-locational synergies. Product slates and system designs are carefully coordinated to optimize the use and output of chemical by-products and to use steam, heat, and power as efficiently as possible.

Along the GOM, the petrochemical industry is heavily concentrated in coastal Texas, south Louisiana, and in various counties along the Alabama, Mississippi, and Florida coasts. In many ways, these petrochemical facilities can be thought of as another form of “hydrocarbon processor.” They use natural gas, liquefied petroleum gas, and natural gas liquids to create products much like a refinery takes crude oil and converts it into a variety of products such as gasoline, distillates, kerosene, and other products.

Transportation

The most critical highway for the Nation’s energy supply network is Louisiana Highway 1 (LA 1). On November 28, 1995, Louisiana Highway 1 was designated as part of the National Highway System. The National Highway System Designation Act of 1995 (109 Statute 568, Public Law 104-59) designated 160,955 mi (259,032 km) of interstate, highways, and other roads that are critical for the economy, defense, and mobility of the Nation as the National Highway System. The LA 1 Project Task Force was established by Louisiana Executive Order MJF 98-46 to evaluate the feasibility of improving LA 1 from Grand Isle/Port Fourchon, Louisiana, to points north because of its vital role as the main, and in some places only, conduit for moving goods on a daily basis and evacuating people in the face of a tropical storm system or hurricane (Louisiana Office of the Governor 1998). The LA 1 Coalition was founded to coordinate public information and funding efforts. The highway improvements are planned in phases and only the first phase, which was to raise a two-lane highway connecting Port Fourchon to Leeville, Louisiana, has been completed. When all four phases are completed, the highway will be a four-lane highway from Port Fourchon to Golden Meadow, Louisiana, and a four-lane highway at grade level to Larose, Louisiana (LA 1 Coalition 2020a). Louisiana Highway 1 serves as an extremely important connector and conduit.

- It is the only road connecting Port Fourchon and the Louisiana Offshore Oil Port.
- Port Fourchon is the main energy port in the Gulf of Mexico region.
- Together, the Louisiana Offshore Oil Port and Port Fourchon service nearly 17 percent of U.S. domestic crude oil production and 4 percent of natural gas production.
- Port Fourchon and LA 1 service and support nearly all of the deepwater oil and gas production in the Gulf of Mexico, contributing ~$4.5 billion to the U.S. Treasury.
- Over 24,000 commercial trucks traverse LA 1 to Port Fourchon to provide equipment and supplies to offshore operations during peak months of the year.
- LA 1 is the sole highway, known as the “Gulf to Market” Road for transport of Louisiana oysters, shrimp, crabs, and fish. (In 2017, over $41 million of seafood were produced in the coastal region supported by LA 1).
- LA 1 is also the only road to access coastal restoration projects in the lower parish areas, eco-tourism sites around Grand Isle and Elmer Island, and recreational fishing access points.
- Thousands of residents, tourists, and workers depend on LA 1 to safely evacuate the coastal region in advance of hurricanes and tropical storms (LA 1 Coalition 2020b).

While the list of facts and figures surrounding the importance of LA 1 go far beyond what is listed above, the absolute critical connection LA 1 provides is most clearly depicted by **Figure 4.4.1-7**. The new elevated highway shows up as bright white, going straight across open water. The old LA 1 that is slowly being submerged is visible to the left as a curvy road that seems to end in water, surrounded by what little remains of the marsh. Port Fourchon, visible at the bottom of the photo, depends solely on LA 1 for all connection to the rest of the Nation.

Figure 4.4.1-7. LA Hwy 1 Connecting Port Fourchon and Leeville, Louisiana (Photo Credit: (LA 1 Coalition 2018). The new elevated highway is bright white and the old LA 1 is the curving road to its left. Port Fourchon is visible at the bottom of the photo.

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. 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, which provides the only link between Port Fourchon, Louisiana, and which services 90 percent of the deepwater oil and gas production in the Gulf of Mexico and the rest of the Nation.

The major forms of OCS crew, supply, and product transportation discussed in the following section includes heliports, OCS support vessels, coastal pipelines/pipeline landfalls/pipeline shore facilities, and coastal barging/barge terminals. As the oil and gas industry continues to evolve so do the requirements of the onshore support network. With advancements in technology, the shoreside supply network continues to be challenged to meet the needs and requirements of the industry. All crew and supplies must be transported between land-based facilities to marine vessels or helicopters and offshore destinations. Likewise, all offshore oil and gas production must be transported onshore in some manner, whether by pipeline or tanker. For more detail on transportation as an IPF, refer to **Chapter 2.5.1.2** (Support Facilities and Transportation).

Heliports

Heliports are centralized locations where helicopters disembark for offshore service. Helicopters move crew and equipment to offshore areas and serve as one of the primary modes for transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and, at other times, to transport management and special service personnel to offshore exploration and production sites. While supply boats are typically used for short-haul service, helicopters are the primary means of transportation for longer distances as well as instances when speed of delivery (i.e., equipment and personnel) may be pressing. In addition, equipment and supplies are sometimes transported. For small parts needed for an emergency repair or for a costly piece of equipment, it is more economical to get it to and from offshore fast rather than by supply boat. For example, the Bell 206L Long Ranger has a fuel capacity of 110 gallons and can travel up to 320 nmi (368 mi; 593 km). Its cruising speed at sea level is about 130 kn (150 mph). This would include most deepwater platforms and facilities in the GOM. A supply boat (specifically a crew boat for transporting personnel), on the other hand, has a cruising speed of 20-35 kn (23-40 mph).

Heliport service providers usually retain a mix of size and quantity of aircraft, with their fleets categorized into small, medium, and large helicopters. The small helicopters are better suited for support of production management activities, daytime flights, and shorter routes. Many of the shallow-water production facilities in the GOM are too small to accommodate anything larger than a small helicopter, making the GOM a strong market for this group of helicopters. Medium helicopters are the most versatile part of an air transportation company's fleet because they are equipped to fly in a variety of operation conditions, are capable of flying longer distances, and can carry larger payloads than small helicopters. Large helicopters are also able to fly in a variety of different operations, but they can also perform in harsh weather conditions, carry larger payloads, fly longer distances, and hold up to 25 passengers. Medium and large helicopters are most commonly used for crew changes on large offshore production facilities and drilling rigs.

This industry is largely dependent on the level of production, development, and exploration in the GOM. The demand for helicopters increases with an increase in activity levels associated with oil and gas production; however, as oil and gas companies seek to reduce costs with respect to air transportation services, the demand for the frequency of these services is reduced. Greater total (and relative) deepwater activities in the GOM are forcing significant changes on the transportation industry in the region. For example, the helicopter and vessel industries must have the capability of traversing longer distances with more cargoes that were necessary even a decade ago.

Most service providers maintain a mix of small-, medium-, and large-sized aircrafts to meet the diverse needs of the offshore industry. A few people making a short, daytime trip in good weather to a small production site would need only a small helicopter carrying 4-7 passengers, whereas shift change crews, trips to distant locations, bad weather, international markets, or large loads would require the use a medium-sized craft carrying up to 13 passengers or even larger ones holding up to 25 passengers. As production activity moves ever farther offshore into the deep water of the Gulf of Mexico, the need for medium and large helicopters will continue.

Industry consolidation has resulted in a small number of large helicopter service providers. Some competitors in this region are smaller, privately owned entities or subsidiaries of larger companies. These companies include Evergreen, Houston Helicopters, and Rotorcraft Technologies. There are no actively utilized OCS-related heliports in Florida, but the infrastructure exists should the EPA be opened up in the future.

OCS Support Vessels

The primary types of OCS support vessels include anchor handling, towing, and supply vessel (AHTS), offshore supply vessels (OSVs) and their larger cousins, the marine platform supply vessels, as well as crew boats and their related fast support vessels. These vessels work solely to provide services to the offshore oil and gas industry, serving primarily exploratory and developmental drilling rigs and production facilities, and to support offshore and subsea maintenance activities. In addition to transporting deck cargo, most of these also transport liquid mud, potable and drilling water, diesel fuel, dry bulk cement, and personnel between shore bases and offshore rigs and facilities.

The AHTS vessels tow rigs to their locations and come equipped with powerful winches to lift and position the rig's anchors. Some AHTS vessels can carry small amounts of supplies, such as drill pipe or drilling fluid, while others are limited to carrying rigs and rig anchors. Most newer, deepwater AHTS vessels are equipped with stronger winches, dynamic positioning capability, and more room to transport supplies (Barrett 2008).

The OSVs and platform supply vessels deliver drilling supplies such as liquid mud, dry bulk cement, fuel, drinking water, drill pipe, casing, and a variety of other supplies to drilling rigs and platforms. The majority of OSVs in service are old, legacy boats built during the boom in the late 1970s/early 1980s. A typical boat from that era is about 180 ft (55 m) long and can carry about 1,200 bbl of liquid mud and about 1,000 tons (dead weight tons) of deck cargo. New generation OSVs are between 220 and 295 ft (67 and 90 m) long and can carry 3-10 times as much liquid mud and 2-4 times as much deck cargo. New generation supply boats can haul about 3-10 times more liquid mud, 2-4 times as much deck cargo, and come equipped with global positioning systems and multiple thrusters to correctly position the boat (Barrett 2008).

Crew boats transport personnel to, from, and between offshore rigs and platforms. These boats are much smaller than the AHTS vessels or OSVs and can range in size from 75 to 190 ft (23 to 58 m). They are classified by cruising speed, and the smaller ones are used to transport crews between offshore platforms rather than to and from shore. The fast support vessels can transport crews swiftly but are only able to carry a limited amount of supplies (Barrett 2008).

The FPSOs consist of a floating tank system designed to process and store all of the oil or gas produced from a nearby deepwater platform until it can be offloaded into tankers or transported through pipelines. The FPSOs, while new to the GOM, are used extensively in other countries as an alternative to installing expensive pipelines.

Coastal Pipelines/Pipeline Landfalls/Pipeline Shore Facilities

A mature pipeline network exists in the GOM to transport oil and gas production from the OCS to shore. Almost the entirety of Federal OCS production is transported to shore via pipelines, with the exception of a small amount from shallow water that is barged to shore. Most new OCS pipelines connect to existing pipelines offshore. In recent decades, there has been a steady decline in the number of new pipeline construction projects that result in new pipeline landfalls (MMS 2007). About 250 of the active OCS pipelines cross the Federal/State boundary into State waters. There are nearly 1,900 km (1,181 mi) of OCS pipelines in State waters. Over half of the pipelines in State waters are directly the result of the OCS Oil and Gas Program.

Where a pipeline crosses the shoreline is referred to as a pipeline landfall. Gulfwide, about 60 percent of OCS pipelines entering State waters tie into existing pipeline systems and do not result in new pipeline landfalls. About 90 percent of OCS pipeline landfalls are in Louisiana (MMS 2007). The oldest pipeline systems are also in Louisiana; some date back to the 1950s. There are over 100 active OCS pipelines making landfall, resulting in 200 km (124 mi) of pipelines onshore, with an average of 2 km (1 mi) per pipeline. About 80 percent of the onshore length of OCS pipelines is in Louisiana, with the longest being 50 km (31 mi). A small percentage of onshore pipelines in the EIAs are directly the result of the OCS Oil and Gas Program.

The busiest decades for OCS pipeline landfall installations were the 1960s and 1970s when the majority of all OCS pipeline landfalls were installed. As the OCS pipeline network became more established, the number of new Federal OCS pipeline landfalls decreased. Since the mid-1980s, the long-term trend is for new Federal OCS pipelines to tie into existing systems rather than creating new landfalls. Since 1986, the 5-year moving average of new Federal OCS pipeline landfalls has been below two per year.

The term “pipeline shore facility” is a broad term describing the onshore location where the first stage of processing occurs for OCS pipelines carrying different combinations of oil, condensate, gas, and produced water. These facilities may also be referred to as a separation or field facilities. Pipelines carrying only dry gas do not require pipeline shore facilities; the dry gas is piped directly to a gas processing plant. Although in some cases some processing occurs offshore at the platform, only onshore facilities are addressed in this section.

Pipeline shore facilities may separate, process, pump, meter, and store oil, water, and gas depending on the quality of the resource carried by the pipeline. After processing and metering, the liquids are either piped or barged to refineries or storage facilities. The gas is piped to a gas processing plant for further refinement, if necessary; otherwise, it is transported via transmission lines for distribution to commercial consumers. Water that has been separated out is usually disposed of into onsite injection wells. A pipeline shore facility may support one or several pipelines. Typical facilities occupy 2-25 ha (5-62 ac).

Coastal Barging/Barge Terminals

There is a tremendous amount of barging that occurs in the coastal waters of the GOM, and no estimates exist of the volume that is attributable to the OCS industry. Secondary barging of OCS oil often occurs between terminals or from terminals to refineries. Oil that is piped to shore facilities and terminals is often subsequently transported by barge up rivers, through the Gulf Intracoastal Waterway, or along the coast.

Barges may be used offshore to transport oil and gas, supplies such as chemicals or drilling mud, or wastes between shore bases and offshore platforms. Barges are non-self-propelled vessels that must be accompanied by one or more tugs. Because of this, barge transport is usually constrained to shallow waters of the GOM, close to the shoreline.

Barging of OCS oil from platforms to shore terminals is an option used by the oil industry in lieu of transporting their product to shore via pipeline. A platform operator generally decides at the beginning of a development project whether the production will be barged or piped. Other types of barging operations may occur in connection with OCS operations. Besides barging from platform to shore terminal, a few platform operators choose to barge their oil to other platforms where it is then offloaded to storage tanks and later piped to shore. Barging is used very infrequently as an interim transport system prior to the installation of a pipeline system.

Barge terminals are the receiving stations where oil is first offloaded from barges transporting oil from OCS platforms. These facilities usually have some storage capabilities and processing facilities. Some barge terminals may also serve as pipeline shore facilities.

Because the volumes of oil reported to BOEM are determined at the offshore locations prior to barging, the final destination of the oil varies. Therefore, BOEM does not have an exact number of onshore terminals receiving OCS oil production. Several barge terminals located along the Gulf Coast receive State production or imports. Barged OCS production may be taken to any existing barge terminal. Historically, the OCS oil industry has used the following barge terminals in the GOM: Matagorda Island, Texas City, Beaumont, and Nederland, Texas; and Amelia, Lake Charles, Gibson, Calumet, and Empire, Louisiana. These barge terminals may also receive oil from State production or imports.

Coastal Land Loss

Coastal land loss resulting from erosion, subsidence, and coastal storms is one of the more substantial effects 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. **Figure 4.4.1-8** shows the amount of land that coastal Louisiana has lost from 1932 to 2010.

Figures 4.4.1-9 and 4.4.1-10 illustrate scientists' projections for future land loss in Louisiana. The moderate scenario assumes more mitigating measures, and the less optimistic scenario shows the projected 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.

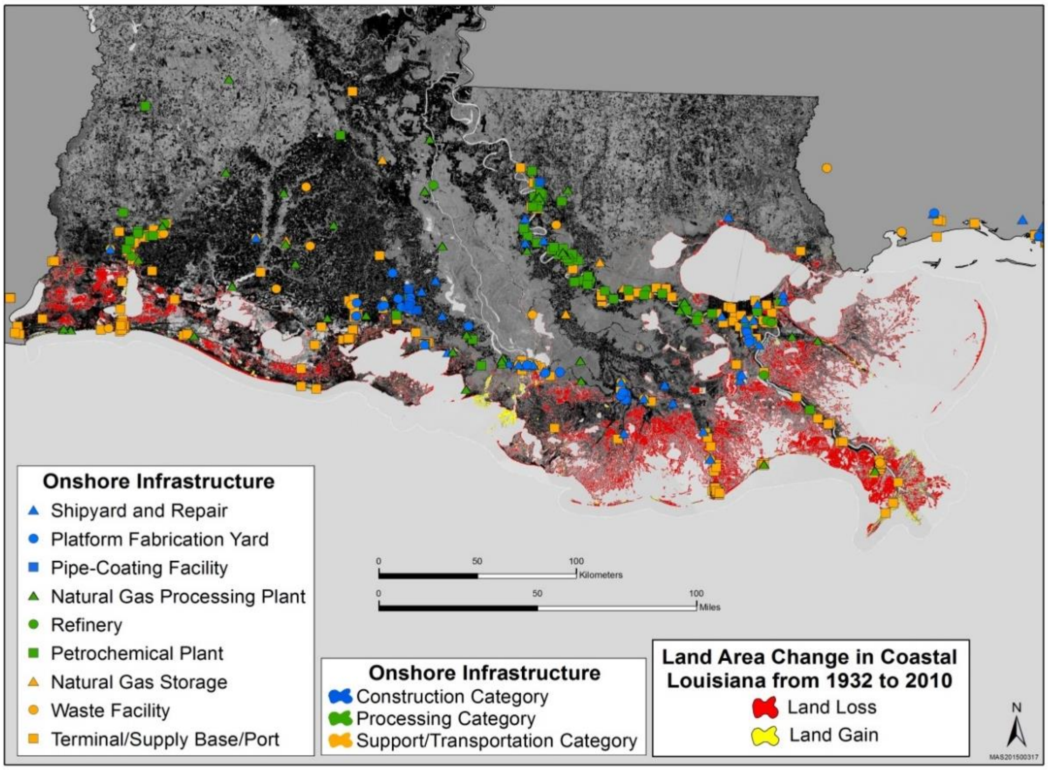


Figure 4.4.1-8. Historical Land Loss in Louisiana, 1932-2010.

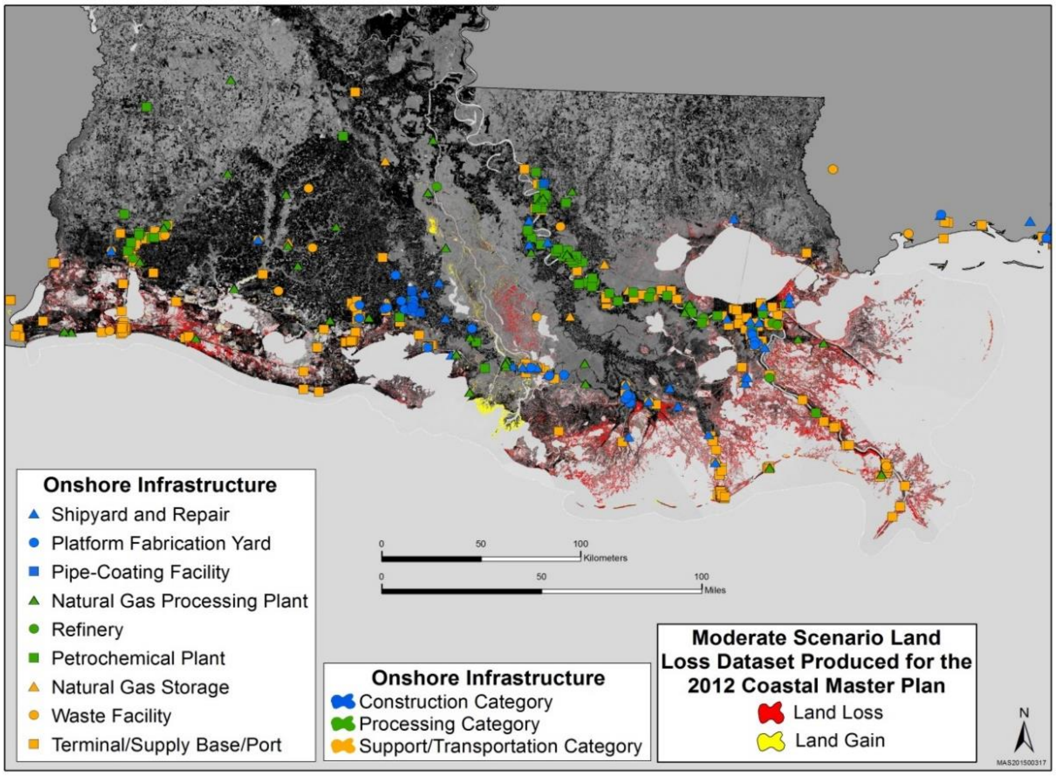


Figure 4.4.1-9. Moderate Scenario: Projected Land Loss in Louisiana.

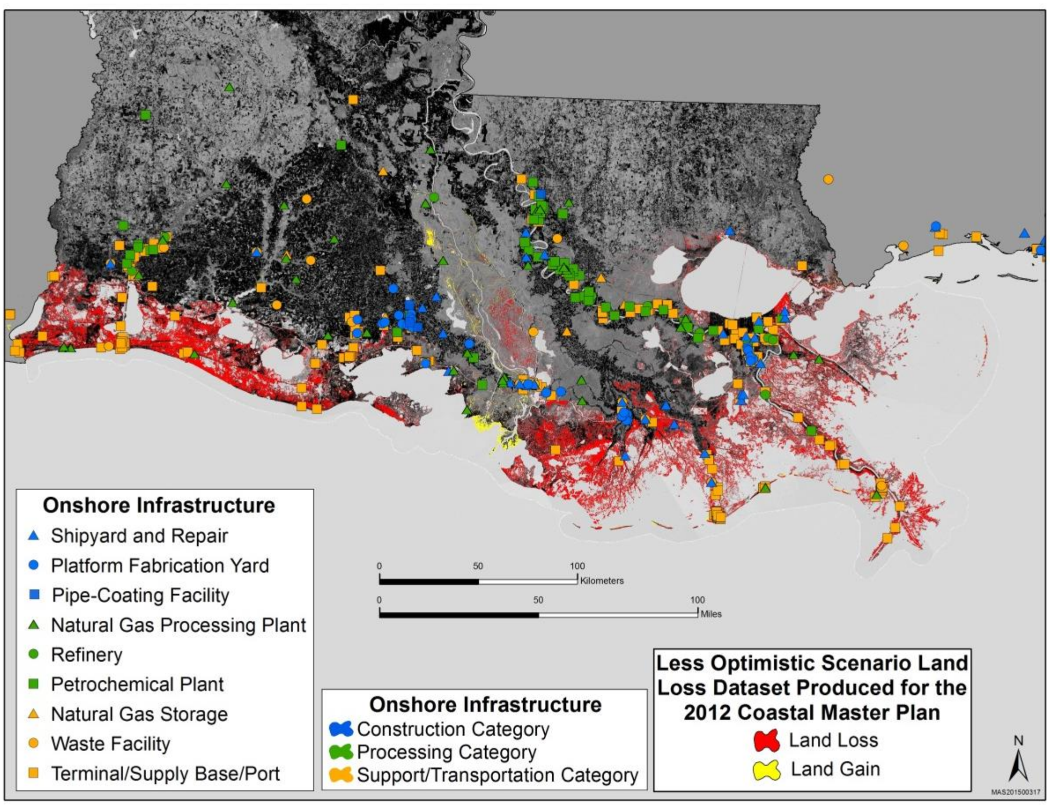


Figure 4.4.1-10. Less Optimistic Scenario: Projected Land Loss in Louisiana.

Analysts have noted that $100 billion of oil and gas infrastructure is under threat of inundation in coastal Louisiana (Traywick 2016). Since that analysis, studies have updated subsidence rates along much of coastal Louisiana, finding them to be higher than previously known (Nienhuis et al. 2017) and identified communities and areas at higher risk of flooding and effective inundation under different sea-level rise scenarios, including large areas in Louisiana and Texas (Dahl et al. 2017b; Spanger-Siegfried et al. 2017). A 2018 report by the National Academies of Sciences, Engineering, and Medicine found that more needs to be done to gain a better understanding of how environmental changes affect coastal communities and infrastructure, especially Gulf Coast energy infrastructure (National Academies of Sciences, Engineering, and Medicine 2018). Particularly susceptible to storm damage and land loss, the State of Louisiana has invested over $800 million in projects to restore its barrier islands, and the State's 2017 Coastal Master Plan calls for an additional $1.5 billion over the next 50 years in storm protection and coastal restoration projects (Baurick 2018). For more detail on coastal land loss as an IPF, refer to **Chapter 2.5.2.1** (Sea-Level Rise and Subsidence).

4.4.1.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and land use and coastal infrastructure. **Figure 4.4.1-11** provides a synopsis of the IPF categories that currently affect or have the potential to affect land use and coastal infrastructure in the Gulf of Mexico OCS. Following **Figure 4.4.1-11** is a summary of those potential effects on land use and coastal infrastructure as well as a brief discussion of the IPF categories identified in **Figure 4.4.1-11** that are not likely to affect land use and coastal infrastructure, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to land use and coastal infrastructure, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

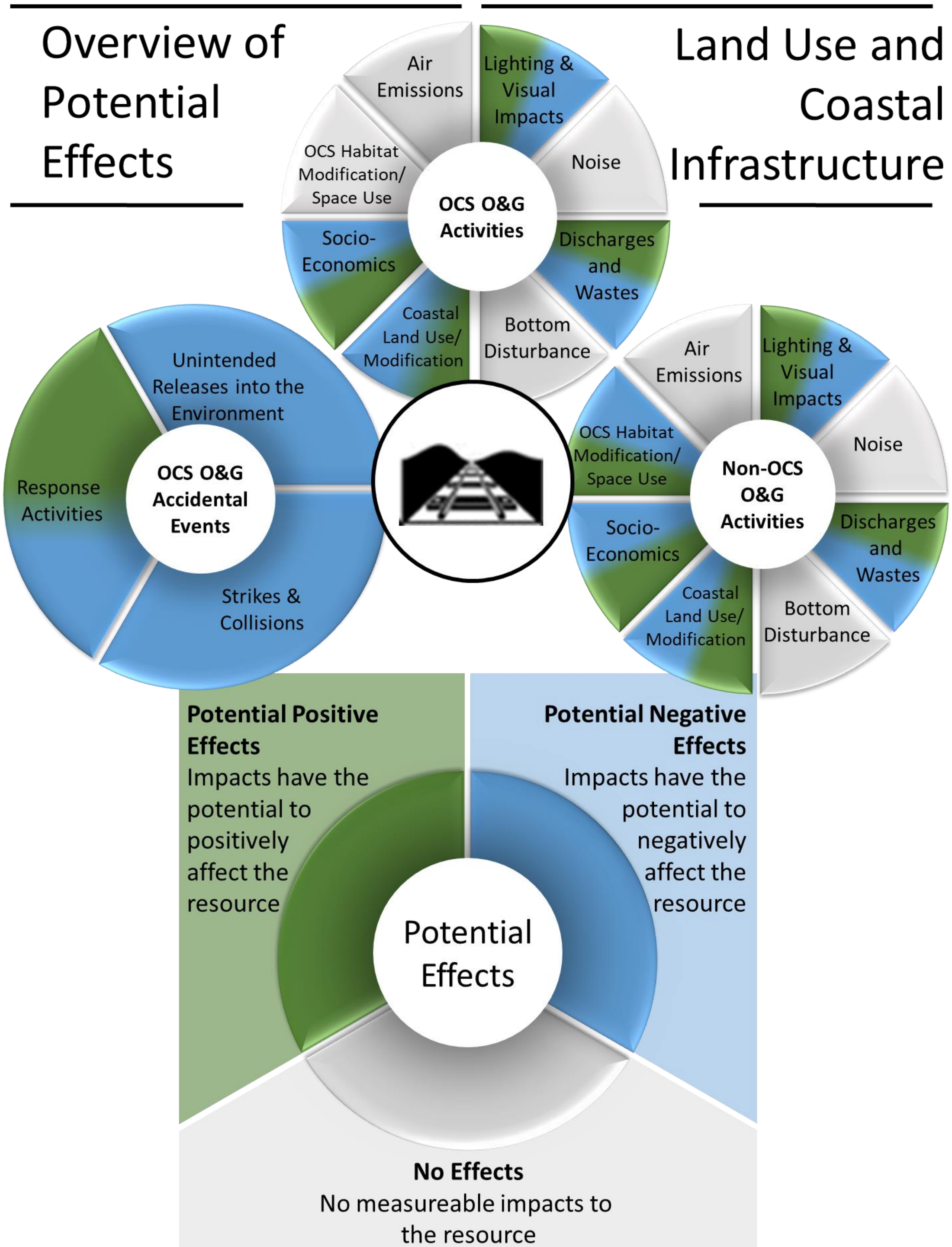


Figure 4.4.1-11. Potential Interactions Between the Impact-Producing Factors Identified in ***Chapter 2*** *and Land Use and Coastal Infrastructure. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.4.1.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.1-11 highlights the IPF categories of non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect land use and coastal infrastructure in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.2)

Land use and coastal infrastructure may be affected by discharges and wastes, including dredged material disposal, land-based discharges associated with agricultural uses, trash and debris, and oil spills from State oil and gas activities that occur near or onshore. Potential effects to land use and coastal infrastructure from discharges and wastes associated with non-OCS oil- and gas-related activities could range from positive to negative.

Dredged material disposal often benefits surrounding land by shoring up areas undergoing subsidence and improving previous land uses. For example, the Coastal Wetlands Park at Port Fourchon, Louisiana, was developed from the beneficial use of dredged materials produced from projects to expand the port's capacity with new slips and deeper canals. Land-based discharges are often associated with agricultural uses and may contribute to negative effects that include pesticide and nutrient runoff and changes in water and soil quality. Land use also can be negatively affected by the various types of trash and debris that may accumulate onshore, such as household and industrial trash dumped on vacant lots. Oil spills from State oil and gas activities that may occur near or onshore may negatively affect land use and coastal infrastructure by interfering with the use and viability of those properties and facilities affected.

Coastal Land Use/Modification (Chapter 2.5.2)

Coastal land use/modification that may affect land use and coastal infrastructure include sea-level rise and subsidence, saltwater intrusion, erosion, maintenance dredging of navigation canals, coastal restoration programs, and tourism infrastructure. Potential effects to land use and coastal infrastructure from coastal land use associated with non-OCS oil- and gas-related activities could range from positive to negative.

Sea-level rise and subsidence, saltwater intrusion, and erosion contribute negatively to the ongoing coastal land loss issue facing coastal areas in the Gulf of Mexico region, particularly in Louisiana. Maintenance dredging of navigation canals produces positive effects for coastal infrastructure such as ports and terminals by improving access and utilization feasibility. Coastal restoration programs provide beneficial effects for land use with efforts such as wetlands and marsh restoration and beach nourishment projects. Tourism infrastructure such as parks, beaches, boat launches, and camp grounds contribute positively to land use and coastal infrastructure by attracting visitors who contribute to the local economy, building up State and local revenues that then become available for use in improving various public works, roads, bridges, educational, and health system supports, and future land development or conservation projects.

Lighting and Visual Impacts (Chapter 2.6.2)

Visual impacts can affect land use in coastal areas by detracting from or enhancing the intended use and enjoyment of private and public properties along the coast. Coastal or nearshore lighting from vessels or State oil and gas activities may negatively affect land use by diminishing the visual aesthetics for some recreational sites and detracting from some nature experiences. However, because aesthetics can be subjective, coastal or nearshore lighting can also have positive effects on land use by improving the visibility of structures and adding contrast to the landscape. A detailed discussion of potential visual impacts is provided in **Chapter 4.4.5** (Tourism and Recreational Resources).

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

While offshore habitat modification, by definition, does not affect land use and coastal infrastructure, there are some potential issues related to coastal and nearshore space use from non-OCS oil- and gas-related activities that may be relevant. These space-use conflicts involve recreation, ports and shipping, sand borrowing and coastal restoration, and renewable energy development. The space-use conflicts considered here occur in coastal or nearshore waters, not on the OCS. Potential effects to land use and coastal infrastructure from offshore space use associated with non-OCS oil- and gas-related activities could range from positive to negative.

Recreation is a standard type of land use, by definition. However, recreational activities that occur onshore or are based nearshore invariably may have space-use conflicts with other land uses such as ports, shipping, housing, industry, and transportation. For example, new land developments can negatively affect tourism and recreational resources by reducing land available for these activities and diminishing pristine recreational experiences through new infrastructure presence. Conversely, OCS sand borrowing provides the resources needed for beach nourishment projects. These, along with coastal restoration projects, positively affect land use and coastal infrastructure by mitigating the devastating effects of coastal land loss. In addition, coastal restoration may have a positive effect on recreation and tourism, boosting the economy in the area of the restoration. More information about recreational uses and potential space-use conflicts are detailed in **Chapter 4.4.5** (Tourism and Recreational Resources).

Ports and shipping are important components of industrial activities that positively affect land use and coastal infrastructure by contributing to and supporting the local and regional economies. Ports serve as the vector for all manner of intermodal transportation that involve not only shipping via waterways but also transport by railway and highway of all manner of goods and services. Critically important, ports provide the path for the various supply chains that support non-OCS oil- and gas-related activities, in addition to OCS oil- and gas-related activities. Activity at ports and associated transportation can positively affect the economy. In the very early planning stages, renewable energy development in the GOM could potentially affect land use and coastal infrastructure by generating demand for port usage, fabrication yard business, and property leasing for support services and businesses that would need to develop in the GOM along with this young industry. These could all lead to positive effects to the local economy. Conversely, when modifications of port facilities are required (e.g., dredging to allow for deeper draft vessels or development of additional acreage for support facilities), these can negatively affect surrounding land use by reducing available habitat for species harvested by subsistence hunters and fishers. **Chapter 4.4.4** (Subsistence Fishing) discusses subsistence fishing in the GOM region.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Socioeconomic changes and drivers that may affect land use and coastal infrastructure are numerous. Although not an exhaustive list, the possible IPFs related to non-OCS oil- and gas-related activities that are typically considered by BOEM include oil and gas activity in State waters, onshore oil and gas activities (includes private, State, and Federal lands), transportation systems and ports, construction and maintenance of industrial facilities, agricultural uses, urbanization, demographic shifts (in-migration, out migration), evolution of State and Federal regulations, planning and zoning, development of residential areas and recreational facilities, modifications to public facilities (such as water, sewer, educational, and health facilities), military activities, fluctuations in global commodity markets, global, national and regional economic trends, and more recently, global pandemics.

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. For all coastal infrastructure types, especially processing facilities, it has proven difficult to parse out what percentage of demand is generated by non-OCS oil- and gas-related activities as opposed to OCS oil- and gas-related activities. Although this makes a quantitative analysis of non-OCS oil- and gas-related activities versus OCS oil- and gas-related activities difficult, general effects of the non-OCS oil- and gas-related activities on coastal land use and infrastructure are discussed herein.

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 positive and negative effects to land use and coastal infrastructure, in varying degrees, depending on the magnitude of each project. For example, adding a spur to a highway to improve a transportation system may positively affect transport of a product but negatively affect land use in the area if a recreational area is lost. Similarly, construction or expansion and maintenance of non-OCS-related industrial facilities, such as paper mills and aluminum plants, could affect land use and coastal infrastructure depending on proximity and scale of the work being done. Positive effects could occur for the industry obtaining improvements, but negative effects could occur to nearby natural landscapes, agricultural areas, or air and water quality.

Changes in the oil and gas industry and trends in demand can affect the land use and economy in an area. Over the past several years, there has been a substantial decrease in offshore natural gas production, 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 to export natural gas to foreign consumers. Expansions at existing LNG facilities or the construction of new LNG facilities to export onshore shale production could negatively affect land use by reducing available land for conservation efforts or recreational activities, but it could positively affect the LNG company benefitting from the project by increasing profits and also could benefit associated industries that gain efficiencies by utilizing the new facility.

Agricultural uses may negatively affect land use and coastal infrastructure. Agriculture places many demands on the environment and produces effects that include, but are not limited to, habitat fragmentation, pesticide and nutrient runoff, competition with urban 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, helping to mitigate some of the negative effects (Lubowski et al. 2006). In addition to laws to aid in the mitigation of environmental effects, Federal and State agencies offer funding to qualifying landowners and operators to complete activities through conservation programs. Some conservation activities, similar to conventional farming activities, may affect natural resources due to soil disturbance and hydrology modification/restoration. These activities may produce negative effects during implementation phases; however, they are designed to produce positive or neutral effects during the lifespan of the practice, if maintained according to the specifications.

The land use and coastal infrastructure in the Gulf of Mexico EIAs with the highest numbers of people can be affected by urbanization. Demographic shifts as people move in and out of areas contribute to effects on land use and coastal infrastructure. 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 negative effects 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, resulting in a positive impact to surrounding air and water quality. Trends in urban land use can be largely determined by economics, demographic shifts, local ordinances, and zoning (USEPA 2013b).

Land-use patterns vary greatly by region, reflecting differences in soils, climate, topography, and patterns of population settlement. Within the geo-political realm, 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 can affect land-use patterns and coastal infrastructure. Land-use changes would largely depend upon local zoning and economic trends. For example, the region surrounding Mobile Bay differs dramatically on the east and west sides of the bay. Extensive industrial and commercial zoning and activities predominate on the western side of the bay (e.g., Port of Mobile, natural gas processing, oil and gas support services such as umbilical fabrication), while the eastern side of the bay is characterized by minimal industrial zoning and many more recreational and tourist activities (e.g., Gulf Shores and

Ft. Morgan beaches, Fairhope, Alabama; and other small town antique shops; and Foley shopping outlets). Fluctuations and expansions of these kinds of activities are guided and affected by economic trends, local ordinances, and zoning, which affect land use on a range of positive to negative, depending on nature of the specific projects and the viewpoints of the parties involved or affected.

Regular changes in economic trends on the regional, national, and global levels can have a major positive and negative effect on land use and coastal infrastructure. 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, a drop in the price of oil can keep the price of gasoline down, which is good for people and businesses that drive cars and trucks to travel. However, the downturn can also lead to many layoffs in the oil and gas industry. This scenario was seen with the drop in the price of oil from the end of 2014 through 2015 (Larino 2015; Stickney 2015; Strauss 2015).

In 2020, negative effects to land use and coastal infrastructure have occurred from the COVID-19 pandemic. These impacts are ongoing, widespread, and not completely understood because they are still unfolding. From the initial stay-at-home orders and business closures to the early re-openings that led to a surge in new cases and renewed public health restrictions to prevent the spread of the virus, the pandemic continues to disrupt daily living. As a consequence, the Nation is experiencing a severe economic downturn (BEA 2020) with historic unemployment (BLS 2020) and serious impacts to the fiscal health of local and State governments, public services, housing, and energy markets (Garnham 2020; McNichol and Leachman 2020; Pagano and McFarland 2020; Tsai and York 2020). There are two main drivers of the dramatic and negative reversal in the energy markets: the COVID-19 pandemic, which caused a steep drop in energy demand; and the flooding of the fuel energy market by feuding OPEC nations. These events are producing long-term structural changes in the oil and gas industry (Dismukes 2020a). The effects of these disruptive events will continue to ripple throughout the economy and will likely affect land use and coastal infrastructure in multiple ways. For example, unemployed persons may not be able to pay their rent, which means decreased revenues for landlords who need to pay their mortgages and make repairs to properties, leading to a greater likelihood of evictions for renters, foreclosures for the landlords, and the increased likelihood of blight from lack of property maintenance. Homeowners face the same issues, and these negative effects flow to lending institutions, local businesses, and local and State governments. Plans for land development or infrastructure expansion will necessarily shift or disappear. Property values in some areas may decline and public services will likely decrease. Experts are predicting long-term negative effects for the energy sector in Louisiana (Mosbrucker 2020), which likely holds true for other states with a large energy sector. At this point, we do not have a complete picture of all the effects related to the pandemic and commodity price volatility, but BOEM will monitor the situation as it continues to unfold.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined air emissions, bottom disturbances, and noise are not likely to affect land use and coastal infrastructure. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air emissions as discussed in **Chapter 2.1.2** are not likely to cause effects to land use or coastal infrastructure because decisions regarding the intended use and development of private and public properties are not dependent on a determination regarding levels or types of air emissions. For USEPA-designated non-attainment areas, emissions from the development of the property may be limited in the amount of emissions permitted, but land use itself would not be limited. Bottom disturbance as discussed in **Chapter 2.3.2** refers to impacts that occur at the bottom of the ocean on the OCS, which is far removed from land use and coastal infrastructure and thus not analyzed in detail here because activity on the seafloor would not affect land use and coastal infrastructure. Noise as discussed in **Chapter 2.4.2** refers to noise in and above the ocean and would not affect land use and coastal infrastructure because this resource is located onshore and thus not affected by noise in and above the ocean.

4.4.1.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.1-11 highlights the IPF categories associated with routine OCS oil- and gas-related that could potentially affect land use and coastal infrastructure in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Discharges and Wastes (Chapter 2.2.1)

Discharges and wastes from routine OCS oil- and gas-related activities that could have potential effects to land use and coastal infrastructure include onshore disposal of wastes generated by offshore OCS activities, onshore disposal and storage facilities, and discharges from onshore support facilities. Potential effects to land use and coastal infrastructure from discharges and wastes associated with OCS oil- and gas-related activities could range from positive to negative. The potential effects that could occur to land use and coastal infrastructure from large increases in discharges and wastes are described below. However, based on current projections, the existing infrastructure is sufficient to handle current and projected discharges and wastes from OCS oil- and gas-related activities.

Onshore disposal of wastes generated from OCS oil and gas facilities contribute to the potential for expansion of capacity at onshore waste facilities. The volume of OCS waste generated is closely correlated with the level of offshore drilling and production activity (Dismukes et al. 2007). If an expansion were to occur, such expansions would temporarily provide an economic boost to the community through jobs and demand for construction materials and support services. These positive effects would be limited in nature and offset by the increased potential for unwanted discharges. However, land use may be negatively affected if a new waste disposal facility needs to be constructed because of an excessive quantity of waste coming to shore. In addition, the potential exists for land use and coastal infrastructure to be negatively affected by unauthorized discharges from onshore support facilities in violation of the Clean Water Act, which could contribute to pollution issues and potential groundwater contamination.

However, existing solid-waste disposal infrastructure is currently 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. Therefore, new or expanded onshore waste facility construction is not anticipated based on current projections for industry needs.

Coastal Land Use/Modification (Chapter 2.5.1)

Routine OCS oil- and gas-related activities drive demand for onshore support infrastructure and contribute to any land-use changes that may occur as a result of these activities. The potential effects that could occur to land use and coastal infrastructure from coastal land use/modification are described below. However, based on current projections, the existing infrastructure is sufficient to handle current and projected activities from OCS oil- and gas-related activities.

Potential effects related to routine OCS oil- and gas-related activities include those activities surrounding current operations at OCS oil- and gas-related infrastructure including construction facilities, support facilities, and transportation and processing facilities that could result from OCS oil and gas industry-generated service demand increases. Land use may be affected by any expansions at existing facilities or construction of new facilities onshore that support offshore OCS oil- and gas-related activities. Due to the environmental regulations inherent in permitting (permits and approvals are handled by regulatory authorities other than BOEM) 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) should there be an increase in demand for services. Expansions of existing facilities can generate a positive momentum with increased capabilities leading to increased profitability. Conversely, expansions could negatively affect land use by building on agricultural or recreational areas. For example, an increase in coastal infrastructure can negatively affect tourism and recreational resources by reducing land available for these activities. More information about recreational uses and potential space-use conflicts are detailed in **Chapter 4.4.5** (Tourism and Recreational Resources).

However, the coastal infrastructure that supports offshore OCS oil- and gas-related activities is well established and expansive in the GOM region, and is not prone to rapid fluctuations. Therefore, new or expanded infrastructure is not anticipated based on the existing infrastructure and current projections for industry needs.

Ports associated with OCS oil- and gas-related activities are important components of industrial activities that can positively affect land use and coastal infrastructure by contributing to and supporting the local and regional economies. Ports serve as the vector for all manner of intermodal transportation that involve not only OCS oil- and gas-related transport via waterways but also the transport of industry-related materials by railway and highway. Critically important, ports provide the path for the various supply chains that support OCS oil- and gas-related activities. Activity at ports and associated transportation can positively affect the economy. Conversely, when modifications of port facilities are required (e.g., dredging to allow for deeper draft vessels or development of additional acreage for support facilities), these can negatively affect surrounding land use by reducing available habitat for species harvested by subsistence hunters and fishers. **Chapter 4.4.4** (Subsistence Fishing) discusses subsistence fishing in the GOM region.

Lighting and Visual Impacts (Chapter 2.6.1)

Visual impacts can affect land use in coastal areas by detracting from or enhancing the intended use and enjoyment of private and public properties along the coast. Offshore OCS oil- and gas-related lighting may negatively affect land use by diminishing the visual aesthetics for some recreational sites by detracting from some nature experiences. However, because aesthetics can be subjective, platform lighting can also have positive effects on land use by improving visibility of the platforms and adding contrast to the landscape. Detailed discussion of potential visual impacts is provided **Chapter 4.4.5** (Tourism and Recreational Resources).

Socioeconomic Changes and Drivers (Chapter 2.8.2)

Socioeconomic changes and drivers that may negatively or positively affect land use and coastal infrastructure are connected indirectly to routine operations as demonstrated by changes in the levels of OCS oil- and gas-related activities (i.e., G&G seismic, leasing, exploration, development, production, and decommissioning). These socioeconomic drivers of OCS oil- and gas-related activity levels include fluctuations in oil and natural gas prices; economic shifts on the local, State, national and global levels; fluctuations in the gross domestic product; rising or decreasing corporate profits; supply chain effects; government revenue (local, State, and Federal); changes in government regulations and policies at all levels; labor demands; skilled workforce shortages; and variations in global market supply and demand. These indirect drivers affect all of the socioeconomic resources analyzed in BOEM’s environmental impact analyses.

Although coastal infrastructure is well established and not prone to rapid fluctuations, fluctuations in OCS exploration, development, and production activity levels can affect 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 could affect infrastructure facilities by potentially increasing profits and the need to hire additional employees. This would be a positive effect 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 effect could occur. Decreases in demand for services could cause a negative ripple impact through the local (and possibly regional) economies. The OCS oil- and gas-related activity levels related to shipyards, shipbuilding, and transportation services can fluctuate based on changes in demand, commodity prices, and offshore service vessel day rates. When activity levels increase, commuter and truck traffic increase, producing additional wear and tear on the transportation infrastructure.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that air emissions, bottom disturbance, noise, and offshore habitat modification/space use are not likely to affect land use and coastal infrastructure. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air emissions as discussed in **Chapter 2.1.1** are not likely to cause effects to land use or coastal infrastructure because air emissions from OCS oil- and gas-related activities occur offshore in OCS waters, far from land. Bottom disturbance as discussed in **Chapter 2.3.1** refers to impacts that occur at the bottom of the ocean on the OCS, which is far removed from land use and coastal infrastructure and thus not analyzed in detail here because activity on the seafloor would not affect land use and coastal infrastructure. Noise as discussed in **Chapter 2.4.1** refers to noise in and above the ocean and would not affect land use and coastal infrastructure because this resource is located onshore and thus not affected by noise in and above the ocean. As discussed in **Chapter 2.7.1**, offshore habitat modification/space-use conflicts related to routine OCS oil- and gas-related activities include those activities in Federal OCS waters associated with the sea surface, airspace, water column, and seafloor. These activities are located many miles offshore, far removed from onshore land use and coastal infrastructure. The OCS oil- and gas-related activities differ from non-OCS oil- and gas-related activities (such as State oil and gas activities) in that the non-OCS oil- and gas-related activities can occur onshore and nearshore and can affect coastal land use and infrastructure. However, OCS oil- and gas-related activities occur too far from shore to affect the coastal land use and infrastructure.

4.4.1.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.1-11 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect land use and coastal infrastructure in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Potential effects associated with releases into the environment that may affect land use and coastal infrastructure include oil spills and chemical spills related to routine OCS oil- and gas-related activities. Typically, oil and chemical spills occur at differing levels of severity, based in part on the geographic location, volume spilled, and type of oil or chemical. Oil spilled in the offshore areas normally volatilizes and is dispersed by currents, so it has a low probability of contacting and affecting coastal areas. Oil and chemical spills in coastal and inland waters, such as those resulting from the operations of offshore supply vessels, pipelines, barges, tanker ships, and ports, are more likely to negatively affect land use and coastal infrastructure. For example, if waterways are closed to traffic following a spill, this may result in effects to upstream and downstream business interests as it impedes the flow of commerce. Other potential effects from oil or chemical spills 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 intensity of any effects related to a spill 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 effects of a spill as harshly as those who are most dependent on the affected waterway for transport.

Response Activities (Chapter 2.9.2)

Potential effects related to spill response may be negative or positive for land use and coastal infrastructure. The influx of spill-response workers could contribute to filling short-term rental vacancies at hotels, apartments, and other properties that could provide housing, which could be a positive effect on land use and, by extension, the local economies.

Conversely, spill-response activities may also affect land use and coastal infrastructure because of the requisite needs for staging operations, equipment handling, and waste disposal. Depending on where a spill occurs, it is expected that the oil-spill response equipment needed to respond to an offshore spill 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. The potential effect of spill-response activities on land use and coastal infrastructure would depend on the spill's location, duration, and whether the event is a small-scale spill or a larger spill.

Spill response generates large quantities of waste and this can strain existing waste disposal capacity and increase the risk of solid and liquid waste being disposed of improperly, thereby generating negative effects for land use and coastal infrastructure. For example, potential effects 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 the spill response may result in localized increased wear and tear. The severity of spill-response effects on land use and coastal infrastructure would depend on the spill's location, duration, and whether the event is a small-scale spill (<1,000 bbl) or a larger spill (≥1,000 bbl).

Strikes and Collisions (Chapter 2.9.3)

Vessel collisions may be associated with OCS oil- and gas-related activities. The majority of offshore vessel collisions involve service vessels colliding with platforms or pipeline risers, although sometimes vessels collide with each other. The collisions could result in the spilling of chemicals or oil, but offshore spills resulting from collisions do not typically affect coastal areas (refer to the "Unintended Releases into the Environment" section in **Chapter 2.9.1**). Vessel collisions in coastal waters may involve other vessels or stationary structures like bridges and docks. The spill itself may affect land use (refer to the "Unintended Releases into the Environment" section in **Chapter 2.9.1**). Land use may be also be negatively affected if a bridge, pier, or other structure is involved because it could disrupt the transportation of goods, services, and people to and from work and schools. The severity of the effects on coastal land use would be dependent on the location of the vessel collision, the size of the vessels involved, and whether the collision involves a bridge, pier, or other structure. Potential effects associated with strikes are not applicable to land use and coastal infrastructure.

4.4.2 Commercial Fisheries

4.4.2.1 Resource Description

The Gulf of Mexico is home to a large and complex commercial fishing industry. 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.). The biological aspects of the affected environment for the targeted species are discussed in detail in **Chapter 4.3.1** (Coastal Communities and Habitats) and **Chapter 4.3.4** (Fish and Invertebrates), and in BOEM's Biological Environmental Background Report (BOEM 2021b).

Fisheries landed offshore Louisiana typically account for the most fisheries revenue, followed by Texas, West Florida, Alabama, and Mississippi. Shrimp species (particularly white shrimp and brown shrimp) account for the most landings revenues in the Gulf of Mexico. Menhaden is primarily caught in State and Federal waters offshore Louisiana and Mississippi. Oysters 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.

There were $912 million in finfish and shellfish landings in the Gulf of Mexico in 2016, which comprised 17.1 percent of total U.S. landings revenues (NMFS 2018c). Panel A of **Table 4.4.2-1** 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 2013 through 2016. There were $92 million in landings revenues in 2016, compared with $941 million in 2013, $1.17 billion in 2014, and $887 million in 2015. Fisheries landed offshore of Louisiana accounted for the most fisheries revenue in 2016, 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 ($412,947,000 in 2016) 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 (1.36 billion pounds in 2016) landed in the Gulf of Mexico (NMFS 2018c). Menhaden landings accounted for the second most landings revenue ($143,339) in 2016. Menhaden is primarily caught in State and Federal waters offshore of Louisiana and Mississippi. Oysters ($90,399,000) and blue crab ($64,632,000) accounted for the third and fourth highest landings revenues in 2016 (NMFS 2018c). 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 4.4.2-1. Landings Revenues: Landings Revenue by Species and State.

Panel	Species	2013	2014	2015	2016
Panel A: Gulfwide	Shrimp	513,055	587,267	371,845	412,947
Panel A: Gulfwide	Menhaden	90,643	80,402	138,511	143,339
Panel A: Gulfwide	Oysters	76,450	93,007	99,324	90,399
Panel A: Gulfwide	Blue crab	61,804	79,458	74,525	64,632
Panel A: Gulfwide	Spiny lobster	46,744	53,415	44,055	39,367
Panel A: Gulfwide	Groupers	24,628	30,435	27,671	28,694
Panel A: Gulfwide	Red snapper	20,621	23,158	27,437	26,450
Panel A: Gulfwide	Crawfish	16,490	16,088	6,851	11,877
Panel A: Gulfwide	Mullets	13,222	11,626	7,568	7,825
Panel A: Gulfwide	Tunas	7,308	6,334	4,502	5,790
Panel A: Gulfwide	Total Revenue	941,557	1,059,780	886,519	912,050
Panel B: Louisiana	Shrimp	182,210	238,665	113,700	137,735
Panel B: Louisiana	Menhaden	80,262	72,844	85,322	132,105
Panel B: Louisiana	Oysters	44,872	67,482	85,090	68,540
Panel B: Louisiana	Blue crab	51,568	66,706	58,069	49,408
Panel B: Louisiana	Crawfish	16,490	16,088	6,851	11,877
Panel B: Louisiana	Red snapper	4,824	6,427	6,610	5,948
Panel B: Louisiana	Tunas	4,595	4,276	2,743	4,414
Panel B: Louisiana	King mackerel	1,517	2,414	2,006	2,152
Panel B: Louisiana	Vermillion snapper	474	700	633	925
Panel B: Louisiana	Mullets	626	893	418	720
Panel B: Louisiana	Total Revenue	399,064	487,718	373,393	426,116
Panel C: Texas	Shrimp	229,289	226,535	147,957	155,829
Panel C: Texas	Oysters	23,465	19,221	8,254	15,915
Panel C: Texas	Red snapper	7,324	7,617	9,387	10,480
Panel C: Texas	Blue crab	2,331	3,050	5,534	6,414
Panel C: Texas	Black drum	1,699	1,981	2,074	2,266
Panel C: Texas	Groupers	1,168	1,156	1,483	1,601
Panel C: Texas	Vermillion snapper	659	604	920	572
Panel C: Texas	Flounders	73	97	187	236
Panel C: Texas	Atlantic croaker	819	681	NA	NA
Panel C: Texas	Tunas	7	14	3	NA
Panel C: Texas	Total Revenue	68,519	262,589	177,973	195,668
Panel D: West Florida	Shrimp	29,164	42,690	53,175	46,958
Panel D: West Florida	Lobsters	46,749	53,418	44,056	39,371
Panel D: West Florida	Stone crab	24,710	27,911	35,758	28,106
Panel D: West Florida	Red grouper	16,219	21,217	18,931	17,836

Panel	Species	2013	2014	2015	2016
Panel D: West Florida	Red snapper	8,073	8,111	9,997	8,599
Panel D: West Florida	Mullets	11,081	9,387	6,148	6,336
Panel D: West Florida	Blue crab	6,454	7,385	8,487	6,127
Panel D: West Florida	Gag grouper	2,799	2,889	2,782	4,659
Panel D: West Florida	Oyster	5,783	4,178	4,722	4,266
Panel D: West Florida	Quahog clam	921	NA	NA	NA
Panel D: West Florida	Total Revenue	182,172	212,961	215,678	196,706
Panel E: Mississippi	Shrimp	22,072	15,229	12,613	15,156
Panel E: Mississippi	Menhaden	10,230	7,358	52,962	10,973
Panel E: Mississippi	Oysters	1,544	1,685	969	1,088
Panel E: Mississippi	Blue crab	416	997	1,209	895
Panel E: Mississippi	Mullets	61	25	12	22
Panel E: Mississippi	Red snapper	NA	307	NA	NA
Panel E: Mississippi	Total Revenue	34,970	26,014	68,535	28,969
Panel F: Alabama	Shrimp	50,321	64,149	44,399	57,271
Panel F: Alabama	Blue crab	1,036	1,319	1,225	1,788
Panel F: Alabama	Red snapper	401	697	1,443	1,423
Panel F: Alabama	Spanish mackerel	940	472	705	833
Panel F: Alabama	Oysters	786	441	290	590
Panel F: Alabama	Mullets	1,178	1,046	761	514
Panel F: Alabama	Total Revenue	56,832	70,497	50,940	64,592

Various ports along the Gulf Coast serve as the starting point for the fisheries supply chain. Most fisheries landings are brought to shore at the following locations: Brownsville-Port Isabel, Galveston, and Port Arthur, Texas; Intracoastal City, Dulac-Chauvin, and Empire-Venice, Louisiana; and Bayou La Batre, Alabama. Fisheries revenues received in 2016 at these ports are listed in descending order: Empire-Venice, Louisiana ($122 million); Brownsville-Port Isabel, Texas ($53 million); Dulac-Chauvin, Louisiana ($48 million); Bayou La Batre, Alabama ($45 million); Galveston, Texas ($45 million); Port Arthur, Texas ($33 million); and Intracoastal City, Louisiana ($26 million) (NMFS 2020d).

After arriving at port, fish landings then proceed through supply chains that include dealers, processors, distributors, markets, and restaurants. Supply chain effects of fisheries landings are estimated by NMFS using economic modeling techniques. These effects include estimates of the number of jobs and the amount of value-added supported by fisheries landings in each Gulf Coast State (NMFS 2018c). The large effects on jobs and revenue seen in Florida are due to its high numbers of seafood importers, wholesalers, distributors, and retailers.

(1) Florida (76,749 jobs; $5,658,897,000)

(2) Louisiana (36,102 jobs; $1,023,361,000)

(3) Texas (21,507 jobs; $898,617,000)

(4) Alabama (12,058 jobs; $287,906,000)

(5) Mississippi (4,586 jobs; $112,697,000)

Fisheries are managed by NOAA Fisheries (NMFS), as advised by the regional fisheries management councils, such as the Gulf of Mexico Fishery Management Council. Commercial fisheries are regulated by various mechanisms, including permitting, closures, quotas, and gear restrictions. 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). Commercial fishing regulations are very detailed and change on a regular basis depending on a variety of factors including stock assessment and catch statistics. Changes can occur on short notice, especially time closures based on allowable catches. The NOAA Fisheries reports each year to Congress and the Fishery Management Councils on the status of all fish stocks in the Nation. The Gulf of Mexico Fishery Management Council provides the current information on commercial fishing rules for U.S. Federal waters of the Gulf of Mexico (Gulf of Mexico Fishery Management Council 2020).

4.4.2.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and commercial fisheries. **Figure 4.4.2-1** provides a synopsis of the IPF categories that currently affect or have the potential to affect commercial fisheries in the Gulf of Mexico OCS. Following **Figure 4.4.2-1** is a summary of those potential effects on commercial fisheries as well as a brief discussion of the IPF categories identified in **Figure 4.4.2-1** that are not likely to affect commercial fisheries, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to commercial fisheries, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

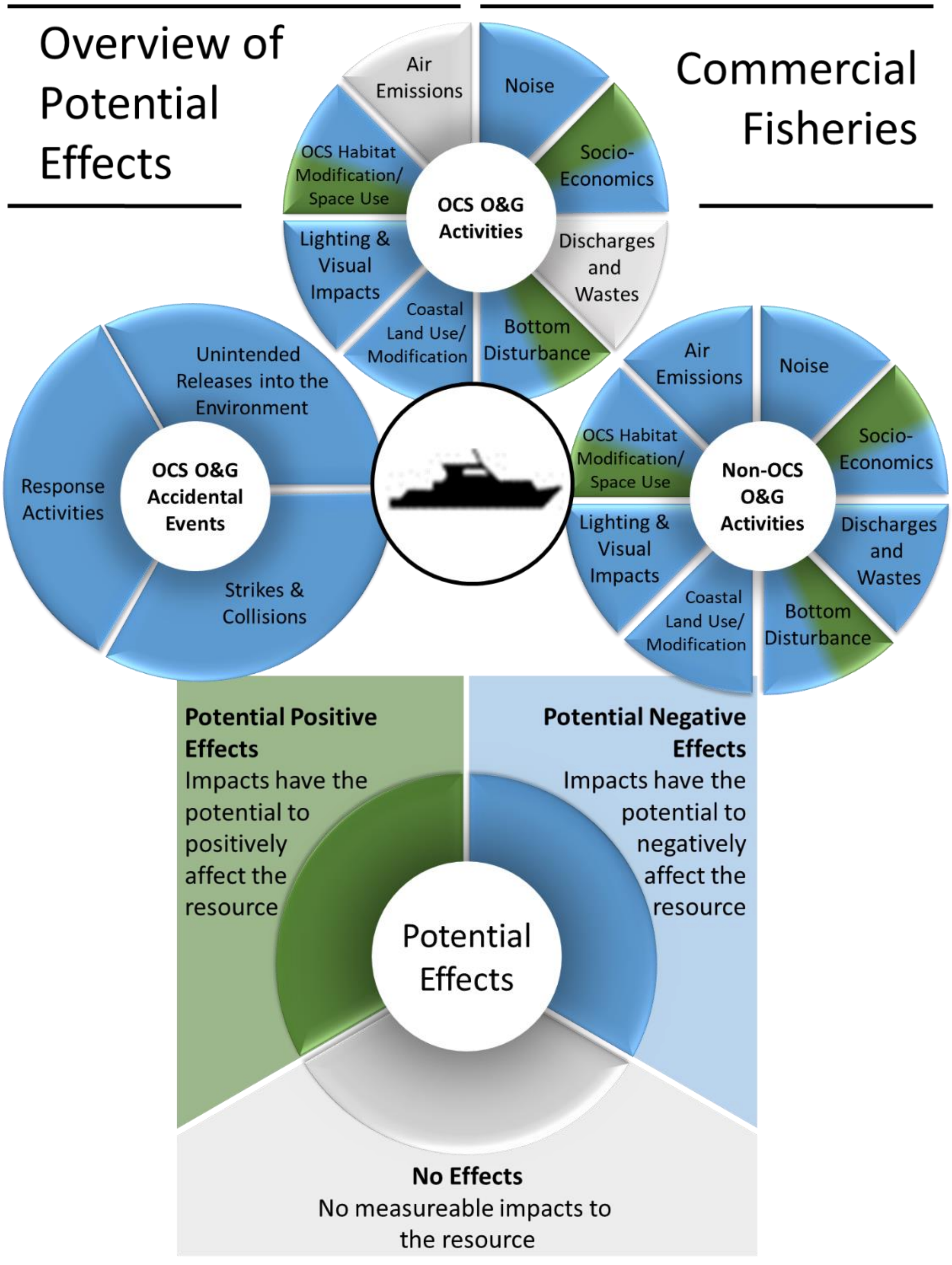


*Figure 4.4.2-1. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Commercial Fisheries. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G=oil and gas)*

4.4.2.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.2-1 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect commercial fisheries in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Commercial fisheries are dependent on the health of fish and invertebrate populations. Although air emissions from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Air emissions resulting from non-OCS oil- and gas-related activities may have negative effects on coastal habitats upon which many of these species depend. Air pollutants result from manmade and natural sources (e.g., vehicle emissions and wildfires) and contribute to increased CO_2, leading to ocean acidification, which can negatively affect fish and invertebrate resources' health and their habitat. To the extent that air emissions can negatively affect coastal habitats and fish and invertebrates, commercial fisheries can also experience negative effects in terms of reduced catches and landing revenues. Detailed descriptions of the potential effects of non-OCS air emissions to fish and invertebrate populations upon which commercial fisheries depend, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Discharges and Wastes (Chapter 2.2.2)

Discharges and wastes associated with non-OCS oil- and gas-related activities can indirectly affect commercial fisheries by negatively affecting fish and invertebrate populations. Detailed descriptions of the potential effects of discharges and wastes to fish and invertebrate populations, upon which commercial fisheries depend, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b). Decreases in water quality caused by the influx of freshwater from rivers carrying excess nutrients and chemicals related to agricultural and industrial uses inland and discharges of chemical waste products from non-point sources and accidental discharges, can negatively affect the health and survival of non-mobile species (e.g., oysters). Because the success of commercial fisheries depends on the health of the target species, if these species are negatively affected by discharges and wastes, then commercial landings, revenues, and associated fisheries reliant economies can also be negatively affected. For example, in September 2019, a Federal disaster declaration was issued for Louisiana, Mississippi, and Alabama when oyster and coastal shrimp fisheries were severely impacted by freshwater flooding into the Mississippi Sound as a result of freshwater flow from the Bonnet Carrè Spillway, which was opened multiple times from 2016 to 2020 to relieve pressure on Mississippi River levees (Byrd 2019; DOC 2019). The economic impacts to commercial fisheries for the 2016-2020 time period are not yet clear; however, Posadas and Posadas Jr. (2017) studied the impact of the 2011 Bonnet Carrè Spillway opening and estimated that the Mississippi oyster fishery suffered foregone landing values ranging from $21.8 to $46.0 million, lost 145-324 jobs per year from 2011 to 2013, and lost labor income estimated at $1.8-$8 million per year.

Accidental oil spills in State waters from State oil and gas activities 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 affected by an oil spill associated with State oil and gas activities. Should a target population be negatively affected by non-OCS oil- and gas-related oil spills, the landings, revenues, and associated commercial fishery could also be negatively affected.

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbances related to non-OCS oil- and gas-related activities such as indiscriminate commercial fishing practices, offshore dredging and sand mining, placement of artificial reefs, and State oil and gas production can negatively or positively affect fish and invertebrates, thereby causing indirect effects to commercial fisheries landings. Indiscriminate commercial fishing practices (e.g., trawling and pots) can injure or kill many fish species caught as bycatch, such as juveniles of commercially important species, reducing fish populations and negatively affecting potential landings and revenues because the juvenile fish unintentionally caught would not be available for future harvesting. Sediment dredging and disposal, sand mining, anchoring, and offshore marine transportation disturb sediments and increase turbidity. Turbidity can cause smothering of benthic prey as well as eggs, larvae, and juvenile fishes that would either be food for commercially targeted species or mature and become targeted by commercial fishers. Therefore, turbidity can negatively affect commercial fisheries by decreasing the availability of commercially important fish and invertebrates. The biological consequences of these changes are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats) and **Chapter 4.3.4** (Fish and Invertebrates), and in BOEM's Biological Environmental Background Report (BOEM 2021b).

Conversely, the installation of production structures related to State oil and gas activities, as well as artificial reef placement, could enhance reef fish habitat and thus improve some commercial fishing opportunities by congregating some fish and invertebrates near the structures. The ultimate decommissioning of production structures could negatively affect fish populations in the area by generating turbidity, removing habitats, and if explosives are used, causing fish mortality. However, those negative effects would be localized and not expected to have any long-term effects because turbidity subsides, surviving fish move to other habitats, and fish populations are expected to recover from localized fish mortality. To the extent that fish and invertebrates are positively or negatively affected by bottom disturbances, commercial fisheries can indirectly experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies. Detailed descriptions of the potential effects of bottom disturbances to fish and invertebrates, upon which commercial fisheries depend, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats),

Chapter 4.3.4 (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.2)

Although sound from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by non-OCS oil- and gas-related activities may negatively affect commercial fisheries. To the extent that anthropogenic sound caused by non-OCS oil- and gas-related activities can negatively affect fish and invertebrates, it can indirectly affect commercial fisheries. Anthropogenic sound can cause displacement, physical harm, or fatalities to fish and invertebrates, which can lead to decreased fishing landings and revenues, which can negatively affect jobs and incomes throughout the commercial fisheries supply chain. Examples of non-OCS oil- and gas-related activities that can produce underwater noise include recreational boating activities, commercial fishing vessels, cruise ships, cargo vessels, military activities, dredging operations, and in-water construction. Detailed descriptions of the potential effects of non-OCS-related anthropogenic sound to fish and invertebrates, upon which commercial fisheries depend, are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

Although coastal land use from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Coastal land disturbances caused by non-OCS oil- and gas-related activities (e.g., coastal developments such as industrial and residential construction near harbors, waterways, and beachfronts) can negatively affect fish and invertebrate species important to commercial fisheries by modifying or degrading coastal vegetation and submerged aquatic vegetation habitats such as salt marsh grasses crucial to various life stages of commercially important fish species. Non-OCS oil- and gas-related coastal land disturbing activities may negatively impact commercial fisheries to the extent that landing numbers and revenues could be affected. Detailed descriptions of the potential effects of non-OCS oil- and gas-related coastal land disturbances to fish and invertebrates upon which commercial fisheries depend are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Lighting and Visual Impacts (Chapter 2.6.2)

Non-OCS oil- and gas-related activities can produce artificial lighting from public and private docks and piers and industry-related infrastructure that can interfere with natural predator-prey interactions causing negative effects to fish and invertebrates. Although lighting from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Any negative effects experienced by fish and invertebrates may also result in negative effects to commercial fisheries by potentially decreased landings. Detailed descriptions of the potential effects of non-OCS-related artificial lighting to fish and invertebrate populations upon which commercial fisheries depend are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Although space-use conflicts from non-OCS oil- and gas-related activities are not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), localized effects to fish may occur. Commercial fishermen may encounter space-use conflicts with non-OCS oil- and gas-related activities in State waters and recreational, commercial, and military vessels that temporarily restrict access to fishing areas. Vessel space-use conflicts may particularly occur near major ports and in shipping lanes as vessels transit to and from shore. There is a large amount of vessel traffic in the Gulf of Mexico, particularly near major ports. VesselFinder Limited (2020) and Marine Vessel Traffic (2020) provide maps of current and historical vessel traffic in the Gulf of Mexico. In many instances throughout the GOM, competition between commercial and recreational fishermen targeting the same species led to depleted fish stocks and habitat alterations, reducing overall landings. Wetlands loss and other ecosystem degradation can also negatively affect commercial fishing by reducing nursery habitat for fish and invertebrates (refer to **Chapter 4.3.1** [Coastal Communities and Habitats], **Chapter 4.3.4** [Fish and Invertebrates], and the Biological Environmental Background Report (BOEM 2021b), negatively affecting fish populations and landings. Sand borrowing activities for beach renourishment projects may temporarily conflict with commercial fishing activities, but sand borrowing projects do not have a large footprint and are not a permanent disruption for commercial fishers, who will avoid those areas. Renewable energy projects have not yet been developed on the Gulf of Mexico OCS, but if they are, some conflicts with fishing activities could occur, depending on project location and any mitigations that may be developed to address space-use conflicts. Any military areas or ocean dumping sites that are permanently off limits could cause a permanent space-use conflict for commercial fishing in that fishing cannot occur in those areas. As a result, these areas have not been fished in so long that historical and current landings and revenues data do not include these areas and economic fluctuations from unfished areas would not be seen in landings and revenues data.

Offshore habitat modification caused by non-OCS oil- and gas-related oil and gas structure emplacement in State waters can cause positive effects to commercial fisheries by providing habitat for fish populations for a period of years until the structures are decommissioned, which may have negative or positive effects depending on the nature of the decommissioning. For example, if the structures are toppled in place or transported to artificial reef sites, the negative effects of structural habitat loss would be mitigated by a form of habitat replacement. Complete removal of a structure could cause short-term negative effects for fish populations, such as turbidity, habitat loss, and if explosives are used, localized fish mortality. However, turbidity subsides, surviving fish move to other habitats, and fish populations would be expected to recover from localized fish mortality. To the extent that fish populations are positively or negatively affected by offshore habitat modification, commercial fisheries can experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies. Detailed descriptions of the potential effects of offshore habitat modification to fish and invertebrate populations, upon which commercial fisheries depend, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Various economic forces associated with non-OCS oil- and gas-related activities also may positively or negatively affect commercial fisheries. Participants in the GOM seafood industry compete with participants in various other domestic and international markets. The NMFS (2018c) presents various statistics regarding these markets. For example, GOM shrimp competes with a large import market. If there is a high demand for GOM shrimp, the commercial fishery would experience a positive economic benefit; however, if imported shrimp takes the place of GOM-caught shrimp, the GOM fishery would experience a negative economic impact. Demand for GOM seafood is also positively correlated with the overall state of the economy.

Fisheries management strategies employed by NMFS, the Gulf of Mexico Fishery Management Council, and various State agencies also may affect commercial fisheries. Fisheries managers develop strategies for commercially important species such as shrimp and red snapper, such as limiting the season for fishing and the size and number of fish allowed to be caught to ensure appropriate conservation management of the species (NMFS 2015a; 2015b). For example, a fishery may be closed for a certain amount of time to ensure a healthy population of a species; however, when the fishery is closed, the fishers are unable to catch and sell that species, resulting in a negative economic effect to the commercial fishery. Conversely, the closure could result in a positive effect to the fishery once a healthy population is established.

4.4.2.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.2-1 highlights the IPF categories associated with routine OCS oil and gas development that could potentially affect commercial fisheries in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Bottom Disturbance (Chapter 2.3.1)

Although bottom disturbance from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), to the extent that bottom disturbance affects localized fish and invertebrates, it can also affect commercial fisheries and the commercial fisheries supply chain. Bottom-disturbing activities associated with routine OCS oil- and gas-related activities (e.g., pipelaying, drilling, anchoring, and structure emplacement) can cause negative effects (e.g., turbidity and sedimentation) and positive effects (e.g., habitat formation from structure emplacements) for fish and invertebrates. Turbidity can cause smothering of benthic prey as well as eggs, larvae, and juvenile fishes that will either be food for commercially targeted species or mature and become targeted by commercial fishers. Therefore, turbidity can negatively affect commercial fisheries by decreasing the availability of commercially important fish species. Conversely, OCS oil- and gas-related structures could enhance reef fish habitat and thus improve some commercial fishing opportunities by congregating some fish near the structures (Scott-Denton et al. 2011). The ultimate decommissioning of production structures could negatively affect fish and invertebrates in the area by generating turbidity, removing habitat, and if explosives are used, causing fish mortality. However, those negative effects would be localized and not expected to have any long-term effects because turbidity subsides, surviving fish move to other habitats, and fish populations would be expected to recover from localized fish mortality. To the extent that fish and invertebrates are positively or negatively affected by bottom disturbance, commercial fisheries can experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies. Detailed descriptions of the potential effects of bottom disturbances to localized fish and invertebrates, upon which commercial fisheries depend, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.1)

Although sound from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by routine OCS oil- and gas-related activities may negatively affect commercial fisheries indirectly through displacement, physical harm, or fatalities to localized fish populations. The severity of these effects would be based on the vulnerability of fish and invertebrate populations. Disturbances to those populations can have proportionate negative effects on landings and the seafood supply chain. Detailed descriptions of the potential effects of anthropogenic sound to localized fish and invertebrate populations, upon which commercial fisheries depend, are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.1)

Although coastal land use from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Commercial fisheries may be indirectly and negatively affected by routine OCS oil- and gas-related coastal land disturbance activities such as the construction of new onshore facilities, pipeline landfalls, and navigation canal dredging, which can modify habitat and affect localized fish and invertebrate resources. Fish and invertebrate species important to commercial fisheries can be negatively affected through the modification of coastal vegetation and submerged aquatic vegetation habitats, such as salt marsh grasses crucial to various life stages of commercially important fish species. Coastal land disturbance can result in a reduction of commercially important fish and invertebrates, which may negatively affect commercial fisheries through reduced landings and revenues. Coastal land disturbances for OCS oil- and gas-related activities are typically localized in nature and of short-term duration. Detailed descriptions of the potential effects of coastal land disturbance activities to localized fish and invertebrate populations, upon which commercial fisheries depend are provided in

Chapter 4.3.1 (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Lighting and Visual Impacts (Chapter 2.6.1)

Although lighting from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Artificial lighting associated with routine OCS oil- and gas-related activities (e.g., offshore standing platforms, tension-leg platforms, drillships, onshore facilities, and docked vessels) can negatively affect fish and invertebrate resources because lighting can interfere with natural predator-prey interactions. If these effects cause a decrease in species populations, then commercial fisheries also may be negatively affected by decreases in potential landings. Detailed descriptions of the potential effects of lighting to localized fish and invertebrate resources, upon which commercial fisheries depend, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Although space-use conflicts from OCS oil- and gas-related activities are not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), localized effects to fish may occur. Space-use conflicts with commercial fishing can arise from routine OCS oil- and gas-related operations such as service-vessel traffic, seismic surveys, pipeline emplacement, drilling, and production structure emplacement and removals in that commercial fishing cannot occur in the same areas where these OCS oil- and gas-related activities are occurring. 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 affect the shrimp fishery by a reduction in fishable seafloor, particularly in an area where many structures are present. Offshore habitat modification can cause potential effects to fish and invertebrates, which range from positive (e.g., structure emplacement adding new habitat) to negative (e.g., structure removal reducing habitat). For example, production platforms can facilitate fishing for reef fish such as red snapper and groupers because these commercially important species congregate around the structure. However, the eventual decommissioning of a platform could reverse the effects of structure emplacement by removing the fish-attracting structure unless the structure was reefed in place or moved to an artificial reef site. Detailed descriptions of the potential effects of offshore habitat modification to localized fish and invertebrate populations, upon which commercial fisheries depend, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Socioeconomic Changes and Drivers (Chapter 2.8.2)

Routine OCS oil- and gas-related activities are indirectly associated with socioeconomic changes and drivers that can positively or negatively affect commercial fisheries. For example, to the extent that OCS activity levels increase, the potential for new structure emplacements increases, which creates new fish habitats and opportunities for commercial fishers to increase landing revenues. Similarly, to the extent that OCS activity levels decrease, the potential for new structure emplacements decreases, reducing opportunities for commercial fishers to increase landing revenues. Variations in the level of OCS oil- and gas-related activities (G&G seismic, leasing, exploration, development, production, and decommissioning) are modulated by many variables. A few of these include financial solvency of oil and gas companies, changes in commodity prices, economic changes (regional, national and global), energy market shifts, government regulatory changes, skilled workforce availability and fluctuations in supply and demand. **Chapter 2.8** discusses these socioeconomic variables in detail.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that air emissions and pollution, and discharges and wastes are not likely to affect commercial fisheries. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

As detailed in **Chapter 2.1**, air emissions related to routine oil- and gas-related activities are highly regulated and monitored and very unlikely to affect commercial fisheries. Discharges and wastes associated with routine OCS oil- and gas-related activities are also regulated (refer to **Chapter 2.2**). Neither air emissions or discharges and wastes from OCS oil- and gas-related activities are anticipated to exceed regulated levels and therefore are not considered likely to cause population-level effects to fish and invertebrate resources (refer to **Chapter 4.3.1** [Coastal Communities and Habitats] and **Chapter 4.3.4** [Fish and Invertebrates]). Therefore, commercial fisheries, which are indirectly affected by the same IPFs as fish and invertebrate resources, are not considered likely to be affected by air emissions and pollution or discharges and wastes associated with routine oil- and gas-related activities.

4.4.2.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.2-1 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect commercial fisheries in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Unintended releases into the environment, such as chemical or oil spills, can affect commercial fisheries by affecting the fish and invertebrate populations that support commercial fishing activities, by affecting fishermen’s access to those populations or by affecting the seafood supply chain. For example, an oil spill could have lethal and sublethal effects on fish and shellfish species in the area of the spill. The corresponding effects to commercial fishing would depend on the number of target species affected by the spill, the size of the oil spill, the length of time an area was closed as a result of the spill, and the types and scales of commercial fishing activities in an impacted area. 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 nearshore 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. Detailed descriptions of the potential effects of releases into the environment, such as oil spills, discharges, and trash and debris, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Oil spills can also have impacts to the supply or demand for seafood (Carroll et al. 2016). For example, an oil spill could cause seafood safety concerns, which would reduce the demand for the affected species, negatively affecting the commercial fishing industry. An oil spill could also cause certain fishermen to stop fishing to participate in the cleanup operations or for economic reasons such as the fuel expense to reach safe fishing grounds may make fishing cost prohibitive. A large oil spill could have some longer-term impacts on commercial fisheries and may not be evident for several years. If the long-term effects on fish influence catch, there could be a negative effect on commercial fisheries.

Response Activities (Chapter 2.9.2)

Spill-response activities can cause negative but localized space-use conflicts for commercial fishermen at ports and offshore where fishermen would need to avoid certain fishing areas while spill response is ongoing. Spill-response activities may negatively affect fish and invertebrate resources, particularly oysters, because such resources are not mobile, cannot engage in avoidance behaviors, and can suffer mortality caused by dispersant use or improper anchoring. As a result, commercial fisheries can be affected by these negative effects to target species populations, causing reduced landings and revenues, thereby adversely affecting the coastal economies associated with those fisheries. Detailed descriptions of the potential effects of spill-response activities regarding fish and invertebrates, upon which commercial fisheries depend are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Strikes and Collisions (Chapter 2.9.3)

Accidental strikes typically would not affect most fish and invertebrates because their mobility allows them to avoid vessels. Only whale sharks (not commercially significant) in the GOM are known to be susceptible to vessel strikes. Commercial fisheries are more likely to be negatively affected by vessel collisions; however, these would be localized in effect and not likely to interfere with commercial fishing activities unless they occur on inland waterways and disrupt the flow of vessels, possibly interfering with commercial fishing vessels coming from and going to port. Even then, the disruption would be expected to be short term with minimal localized effects. Some vessel collisions may result in oil spills, which also may negatively affect commercial fisheries as discussed above. Detailed descriptions of the potential effects of an oil spill to fish and invertebrate resources are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

4.4.3 Recreational Fishing

4.4.3.1 Resource Description

Marine recreational fishing in the Gulf of Mexico is very popular with both residents and tourists, and it is economically important to the coastal states of Florida, Alabama, Mississippi, Louisiana, and Texas. The recreational fishing resource category includes land-based, coastal, and offshore fishing. Recreational fishing is primarily confined to smaller, closer inshore areas of the Gulf of Mexico than commercial fishing. This resource includes private land and vessel-based fishing, rental boat fishing, and charter boat fishing. Recreational fishing activities on the OCS take several forms (e.g., bottom fishing, trolling, and spearfishing).

The GOM's extensive estuarine habitats, live bottom habitats, and artificial substrates (including artificial reefs, shipwrecks, and oil and gas platforms) support several valuable recreational fisheries. Artificial and natural reefs provide habitat for fish and are frequently visited by recreational fishers. The OCS structures and platforms serve as landmarks for fishers and provide habitat for many species.

In Texas, the most common, preferred recreational fishing species in Federal waters are red snapper (*Lutjanus campechanus*) and king mackerel (*Scomberomorus cavalla*). In Louisiana, Mississippi, and Alabama the most popular recreational species are spotted seatrout (*Cynoscion nebulosus*), Atlantic croaker (*Micropogonias undulatus*), sand seatrout (*Cynoscion arenarius*), pinfish (*Lagodon rhomboides*), red drum (*Sciaenops ocellatus*), and Spanish mackerel (*Scomberomorus maculatus*). Species most commonly landed by recreational fishermen in West Florida include pinfish (*Lagodon rhomboides*), spotted seatrout, gray snapper (*Lutjanus griseus*), white grunt (*Haemulon plumieri*), Spanish mackerel, and red drum (*Sciaenops ocellatus*).

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. The NMFS, through its Marine Recreational Information Program and partnerships with various State agencies, provides recreational fishing landings and effort data for the Gulf Coast States.

Table 4.4.3-1 presents data on the number of angler trips taken from 2014 to 2019 in the CPA and EPA, which includes Louisiana, Mississippi, Alabama, and West Florida. The NMFS collects and provides public access to data on recreationally targeted species, landings, and angler effort (NMFS 2020j). The NMFS provides recreational fishing catch data for Louisiana through 2019 (NMFS 2020j); however, recreational fishing effort data for Louisiana are provided by the (Louisiana Department of

Wildlife & Fisheries 2020b). The NMFS also publishes annual reports summarizing these data and the economic impacts to the United States (NMFS 2018c).

The total number of angler trips in these four states showed declines in 2018 and 2019, decreasing from 57.5 million trips in 2017 to 54.5 and 48.7 in 2018 and 2019, respectively. In 2019, there were 35.6 million angler trips in West Florida, 2.1 million angler trips in Louisiana, 6.7 million angler trips in Alabama, and 4.2 million angler trips in Mississippi. **Table 4.4.3-1** also breaks down these trips by location and mode. The three geographic locations for each state are inland (i.e., inshore saltwater and brackish waterbodies), State ocean waters, and Federal ocean waters (beginning in 2014, Louisiana no longer reports fishing effort by geographic location). The three modes of fishing reported by West Florida, Alabama, and Mississippi are shore fishing, charter fishing, and private/rental fishing. Louisiana reports two modes of fishing, charter fishing, and private/shore fishing. The last column in **Table 4.4.3-1** presents the percentage of recreational fishing in 2019 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. Across the three states that report by geographic location (i.e., Florida, Alabama, and Mississippi), in 2019, 57 percent of recreational fishing occurred in inland waters, 34.4 percent occurred in State ocean waters, and 8.6 percent occurred in Federal ocean waters. In 2019, for the three states of Florida, Alabama, and Mississippi, 39.6 percent of recreational fishing occurred on private or rental boats, 58 percent occurred from shore, and 2.5 percent occurred on charter boats (NMFS 2020j).

Table 4.4.3-1. Central Planning Area and Eastern Planning Area Effort Data: Angler Trips in the Gulf of Mexico.

Area	2014	2015	2016	2017	2018	2019	% of State Total in 2019
Alabama Shore Ocean (<3 nmi)	2,620,556	3,317,838	3,687,319	4,179,744	3,837,424	3,813,951	57.12%
Alabama Shore Inland	1,736,526	1,335,348	1,518,289	1,679,783	915,201	985,162	14.75%
Alabama Charter Ocean (<3 nmi)	24,562	14,752	12,671	18,634	40,867	52,296	0.78%
Alabama Charter Ocean (>3 nmi)	45,866	58,827	70,319	56,800	52,816	81,195	1.22%
Alabama Charter Inland	16,898	22,608	20,953	18,009	1,265	2,534	0.04%
Alabama Private/Rental Ocean (<3 nmi)	361,653	272,609	348,660	373,869	259,902	221,485	3.32%
Alabama Private/Rental Ocean (>3 nmi)	347,075	474,198	544,064	895,753	564,318	748,861	11.22%

Area	2014	2015	2016	2017	2018	2019	% of State Total in 2019
Alabama Private/Rental Inland	1,328,652	1,333,538	1,117,325	1,270,868	1,008,852	771,400	11.55%
Alabama Total	6,481,788	6,829,718	7,319,600	8,493,460	6,680,645	6,676,884	-
West Florida Shore Ocean (<10 nmi)	9,624,055	10,377,639	10,405,992	12,734,873	11,608,778	5,990,285	16.81%
West Florida Shore Inland	9,448,994	7,808,006	9,842,812	10,307,958	11,236,412	13,376,927	37.53%
West Florida Charter Ocean (<10 nmi)	202,809	226,782	240,511	205,642	229,258	238,232	0.67%
West Florida Charter Ocean (>10 nmi)	330,454	388,395	375,804	395,469	406,252	574,800	1.61%
West Florida Charter Inland	159,684	153,986	188,307	171,119	189,399	171,110	0.48%
West Florida Private/Rental Ocean (<10 nmi)	5,569,249	5,450,553	6,551,661	6,494,490	5,971,212	5,534,129	15.53%
West Florida Private/Rental Ocean (>10 nmi)	2,243,024	2,017,217	1,803,440	2,283,603	2,181,979	2,463,088	6.91%
West Florida Private/Rental Inland	11,047,013	9,307,429	9,527,889	9,247,023	9,173,111	7,296,271	20.47%
West Florida Total	38,625,282	35,730,007	38,936,416	41,840,177	40,996,401	35,644,842	-
Louisiana[1] Charter Boat	130,614	159,789	179,234	178,717	183,310	168,571	8.00%
Louisiana[1] Private/Shore	2,096,246	2,266,506	2,063,347	2,127,350	2,092,640	1,939,883	92.00%
Louisiana[1] Total	2,226,860	2,426,295	2,242,581	2,306,067	2,275,950	2,108,454	-
Mississippi Shore Ocean (<3 nmi)	-	-	44,270	-	31,098	-	0.00%
Mississippi Shore Inland	2,808,499	2,983,996	2,915,721	3,225,480	2,977,853	2,824,859	66.83%
Mississippi Charter Ocean (<3 nmi)	3,939	13,064	6,091	3,509	4,778	638	0.02%
Mississippi Charter Ocean (>3 nmi)	-	1,347	2,019	2,565	326	3,178	0.08%
Mississippi Charter Inland	13,173	27,110	16,580	10,396	14,175	16,387	0.39%

Area	2014	2015	2016	2017	2018	2019	% of State Total in 2019
Mississippi Private/Rental Ocean (<3 nmi)	20,340	85,961	123,567	52,915	107,619	167,968	3.97%
Mississippi Private/Rental Ocean (>3 nmi)	107,609	204,847	102,779	158,032	120,283	134,447	3.18%
Mississippi Private/Rental Inland	1,357,950	1,277,245	1,506,887	1,394,685	1,298,826	1,079,291	25.53%
Mississippi Total	4,311,510	4,593,570	4,717,914	4,847,582	4,554,958	4,226,768	-
Gulf of Mexico Total CPA and EPA Effort Data[2] Totals	51,645,440	49,579,590	53,216,511	57,487,286	54,507,954	48,656,948	-

nmi = nautical mile

[1] Effort data are now from “LA Creel” from 2014 onwards, which do not have the same details.

[2] Since Louisiana no longer offers fine details, totals are collapsed to a single total.

Sources: Louisiana Department of Wildlife & Fisheries 2020b; NMFS 2020j.

Table 4.4.3-2 presents data on the most commonly landed species by recreational fishermen in the CPA from 2014 to 2019 in Louisiana, Mississippi, and Alabama combined. Landings data for these states are presented separate from data for West Florida since most OCS oil- and gas-related activities are anticipated to 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 2019, there were noticeable increases in landings of Spanish mackerel, red snapper, southern kingfish, and black drum; several species landings were lower in 2019 than had been observed in prior years, including spotted seatrout, red drum, sand seatrout, and stiped mullet. Dolphin landings increased from 13,661 in 2018 to 37,601 in 2019, a decrease, however, from the peak of 110,249 in 2015 (NMFS 2020j).

Table 4.4.3-2. CPA Catch Data: Number of Fish Species Caught by Recreational Anglers from 2014 through 2019 in Louisiana, Mississippi, and Alabama Combined.

Species/Year	2014	2015	2016	2017	2018	2019
Atlantic Croaker	9,507,538	8,328,154	6,634,881	13,273,520	12,546,989	11,339,829
Black Drum	399,303	380,414	418,738	705,551	704,052	998,807
Blackfin Tuna	62,301	44,801	87,278	88,246	40,113	27,652
Cobia	71,518	31,486	69,802	51,459	70,058	96,462
Dolphin	35,109	110,249	78,494	17,139	13,661	37,601
Gag	3,871	3,636	22,920	6,394	2,224	5,499
Gray Snapper	254,354	595,784	904,494	1,922,571	519,099	634,467
Greater Amberjack	139,046	90,813	150,979	169,487	87,779	23,877

Species/Year	2014	2015	2016	2017	2018	2019
Little Tunny	151,858	51,922	258,993	150,589	37,890	71,655
Pinfish	2,789,443	6,470,077	5,231,761	2,286,145	4,737,757	3,417,577
Red Drum	3,520,288	2,929,088	3,132,300	4,927,491	5,536,093	2,948,880
Red Grouper	4,685	2,450	261	2,872	1,781	121
Red Snapper	2,651,163	2,659,298	4,049,823	4,635,806	2,992,015	3,660,287
Sand Seatrout	4,805,234	6,207,565	7,591,878	12,735,547	7,676,005	5,189,229
Sheepshead	888,615	3,006,622	734,229	2,057,130	1,023,609	750,903
Southern Flounder	798,443	828,259	781,613	342,519	571,038	311,435
Southern Kingfish	1,653,055	2,308,836	3,195,567	2,465,074	1,527,764	1,969,898
Spanish Mackerel	684,960	3,379,205	2,327,829	3,907,908	3,222,994	,885,885
Spotted Seatrout	7,386,012	11,453,777	16,603,397	13,042,064	8,369,115	5,132,750
Striped Mullet	3,365,388	4,761,882	2,424,474	2,238,541	3,207,995	1,243,879

Source: NMFS 2020j.

Table 4.4.3-3 presents data on the species most commonly landed by recreational fishermen in the EPA from 2014 to 2019 in West Florida. These species include pinfish (*Lagodon rhomboides*), spotted seatrout, gray snapper (*Lutjanus griseus*), Spanish mackerel, white grunt (*Haemulon plumieri*), and red drum (*Sciaenops ocellatus*). In 2019, landings of most species were similar to landings observed from 2014 through 2019. However, there were noticeable increases in landings of red drum, Spanish mackerel, little tuny, and dolphin; there were noticeable decreases in landings of pinfish, sheepshead, Atlantic croaker, and spotted seatrout (NMFS 2020j).

Table 4.4.3-3. EPA Catch Data: Fish Species Caught by Recreational Anglers from 2014 through 2019 in West Florida.

Species/Year	2014	2015	2016	2017	2018	2019
Atlantic Croaker	1,912,279	848,313	973,130	1,264,196	2,878,607	862,545
Black Drum	768,551	533,435	456,350	594,335	470,808	341,487
Blackfin Tuna	37,254	80,016	64,663	91,708	71,872	36,845
Cobia	207,656	313,825	152,409	151,067	268,347	117,090
Dolphin	1,245,762	1,896,560	364,331	648,456	576,521	869,272
Gag	2,384,079	1,566,694	2,335,190	3,633,544	2,570,492	2,681,191
Gray Snapper	22,230,431	19,186,166	16,708,901	17,051,874	16,948,734	16,129,965
Greater Amberjack	315,545	484,103	511,712	213,921	246,223	175,958
Little Tunny	426,767	648,469	461,027	576,959	316,218	821,574
Pinfish	32,937,683	25,645,476	23,344,175	24,675,046	23,721,108	17,897,444
Red Drum	6,345,681	8,119,737	6,599,283	5,227,675	6,032,364	10,182,795
Red Grouper	5,795,106	3,579,385	2,969,434	2,893,244	3,730,248	2,068,641
Red Snapper	2,619,382	2,205,674	4,284,104	7,656,598	5,404,374	5,406,247
Sand Seatrout	1,562,458	2,290,724	1,183,369	2,513,456	958,611	703,322
Sheepshead	5,472,651	3,478,698	3,746,843	6,796,152	6,782,937	4,078,131
Southern Flounder	20,736	8,918	31,816	30,888	20,640	100,817
Southern Kingfish	195,582	282,347	111,471	151,994	238,918	59,212
Spanish Mackerel	9,960,120	6,355,392	6,031,330	10,398,758	7,682,900	10,332,893
Spotted Seatrout	18,838,197	18,421,294	26,294,751	28,628,758	19,767,275	18,002,693
Striped Mullet	4,266,960	2,621,569	4,401,025	2,483,775	3,892,336	3,024,393
White Grunt	12,171,979	7,869,280	8,464,964	8,836,840	7,443,771	6,425,169

Source: NMFS 2020j.

Table 4.4.3-4 provides data on the number of recreational fishing trips in the WPA during each season of 2015-2019 in Texas bays, State waters, and the Exclusive Economic Zone (Fisher 2020a; 2020b). There were 1,313,478 angler trips in 2019, slightly higher than in prior years. The least amount of recreational fishing occurs in Federal waters, where most OCS oil- and gas-related activities occur. In 2019, 95.2 percent of fishing occurred in bays, 2.2 percent occurred in State ocean waters (Texas Territorial Sea), and 2.6 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 2019, 73.8 percent of angler trips occurred in Season B, and 28.5 percent of trips occurred by charter boats. In recent years, fishing during Season A has been relatively stable, while fishing during Season B has been increasing.

Table 4.4.3-4. Texas Effort Data: Number of Angler Trips from 2015 through 2019.

Area	Season A Private	Season A Charter	Season A Total	Season B Private	Season B Charter	Season B Total	Annual Total Private	Annual Total Charter	Annual Total
2015 Bay	262,952	36,570	299,522	590,080	104,155	694,235	853,032	140,725	993,757
2015 TTS	4,888	546	5,434	25,294	3,105	28,399	30,182	3,651	33,833
2015 EEZ	62	0	62	12,926	2,520	15,446	12,988	2,520	15,508
2015 Total	267,902	37,116	305,018	628,300	109,780	738,080	896,202	146,896	1,043,098
2016 Bay	365,406	38,717	404,123	621,886	0	621,886	987,292	38,717	1,026,009
2016 TTS	2,062	966	3,028	21,449	4,260	25,709	23,511	5,226	28,737
2016 EEZ	352	307	659	13,959	2,453	16,412	14,311	2,760	17,071
2016 Total	367,820	39,990	407,810	657,294	6,713	664,007	1,025,114	46,703	1,071,817
2017 Bay	378,732	52,784	431,516	535,485	128,548	664,033	914,217	181,332	1,095,549
2017 TTS	5,515	3,821	9,336	15,461	3,463	18,924	20,976	7,284	28,260
2017 EEZ	224	179	403	17,412	2,604	20,016	17,636	2,783	20,419
2017 Total	384,471	56,784	441,255	568,358	134,615	702,973	952,829	191,399	1,144,228
2018 Bay	347,014	35,719	382,733	543,689	257,529	801,218	890,703	293,248	1,183,951
2018 TTS	4,725	1,141	5,866	21,688	8,193	29,881	26,413	9,334	35,747
2018 EEZ	526	0	526	20,831	5,972	26,803	21,357	5,972	27,329
2018 Total	352,265	36,860	389,125	586,208	271,694	857,902	938,473	308,554	1,247,027
2019 Bay	291,208	48,638	339,846	594,071	316,368	910,439	885,279	365,006	1,250,285
2019 TTS	3,190	824	4,014	22,159	3,141	25,300	25,349	3,965	29,314
2019 EEZ	878	0	878	27,322	5,679	33,001	28,200	5,679	33,879
2019 Total	295,276	49,462	344,738	643,552	325,188	968,740	938,828	374,650	1,313,478

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, it is counted as multiple trips.

Source: Fisher 2020b.

Table 4.4.3-5 provides data regarding the individual species caught by anglers in the WPA during 2015-2019 in Texas. 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 sea trout. Red snapper (*Lutjanus campechanus*) and king mackerel (*Scomberomorus cavalla*) are the most popular species in Federal waters. The 2019 landings of most species were in the ranges observed in prior years. However, landings of Atlantic croaker continued on a downward trend. Landings of red snapper gradually increased from 2015 through 2019, and black drum, sand seatrout, and sheepshead show increases in recent years.

Table 4.4.3-5. Texas Catch Data: Top Species Landed by Recreational Fishermen.

Panel	Species	2015	2016	2017	2018	2019
Panel A: Total Landings	Atlantic Croaker	213	125	67	64	55
Panel A: Total Landings	Black Drum	127	138	164	139	175
Panel A: Total Landings	King Mackerel	8	11	15	24	17
Panel A: Total Landings	Red Drum	241	288	300	276	304
Panel A: Total Landings	Red Snapper	49	30	44	54	76
Panel A: Total Landings	Sand Seatrout	109	135	96	59	102
Panel A: Total Landings	Sheepshead	50	105	59	84	122
Panel A: Total Landings	Southern Flounder	85	103	76	42	68
Panel A: Total Landings	Spotted Seatrout	824	1024	982	746	999
Panel B: Landings in Bays	Atlantic Croaker	213	118	64	64	53
Panel B: Landings in Bays	Black Drum	127	137	163	135	175
Panel B: Landings in Bays	King Mackerel	--	--	--	--	--
Panel B: Landings in Bays	Red Drum	239	283	295	274	301
Panel B: Landings in Bays	Red Snapper	--	--	--	--	--
Panel B: Landings in Bays	Sand Seatrout	108	130	91	54	97
Panel B: Landings in Bays	Sheepshead	50	105	59	84	122
Panel B: Landings in Bays	Southern Flounder	85	103	76	42	68
Panel B: Landings in Bays	Spotted Seatrout	809	1012	974	736	986
Panel C: Landings in State Waters	Atlantic Croaker	--	7	2	--	1
Panel C: Landings in State Waters	Black Drum	--	--	--	2	--
Panel C: Landings in State Waters	King Mackerel	4	5	5	11	5
Panel C: Landings in State Waters	Red Drum	1	3	4	2	2
Panel C: Landings in State Waters	Red Snapper	34	20	23	24	31
Panel C: Landings in State Waters	Sand Seatrout	1	2	3	5	3
Panel C: Landings in State Waters	Sheepshead	--	--	--	--	--
Panel C: Landings in State Waters	Southern Flounder	--	--	--	--	--
Panel C: Landings in State Waters	Spotted Seatrout	14	10	6	9	12
Panel D: Landings in the EEZ	Atlantic Croaker	--	--	--	--	--
Panel D: Landings in the EEZ	Black Drum	--	--	--	1	--
Panel D: Landings in the EEZ	King Mackerel	4	5	9	13	12
Panel D: Landings in the EEZ	Red Drum	--	1	--	--	--
Panel D: Landings in the EEZ	Red Snapper	15	10	20	30	45
Panel D: Landings in the EEZ	Sand Seatrout	--	2	1	0	1
Panel D: Landings in the EEZ	Sheepshead	--	--	--	--	--
Panel D: Landings in the EEZ	Southern Flounder	--	--	--	--	--
Panel D: Landings in the EEZ	Spotted Seatrout	--	--	--	--	--

(1) Fish landings are presented in thousands of fish.

(2) The Texas Parks and Wildlife Department 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 reflect combined catch for Seasons A and B. For example, the catch data for 2017 reflects catch from November 21, 2016, to November 20, 2017.

Source: Fisher 2020a.

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. Trip expenditures include such things as transportation costs, fuel, boat launch fees, rentals or charters, and bait expenses. Durable purchases include spending on things such as fishing equipment and fishing boats. 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 (NMFS 2020j); 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.

(1) West Florida ($4,11,852; 60,179 jobs)

(2) Texas ($1,237,327; 16,030 jobs)

(3) Louisiana ($1,003,379; 14,142 jobs)

(4) Alabama ($1,029,958; 16,114 jobs)

(5) Mississippi ($344,6052; 5,351 jobs)

4.4.3.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and recreational fishing. **Figure 4.4.3-1** provides a synopsis of the IPF categories that currently affect or have the potential to affect recreational fishing in the Gulf of Mexico OCS. Following **Figure 4.4.3-1** is a summary of those potential effects on recreational fishing as well as a brief discussion of the IPF categories identified in **Figure 4.4.3-1** that are not likely to affect recreational fishing, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to recreational fishing, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

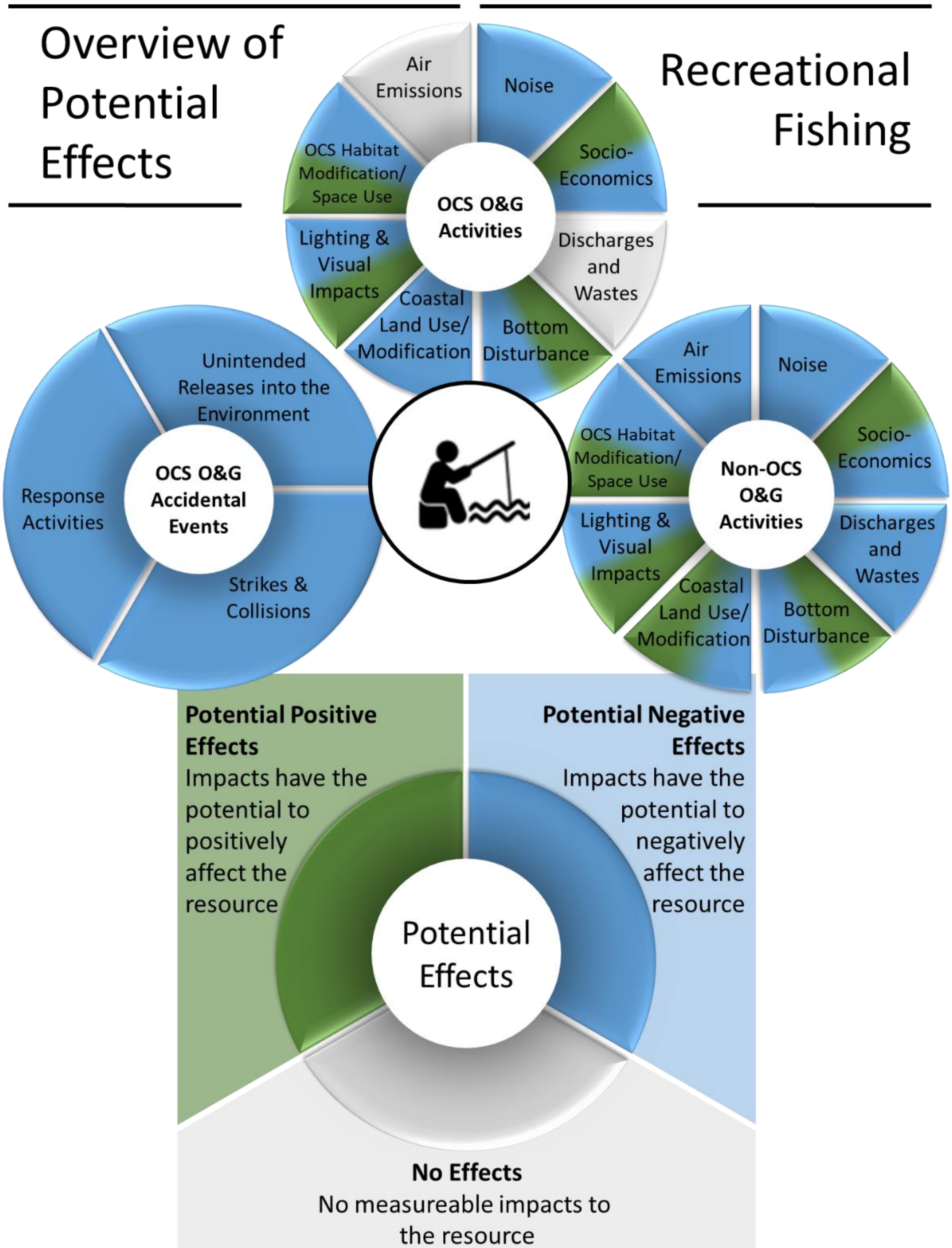


*Figure 4.4.3-1. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Commercial Fisheries. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.4.3.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.3-1 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect recreational fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Recreational fishing depends on the health of fish and invertebrate populations. Although air emissions from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Air emissions resulting from non-OCS oil- and gas-related activities may have negative effects on coastal habitats upon which many of these species depend. Air pollutants result from manmade and natural sources (e.g., vehicle emissions and wildfires) and contribute to increased CO_2, leading to ocean acidification, which can negatively affect fish and invertebrate resources' health and their habitat. To the extent that air emissions can negatively affect coastal habitats and fish and invertebrates, recreational fishing can also experience negative effects in terms of reduced aesthetic enjoyment and catches. Detailed descriptions of the potential effects of non-OCS air emissions and pollution to fish and invertebrate populations are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Discharges and Wastes (Chapter 2.2.2)

Discharges and wastes associated with non-OCS oil- and gas-related activities can indirectly and negatively affect recreational fishing by negatively affecting fish and invertebrate populations. For example, decreases in water quality caused by the influx of freshwater from rivers carrying excess nutrients and chemicals related to agricultural and industrial uses inland and discharges of chemical waste products from non-point sources and accidental discharges can expand the size of the hypoxia zone in the GOM, which can cause pelagic species of recreational interest to re-locate. The movement of the fish can interfere with recreational fishers' access to desired species by extending the distance to reach fishing grounds, increasing fuel costs, and interfering with the aesthetic enjoyment of the activity. In addition, these negative effects could also potentially lead to less demand for charter fishing and a negative ripple effect through the economic supply chain. Detailed descriptions of the potential effects of discharges and wastes to fish and invertebrate populations are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Accidental oil spills in State waters from State oil and gas activities could affect recreational fishing by polluting the waters, harming or killing target fish, closing areas to fishing, and negatively effecting the aesthetic fishing experience. The early life stages of fish are generally more vulnerable to oil exposure and could be affected if a spill coincides with a spawning event or if a spill impacts a nursery habitat, many of which are inshore. Refer to **Chapter 4.3.1** (Coastal Communities and

Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b) for more detail on the biological effects to fish and their habitat from oil spills. Should fish and invertebrates be negatively affected by non-OCS oil- and gas-related oil spills, the landings, as well as demand for fishing charters, could be reduced.

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbances related to non-OCS oil- and gas-related activities can negatively or positively affect fish and invertebrate resources, thereby causing indirect effects to recreational fishing. Indiscriminate commercial fishing practices (e.g., trawling and pots) can injure or kill many fish species caught as bycatch, reducing the potential for recreational fishers to catch these fish. Sediment dredging and disposal, sand mining, anchoring, and offshore marine transportation disturb sediments and increase turbidity resulting in negative effects to fish and invertebrates. Benthic prey, juvenile fishes, eggs, and larvae can all be smothered from turbidity causing harm or death, negatively affecting recreational fishing by decreasing the availability of important fish and invertebrates. The biological consequences of these changes are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b). If these effects are large enough, there could be negative effects on the economic supply chain for recreational fishing through reduced private or charter fishing trips and reduced purchases of durable equipment.

Conversely, the installation of production structures related to State oil and gas activities as well as artificial reef placement could enhance reef fish habitat and thus improve recreational fishing opportunities by congregating some fish and invertebrates near the structures. Accessible fishing structures can lead to an increase in recreational fishing trips with a positive ripple effect through the economic supply chain. Although the ultimate decommissioning of production structures could negatively affect fish populations in the area by generating turbidity, removing habitats, and if explosives are used, causing fish mortality, those negative effects would be localized and not expected to have any long-term effects because turbidity subsides, surviving fish move to other habitats, and fish populations are expected to recover from localized fish mortality. To the extent that fish and invertebrates are positively or negatively affected by bottom disturbances, recreational fishing can indirectly experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies. Detailed descriptions of the potential effects of bottom disturbances to fish and invertebrates are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.2)

Although sound from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by non-OCS oil- and gas-related activities may negatively affect recreational fishing. To the extent that anthropogenic sound caused by non-OCS oil- and gas-related activities can negatively affect fish populations, it can indirectly affect recreational fishing.

Anthropogenic sound could cause displacement or physical harm or fatalities within fish populations. These effects could lead to decreased landings or reduced aesthetic enjoyment of the recreational activity, potentially leading to less demand for charter fishing, and a negative ripple effect through the economic supply chain. Examples of non-OCS oil- and gas-related activities that can produce underwater noise include recreational boating activities, commercial fishing vessels, cruise ships, cargo vessels, military activities, dredging operations, and in-water construction. Detailed descriptions of the potential effects of anthropogenic sound to fish and invertebrates, which are very important to recreational fishing, are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

Although coastal land use from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Coastal land disturbances caused by non-OCS oil- and gas-related activities (e.g., coastal developments such as industrial and residential construction near harbors, waterways, and beachfronts) can negatively affect fish and invertebrate species important to recreational fishing by modifying or degrading coastal vegetation and submerged aquatic vegetation habitats such as salt marsh grasses crucial to various life stages of recreationally important fish species. Detailed descriptions of the potential effects of non-OCS-related coastal land disturbances to fish and invertebrates, upon which recreational fishing depends, are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b). Non-OCS oil- and gas-related coastal land-disturbing activities may negatively affect recreational fishing to the extent that reduced catch interferes with recreational fishers' aesthetic enjoyment and potentially decrease demand for charter services. These negative effects would be localized in nature and temporally limited in the case of construction activities.

Conversely, recreational fishing can be positively affected by coastal land disturbances if they involve improvements to existing coastal infrastructure or development of new support infrastructure, such as hotels and restaurants, that would attract economic inputs from recreational fishers. In addition, construction of piers and boat launches can positively affect recreational fishing by increasing fishing opportunity.

Lighting and Visual Impacts (Chapter 2.6.2)

Non-OCS oil- and gas-related activities can produce artificial lighting from public and private docks and piers and industry-related infrastructure that can interfere with natural predator-prey interactions and larval settlement site selection, potentially causing negative effects to fish and invertebrates. Although lighting from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Any declines in localized fish and invertebrate numbers may negatively affect recreational fisheries by decreasing potential landings. Conversely, artificial lighting can also cause positive effects for recreational fishing because many recreational fishers enjoy night fishing at public and private docks where the lights attract fish to be caught as well as provide safety for fishing at night. Detailed descriptions of the potential effects of non-OCS-related artificial lighting to fish and invertebrates are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Although space-use conflicts from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), localized effects to fish may occur. Recreational fishing may encounter negative space-use conflicts with non-OCS oil- and gas-related activities in State waters, as well as recreational and military vessels that temporarily restrict access to fishing areas. Vessel space-use conflicts may particularly occur near major ports and in shipping lanes as vessels transit to and from shore. There is a large amount of vessel traffic in the Gulf of Mexico. VesselFinder Limited (2020) and Marine Vessel Traffic (2020) provide maps of current and historical vessel traffic in the Gulf of Mexico. In many instances throughout the GOM, competition between commercial and recreational fishermen targeting the same species led to depleted fish stocks and habitat alterations, reducing overall landings. Wetlands loss and other ecosystem degradation can also negatively affect recreational fishing by reducing nursery habitat for fish and invertebrates (refer to **Chapter 4.3.1** [Coastal Communities and Habitats], **Chapter 4.3.4** [Fish and Invertebrates], and the Biological Environmental Background Report [BOEM 2021b]), negatively affecting fish populations and landings, as well as negatively affecting the aesthetic experience while recreational fishing. Sand borrowing activities for beach nourishment projects may temporarily conflict with recreational fishing activities, but sand borrowing projects do not have a large footprint and are not a permanent disruption for recreational fishers, who would avoid those areas. Renewable energy projects have not yet been developed on the Gulf of Mexico OCS, but if they are, some conflicts with fishing activities could occur, depending on project location and any mitigations that may be developed to address space-use conflicts. Any military areas or ocean dumping sites that are permanently off limits could cause a permanent space-use conflict for recreational fishing in that fishing cannot occur in those areas. However, since there are many open areas nearby closed areas, the closures should not affect recreational fishing or catch.

Offshore habitat modification caused by non-OCS oil- and gas-related structure emplacement in State waters can cause positive effects to recreational fishing by providing habitat for fish populations for a period of years until the structures are decommissioned, which may have negative or positive effects depending on the nature of the decommissioning. For example, if the structures are toppled in place or transported to artificial reef sites, the negative effects of structural habitat loss would be mitigated by a form of habitat replacement. Complete removal of a structure could cause short-term negative effects for fish and invertebrates such as turbidity, habitat loss, and if explosives are used, localized fish mortality. However, turbidity subsides, surviving fish move to other habitats, and fish populations would be expected to recover from localized fish mortality. Detailed descriptions of the potential effects of offshore habitat modification to fish and invertebrates are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the

Biological Environmental Background Report (BOEM 2021b). To the extent that fish and invertebrates are positively or negatively affected by offshore habitat modification, recreational fishing can experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Various economic forces associated with non-OCS oil- and gas-related activities also may affect recreational fishing. Changes in commodity prices can negatively affect fuel costs for fishers who are likely to alter their behavior due to this economic disincentive. Overall regional economic conditions also affect whether or not people decide to charter a fishing trip or take their own boats out. If economic times are hard, the levels of recreational fishing are likely to decrease, causing supply chain effects related to decreased demand for services depending on the recreational fishing sector. Negative economic effects associated with global or national events, such as the COVID-19 pandemic, could also discourage recreational fishing activity. Tropical storms and hurricanes can affect boats and other infrastructure that support recreational fishing. Conversely, when economies are flourishing with high gross domestic product and low unemployment, recreational fishing activity would increase, positively feeding back into the economy. Recreational fishing would also be positively correlated with general trends in tourism and the overall economy. Fisheries management strategies employed by NMFS, the Gulf of Mexico Fishery Management Council, and various State agencies also may positively and negatively affect recreational fishing. The incredibly short recreational red snapper season in the GOM, mandated by governing agencies, can be viewed negatively (recreational fishers resent not being allowed more days and less stringent limits on red snapper as commercial fisheries are allowed) or positively (conservationists view the restrictions as good for maintaining or restoring species so they will be available for future generations to catch).

Recreational fishing activity is also heavily influenced by regulations and competition between commercial and recreational fishermen targeting the same species. National concern for the health and sustainability of marine fisheries has led to the development of fishery management plans, which affect recreational fish species in the GOM. Fisheries management plans focused on targeted species, such as red snapper, have led to size and creel limits as well as seasonal closures and gear restrictions or modifications in both commercial and recreational fishing. The Magnuson-Stevens Fishery Conservation and Management Act requires that fishery management plans also identify essential fish habitat to allow it to be protected from fishing, other coastal and marine activities, and developments.

4.4.3.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.3-1 highlights the IPF categories associated with routine OCS oil and gas development that could potentially affect recreational fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Bottom Disturbance (Chapter 2.3.1)

Although bottom disturbance from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), to the extent that bottom disturbance affects localized fish and invertebrates, it can also affect recreational fisheries and the economic sectors they support. Bottom-disturbing activities associated with routine OCS oil- and gas-related activities (e.g., pipelaying, drilling, anchoring, and structure emplacement) can cause negative effects (e.g., turbidity and sedimentation) and positive effects (e.g., habitat formation from structure emplacements). Turbidity can cause smothering of benthic prey as well as eggs, larvae, and juvenile fishes that may be fished recreationally. Harm or death to fish and invertebrates as a result of smothering can negatively affect recreational fishing by decreasing the availability of fish. Conversely, OCS oil- and gas-related structures could enhance reef fish habitat and thus improve some fishing opportunities by congregating fish populations near the structures (Scott-Denton et al. 2011). Hiett and Milon (2002) estimate that over 20 percent of all recreational fishing activity in the Gulf of Mexico occurs within 300 ft (91 m) of an oil and gas structure. The extent to which a rig will serve as an attractor to fish will depend on the fish populations in nearby areas and the extent to which structure emplacement will support recreational fishing activity will depend on location. For example, oil rigs very far offshore are less likely to support recreational fishing activity since most recreational fishing typically takes place inshore. Although the ultimate decommissioning of production structures could negatively affect fish in the area by generating turbidity, removing habitat, and if explosives are used, causing localized fish mortality, those negative effects would be localized and not expected to have any long-term effects because turbidity subsides, surviving fish move to other habitats, and fish populations would be expected to recover from localized fish mortality. To the extent that fish and invertebrates are positively or negatively affected by bottom disturbance, recreational fishing can experience positive or negative effects to potential landings, revenues, and associated fisheries reliant economies. Detailed descriptions of the potential effects of bottom disturbances to localized fish and invertebrate populations are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.1)

Although sound from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by routine OCS oil- and gas-related activities may negatively affect recreational fishing indirectly through displacement, physical harm, or fatalities within localized fish populations. The severity of these effects would be based on the vulnerability of fish and invertebrate populations. Disturbances to those populations can have proportionate negative effects on recreational fishing and the economic sectors it supports. Detailed descriptions of the potential effects of anthropogenic sound to localized fish and invertebrate populations are provided in **Chapter 4.3.4** (Fish and Invertebrates) and the Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.1)

Although coastal land use from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Recreational fishing can be indirectly and negatively affected by routine OCS oil- and gas-related coastal land disturbance activities such as construction of new onshore facilities, pipeline landfalls, and navigation canal dredging that can negatively affect fish and invertebrate resources. Fish and invertebrate species important to recreational fisheries can be negatively affected through the modification of coastal vegetation and submerged aquatic vegetation habitats such as salt marsh grasses crucial to various life stages of fish species. Coastal land disturbance can result in a reduction of recreationally important fish, which may negatively affect recreational fishing through reduced landings, which could lead to reduced charter trips. Coastal land disturbances for OCS oil- and gas-related activities are typically localized in nature and of short duration. Detailed descriptions of the potential effects of coastal land disturbance activities to localized fish and invertebrate populations are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Lighting and Visual Impacts (Chapter 2.6.1)

Although lighting from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Artificial lighting associated with routine OCS oil- and gas-related activities (e.g., offshore standing platforms, tension-leg platforms, drillships, onshore facilities, and docked vessels) can negatively affect localized fish and invertebrate resources by altering predator-prey interactions and larval settlement site selection. If these effects cause a decrease in species populations, then recreational fishing also may be negatively affected by decreases in potential catches and by extension, aesthetic enjoyment. Conversely, artificial lighting can also cause positive effects because many recreational fishers enjoy night fishing near offshore platforms where the lights attract fish to be caught. Detailed descriptions of the potential effects of OCS-related artificial lighting to localized fish and invertebrate populations are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Although offshore habitat modification from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), localized effects to fish may occur. Offshore habitat modification from OCS oil- and gas-related activities can cause potential effects to fish and invertebrate resources, which range from positive (e.g., structure emplacement adding new habitat) to negative (e.g., structure removal reducing habitat). For example, 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. The BSEE presents more information regarding the status of Rigs-to-Reefs activities in the Gulf of Mexico (BSEE 2020). 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. Detailed descriptions of the potential effects of offshore habitat modification to fish and invertebrates are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Space-use conflicts also can cause negative effects to recreational fishing that arise from routine OCS oil and gas operations such as seismic surveys, pipeline emplacement, drilling, and production structure emplacement and removals in that recreational fishing cannot occur in the same areas where some of these OCS oil- and gas-related activities are taking place. 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 trolling in the associated area because gear can become entangled with the structure as the fishing vessel passes.

The OCS oil- and gas-related vessel traffic contributes to space-use conflicts with recreational fishers. 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. Recreational vessels can often easily avoid temporary OCS vessel traffic. The extent of potential effects 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.

Socioeconomic Changes and Drivers (Chapter 2.8.2)

Routine OCS oil- and gas-related activities are indirectly associated with socioeconomic changes and drivers that can positively or negatively affect recreational fisheries. For example, to the extent that OCS activity levels increase, the potential for new structure emplacements increase, which creates new fish habitats and opportunities for recreational fishers to visit. Similarly, to the extent that OCS activity levels decrease, the potential for new structure emplacements decrease, reducing opportunities for recreational fishers to visit, as well as reducing the number of charter boats that visit these structures. Variations in the level of OCS oil- and gas-related activities (i.e., G&G seismic, leasing, exploration, development, production, and decommissioning) are modulated by many variables. A few of these include financial solvency of oil and gas companies, changes in commodity prices, economic changes (i.e., regional, national, and global), energy market shifts, government regulatory changes, skilled workforce availability, and fluctuations in supply and demand. **Chapter 2.8** discusses these socioeconomic variables in detail.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that air emissions and pollution, and discharges and wastes are not likely to affect recreational fishing and, therefore, were not analyzed in detail. As detailed in **Chapter 2.1**, air emissions related to routine oil- and gas-related activities are highly regulated and monitored and very unlikely to affect recreational fishing. Discharges and wastes associated with routine OCS oil- and gas-related activities are also highly regulated (refer to **Chapter 2.2**). Neither air emissions nor wastes and discharges from OCS oil- and gas-related activities are anticipated to exceed regulated levels and therefore are not considered likely to cause significant effects to fish and invertebrate resources at the population level (refer to **Chapter 3.4.1** [Coastal Communities and Habitats] and **Chapter 4.3.4** [Fish and Invertebrates]) or recreational fishing that relies on these resources. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

4.4.3.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.3-1 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect recreational fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Oil spills can arise from accidents with respect to OCS oil- and gas-related vessels, pipelines, drilling operations, or production operations. The exact effects of an oil spill on recreational fisheries would depend on the locations of oil spills, the species affected, the intensity of recreational fishing activity in the affected area, and the substitutions available for any lost fishing access. Oil spills and other accidental events could indirectly affect recreational fishing activity through their effects on fish and their habitats in the affected areas. A spill could either contaminate fish in the immediate area or cause fish to move during the duration of the spill. A spill would likely cause more direct harm to larvae and eggs than adults, which could possibly affect recreational species in the longer term. Should fish populations that support recreational fishing decline, recreational fishing activity could decline, as well negatively affecting the economic supply chain related to recreational fishing. The detailed potential effects of oil spills on fish populations that support recreational fishing are described in **Chapter 3.4.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Oil spills can also lead to localized fishing closures that could directly affect fishermen's access to fish resources. The size of the closure would be dependent on the size of the oil spill. Small-scale spills should not affect recreational fishing to a large degree due to the likely availability of substitute fishing sites in neighboring regions. A large spill can have substantial effects on recreational fishing due to the larger potential closure regions and due to the wider economic implications, such closures can have. However, the longer-term implications of a large oil spill would primarily depend on the extent to which fish ecosystems recover after the spill has been cleaned. In addition, the corresponding effects to recreational fishing would depend on the types and scales of recreational fishing activities in an impacted area. 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 affect recreational fishing accessibility 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. The OCS oil spills most likely to affect recreational anglers would mostly be shallow-water spills since the recreational anglers are typically less likely to venture far offshore and most recreational fishing is conducted close to shore.

The effects of an oil spill on recreational fishing are different from those experienced by the commercial fishing industry in several ways. Most directly, the benefits received by anglers from fishing activity are determined by subtle issues such as the enjoyment of the fishing process and the aesthetics of a particular fishing site. As a result, the damage of an oil spill to recreational fishing would be determined by issues such as the availability of substitute fishing sites in a region and the additional costs of attending alternate sites. Any disruption to recreational fishing activity would also have broader economic implications to a particular geographic region. Disruptions to recreational fishing could affect boat launches, bait shops, and durable fishing equipment manufacturers (Carroll et al. 2016).

One study has estimated that the recreational fishing industry contributes $9.8 million in direct expenditures, $23 million in total sales, and 183 jobs per day to the economy of the Gulf of Mexico (Carroll et al. 2016; Gentner and Steinback 2008). Any reductions in recreational fishing could also negatively affect the various firms that supply goods and services to anglers. In addition, public perception of the effects of a spill on marine life and its extent may ultimately result in a loss of revenue for the fishing-related recreation industry. Party and charter boat recreational fisheries often have loss of income because of reduced interest in fishing when a spill has occurred. Local hotel, restaurant, bait and tackle shops, and boat rental companies associated with recreational fisheries may experience reduced sales because of the public perception of the effects of an oil spill (Carroll et al. 2016). A study following the *Exxon Valdez* spill in Alaska estimated $31 million in direct recreational fishing losses due to the spill (Carson and Hanemann 1992).

Response Activities (Chapter 2.9.2)

Spill-response activities can cause negative but localized space-use conflicts for recreational fishing at ports and offshore where fishers would need to avoid certain fishing areas while spill response is ongoing. Spill-response activities may affect fish and invertebrate resources, particularly oysters, because such resources are not mobile, cannot engage in avoidance behaviors, and can suffer mortality caused by dispersant use or improper anchoring. As a result, recreational fishing can be affected by these negative effects to target species' populations, causing reduced landings and adversely affecting charter boat revenues and by extension, the coastal economies associated with those fisheries. Detailed descriptions of the potential effects of spill-response activities to fish and invertebrate populations are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

Strikes and Collisions (Chapter 2.9.3)

Accidental strikes typically would not affect most fish and invertebrates because their mobility allows them to avoid vessels. Only whale sharks (not recreationally significant) in the GOM are known to be susceptible to vessel strikes. Recreational fishing may be negatively affected by vessel collisions; however, these would be localized in effect and not likely to interfere with recreational fishing activities unless they occur on inland waterways and disrupt the flow of vessels, possibly interfering with fishing vessels coming from and going to port. Even then, the disruption would be expected to be short term with minimal localized effects. Some vessel collisions may result in oil spills, which also may negatively affect recreational fishing as discussed above. Detailed descriptions of the potential effects of an oil spill to fish and invertebrate resources are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and the Biological Environmental Background Report (BOEM 2021b).

4.4.4 Subsistence Fishing

4.4.4.1 Resource Description

Definition of Subsistence

Subsistence fishing is a form of wild resource use in addition to and overlapping with commercial and recreational fishing. The three forms of fishing are managed together and often involve the same individuals. For these reasons, subsistence fishing, and subsistence in general, is difficult to define, identify, and analyze, and cannot be quantified. In its environmental justice guidance, the CEQ (1997, pages 31-32) explicitly recognizes that subsistence should be considered and specifies that

> In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence.

It further specifies that minority and low-income populations or Indian tribes or subpopulations of those groups may have differential rates or patterns of consumption than the general population and should be considered. The CEQ does not, however, define subsistence. For the purposes of this analysis, subsistence is defined as

> a diverse array of activities (or practices) that are governed by non-market logics, have goals other than generating profit, and, while contributing to food needs, also contribute to the pleasure of producing fresh, flavorful, valued foods and sharing those with friends and family. Most importantly, those who participate in subsistence activities are themselves embedded in households and social networks that involve multiple livelihoods or hybrid economies (based on the work of (Walton and Regis 2019).

BOEM selected this definition for this analysis because it has four key benefits. First, it includes the widest possible range of how the food is acquired, i.e., anything other than market exchange with the goal of making a profit. This will allow for the maximum range of subsistence fishing to be analyzed here and help prevent any from being left out. Second, it explicitly includes the social networks of subsistence fishers. Like supply chains for products on the market, this focuses attention on the variety of people involved in the production, exchange, and consumption of the product, thus providing for a more complete analysis. Third, it includes the non-consumption benefits gained by subsistence fishers, specifically those associated with the emotional response to the subsistence experience. This is sensitive to the CEQ's concern with differential use. Fourth, it is not limited to environmental justice populations. BOEM recognizes that subsistence can be economically, socially, and culturally significant to a broader range of residents in the area of interest; therefore, it would be incomplete to analyze only environmental justice communities. While this definition of subsistence includes many different species of plants and animals, and the practices associated with their acquisition, this chapter describes and analyzes only subsistence fishing. Other elements are discussed in **Chapter 4.4.6** (Social Factors).

Overview of the Area of Analysis

Subsistence in the continental U.S. is poorly understood, and research on subsistence fishing in the area of analysis in the five Gulf Coast States is limited. Therefore, this analysis relies on the information in the existing literature, including analyses relevant to but outside the area of analysis, to paint a reasoned picture of subsistence practices there. This chapter describes what is known about existing subsistence fishing. Additional information related to environmental justice communities is provided in **Chapter 4.4.6** (Social Factors). This chapter begins with a general overview of the area of analysis and provides discussions of the regulatory framework and fish advisories, the practice of subsistence fishing, and a note about the longstanding interrelationship between fishing and the oil and gas industry in the Gulf of Mexico.

The 133 counties and parishes in the area of interest in the five Gulf Coast States, i.e., the EIAs illustrated in **Figure 4.4.4-1** (refer to **Chapter 2.5** for additional information on EIAs), are diverse in human settlement, demographic, and cultural characteristics, habitat, fish populations, physical access to fishing, and regulations governing access. For the purposes of this analysis, it is assumed that most species targeted by commercial and recreational fishers for human consumption may be used for subsistence, though BOEM recognizes that not all fishing occurs legally. This includes, but is not limited , sheepshead, red snapper, scad, ladyfish, sardines, spotted seatrout, grouper, mullet, Spanish and king mackerel, amberjack, multiple species of drum, several species of tuna, oyster, blue crab, stone crab, four species of shrimp (i.e., pink, white, brown, and rock), crawfish, and spiny lobster.

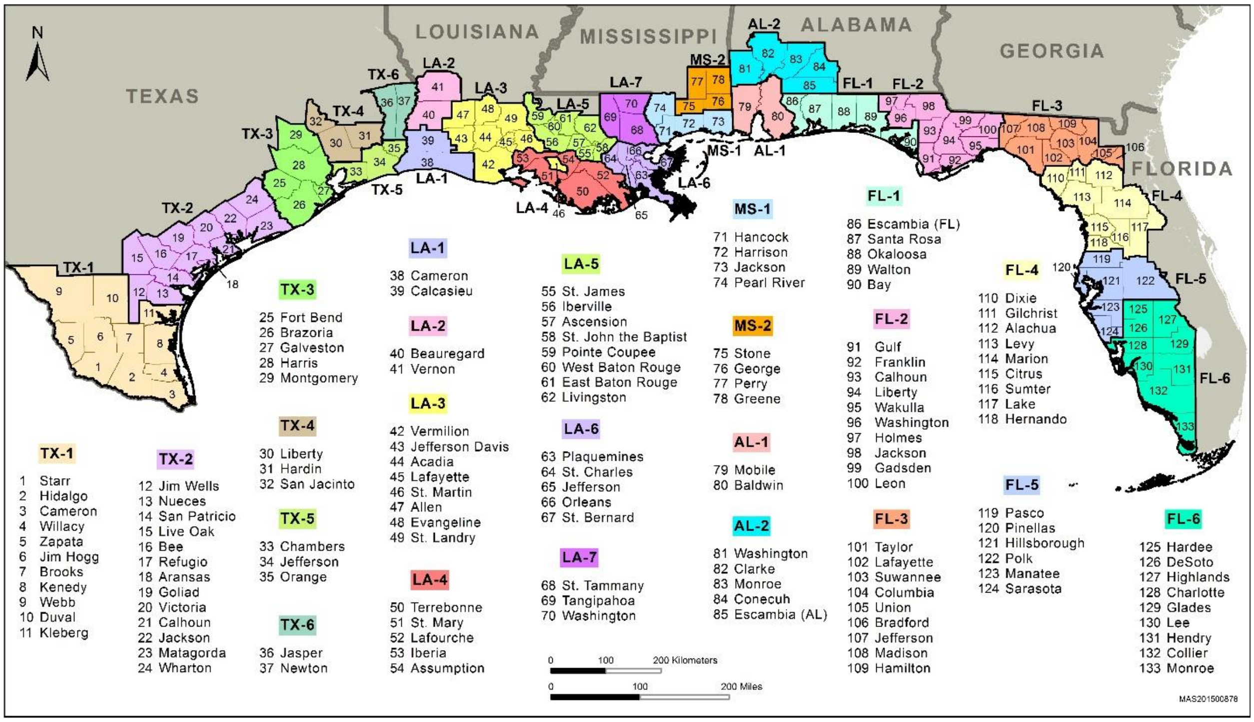


*Figure 4.4.4-1. Economic Impact Areas along the Gulf Coast (reprint of **Figure 2.5-1**).*

Minority populations can have patterns of resource use that differ from the general population and require special attention in environmental analyses (CEQ 1997). **Figure 4.4.4-2** illustrates the distribution of minority populations across Texas and Louisiana, and **Figure 4.4.4-3** illustrates the distribution of minority populations across Mississippi, Alabama, and Florida. 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 (U.S. Census Bureau 2013a). **Figure 4.4.4-4** illustrates the percentage of poverty level in Texas and Louisiana, and **Figure 4.4.4-5** illustrates the percentage of poverty level in Mississippi, Alabama, and Florida. Within the 133 counties/parishes that comprise the EIAs, 104 counties/parishes have residents living below the national average of 14.5 percent. Willacy County, Texas, has the highest poverty level (40%) and Fort Bend County, Texas, has the lowest poverty level (8.4%) (U.S. Census Bureau (2013b; 2013c).

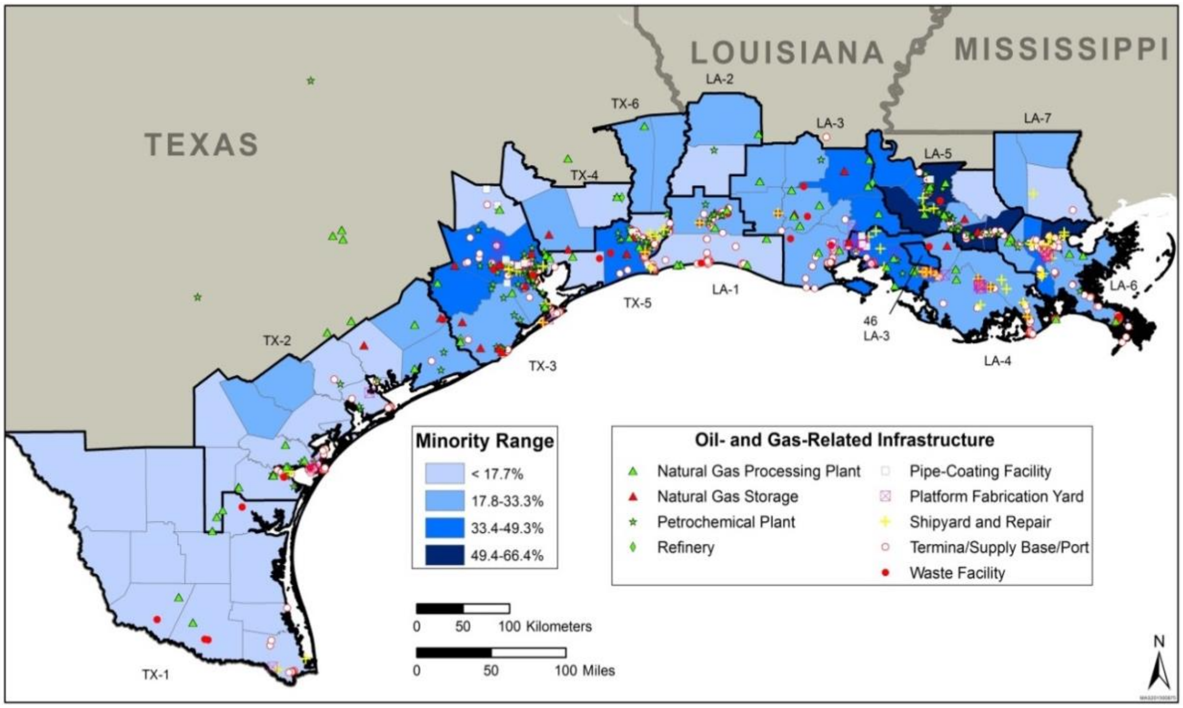


Figure 4.4.4-2. Percentage of Minority Populations in Texas and Louisiana in Relation to Oil- and Gas-Related Infrastructure.

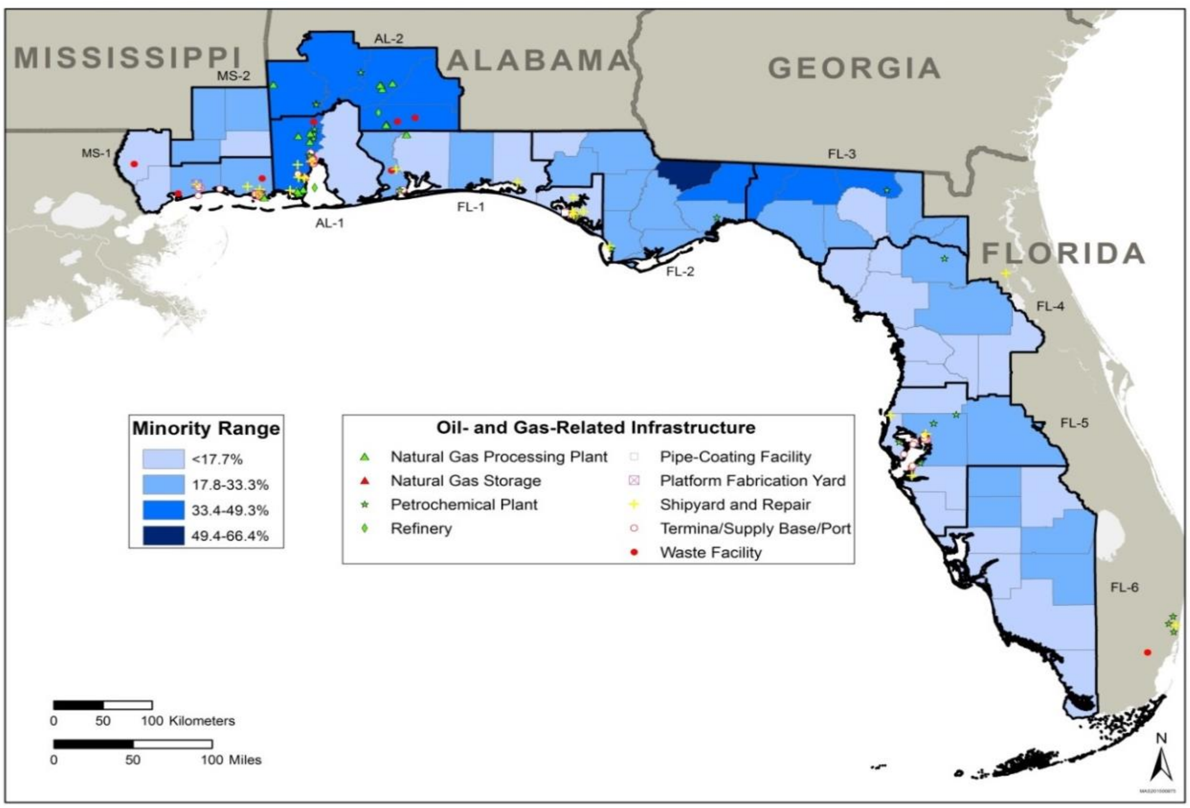


Figure 4.4.4-3. Percentage of Minority Populations in Mississippi, Alabama, and Florida in Relation to Oil- and Gas-Related Infrastructure.

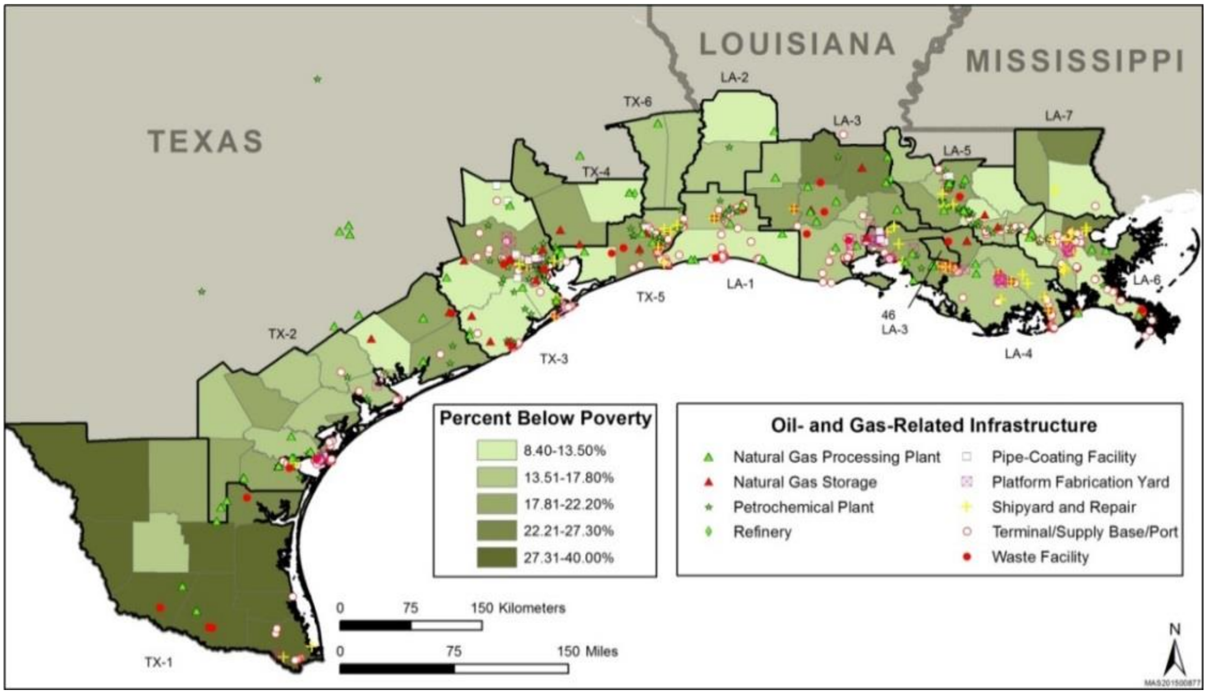


Figure 4.4.4-4. Percentage of Population Below Poverty in Texas and Louisiana.

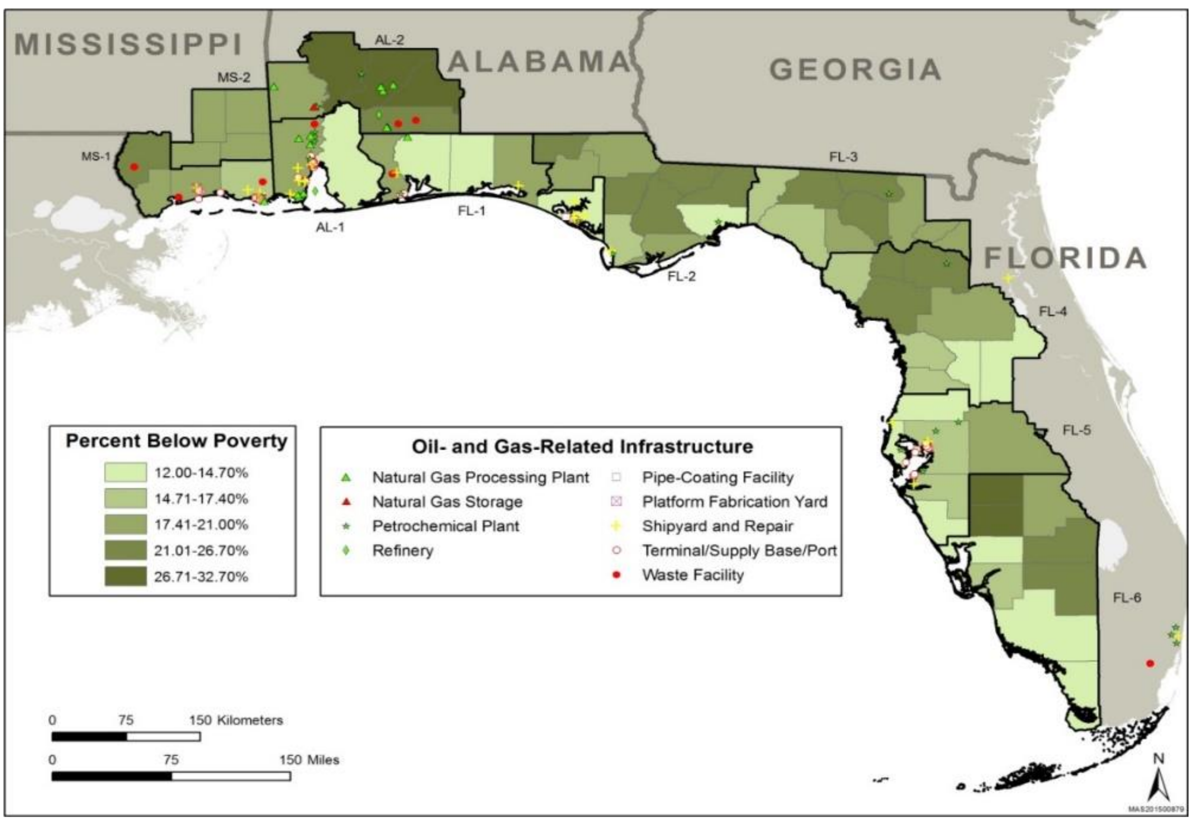


Figure 4.4.4-5. Percentage of Population Below Poverty in Mississippi, Alabama, and Florida.

Poverty and low income can be associated with food insecurity, or a lack of available, affordable, healthy food, which can be a problem in rural and urban areas that lack places to procure food. In 2018, the latest year data are available, nationally 11.1 percent of the non-institutionalized civilian population was food insecure, marking a 6-year trend of improvement and the first year that the rate fell to a pre-2008 level (Coleman-Jensen et al. 2019). Though much of the food-insecure population are also impoverished, as of 2017, 29 percent of the food-insecure population was above the threshold of 185 percent of the poverty line (Feeding America 2019). Of the five Gulf Coast States, Texas, Louisiana, Mississippi, and Alabama all had rates of food insecurity above the national average, though all saw declines in its rate between 2016 and 2018 (Coleman-Jensen et al. 2019).

While the COVID-19 impacts are still developing and, therefore, their extent is unknown. To date the virus has served to increase food insecurity across the United States (Feeding America 2020), with predictions that the impacts will last for over a year (Balogun 2020). Even before the impact of COVID-19, areas within the area of analysis were a food desert, including, for example, large portions of the four Rio Grande Valley counties (i.e., Starr, Willacy, Hidalgo and Cameron Counties) where there are few places to purchase food other than fast food and where the shrinking number of grocery stores are located far from the lowest income communities who lack the transportation to reach them regularly (Galvin 2018). Any food-insecure populations that fish or receive fish from their networks in a food desert would be more significantly impacted by changes in access to that resource. While the relationship between food insecurity, food deserts, and subsistence fishing is unknown, it is known that not all food-insecure populations are impoverished.

Access to transportation is also significant in a population’s ability to access food and, while linked to poverty and income, is separate from them. For this reason, this analysis assumes that a subset of the subsistence fishing population is transportation limited, more likely to fish close to home, and will be more significantly impacted by changes to fishing access. While linked, focusing analysis of food acquisition on poverty level risks missing subsistence fishers; therefore, though this analysis pays additional attention to low-income populations or those with limited transportation, it is not limited to them.

Regulatory Framework

Fishing in the five Gulf Coast States and the Gulf of Mexico is managed and regulated by the five states, NOAA Fisheries, and the Gulf of Mexico Fishery Management Council. In this region, there is no explicit regulatory category for subsistence fishing. Fishing regulations and permitting/licensing are divided into commercial and recreational, State and Federal waters, freshwater and saltwater, gear types, and species. While neither explicitly includes subsistence fishers in their considerations, both include provisions that may influence their use by subsistence fishers. Because regulations are very detailed and change regularly, a high-level overview is provided here, with a focus on aspects that influence their use for subsistence fishing.

Commercial fisheries regulations are designed to manage fishers who sell their catch for profit. They universally exclude the sale of game fish. Depending on jurisdiction, the boat, boat captain, gear, crew, or individual fish may need separate permits, licenses, or tags. This analysis focuses on State regulations because they cover inshore and nearshore fisheries that are most accessible to the widest range of subsistence fishers and include those aspects of the regulations that most directly impact subsistence practices, i.e., who the fisher can sell to and if they can keep other species.

In Texas, commercial anglers may sell their catch to dealers or non-dealers, but commercial shellfish harvesters must sell only to Certified Shellfish Dealers. Shrimpers may possess nongame fish taken by shrimp trawl, with restrictions, and may only fish recreationally from shrimp boats if the commercial plates are removed (Texas Parks and Wildlife Department 2020d), requiring them to be separate trips. In Louisiana, commercial fishers may sell to those who have a Wholesale/Resale Seafood Dealer License unless they have such a license themselves or have a Fresh Products License that allows sale directly to the consumer. Crabbers may retain a certain number and type of fish caught in crab gear for personal consumption; others must have a recreational license to take and retain game fish, though they are illegal to possess when using certain types of (Louisiana Department of Wildlife & Fisheries 2020a). In Mississippi, freshwater commercial fishers may "sell, resell, ship or purchase for resale" (Mississippi Department of Wildlife Fisheries & Parks 2020a) as may saltwater commercial fishers. Uniquely among the five states, in Mississippi, freshwater and saltwater commercial fishing are regulated by two different agencies, adding a layer of difficulty for anyone who might wish to hold both licenses. Mississippi law makes explicit provision for commercial shrimpers (Mississippi Code § 49-15-96) and oystermen (Mississippi Code § 49-15-46(7)) to retain certain other species for personal consumption without possession of a separate license. In Alabama, fishers may only sell their catch if it is a non-game species and they possess a fish dealer's license (Alabama Department of Conservation and Natural Resources 2019) or, in the case of saltwater fishers, if they sell directly to a licensed Alabama seafood dealer or are a seafood dealer (Alabama Department of Conservation and Natural Resources 2020b). Freshwater commercial fishers may not take game fish using commercial gear and may not possess game fish when using commercial gear (Alabama Department of Conservation and Natural Resources 2019). Saltwater commercial fishers may only possess game fish if they have a recreational (Alabama Department of Conservation and Natural Resources 2020b) license. In Florida, the regulations specify that commercial freshwater fishers may sell to anyone but may not purchase fish for resale (Florida Fish and Wildlife Conservation Commission 2020b) or possess game fish when using commercial gear (Florida Fish and Wildlife Conservation Commission 2020a). Fishers must have a saltwater commercial license to "Sell, barter or exchange for merchandise any saltwater products" and may only sell to those with a Wholesale Saltwater Products Dealer License unless they possess a Retail Saltwater Products Dealer License and may not take game fish with commercial gear (Florida Fish and Wildlife Conservation Commission 2020d). Though it is beyond the scope of this analysis to provide further detail on these regulations, this overview illustrates that commercial license holders may access multiple species at one time and that to whom they can sell their catch varies widely from state to state. This significantly alters the range of livelihood options available to fishers, precluding analysis of impacts at a Gulfwide scale.

In all states, recreational fishing is divided by water type (fresh or salt) and gear type, with free fishing for youth and reduced cost or free licenses for senior residents and some disabled residents. All states also have exemptions for fishing on certain kinds of private property or on licensed charter vessels, and free fishing days (Alabama Department of Conservation and Natural Resources 2020c; Florida Fish and Wildlife Conservation Commission 2020c; Louisiana Department of Wildlife &

Fisheries 2020c; Mississippi Department of Wildlife Fisheries & Parks 2020b; Texas Parks and Wildlife Department 2020b).

Two states have additional license options or exceptions relevant to subsistence fishing. In Louisiana, while residents must have a basic license, with additional fees for saltwater access, cane pole (pole without a retrieval mechanism) licenses are available at low cost to residents ($2.50 for the year) and are valid in any water type (Louisiana Department of Wildlife & Fisheries 2020c). In Florida, individuals serving in the Armed Forces and their families, and disabled veterans are exempt from basic fishing licenses, as are Florida residents in possession of a State-issued identification card providing their eligibility for food stamps, temporary cash assistance, or Medicaid when they fish for noncommercial purposes with poles without a line retrieval mechanism (cane poles) in their home county, on their homestead, or in saltwater from land or a structure attached to land (Florida Fish and Wildlife Conservation Commission 2020c). Both cane pole exceptions provide no or low-cost access to fishing for this culturally important gear type.

While subsistence fishing is enforced under the same laws as commercial and recreational fishing, as with those industries, those laws are not always obeyed. This can include fishing without the proper license, taking too many individuals or individuals of prohibited species, fishing in prohibited areas or with prohibited gear (Crow et al. 2013) or in areas that are closed due to pollution (USEPA, Office of Inspector General 2017e). Research outside the study area, in New York and New Jersey, found that fishers overestimate their own knowledge and belief that fish are safe, leading them to consume potentially hazardous amounts of fish from an estuary known to be polluted (May and Burger 1996). While outside the area of interest and dated, this research corroborates what is known about risk perception in the general population and is therefore likely valid for the area of analysis as well. Within the Gulf Coast States, in an analysis of Florida Fish and Wildlife Conservation Commission citations for wildlife offenses in 2006, (Crow et al. 2013) identified gender and racial disparities in wildlife crime, with white males significantly more likely to be cited, as well as regional variation. The authors note that minorities are more likely to be charged with crimes associated with subsistence fishing, i.e., African Americans and Hispanics as more likely than whites to be charged with crimes associated with subsistence fishing (permitting and illegal possession of fish) while whites and Hispanics are more likely to be charged with crimes associated with illegal fishing methods. They also note that enforcement priorities appear to differ across regions, though they caution that further study is needed on that point. While these findings are the results of a single study directly applicable to Florida, they point to patterns of differential use of natural resources between whites and minorities that are consistent with findings from related studies in other states, with whites associated with more expensive gear than minorities. It is not clear from their analysis if the crimes were committed intentionally or because of a lack of understanding or awareness of the laws.

Minority groups may also have difficulty in their relationships with resource managers and enforcement agencies, as identified by Crow et al. (2013). Schewe et al. (2019) analyzed participation of Vietnamese-American fishers in coastal Louisiana, Mississippi, and Alabama in collaborative resource management of commercial fisheries. They found that mistrust, language barriers, and use of digital technologies by management agencies limit opportunities for participation by community members, but citizen-science, when well designed, can facilitate community engagement. Though focused on participatory management and not enforcement actions, this is illustrative of the relationship between this population and resource managers as a whole.

While laws and regulations, and advisories are not always obeyed, intentionally or not, they still serve to limit and bound the use of the resource. This has implications for resource management and analysis of the impacts of an action. Though it is not known how much fishing activity occurs legally, this analysis assumes that most, but not all, fishing occurs legally and that laws and advisories will be followed more in areas where they are clearly posted in languages and formats easily understood by the population that fishes that area.

Practice of Subsistence Fishing in the Gulf of Mexico Region

The division of subsistence fishing practice between commercial, recreational, and those who are not required to carry a license means that there is no official record of fishers, effort, or catch. Additionally, the practices are poorly understood. Multiple studies in the region have targeted subsistence fishers or discuss them as part of a larger population, allowing for some understanding of these practices. On the whole, the studies are targeted on one or a small set of locations and illustrate a range of potential practices and impacts. Though many of these studies reference research from outside the area, given the locally specific nature of subsistence practices, this analysis focuses primarily on research from within the greater region.

Fishing and the offshore oil and gas industry have a long, closely intertwined history in Louisiana. In a study of the history of the offshore oil and gas industry in southern Louisiana, the authors describe the evolution of practices and development of onshore oil and gas practices and the practices of local mariners, fishermen, and residents to this new facet of the oil and gas industry, noting that fishing persisted as a livelihood strategy in conjunction with offshore oil and gas employment, either simultaneously or during downturns in the oil industry (Austin 2008; Austin et al. 2002a; 2008; McGuire 2008; Sell and McGuire 2008).

In Louisiana, Hemmerling and Colten (2017) identified potential impacts of OCS oil- and gas-related hazards on minority and low-income populations in three coastal parishes (i.e., Lafourche, Jefferson, and St. Bernard) using GIS techniques to integrate the locations of OCS oil- and gas-related activities, census data, and transportation data from the early 2000s, with attention to freshwater fish and other key subsistence resources. This study identified oil and gas infrastructure, areas of hunted or fished wildlife potentially impacted by that infrastructure, and the proximity of minority populations that could be at risk if they relied on those resources and an issue were to arise. For freshwater fish habitat the results were mixed. Only in Jefferson Parish did minority populations have differential likelihood of living near potentially impacted fish; the Asian population was more likely to live in those areas while the African-American population was much less likely to live in proximity. Though the data underlying this study are almost 20 years old, it documents the extremely location-specific nature of the relationship between populations, infrastructure, and resources.

The first systematic study of subsistence in coastal Louisiana was Walton and Regis (2019). It is their definition of subsistence that BOEM uses in this analysis. Focusing on subsistence practices, which they also term hunting and harvesting, in Terrebonne and Lafourche Parishes in the early 2010s, they find that subsistence is widespread and deeply engrained in local culture and practice. In the study area, subsistence practices are used as part of larger livelihoods for households and families that often involve many strategies, including hunting, fishing, gardening, sharing, and wage employment. Though many study participants spoke of the direct economic benefits, some noted that they lost money on particular forms of subsistence but continued to practice them because of their cultural, emotional, or social importance. In general, participants cited the overwhelming importance of social and cultural gains, including time spent with relatives, children learning how to be a member of the family and society (socialization), ability to provide food for large family gatherings, time outside, sport or recreation, and connection to heritage. This heritage is tied to ethnicity and regional identity, and the authors note that subsistence practices, their meaning, and use are complex and place-specific; therefore, their results may not apply to other places and communities. They documented species used, including 12 kinds of fish, 4 types of shellfish, game animals and birds, domesticated animals, and dozens of wild and domestic plants. This study emphasizes the widespread nature of the practice within the region and the place-specific nature of how it is carried out.

Austin et al. (2014a; 2014b) discuss the short-term impact of the *Deepwater Horizon* oil spill on coastal communities, including subsistence fishing. They document the importance of subsistence fishing to livelihood strategies of residents of coastal Alabama and Louisiana, including Native American, Vietnamese, white, and African American residents, to feed themselves, their families, and their friends and neighbors. Separate research on the social impacts of the *Deepwater Horizon* oil spill indicates that the recovery of fishermen has been uneven, full recovery has not yet been attained, and the coastal fishing communities in Louisiana have been faced with the most lasting negative impacts (Halmo et al. 2019).

Outside the area of analysis, but within a coastal state in an area with similar social relations, a number of studies have been conducted by a group of researchers in the Mississippi Delta. Brown et al. (1998) analyzed participation of white and African American residents of two Mississippi Delta communities in subsistence practices (including fishing) for lifestyle or economic reasons. They found that fishing participation for both African American and white fishermen has both social and economic dimensions, though different, and participation for social reasons may prevent participants from achieving economic growth in other ways, such as by moving away from opportunities and towards educational and economic opportunities. Continuing the same research, Brown and Toth Jr. (2001) determined that participation of African American and white residents is based on culture that structures where they fish and for what species, what licenses and gear they use, and how they distribute their catch. For example, many of the white fishermen they interviewed held commercial licenses to get access to more efficient gear that they could use to increase their catch for personal use or to give it away, often to be used for public events such as fundraiser fish fries, though some sold part of the catch to pay for expenses. They emphasize the cultural and social importance of fishing and the social status that giving away the catch brought the fishermen, noting that some fishermen reflected that the practice cost them money. In contrast, African American fishers tended to fish nearby and more frequently, in part because of possession limits for their preferred species. They also predominantly used cane poles, regardless of their financial capacity, which are a simple and inexpensive gear efficient for fishing in small spaces that has great cultural importance for the community. However, more landowners posted their land, limiting availability of this resource. They share their catch with a small number of close family and neighbors. The authors find fishing to perpetuate race relations rather than alter them. In addition to being a food source, both African Americans and whites use fishing for food security, social contact, and social status and security. In previous research, Brown et al. (1996) noted that African American fishers in the Mississippi Delta preferred to walk to small ponds where they could fish from the bank with cane poles, and fishing skills are often taught by the mother. This set of research illustrates the differences in cultures and strategies of regional subpopulations. It also speaks to the location-specific nature of economic and social strategies and how these can be differentially impacted with changes in access.

In coastal Mississippi, research undertaken during 2010 and 2011 found that, in Pascagoula and Moss Point, Jackson County, there were two kinds of subsistence fishing practices associated with blue crabs: a livelihood strategy and a lifestyle choice (Harrison 2014). In other words, subsistence fishers did so out of economic necessity or because they had the economic security to choose this as their lifestyle, yet each group also reported many of the most important rewards as social and cultural. To cope with the variability in fishing success, they employed multiple strategies, including use of multiple gear types, preserving food, reliance on additional wild and cultivated foods, and sharing their catch. The author reports that African American fishers were more likely to be low-income than white fishers, fish from piers or banks, give fish to relatives and friends, and participate in a distinct livelihood strategy where they used inexpensive gear to catch fish of multiple species, then sell or barter some of the catch to pay for gear and household items. Anglo-Americans were more likely to participate in lifestyle subsistence fishing and fish from boats, and ranked fishing for sport as more important than fishing for food. Harrison (2014) supports the observation that subsistence fishing occurs in the region of residence. Multiple elements of these strategies would or could be illegal in other states, depending on the license held, namely fishing with multiple gear types and selling or bartering some of the catch. In addition to illustrating specifics of subsistence practice in this area, this study further illustrates its locally specific nature.

In the Tampa Bay area, a study of food insecurity and clients at a food pantry found that a strategy used by some to meet their food needs was receiving fish caught and shared by others but that none reported fishing themselves (Arriola 2015). Similarly, another study of the Tampa Bay area found that people experiencing food insecurity would receive food from or trade food with families, neighbors, and friends, though what food they received or traded was not reported (Amador 2014). More recent, preliminary research has found that while a minority of beach, dock, and bridge fishers' fish specifically to eat, a majority keep their fish (Parsons 2019); though these results are limited, additional research is planned. Collectively, these studies illustrate that subsistence fishing can be present in urban areas and form a key part of livelihood even for populations that do not fish themselves.

Collectively, the above studies provide key insights into understanding subsistence fishing practice. First, people from diverse backgrounds practice subsistence fishing. It is not limited to people of particular socioeconomic groups or ethnic backgrounds, though culture and social and economic resources influence how individuals and groups participate and their ability to find substitutes for the benefits they gain from subsistence fishing. Second, while subsistence fishing is, by definition, associated with providing food, it is often much more than that and contributes to the development and maintenance of culture, socialization, social connection, relaxation/recreation, and expression of values. Third, it is location specific as the legal and ecological conditions, cultures, and social relations that constrain or encourage its practice vary from place to place. Fourth, for most, it is one of a number of strategies used to make up livelihoods or, for some, to try to attain food security. It is not, however, tied to being low income as some low income in proximity to fishing do not fish.

4.4.4.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and subsistence fishing. **Figure 4.4.4-6** provides a synopsis of the IPF categories that currently affect or have the potential to affect subsistence fishing in the Gulf of Mexico region. Following **Figure 4.4.4-6** is a summary of those potential effects on subsistence fishing, as well as a brief discussion of the IPF categories identified in **Figure 4.4.4-6** that are not likely to affect subsistence fishing, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to subsistence fishing, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

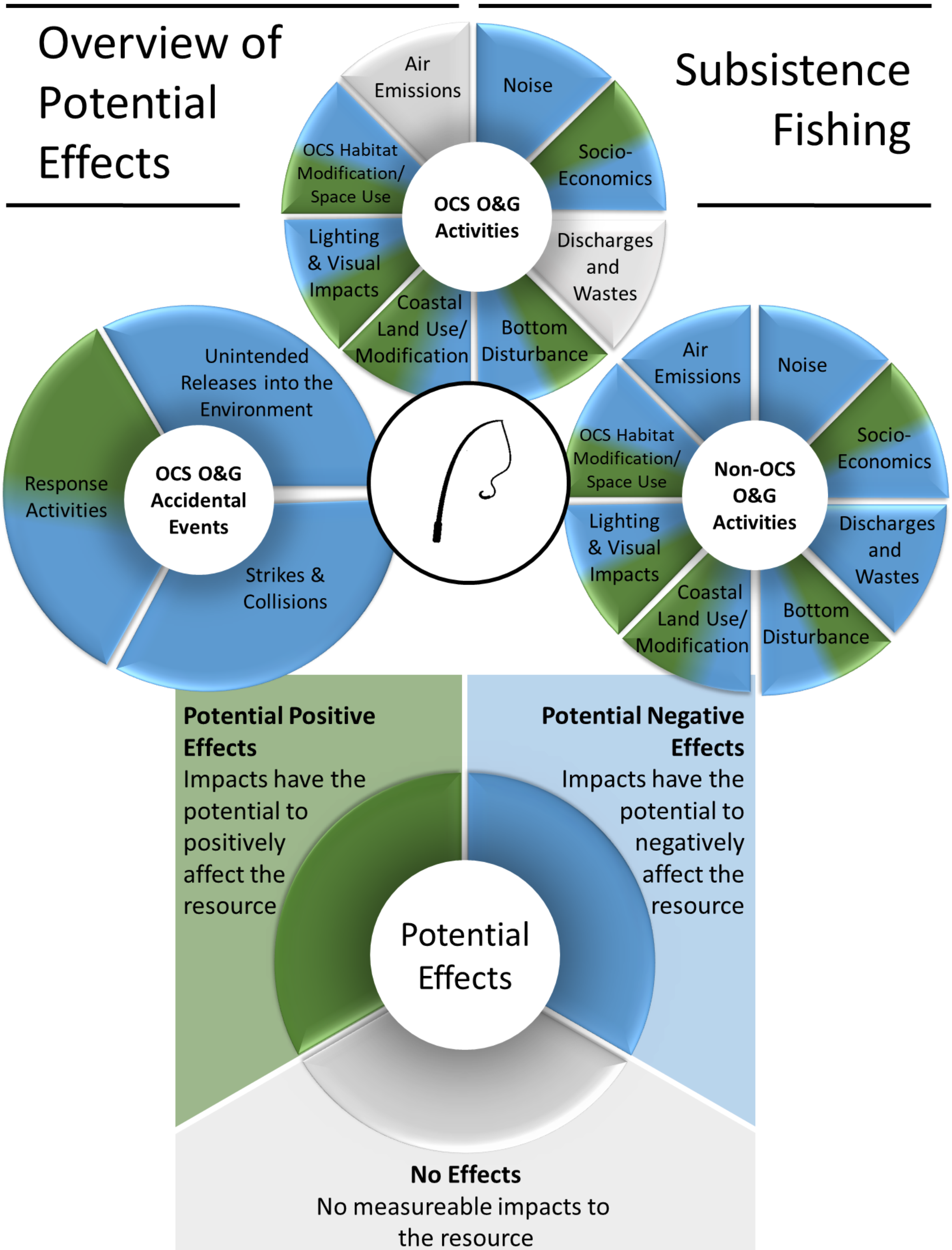


*Figure 4.4.4-6. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Subsistence Fishing. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.4.4.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.4-6 highlights the IPF categories of non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect subsistence fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Subsistence fishing depends on the health of the targeted species. Although air emissions from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Air emissions resulting from non-OCS oil- and gas-related activities may have negative effects on coastal habitats upon which many of these species depend. Air pollutants result from manmade and natural sources (e.g., vehicle emissions and wildfires) and contribute to increased CO_2, leading to ocean acidification, which can negatively affect fish and invertebrate resources health and their habitats. Refer to **Chapter 4.1** (Air Quality), **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.5** (Cultural, Historical, and Archaeological Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional details on air quality and the effects of air quality on resources. To the extent that air emissions can negatively affect coastal habitats and fish and invertebrates, subsistence fishing can also experience negative effects in terms of reduced aesthetic enjoyment and catches. For information on the potential effects of non-OCS oil- and gas-related air emissions on fishers themselves, refer to **Chapter 4.4.6** (Social Factors); for information on the regulations that limit air emissions, refer to **Chapters 2**, **4.1, and 5**, and the Gulf of Mexico OCS Regulatory Framework technical report (BOEM 2020c).

Discharges and Wastes (Chapter 2.2.2)

Discharges and wastes from natural seeps, nonpoint source runoff, sewage, and non-OCS oil- and gas-related human sources can have negative effects on subsistence fishing by influencing species abundance and distribution, access, and safety for consumption. The biological impacts of discharges and wastes are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Non-OCS oil- and gas-related discharges and wastes such as spills from imports or State oil and gas activities, nonpoint source runoff, and sewage releases can close areas to fishing or lead to fish consumption advisories for various lengths of time depending on the content, size, timing, and location of the pollution event, and may be accompanied by cleanup or restoration efforts. Namely, discharges and wastes have the potential to effect subsistence fishers' access to fish and shellfish by physically occupying fishing areas, blocking access routes to fishing areas, or leading resource managers to institute fishing closures or fish advisories due to health and safety concerns if the substance(s) spilled have rendered the fish unsafe for human consumption. Given that subsistence populations may eat significantly more fish than the general population, have additional risk factors for environmental contamination, and may not be aware of or respect fishing closures and advisories, the effectiveness of these closures and advisories at protecting their health is unknown.

Conversely, it is possible that, in the case of a highly publicized spill or release, public concern over fish and shellfish safety will encourage subsistence fishers to not eat the resources, contributing to food insecurity. While there are laws and regulations designed to limit human consumption of unsafe fish, they are not always effective due to poor dissemination of the information, language barriers and lack of understanding on the part of fishers and consumers, or fishers' choice to not follow regulations. Additionally, action is not always taken to protect subsistence fishers through limiting consumption because the locations of pollution are not always known. If the location of pollution is not known, such as in the case of an unreported oil spill or an undetected septic tank leak, subsistence fishers and resource managers may not be able to take action to prevent or limit consumption of the affected fish. The biological consequences of these changes are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbance occurring from non-OCS oil- and gas-related human activity (i.e., dredging, construction, and State pipeline installation or decommissioning) and non-human activity (weather events; refer to **Chapter 3.3.1**) can negatively affect subsistence fishing. These activities can destroy or disrupt habitat by physically occupying areas, encouraging erosion, or changing water quality and increasing sedimentation. These changes can be temporary or permanent and influence species abundance and distribution at the local level, thus reducing their availability to subsistence fishers. The biological consequences of these changes are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Conversely, the installation of structures, including production structures related to State oil and gas activities and artificial reefs, could enhance reef fish habitat and thus improve subsistence fishing opportunities by congregating some fish populations near the structures. Accessible fishing structures can lead to an increase in availability of fish to subsistence fishers. The biological effects of artificial reefs are discussed in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.2)

Although sound from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by non-OCS oil- and gas-related activities may negatively affect subsistence fishing. Noise from vessels, military activities, dredging operations, and in-water construction can negatively affect fish behavior and distribution. Anthropogenic sound could also cause displacement or physical harm or fatalities to fish populations. While these effects are mostly transitory, fish may avoid or behave differently in harbors and waterways that see constant vessel use or experience other noise. In areas where these waters can be accessed from shore or from bridges, underwater noise may lead to reduced catch for subsistence fishers. This is described in **Chapter 4.3.4** (Fish and Invertebrates) and BOEM's Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.2)

Although coastal land use from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Coastal land use can negatively or positively affect subsistence fishing, though most of the effects are negative. Disruption or destruction of habitat through coastal development; land loss; changes in sedimentation, salinity, or water quality; microorganism abundance and distribution; impacts from weather (i.e., hurricanes and other storms, drought; refer to **Chapter 3.3.1**); and pollution can affect species abundance and distribution at the local level. This is described in greater detail in **Chapter 4.3.1** (Coastal Habitats and Communities), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). While this mostly reduces subsistence fishers' access to affected species, in some cases loss of habitat for one species can increase available habitat for another, making them more available to fishers. Coastal restoration projects can restore or build new habitat for species or access points for fishers, though this can come at a cost to access points or habitat for other species; therefore, the effects on subsistence fishing can be positive or negative. Pollution associated with coastal land development can render species unsafe for human consumption and lead resource managers to institute fishing closures or fish advisories due to health and safety concerns. Given that subsistence populations may eat significantly more fish than the general population, have additional risk factors for environmental contamination, and may not be aware of or respect fishing closures and advisories, the effectiveness of these closures and advisories at protecting their health is unknown. Coastal development can also positively or negatively influence access to fishing areas by either creating new access points (docks, piers) or routes for access (canals, roads) or by closing existing access points by installing other infrastructure on top of them, blocking access routes or limiting public entry.

Lighting and Visual Impacts (Chapter 2.6.2)

Although lighting from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates] and **Chapter 4.3.1** [Coastal Communities and Habitats]), localized effects to fish may occur. Light attracts fish at night. Lights are installed on fishing piers for that purpose, which can increase subsistence fishers' access to fish. Light can also provide safety for fishers who use those piers. If lighting is installed on private docks inaccessible to fishers near unlit fishing sites, this may negatively affect their access to fish in that area. Refer to **Chapter 4.3.4** (Fish and Invertebrates) and BOEM's Biological Environmental Background Report (BOEM 2021b) for a discussion of the biological effects of lighting and visual impacts on fish. Visual impacts (other than lighting) from the presence of non-OCS oil- and gas-related activity and infrastructure are not expected to influence the abundance and distribution of subsistence fishing species, access to those species, or their safety for consumption. While the presence of visual impacts may alter the subjective experience of fishers by changing the character of an area, it is not expected that these changes would be great enough to disrupt their fishing activity, particularly for the most vulnerable populations that fish for consumption. Whether visual changes could negatively affect culturally significant uses is unknown.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Although offshore habitat modification and space use from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates]), localized effects to fish may occur. Offshore habitat modification and space use can have negative and positive effects on subsistence fishing. Installation of artificial reefs, non-OCS oil- and gas-related (State) platforms, and potentially renewable energy installations can create habitat and aggregate many species of recreationally and commercially important fish, making them easier for subsistence fishers to find. Structure removal eliminates a concentrated fishing spot but makes the area available for other kinds of commercial fishing use. The biological consequences of these changes are discussed in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Other uses, such as transportation lanes or areas reserved for military activities, can temporarily or permanently limit access to areas, reducing their availability for subsistence fishing.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Socioeconomic drivers from non-OCS oil- and gas-related activities are complex and can have both positive and negative effects on subsistence fishing. Subsistence fishing is influenced by changes in species distribution and abundance, which is influenced by many factors, including human-instigated changes in habitat (i.e., development and restoration activities, as described in the "Coastal Land Disturbance/Modification" and "Offshore Habitat Modification/Space Use" sections of **Chapter 4.4.4.2.1**), management regimes, and human exploitation of the species. Human-instigated changes in habitat are influenced by economic climate and social and cultural patterns and preferences. For example, preferences for urban and suburban residence drive development as people move into those areas, causing habitat fragmentation and increases in pollution. Management of species regulates access and contributes to changes in abundance by altering human use through increases or decreases in access to that species.

Other influences on human use include laws, regulations, and practices, influencing public and private land access and boat use, and global and local economic and social shifts that influence employment, recreation, and consumption, including competition for access to coveted species of fish. For example, culinary trends contributed to a surge in popularity of red snapper, thus increasing pressure on the species. Resource managers responded by imposing strict catch limits. Red snapper is therefore less available for subsistence fishing due to increased competition from commercial and recreational fishers and regulation.

Subsistence fishers' health is also positively and negatively affected by the safety of the fish they consume. This can be influenced by changes in pollution management (i.e., new or revised regulations, changes in enforcement, pollution mitigation, or cleanup programs), calculation and communication of consumption risk, public comprehension and perception of that risk, and public health factors that influence risk levels.

For commercial fishermen who eat or share some of their catch, fluctuations in the commercial fishing industry, including dock prices, fuel prices, the cost of labor, insurance requirements, and length and timing of seasons, will factor into their ability and desire to fish. This, in turn, will impact their social networks who are accustomed to receiving part of the catch. If seasons close early or if it is not financially feasible to fish, they and their networks may lose access to the part of the catch that is not sold on the market.

4.4.4.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.4-6 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect subsistence fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Bottom Disturbance (Chapter 2.3.1)

Although bottom disturbance from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), bottom disturbance, including that resulting from the installation and decommissioning of platforms, pipelines, cables, and other OCS oil- and gas-related structures can have negative effects on subsistence fishing. These activities can destroy or disrupt habitat by temporarily or permanently physically occupying areas, encouraging erosion, or temporarily causing changes in water quality and sedimentation. This changes species abundance and distribution at the local level and, therefore, can reduce a species' availability to subsistence fishers. If bottom-disturbing activities occur at significant times for subsistence fishing, impacts could be more significant. Refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional details on the potential effects of bottom disturbances to localized fish and invertebrate populations. Conversely, OCS oil- and gas- related structures could enhance reef fish habitat and thus improve some subsistence fishing opportunities by congregating fish populations near the structures. The biological effects of infrastructure as reefs are discussed in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.1)

Although sound from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by routine OCS oil- and gas-related activities may negatively affect subsistence fishing indirectly through displacement, physical harm, or fatalities to localized fish populations. The severity of these effects would be based on the vulnerability of fish and invertebrate populations. Disturbances to those populations can have proportionate negative effects on subsistence landings. Detailed descriptions of the potential effects of anthropogenic sound to fish and invertebrates are provided in **Chapter 4.3.4** (Fish and Invertebrates) and BOEM's Biological Environmental Background Report (BOEM 2021b).

Coastal Land Use/Modification (Chapter 2.5.1)

Although coastal land use from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates, and **Chapter 4.3.1**, Coastal Communities and Habitats), localized effects to fish may occur. Coastal land use related to OCS oil- and gas-related activities includes placement of infrastructure (i.e., pipelines, buildings, docks, and roads), maintenance dredging, and canal creation. Changes in onshore infrastructure can impede or facilitate onshore and boat access to fishing areas, as well as species abundance and diversity. The biological effects to fish and their habitats from coastal land use is described in detail in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). These activities have the potential to positively or negatively affect subsistence fishers' access to fish. The OCS oil- and gas-related coastal land use can expand subsistence fishing access by providing or maintaining roads, docks, and canals that increase fishers' access to the resource, if those structures are open to their use. These same activities can also negatively affect subsistence fishing access if they close areas to public use, disrupt species abundance and distribution through habitat destruction or alteration, or if increased vessel and road traffic impedes access. Pollution and runoff from OCS oil- and gas-related coastal land use may also prevent subsistence fishing use through fishing closures and advisories or through warranted or unwarranted public concern.

Lighting and Visual Impacts (Chapter 2.6.1)

Although lighting from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates, and **Chapter 4.3.1**, Coastal Communities and Habitats), localized effects to fish may occur. Lighting from routine OCS oil- and gas-related activity may positively or negatively affect subsistence fishers' access to fish by aggregating fish near docks or other OCS oil- and gas-related structures. If fishers can access these areas, it may improve their catch; if they cannot and the light serves to attract fish away from fishing areas to which they have access, it may decrease the available catch. Refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional details on the effects of lighting on fish. Visual impacts (other than lighting) from routine OCS oil- and gas-related activity, including the visual presence of onshore and offshore infrastructure and vessels are not expected to influence the abundance and distribution of subsistence fishing species, access to those species, or their safety for consumption. While the presence of visual impacts may alter the subjective experience of fishers by changing the character of an area, it is not expected that these changes will be significant enough to disrupt their fishing activity, particularly for the most vulnerable populations that fish for consumption. Whether visual changes could negatively impact culturally significant uses is unknown.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Although offshore habitat modification and space-use conflicts from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4** [Fish and Invertebrates]), localized effects to fish may occur. Offshore habitat modification/space use resulting from routine OCS oil- and gas-related activities can have negative and positive effects on subsistence fishing. Installation of offshore platforms can create habitat and aggregate many species of recreationally and commercially important fish, making them easier for fishers to find. Platform decommissioning eliminates that fishing spot but makes the area available for other kinds of commercial use, such as shrimp trawls. Platforms that are converted to artificial reefs would continue to provide the fish aggregation benefits. The biological consequences of these changes are discussed in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Other uses, such as transportation lanes or areas reserved for military activities, can temporarily or permanently limit access to areas, reducing their availability for subsistence fishing.

Socioeconomic Changes and Drivers (Chapter 2.8.1)

Socioeconomic drivers associated with routine OCS oil- and gas-related activity can positively or negatively affect subsistence fishing. Changes in work schedule and industry cycles can influence fishers' desire and ability to participate in subsistence fishing. These interactions are complex. Oil and gas and support industry workers have a long history of using fishing to mitigate industry cycles and some choose to work in the industry because it allows them time off to fish. Changes in scheduling that impact the amount of continuous time spent at work, movement of centers of industry employment out of rural areas to places more distant from fishing resources, and the general wellbeing of the offshore oil and gas industry can therefore promote or complicate employees' engagement in subsistence fishing.

Walton and Regis (2019) note that subsistence fishing fits into a set of livelihood strategies, which often include wage employment. Employees of offshore oil and gas companies would be employed, and therefore would practice subsistence as an additional strategy. There is some evidence that oil and gas employment, and specifically the schedules worked, allowed workers to engage in subsistence practices and that, for some, this was a key factor in the industry's attractiveness. In a study of New Iberia Parish and Morgan City, Louisiana, on the impacts of the offshore oil and gas industry on industries and families and multigenerational attitudes towards work in the offshore oil and gas industry, Austin et al. (2002a; 2002b) found that the offshore oil and gas and fishing remained interrelated through the 1990s. Workers and their families used subsistence fishing to supplement their livelihood during downturns in the offshore oil and gas industry, and workers liked working offshore jobs with schedules of a week or two on followed by a week off because it allowed them to continue fishing for socialization and recreation, to provide for their family, and to fish with their children. As industry norms on scheduling and length of time offshore evolve, families adjust their subsistence fishing and participation. In recent decades, when downturns in offshore oil and gas and commercial fishing have overlapped, or at times such as after the *Deepwater Horizon* explosion, oil spill, and response, when areas saw closures of both, it has been more difficult to rely on commercial fishing as a support when offshore oil and gas activity and associated employment is down. It is not known how families and individuals have adapted their subsistence practices to these shifts in industry cycles and norms. Where centers of industry employment have moved from Louisiana to urban areas outside the state, most especially the Houston area, it is not clear that employment in the industry serves the same purpose by facilitating subsistence practices, though it is possible that it does so in different ways.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that air emissions and pollution, and discharges and wastes are not likely to affect subsistence fishing. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed OCS oil and gas lease sales.

Air emissions and pollution, and discharges and wastes would not likely affect subsistence use because they are not expected to alter the location, abundance, or safety for consumption of the fish and shellfish species targeted by fishers, as discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b), nor are they expected to influence coastal land use by subsistence fishers. Studies have shown that regulations and environmental conditions do not alter the location where subsistence fishers find food and that subsistence fishers continue to fish in preferred areas, even if fishing is prohibited in areas or an area is polluted (Crow et al. 2013; May and Burger 1996; USEPA, Office of Inspector General 2017e). In addition, as detailed in **Chapters 2.1 and 2.2**, air emissions and discharges and wastes related to routine OCS oil- and gas-related activities are regulated and monitored and very unlikely to affect subsistence fishing because neither air emissions nor wastes and discharges from OCS oil- and gas-related activities are anticipated to exceed regulated levels, and therefore, they are not considered likely to cause effects to fish and invertebrate resources (refer to **Chapter 4.3.1**, Coastal Communities and Habitats; **Chapter 4.3.4**, Fish and Invertebrates; and BOEM's Biological Environmental Background Report (BOEM 2021b) or their catch.

4.4.4.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.4-6 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect subsistence fishing in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Unintended releases into the environment from OCS oil- and gas-related activities such as oil or chemical spills have the potential to negatively affect subsistence. Accidental releases have the potential to reduce subsistence fishers' catch by negatively affecting fish health and contaminating their habitat, as well as affect subsistence fishers' access to fish and shellfish by physically occupying fishing areas, blocking access routes to fishing areas, or leading resource managers to institute fishing closures or fish advisories due to health and safety concerns if the substance(s) spilled potentially has rendered the fish unsafe for human consumption. Given that subsistence populations may eat significantly more fish than the general population, have additional risk factors for environmental contamination, and may not be aware of or respect fishing closures and advisories, the effectiveness of these closures and advisories at protecting their health is unknown. Conversely, it is possible that, in the case of a highly publicized spill or release, public concern over fish and shellfish safety would encourage subsistence fishers to not eat resources that would be safe for consumption, contributing to food insecurity. The biological consequences of the effects of oil spills on fish and invertebrates are discussed **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Spills occurring at economically important times for a fishery or the community supported by the fishery, such as times with low prices or demand, near the opening or closing of a season, when the fishery or community is recovering from a disaster or disruption (e.g., hurricane, economic shock, and fishery closure), would have increased the effects by removing additional resources from subsistence fishers that are already struggling. Spills that occur when the community and fishery are booming or doing well, conversely, would have reduced effects. Spills taking place near shore fishing areas close to low-income or minority populations would have additional economic or social effects if they impede access to fishing grounds or target species die or relocate, depriving the users and their social networks access to the resource. These effects will be particularly felt by those who do not have regular access to transportation to access farther fishing areas that are farther away.

Accidental spills could have the potential to impact subsistence fishers' access to fish and shellfish by physically occupying fishing areas or blocking access routes to fishing areas. The presence of spilled materials, disabled vessels, damaged infrastructure due to vessel collision, or cleanup/repair/salvage personnel and equipment could block access to areas fished from shore or by boat. Accidental events that occur near legal boundaries, such as saltwater and freshwater boundaries or State and Federal water boundaries, that result in closed waters, can prevent access or divert fish populations from one jurisdiction to another. The inability to access areas can affect fishers' physical and legal access to the resource if they are only licensed or permitted to take fish in the jurisdiction that is closed or inaccessible. The length of time that the social and economic effects could last would depend on the nature of the accidental event, the sensitivity of the area, and decisions made about the timing and nature of cleanup and restoration activities, if any occur.

While fishers may be eligible for compensation for catch lost due to industry accident, depending on the size and nature of the event, compensation processes can be unequally accessible to subsistence fishers. A study on the *Deepwater Horizon* explosion, spill, and response (Austin et al. 2014a, 2014c) researched and documented its complex and varied effects on communities, including fishing activity, and described the changes and difficulties associated with filing subsistence claims in the British Petroleum claims process (Austin et al. 2014b). Many of the claims were initially rejected because a subsistence claim category was not available until 2012 and many claims were not formally documented due to the informal nature of subsistence fishing. Claims administrators, however, wanted claims to be well documented, resulting in tension between subsistence fishers and claims administrators (Austin et al. 2014b). Key to success in the claims process was the professionalization of a business or fisher's documentation before the spill and access to information and technology literacy, familiarity with bureaucratic processes, and an English-language speaker. While effects from reasonably foreseeable spills or other accidental events would be less severe than those described in these reports, which detail effects of a catastrophic spill that is not reasonably foreseeable, the types of effects could be similar in content. As noted by Schewe et al. (2019) and described in greater detail above, Vietnamese American fishers in coastal Louisiana, Mississippi, and Alabama are challenged in their relationship with resource managers by mistrust, language barriers, and use of digital technologies, all of which could be exacerbated in the case of an accidental event. Given these findings, communities with limited English language abilities or limited formal education or professionalization may face particular challenges accessing compensation in future spills. For more information on a catastrophic spill, refer to the *Gulf of Mexico Catastrophic Spill Event Analysis* (BOEM, 2021c).

In the case of a spill, fish can be rendered unsafe for human consumption. Safe levels of contaminants for human consumption are set by the U.S. Department of Agriculture, USEPA, the States, and Tribes (USEPA, Office of Inspector General 2017e). If contamination results in closures of fishing areas, this would have heightened impact on subsistence populations who do not have ready access to transportation to other areas. In addition, there could be effects to fishers that hold a particular species that is only available in the closed area in high importance.

Even if there are fisheries closures resulting from contamination, there may or may not be adverse effects from contamination on subsistence fishers. First, fish consumption levels are not, on the whole, designed to account for minority or subsistence populations' level risk, who may have additional risk factors or consume significantly more of a species than was assumed when the consumption levels were set. Second, as discussed above, even when contamination problems are static and known, advisories are not always followed. In the case of a spill, there may be additional problems publicizing fish advisories if the spill is small or unknown, and subsistence fishers may eat or give away contaminated catch without their knowledge. Third, given the above, the public may reduce their consumption of local fish below levels that would be unsafe. In the case of a larger or highly publicized spill, public anxiety about health impacts may stop residents from consuming fish that are safe to eat and may prevent fishers who sell part of their catch from going out to fish if markets dry up. After the *Deepwater Horizon* explosion, oil spill, and response, the market for many Gulf of Mexico fisheries collapsed, including product that was not impacted by the oil spill, due to concerns about seafood safety (Austin et al. 2014b). A similar pattern was found among Native Alaskan subsistence fishers in Alaska after the *Exxon Valdez* oil spill, where they limited their harvests because of health concerns (Fall 1991). While the effects from a reasonably foreseeable spill would be less than what occurred after the *Deepwater Horizon* or *Exxon Valdez* oil spills, they are illustrative of the type of reaction that could be expected.

Response Activities (Chapter 2.9.2)

Spill-response activities have the potential to negatively affect subsistence fishers' access to fish and shellfish by physically occupying fishing areas or blocking access routes to fishing areas. While fishers may be eligible for compensation for catch lost due to industry accident, depending on the size and nature of the event, compensation processes may not be fully accessible to all subsistence fishers and communities with limited English language abilities or limited formal education or professionalization may face additional challenges accessing compensation. Restoration activities associated with spills may positively mitigate the damage and restore habitat, reducing the long-term impact of the spill. In cases where restoration activities are more extensive than returning the area to pre-spill conditions, there may be positive or negative effects on subsistence fishing, depending on the extent, location, and intent of restoration programs, as they can create or destroy habitat for a particular species and access to that species while destroying habitat and access for other species at the same time. The biological consequences of the effects of spill response on fish and invertebrates are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Strikes and Collisions (Chapter 2.9.3)

Vessel collisions with vessels or infrastructure (e.g., bridges, piers, locks, etc.) have the potential to negatively affect subsistence fishers' access to fish and shellfish by physically occupying fishing areas or blocking access routes to fishing areas and jurisdictions. If a vessel collided with a pier or bridge, for example, it could close that area to foot and vehicle traffic until the damage was assessed and repaired. This could prevent fishers from gaining access to those areas that, in the case of a pier, could be the only or best fishing access in the area. Depending on the size of the vessel, location, extent of damage, and difficulty of extraction and repair, the impacts may last for varied amounts of time but the majority are anticipated to be short. Collisions may also result in oil or chemical spills that could negatively affect subsistence by physically occupying fishing areas, blocking access routes to fishing areas, or leading resource managers to institute fishing closures or fish advisories due to health and safety concerns if the substance(s) spilled have potentially rendered the fish unsafe for human consumption (described in the "Unintended Releases into the Environment" section above). The biological consequences of the effects of oil spills on fish and invertebrates are discussed in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b).

4.4.5 Tourism and Recreational Resources

4.4.5.1 Resource Description

Recreational resources are natural or manmade things that are used as part of activities that are primarily for human enjoyment. Tourism encompasses a variety of services and infrastructure that enable humans to spend time away from home in pursuit of recreation, leisure, business, and other endeavors. The Gulf Coast is home to various resources that support tourism and recreational activities. These include ocean-based resources as well as resources in the counties and parishes along the Gulf of Mexico. The coastal beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes are used for recreational activity by residents of the Gulf Coast States and tourists from throughout the Nation, as well as from foreign countries. Publicly owned and administered areas (such as national seashores, parks, beaches, and wildlife lands), as well as specially designated preservation areas (such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, and scenic rivers), attract residents and visitors throughout the year. Commercial and private recreational facilities and establishments (such as resorts, casinos, marinas, amusement parks, and ornamental gardens) also serve as primary interest areas and support services for people who seek enjoyment from the recreational resources near the Gulf of Mexico.

The recreation and tourism industries are sizable in many areas along the Gulf Coast. Beach visitation is one of the most popular recreational activities among coastal states. Beaches along the Gulf Coast are susceptible to effects from both OCS oil- and gas-related activities and from non-OCS oil- and gas-related activities that could affect their availability for recreational use, as well as characteristic conditions for recreators to experience. Wildlife tourism is another prominent feature of the Gulf Coast's recreational landscape available to residents and visitors alike, and thus also vulnerable to effects from past, present, and future OCS oil- and gas-related activities. Artificial reefs are also prolific in the Gulf of Mexico and support many recreational opportunities. The Gulf of Mexico 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 area of interest include various Federal and State entities, such as parks, wildlife refuges, national marine sanctuaries, and national seashores.

Scales of Recreation and Tourism

As described in the Congressional Research Service's report, *The Outdoor Recreation Economy,* the task of measuring outdoor recreation levels in the U.S. is not precise or straightforward due to the varied ways in which sources collect, measure, and define the relevant data across geographic boundaries (Riddle 2019). However, weaving together information from several key data sources over time helps facilitate understanding of the scales of recreation and tourism in the area of interest associated with Gulf of Mexico OCS oil- and gas-related activities. It is important to distinguish that market economy measurements (i.e., employment, output, revenue, etc.) are only some pieces of the puzzle to estimating how people recreate in and visit areas along the Gulf Coast.

BOEM's 23 EIAs are critical to bounding the understanding of how OCS oil- and gas-related activity could affect human resources across the Gulf of Mexico region (Varnado and Fannin 2018). Refer to **Chapter 2.5** for more information about how EIAs in the GOM are defined. **Table 4.4.5-1** below presents data on recreational employment, recreational value-added, tourism employment, and tourism value-added in the EIAs. Value-added, equivalent to an industry's contribution to gross domestic product, is the sum of the industry's total employee compensation, proprietor income, taxes on production and imports, and other property income (Clouse 2020). **Table 4.4.5-1** was derived by applying data from IMPLAN Group LLC (2015) to the methodologies developed by Nadeau et al. (2014b). Nadeau et al. (2014b) 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.

Table 4.4.5-1. 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 Total: Texas EIAs	508,457	20,747,439,369	164,393	10,929,587,884
State Total: Louisiana EIAs	230,653	10,328,465,778	78,023	4,511,247,338
State Total: Mississippi EIAs	34,578	1,614,881,770	14,558	564,744,348
State Total: Alabama EIAs	41,132	1,394,921,898	11,349	755,872,776
State Total: 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: Nadeau et al. 2014b; IMPLAN Group LLC 2015.

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.

The NOAA's "Economics: National Ocean Watch (ENOW)" dataset provides coastal county, State, and regional level estimates of six economic sectors that depend on the oceans and Great Lakes, one of which is tourism and recreation. Even though the relevant industries that makeup the tourism and recreation sector of the ENOW ocean economy slightly differ from the aforementioned methodology, the annually updated data further contextualizes the magnitude of each ocean economy sector across the region and states. In 2016, the largest employment sector in the Gulf of Mexico's ocean economy was tourism and recreation (56.6%) (NOAA and Office for Coastal Management 2019b). The tourism and recreation sector led the ocean economy employment for Louisiana (49.4%), Mississippi (45.4%), Alabama (60.4%), and Florida (82.6%). Texas was the only state where the ocean tourism and recreation sector was not the largest employer in the ocean economy but instead was led by offshore mineral extraction employment (48.2%). Tourism and recreation industries may employ high numbers of people, but wages are often relatively low, meaning their contribution to the gross domestic product may also be relatively low compared to other sectors. On the other hand, the Gulf of Mexico ocean economy is characterized as leading the overall U.S. ocean economy in gross domestic product as a result of the prominent offshore mineral extraction sector, which pays relatively high wages (NOAA and Office for Coastal Management 2019a).

The Department of Commerce was directed in the Outdoor Recreation Jobs and Economic Impact Act of 2016 to work through the Bureau of Economic Analysis with the Departments of Agriculture and Interior to conduct an assessment and analysis of the outdoor recreation economy of the United States, including the effects attributable to the outdoor recreation economy on the overall U.S. economy (Public Law 114-249 [2016]). The Bureau of Economic Analysis released the national Outdoor Recreation Satellite Account estimates in September 2018, which include the outdoor recreation economy's gross output, contribution to the gross domestic product, compensation, and employment. The Bureau of Economic Analysis also released prototype State-level Outdoor Recreation Satellite Account statistics in September 2019 for the years 2012-2017 (Cologer et al. 2019). In 2017, the value added from the outdoor recreation economy to each state in percentage terms in Texas (2.1%), Louisiana (2.5%), Mississippi (2.4%), and Alabama (2%) was similar to the national contribution to the gross domestic product (2.2%), while Florida (4.3%) was nearly double that amount (BEA 2019). Official State Outdoor Recreation Satellite Account statistics are expected to be released in the fall of 2020.

The U.S. Travel Association produces a plethora of data and research on travel and tourism in the U.S., including estimated total annual travel and tourism spending by state. Total spending provides a broad measure of the impact of tourism on the economies of the Gulf Coast States. However, it is important to note that these data focus only on spending by visitors, which excludes spending on recreational activities by local residents. Therefore, the total economic impact of the recreation and tourism industry is likely somewhat greater than these data represent. In 2018, domestic and international travelers spent $76.4 billion in Texas, $13.1 billion in Louisiana, $9.1 billion in Mississippi, $11.5 billion in Alabama, and $102.8 billion in Florida (U.S. Travel Association 2020a; 2020b; 2020c; 2020d; 2020e).

Beaches

Beach visitation is one of the most popular activities along the Gulf Coast. The USEPA has a dynamic online tool, Beach Advisory and Closing On-line Notification system (BEACON 2.0), that lists and provides information regarding the beaches in each county or parish along the Gulf Coast (USEPA 2019). Texas and West Florida have the most beaches along the Gulf of Mexico, although there are also numerous beach areas in Louisiana, Mississippi, and Alabama. The National Survey on Recreation and the Environment, which was discontinued in 2010, estimated 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 2010).

Wildlife Tourism

A variety of information regarding the scales of wildlife tourism in various Gulf Coast areas is presented in (Stokes and Lowe 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 4.4.3** (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 (Energy Information Administration 2020c). 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 (BSEE 2020).

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 area of interest include various Federal and State entities, such as parks, wildlife refuges, national marine sanctuaries, and national seashores. Estimates of the number of visitors, amount of spending, number of jobs, and amount of income in 2018 supported by each National Park Service unit are provided in (Cullinane Thomas et al. 2019). The number of visitors and the amount of total visitor spending supported by National Park Service units along the Gulf Coast range from the Dry Tortugas National Park (56,810 visitors; $3,426,000 spending) to the Gulf Islands National Seashore (4,229,968 visitors; $186,918,000 spending).

National seashores are expanses of seacoast 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, as presented in **Figure 4.4.5-1**. 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 Islands 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 (NPS 2014b).

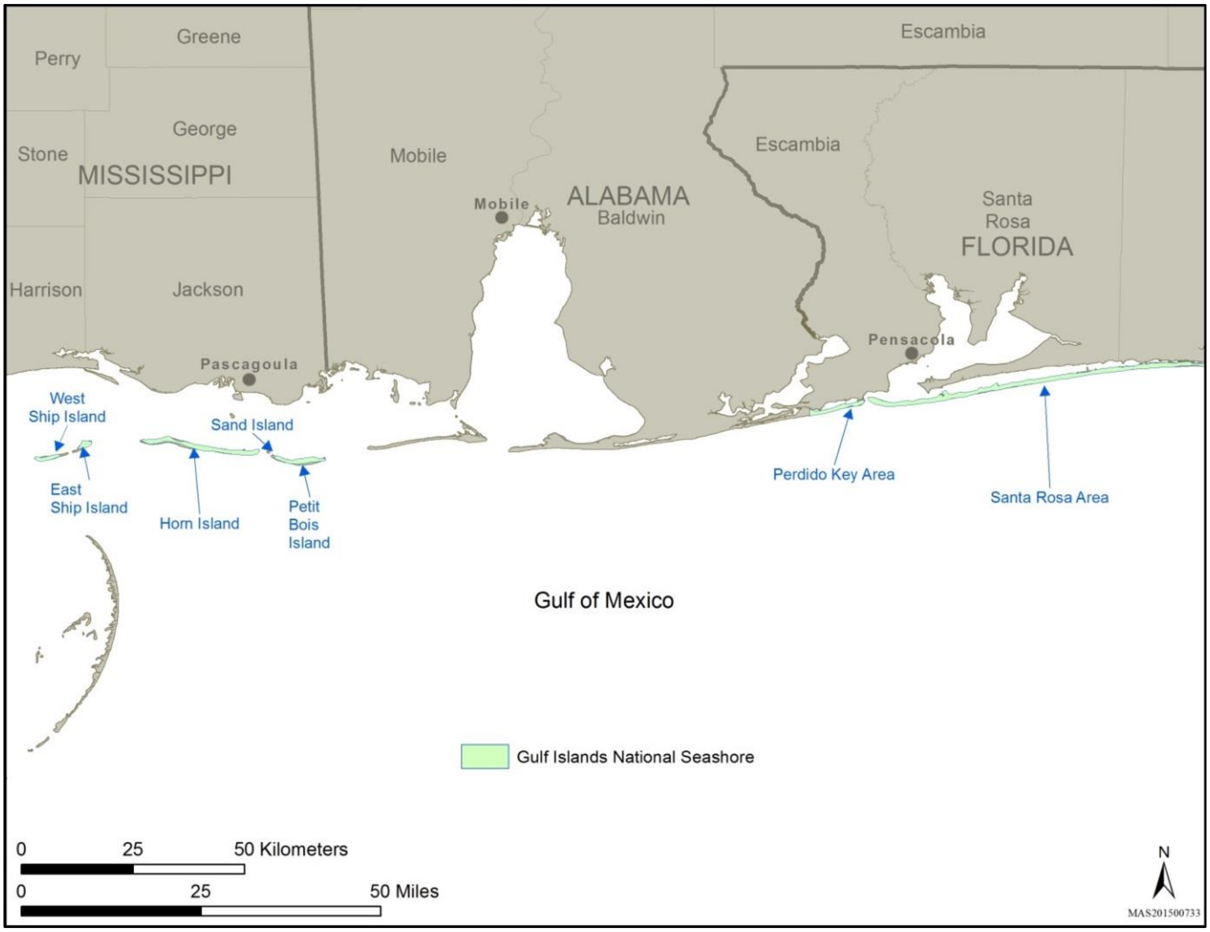


Figure 4.4.5-1. Gulf Islands National Seashore.

The OCS oil- and gas-related structures have historically existed close to Horn and Petit Bois Islands. Most of these structures have been removed; only a few structures remain within 15 mi (24 km) of Horn and Petit Bois Islands. **Figure 4.4.5-2** is a photograph of the remaining OCS structures taken from Petit Bois Island. **Figure 4.4.5-2** also shows a ship passing through the major shipping fairway near Petit Bois Island. In this photograph, the platforms appear barely visible and encompass less of the viewshed than the passing ship.

Figure 4.4.5-2. Photograph of Remaining OCS Structures taken from Petit Bois Island Looking South (Petit Bois Island is within the Gulf Islands National Seashore and is a National Park Service-designated wilderness area).

It is unlikely that a production platform would arise near Horn and Petit Bois Islands in the foreseeable future. Based on data BOEM has provided on the estimated remaining oil and gas reserves for each lease block in the Gulf of Mexico OCS region (Burgess et al. 2019), there are no known remaining oil or gas reserves in unleased blocks within 10 mi (16 km) of the Gulf Islands National Seashore.

As part of the Final Notice of Sale for each regional lease sale in the GOM, BOEM publishes an Information to Lessees and Operators (ITL) with details specific to leasing near the Gulf Islands National Seashore. The ITL allows for consultation with the States of Mississippi and/or Alabama and the National Park Service on a lessee's plans related to visibility concerns as appropriate. The addition of this information in the ITL began with CPA Lease Sale 231. The lease blocks that have previously been included the Gulf Islands National Seashore ITL are illustrated in **Figure 4.4.5-3**. BOEM expects this ITL to be applied to any future GOM lease sales. An excerpt from the ITL for GOM Regionwide Lease Sale 254 in March 2020 is presented below (BOEM 2020b).

> (18) Gulf Islands National Seashore. Bidders and lessees should be aware that postlease plans submitted by lessees proposing development of whole and partial lease blocks within the first 12 miles of Federal waters near the Gulf Islands National Seashore (see State of Mississippi Barrier Island Chain Map at the end of this document) may be subject to additional review 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 mitigation is required. Mitigation could include, but is not limited to, requested changes in location, modifications to the design or direction of proposed structures, pursuing the 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, listed below and shown on the enclosed map, are specifically identified for this ITL in Table 5.

Table 5. Gulf Island National Seashore Blocks with ITLs

Area	OCS Block
Chandeleur Area	1
Mobile	765-767, 778, 779, 809-823, 853-867, 897-910, 942-954, 987-997
Viosca Knoll	24-27

In addition to the ITL, through coordination with the State of Alabama, BOEM has developed a lease stipulation that is issued with each Final Notice of Sale that pertains to blocks located south of and within 15 miles of Baldwin County, Alabama that requires actions to minimize visual impacts from future OCS development operations (**Figure 4.4.5-3**). As an example, Stipulation No. 9 as it appeared in the Final Notice of Sale Package for Lease Sale 254 in March 2020, is presented below (BOEM 2020b).

Stipulation No. 9 will be included in leases issued as a result of this lease sale on blocks located south of and within 15 miles of Baldwin County, Alabama, as shown on the map “Gulf of Mexico, Region-wide Oil and Gas Lease Sale 254, March 2020, Stipulations and Deferred Blocks” included in the Final NOS package.

Stipulation No. 9 – Blocks South of Baldwin County, Alabama

To minimize visual impacts from development operations on this block, the lessee will contact lessees and operators of leases in the vicinity prior to submitting a Development Operations Coordination Document (DOCD) to determine if existing or planned surface production structures can be shared. If feasible, the lessee’s DOCD should reflect the results of any resulting sharing agreement, propose the use of subsea technologies, or propose another development scenario that does not involve new surface structures.

If the lessee cannot formulate a feasible development scenario that does not call for new surface structure(s), the lessee’s DOCD should ensure that they are the minimum distance necessary for the proper development of the block and that they will be constructed and placed using orientation, camouflage, or other design measures in such a manner as to limit their visibility from shore.

The Bureau of Ocean Energy Management (BOEM) will review and make decisions on the lessee's DOCD in accordance with applicable Federal regulations and BOEM policies, and in consultation with the State of Alabama (Geological Survey/Oil and Gas Board).

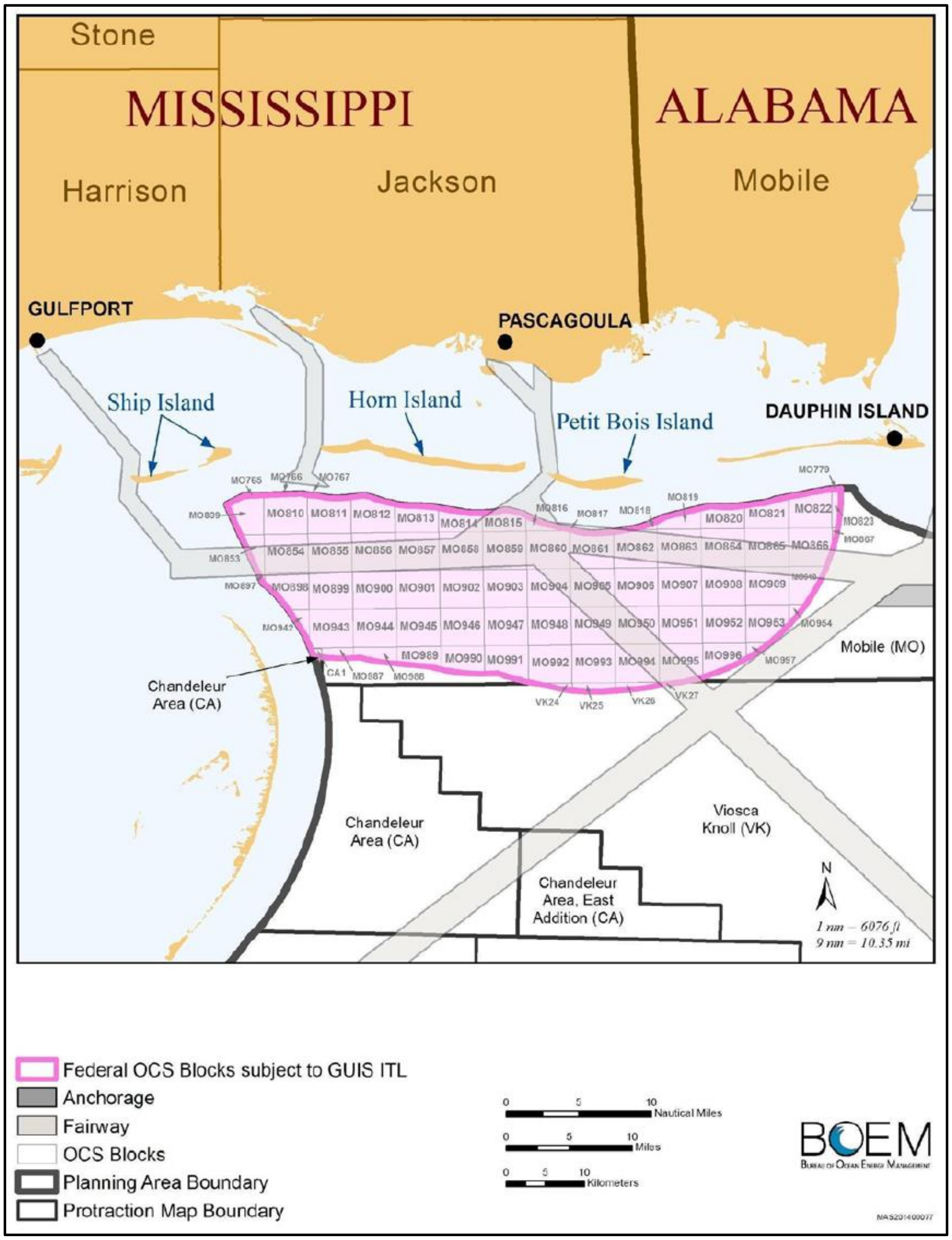


Figure 4.4.5-3. Federal OCS Lease Blocks Subject to the Gulf Islands National Seashore ITL.

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 the Superintendent's Compendium of park rules and regulations (NPS 2020).

4.4.5.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and tourism and recreational resources. **Figure 4.4.5-4** provides a synopsis of the IPF categories that currently affect or have the potential to affect tourism and recreational resources in the Gulf of Mexico OCS. Following **Figure 4.4.5-4** is a summary of those potential effects on tourism and recreational resources, as well as a brief discussion of the IPF categories identified in **Figure 4.4.5-4** that are not likely to affect tourism and recreational resources, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to tourism and recreational resources, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

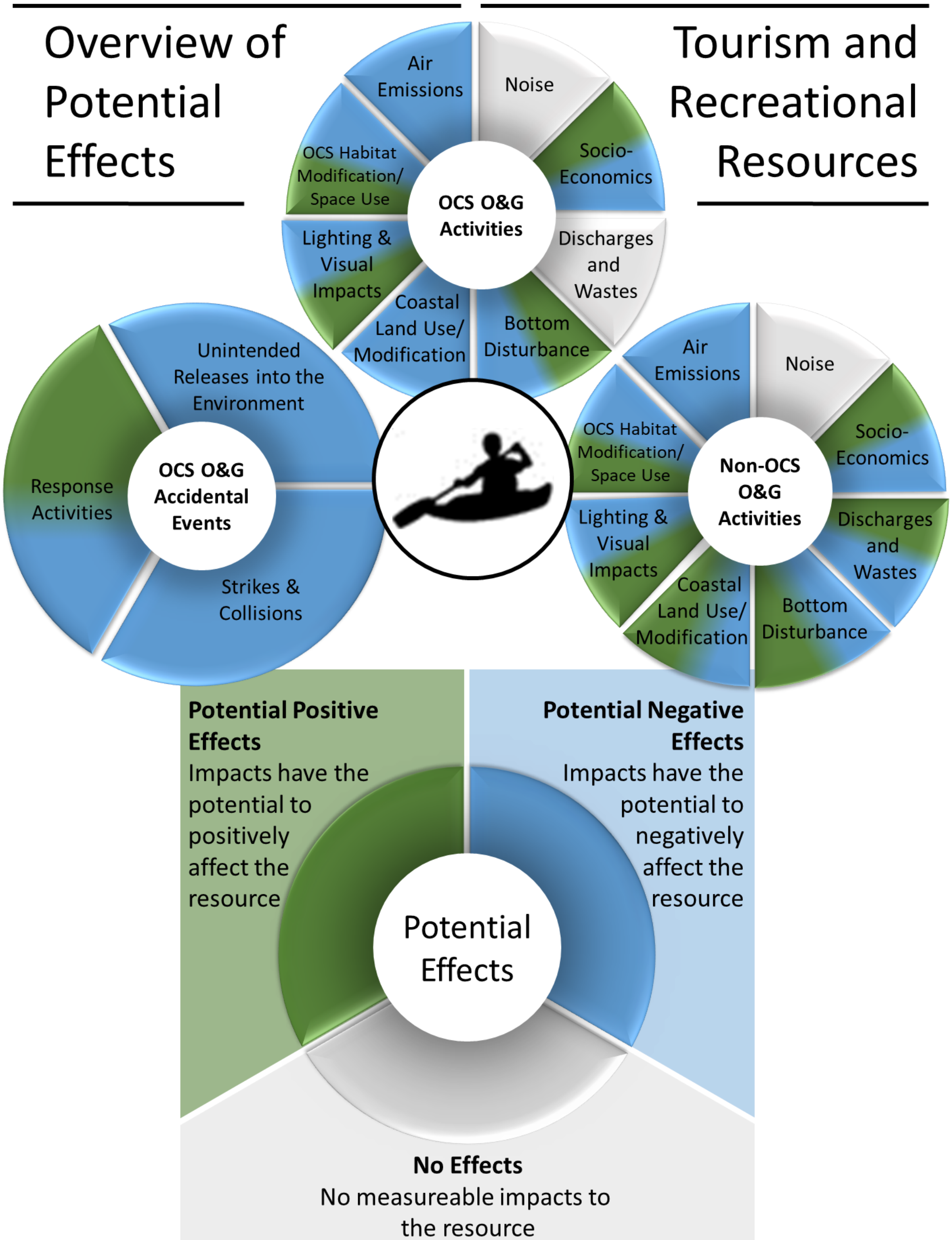


*Figure 4.4.5-4. Potential Interactions Between the Impact-Producing Factors identified in **Chapter 2** and Tourism and Recreational Resources. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.4.5.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.5-4 highlights the IPF categories of non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect tourism and recreational resources in the GOM region. The level of effects from these categories of IPFs could vary depending on the effects' frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions from non-OCS oil- and gas-related activities can have negative effects on tourism and recreation. Air pollutants are released by human activity (i.e., industrial activity, combustion engines, agriculture, and consumer products) and many can also be released by nonhuman activity (i.e., forest fires, high winds, natural seeps, decay of solid waste, and lightning) and include those regulated under NAAQS, hazardous air pollutants, and greenhouse gasses. Fossil fuel combustion can contribute to smog, acid rain, and hazardous air pollutants that can cause cancer or other adverse health effects (USEPA 2013a; 2019b; Wilson et al. 2019b). These releases can negatively affect human health, degrade habitats of culturally and economically significant plant and animal species, damage cultural and archaeological resources, impede visibility, contribute to ocean acidification, and impact weather, climate, and manmade materials. Refer to **Chapter 4.1** (Air Quality), **Chapter 4.3** (Biological Resources and Habitats), **Chapter 4.5** (Cultural, Historical, and Archaeological Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional detail on air quality and the effects of air quality on resources. Many recreational activities or tourist visits depend on visiting natural or archaeological sites, and if those sites are affected or damaged by air pollutants, a visitor's experience may be adversely affected and a visitor may not return. People may also choose not to visit areas with known or visibly poor air quality, as it may affect their health and enjoyment of the visit. For information on the regulations that limit air emissions, refer to **Chapters 2.1, 4.1, and 5**, and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c).

Discharges and Wastes (Chapter 2.2.2)

Non-OCS oil- and gas-related discharges and wastes and marine debris can originate from many sources, including State oil and gas activities, land-based discharges (i.e., sewage treatment plants and industrial manufacturing), nonpoint-source pollution (i.e., excess fertilizers, insecticides, and herbicides from residential areas and agricultural lands), recreational and commercial fishing, cruise ships, and various forms of vessel traffic (i.e., trash and other debris). These sources of discharges and wastes and marine debris are widespread throughout the Gulf Coast, and many government agencies participate in a coordinated effort to combat marine debris through policy and monitoring (Lippiatt et al. 2013; NOAA 2020f; Sheavly 2007). Releases of discharges and wastes and marine debris to the environment can negatively affect recreation and tourism by detracting from the aesthetic values of coastal areas, particularly beaches. These adverse effects resulting from discharges and wastes and marine debris at recreational areas could also lead to reductions in visitation levels and temporary area closures, which could then lead to lost revenues and jobs for affected businesses and other entities like local governments.

However, dredge material can be used to enhance tourism and recreational usage of areas. Dredged material disposal can benefit surrounding land by shoring up areas undergoing subsidence and improving previous land uses. For example, the Coastal Wetlands Park at Port Fourchon, Louisiana, was developed from the beneficial use of dredged materials produced from projects to expand the port's capacity with new slips and deeper canals.

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbance can cause both positive and negative effects on tourism and recreational resources. Artificial reef sites are prolific in the Gulf of Mexico, and while the installation of reefs may disturb the ocean floor, the additional hard substrate provides additional habitat that often enhances opportunities for recreational fishers and divers. Detailed descriptions of the potential effects of bottom disturbances and the addition of hard substrate to fish and invertebrate populations, which can affect recreational fishing, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Initially, artificial reefs placed on the seafloor were utilized by recreational fishermen because fish and invertebrates were attracted to the structure, but artificial reefs have gained popularity with recreational divers for the same reasons. Texas now sites artificial reefs in locations with high population and tourism densities where scuba diving resources are in demand. Divers typically participate in photography, marine identification, and spear fishing during their dive activities on these artificial reefs. In Texas, the demand for dive sites has resulted in positive economic effects for local income and employment in areas near artificial reef placement (Ditton et al. 2002b). The OCS sand borrowing activities may benefit the restoration of recreational beaches by providing more beach area for visitation and tourism. However, OCS sand borrowing may also temporarily disrupt offshore recreational activities like fishing and diving in the borrow area.

Coastal Land Use/Modification (Chapter 2.5.2)

Beach and wetland resources along the Gulf Coast 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 (refer to **Chapter 3**); coastal erosion also lessens protection against future hurricanes. Non-OCS oil- and gas-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 4.3.1** (Coastal Communities and Habitats) and BOEM's Biological Environmental Background Report (BOEM 2021b). Coastal erosion trends could negatively affect recreational resources to the extent that parts of these areas would not be available for recreational activities such as beach visitation, recreational fishing, and boating, as they change and disappear with erosion. As these areas are depleted, there may be fewer locations for recreation and tourism along the Gulf Coast, which in turn can reduce the economic benefits of recreation and tourism in the area. Increased coastal infrastructure (e.g., housing, industry, transportation, etc.) can negatively affect tourism and recreational resources by reducing land available for these activities and diminishing recreational experiences through infrastructure presence. On the other hand, several programs have been created to conserve, protect, and preserve coastal areas along the Gulf Coast facing erosion and other environmental threats, which has led to increased funding opportunities to improve conditions at many recreational sites and to increased support of tourism infrastructure, which has a positive effect on the recreation and tourism economies.

The recreational availability and value of beaches can also be negatively affected by temporary beach disruptions resulting from harmful algal blooms in adjacent waterbodies. For example, the opening of the Bonnet Carré Spillway in 2019 increased the flow of freshwater into Lake Pontchartrain, Lake Borgne, and the Mississippi Sound causing algae blooms off the Gulf Coast, which resulted in many beach closures and the disruption of some recreational activities and seasonal tourism jobs in the area over the summer months (Fitzhugh 2019; Hauser 2019; Sharp 2019; Weatherly 2019a). All Mississippi Coast beaches and waters were reopened by October, with no observed impacts from the algae blooms to the Gulf Islands National Seashore (Walck 2019). While hotel revenue along the Mississippi Coast dropped nearly 3-8 percent in June and July, it is estimated that beach vendors, fishing charters, and other support businesses saw revenue declines of up to 70 percent (Weatherly 2019b). In January 2020, it was announced that low-interest Economic Injury Disaster Loans would be available for small business, including tourism-related businesses, on the Gulf Coast negatively impacted by the algae blooms (Cruz 2020).

In addition, there are also potential health consequences for beachgoers that may interact with harmful algal blooms, such as respiratory, throat, eye, and skin irritations (CDC 2017). The NOAA provides a list of Federal and State tools and resources related to harmful algal blooms in the Gulf of Mexico, including forecast bulletins and a monitoring system, which aim to help stakeholders mitigate issues related to harmful algal blooms (NOAA 2021). If tourists are unable to visit beaches due to harmful algal blooms, they would likely visit other areas. The local businesses in the areas experiencing the harmful algal bloom may also be negatively affected by reduced visitation.

Lighting and Visual Impacts (Chapter 2.6.2)

The Gulf Coast features many marine protected areas that support recreational activities such as wildlife viewing, nature experiences, and beach visitation. Lighting and visual disturbances from coastal infrastructure (i.e., housing, industry, and transportation), ports, shipping fairways, aircraft activity, and State oil and gas infrastructure could negatively affect the recreational experiences at sites, including protected areas, along the Gulf Coast. State oil and gas activities occur close to shore and, thus, expectedly cause visual impacts for nearby coastal recreational areas. The visual aesthetics for some recreational sites could also be affected by major nearby shipping fairways and non-OCS oil- and gas-related aircraft activity. The severity of these effects would depend on the type of recreational area and on the extent to which vessel traffic, aircraft, and platforms are visible. For example, the visual aesthetics at Horn and Petit Bois Islands in the Gulf Islands National Seashore would be influenced by the major shipping fairway between the islands. This shipping artery leads to the Port of Pascagoula, which is Mississippi's largest port and the 28th most active port in the United States (USACE 2017b). Visual aesthetics may be subjective depending on the location of the object, its lighting, and people in question. For example, platform lighting can detract from some nature experiences, but it can also improve visibility of the structure and add contrast to the landscape. In addition, lighting may enable nighttime recreation in some areas and could improve safety for recreators, such as lighting on a pier that could enable recreational fishing at night.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Space-use conflicts with recreational activities may arise from commercial and military vessel traffic. Commercial and military activities could disrupt recreational fishing, diving, and boating depending on the timing and location of the activity. **Chapter 2.7.2.5** discusses the various military warning areas and water test areas, and **Chapter 7.2** discusses the Military Areas Stipulation as it applies to GOM leases. Sand borrowing activities for beach nourishment projects may temporarily conflict with recreational boating and water activities, but sand borrowing projects do not have a large footprint and are not a permanent disruption for recreators, who would avoid those areas. Renewable energy projects have not been developed on the Gulf of Mexico OCS yet, but if they are, some conflicts with recreational water activities could occur, depending on project location and any mitigations that may be developed to address space-use conflicts. Any military areas or ocean dumping sites that are permanently off limits could cause a permanent space-use conflict for recreational boating and water activities in that these activities cannot occur in those areas. However, since there are many open areas nearby closed areas, the closures should not affect recreational resources. As discussed in "Bottom Disturbance" above, the placement of artificial reefs on the seafloor can enhance recreational fishing and diving opportunities, and beach restoration can positively affect beach visitation and associated tourism, creating additional tourism-related economic benefits in the area.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

The recreational resources along the Gulf Coast could be subject to various positive and negative effects arising from economic development, which is one of the major drivers of socioeconomic change that affects recreational resources. For example, there may be pressures to develop industrial areas in existing parks and use other natural resources, eliminating some natural or recreational areas. However, development may also encourage the expansion of other recreational resources, such as hotels and restaurants, to accommodate increased tourism and/or recreational activities. Recreational and tourism activities are also 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. The projected path of the economies along the Gulf Coast could also be influenced by national and regional economic trends. For example, the recent pandemic of coronavirus (COVID-19), which spreads from person-to-person, has led to severe economic disruption in the United States as many states and cities have issued stay-at-home orders for extended lengths of time. Oxford Economics (2020) has modeled the expected downturns for the U.S. travel industry in 2020 resulting from COVID-19 and estimates travel sector revenue losses will exceed any other sector on the national scale, outpacing by more than nine times the impact of 9/11 on travel sector revenue. More information regarding economic factors can be found in **Chapter 4.4.7**.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from non-OCS oil- and gas-related activities described in **Chapter 2** and determined that noise is not likely to affect tourism and recreational resources. Therefore, noise was excluded from detailed analysis pertaining to tourism and recreational resources and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

Noise, as discussed in **Chapter 2.4**, refers to noise in and above the ocean, which is not expected to affect coastal tourism and recreational resources. For ocean-based recreational activities, recreators would likely contribute to anthropogenic noise as opposed to being affected by noise because offshore recreators use boats, which contribute to vessel noise. These elevated levels of watercraft noise were observed in areas of recreational boat usage, including areas within the Gulf Islands National Seashore (White 2014).

4.4.5.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.5-4 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect tourism and recreational resources in the GOM region. The level of effects from these categories of IPFs could vary depending on the effects' frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

Air emissions and pollution from routine OCS oil- and gas-related activities are highly regulated and monitored under NAAQS. Air pollutants released from OCS oil- and gas-related activities, including those from fossil fuel combustion and venting, can contribute to smog and acid rain, as well as cause cancer or other adverse health effects (USEPA 2013a; 2019b; Wilson et al. 2019b). Air emissions and pollution can degrade recreational or tourist destinations such as habitats of culturally and economically significant species and damage cultural and archaeological resources. Air emissions from land-based, OCS oil- and gas-related infrastructure could pose a persistent effect on tourism and recreation, where people may choose not to visit areas if the air quality is poor or if natural or archaeological resources of interest are damaged or degraded. Refer to **Chapter 4.1** (Air Quality), **Chapter 4.3** (Biological Resources and Habitats), **Chapter 4.5** (Cultural, Historical, and Archaeological Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional detail on air quality and the effects of air quality on resources. Refer to **Chapters 2, 4.1, and 5**, and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for details on the regulations that limit air emissions for OCS oil- and gas-related activities.

Bottom Disturbance (Chapter 2.3.1)

Structure installations, which alter the seabed by providing hard substrate in areas where only sandy bottom existed before, can enhance recreational opportunities in the Gulf of Mexico, but structure removals could then disrupt those same recreational activities at the time of decommissioning. The OCS platforms serve as artificial reefs and, thus, often have beneficial effects 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. 2002a). The location of the platform is an important factor in its use for diving because time and cost associated with traveling to the platform can affect the number of trips to dive on the site (Roberts et al. 1985). Detailed descriptions of the potential effects of bottom disturbances and the addition of hard substrate to fish and invertebrate populations, which can affect recreational fishing and diving, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). The positive effects of platform presence on fishing and diving could be reversed at decommissioning unless a platform is maintained as an artificial reef through a State's Rigs-to-Reefs program. Additional details regarding Rigs-to-Reefs and other artificial reef programs, including the locations of reef sites, can be found in Fikes (2013). The extent to which OCS infrastructure supports recreational activities depends on its location and accessibility to recreators.

Coastal Land Use/Modification (Chapter 2.5.1)

Routine OCS oil- and gas-related activities drive demand for onshore support infrastructure and contribute to any land use changes that may occur as a result of these activities. The potential effects that could occur to tourism and recreational resources from coastal land use/modification are described below. However, based on current projections, the existing infrastructure is sufficient to handle current and projected activities from OCS oil- and gas-related activities.

It is unlikely that new coastal infrastructure would be necessary to support OCS oil- and gas-related activities due to the amount of existing infrastructure and port capacity, but if it were, and if it were developed in a previously undeveloped space, tourism and recreational resources could be negatively affected by the reduction of land available for these activities. Negative aesthetic effects could also then be experienced by recreators viewing wildlife, boating, or fishing in areas where OCS oil- and gas-related ports, navigational fairways, and industry are located. However, even if a recreational space was lost to coastal OCS oil and gas infrastructure in a particular location, it is likely that a number of substitute recreational sites could be available nearby. Land-use changes would largely depend upon local zoning and economic trends.

Lighting and Visual Impacts (Chapter 2.6.1)

The visibility of OCS vessel traffic and platforms can positively or negatively affect the aesthetics of recreational experiences in certain areas. These effects depend on the type of recreational area, the extent to which vessel traffic and platforms are visible, and the subjective opinion of the viewer. The extent to which a platform is visible depends on various factors, including but not limited to, distance, elevation, size, location, weather and atmospheric conditions, air pollution, the curvature of the Earth, lighting, and the viewer's expectations and perceptions (Bounds 2012). 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.

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. Visibility of new OCS platforms from recreational areas would depend on the location of future OCS oil- and gas-related activity.

The U.S. Dept. of Homeland Security, Coast Guard, in its "Aids to navigation on artificial islands and fixed structures," provides guidance for the lighting requirement for offshore OCS structures, including number and orientation of lights, to ensure maritime safety (33 CFR part 67). Negative effects of offshore lighting from OCS oil- and gas-related activities could include a diminished sky-viewing experience at recreational sites, including protected areas, along the Gulf Coast. The relative additional contribution of light pollution resulting from new OCS oil- and gas-related activities could alter how the night sky and natural seascape are perceived by recreators, which could result in reductions in visitation and less desirable visitor experiences at affected sites (i.e., wilderness designated parks). Visual impacts from platforms arising from OCS oil- and gas-related activities could be subjective depending on the location and people in question as preferences vary among recreators. For example, platform lighting can detract from some nature experiences, but it can also improve visibility and add contrast to the landscape, resulting in a positive experience. Comparatively, OCS oil- and gas-related activities occur farther from shore than State oil and gas activities, and thus may cause less visual impact for nearshore and onshore recreators than State oil and gas activities.

Over the years, the National Park Service has raised questions regarding the potential visual impacts from OCS oil- and gas-related 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. For example, the National Park Service has expressed concern regarding the impacts from OCS oil- and gas-related platforms on the sky-viewing experiences on these islands, particularly at night. The National Park Service has provided BOEM with baseline data regarding the overall scales of natural and anthropogenic light at Horn and Petit Bois Islands (NPS 2014a). These 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-related and non-OCS oil- and gas-related light sources.

Historical experiences at other locations offer some insights into the potential visual effects of platforms near Horn and Petit Bois Islands. Bounds (2012) offers evidence that oil and gas development near Dauphin Island (Alabama) caused negative effects to tourism. The visibility of oil and gas structures near Texas and Louisiana appear to have more limited (and in some cases positive) effects (Nassauer and Benner 1984; NPS 2001), although the visual effects of platforms arising from OCS oil- and gas-related activity would be subjective depending on the location and people in question. Some of this literature on visual impacts is dated and may not reflect current public perceptions related to the visibility of offshore platforms. However, these sources demonstrate the historical nuanced perception of offshore infrastructure within the coastal landscape in selected states. For example, platform lighting can detract from some nature experiences, but it can also improve visibility and add contrast to the landscape.

It is unlikely that a production platform would arise near Horn and Petit Bois Islands, part of the Gulf Islands National Seashore (GUIS), in the foreseeable future due to a lack of remaining oil or gas reserves in unleased blocks within 10 mi (16 km) of the islands (Burgess et al. 2019). Horn and Petit Bois Islands are federally designated wilderness areas and are sensitive to disruptions to nature experiences. Even if there were a block leased near Horn or Petit Bois Island, it would likely be developed using minimal structures that tie back to existing platforms due to cost considerations, which is possibly the case for many future projects in areas visible from shore. BOEM's Information to Lessees and Operators issued at each regional lease sale allows for consultation with the States of Mississippi and/or Alabama and the National Park Service on a lessee's postlease OCS development plans related to visibility concerns in lease blocks near the Gulf Islands National Seashore.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

The OCS oil- and gas-related vessel traffic can cause space-use conflicts with recreational vessels navigating in the same areas. However, OCS oil- and gas-related vessels move between onshore support bases (which are typically not near recreational areas) and production areas far offshore (Marine Vessel Traffic 2020), while recreational vessels typically navigate closer to shore, with the exception of recreators that utilize offshore platforms. Any potential disruption of recreational vessel activity would likely be temporary.

There could be space-use conflicts between recreational activities and OCS oil- and gas-related activities. Brody 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 could 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 Gulf Coast, it is unlikely that any particular OCS oil- and gas-related activity would significantly add to space-use conflicts.

As discussed in the "Bottom Disturbance" section, OCS oil and gas structure installations can enhance recreational opportunities such as fishing and diving in the Gulf of Mexico, but structure removals could then disrupt those same recreational activities at the time of decommissioning. The OCS platforms serve as artificial reefs and, thus, often have beneficial effects on recreational fishing and diving (Hiett and Milon 2002). Detailed descriptions of the potential effects of the addition of hard substrate to fish and invertebrate populations, which can affect recreational fishing and diving, are provided in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). The positive effects of platforms could be reversed at decommissioning unless a platform is maintained as an artificial reef through a State's Rigs-to-Reefs program. The extent to which OCS infrastructure supports recreational activities depends on its location and accessibility to recreators.

Socioeconomic Changes and Drivers (Chapter 2.8.2)

The OCS oil- and gas-related activities have the potential to increase or decrease the demand for recreational resources in certain communities. For example, OCS oil and gas presence in an area may reduce the potential for nature viewing, recreational activities, and tourism in a highly developed area but may increase tourism and recreation opportunities in other more pristine or rural areas of the Gulf Coast. Increased demand for recreational resources has the potential to attract new recreational firms to a community, boosting the local economy; however, increased demand also has the potential to lessen the enjoyment of a particular resource by some community members. Since coastal infrastructure is well established and not prone to rapid fluctuations, it may be likely that the existing oil and gas infrastructure would be sufficient to handle the amount of activity associated with future OCS production. Thus, there could be no noticeable increase in disruptions to recreational resources due to future lease sales in the near term. Additionally, there is adequate undeveloped land in the analysis area to handle any new development, so a disturbance to an existing recreational site resulting from future development would be unnecessary. Therefore, these indirect economic factors would likely cause minimal effects to recreational resources.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the routine OCS oil- and gas-related activities described in **Chapter 2** and determined that noise, as well as discharges and wastes, are not likely to affect tourism and recreational resources. Therefore, these IPF categories were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

Discharges and wastes associated with routine OCS oil- and gas-related activities are highly regulated and monitored for proper disposal (refer to **Chapter 2.2**). Recreators are not likely to come into contact with waste at disposal sites nor with discharges from OCS oil- and gas-related activities, and therefore, discharges and wastes are not considered likely to cause effects to tourism and recreational resources. Noise, as discussed in **Chapter 2.4**, refers to noise in and above the ocean, which is not expected to affect coastal tourism and recreational resources. The OCS oil- and gas-related activities occur a distance from shore and thus should not affect nearshore and onshore recreators. In addition, vessels and aircraft rely on specific navigation corridors, so the effects of noise would be spatially restricted and would be limited to the areas near the OCS oil- and gas-related activity, likely for a short -term duration. For ocean-based recreational activities, recreators would likely contribute to anthropogenic noise as opposed to being affected by noise because offshore recreators use boats, which contribute to vessel noise (White 2014).

4.4.5.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.5-4 highlights the IPF categories of accidental events associated with OCS oil- and gas-related activities that could potentially affect tourism and recreational resources in the GOM region. The level of effects from these categories of IPFs could vary depending on the frequency, duration, and geographic extent of the effects as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Air emissions and pollution from routine OCS oil- and gas-related activities are highly regulated and monitored and are not anticipated to exceed regulated levels; however, should air emissions exceed allowable levels, for example during an emergency flaring or venting event, air emissions can have negative effects on tourism and recreation. Tourism-related or recreational activities, such as boating and diving, that could take place near OCS oil and gas platforms, may experience negative effects from air emissions should people be participating in these activities during an accidental air emission (refer to **Chapter 2.9.1.5** for more information). Refer to **Chapter 4.1** (Air Quality) for additional detail on air quality and **Chapters 2 and 5**, and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for details on the regulations that limit air emissions for OCS oil- and gas-related activities.

Drilling fluid, chemical, and oil spills resulting from OCS oil- and gas-related activities could have negative effects on recreation and tourism because they could pollute the water that people are using for swimming, fishing, and diving. Drilling fluid spills and chemical spills would likely be small and at far distances from coastal recreational resources, resulting in very little effects to coastal recreation and tourism. The effects of an oil spill from OCS oil- and gas-related activities would depend on the size and location of the spill. Large oil spills and spills close to shore would have a greater negative effect on recreational resources, tourism, and the economy than smaller spills or spills offshore because large or nearshore spills have a greater chance of coming ashore or affecting a larger area. For example, the New Orleans oil spill of 2008 demonstrated that a coastal spill can affect boating and restaurant businesses in its vicinity, as well as causing some aesthetic impacts to the experiences of tourists in the region (Tuler et al. 2010).

Most oil spills arising from OCS oil- and gas-related activities are likely to be small and localized. An oil spill that remained offshore could cause closures that may affect recreational fishing, diving, and boating. Detailed descriptions of the potential effects of oil spills on fish are provided in **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). The effects of oil spills on recreational fishing is discussed in **Chapter 4.4.3** (Recreational Fishing). An offshore oil spill could also negatively affect nearby coastal areas through media coverage or through misperceptions and uncertainty regarding the extent of the spill. This could lead to temporarily reduced tourism to coastal areas, negatively affecting the local economies.

An oil spill could have more direct effects on tourism and recreational areas if it were to reach coastal areas. A large spill could oil a wetland or beach. Oiled beach regions may have reduced tourism, which can cause economic losses to both individuals and firms in the area of an oiled or closed beach. The negative effects from an oil spill would be compounded if it encumbered a seasonal event, such as a summer beach festival or fishing tournament. However, in the case of a small spill, only small sections of a beach may be oiled or small fishing closures may occur, and there would likely be numerous alternative recreational sites of the same type and size of those affected by accidental spills that could be used for recreation during the duration of an oil spill.

Nadeau et al. (2014a) analyzed the impacts of the *Deepwater Horizon* oil spill on tourism activities in the Gulf of Mexico 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 (NOAA 2016a). However, an oil spill along the lines of the *Deepwater Horizon* oil spill is not reasonably foreseeable. For a detailed analysis of potential issues related to a high-volume, extended-duration catastrophic oil spill, refer to the *Gulf of Mexico Catastrophic Spill Event Analysis* technical report (BOEM 2021d).

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 and recreational use of these areas. The discharge of marine debris is subject to a number of laws and treaties and is regulated and enforced by several agencies. These various laws and regulations would likely reduce the potential damage to recreational resources from the discharge of marine debris from OCS operations. Laws and regulations to reduce the discharge of marine debris 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 several agencies such as the USEPA, NOAA, and USCG. 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 (BSEE NTL No. 2015-G03). This NTL instructs OCS operators to post informational placards that outline the legal consequences and potential ecological harms of discharging marine debris on production facilities and drilling rigs. 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 (refer to **Chapter 4.3.6** [Marine Mammals] and **Chapter 7** [Potential Lease Stipulations]). These various laws, regulations, and NTL would likely reduce the potential damage to recreational resources from the discharge of marine debris from OCS operations.

Response Activities (Chapter 2.9.2)

The NOAA's Environmental Response Management Application (ERMA) mapping system has created environmental sensitivity indexes (ESIs), maps, and point indicators for recreational resources for the coastline along the Gulf of Mexico (NOAA 2020e). The ESI maps 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 partially 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 effects of an OCS oil- and gas-related 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 beach serves as a habitat to an 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.

Recreational resources such as beaches serve as important bases for some local economies. Therefore, oiled beach regions and the resulting cleanup effort can cause reduced visits to beaches and use of recreational areas, as well as economic losses to both individuals and firms in the area of an oiled or closed beach, or one being cleaned. An economic analysis of the costs of hypothetical beach closures along the Texas Gulf Coast was performed by Parsons et al. (2009). They estimate that the economic costs of beach closures along the Padre Island National Seashore would range from $25,000 to $171,000 per day, depending on the time of year at which the closures would occur. On the other hand, restaurants and hotels in the spill-response area could receive an influx of demand from cleanup workers that could offset losses otherwise expected from tourism declines resulting from a spill.

Strikes and Collisions (Chapter 2.9.3)

Vessel collisions could have negative effects on tourism and recreational resources. A collision with a recreational boat could occur and could lead to damages, injuries, lost wages, and other effects for the boat operator and other persons involved. Vessel collisions may also disrupt recreational activities offshore and along the coast, as they could restrict waterway access for other boaters. Vessel collisions in coastal waters may involve other vessels or stationary structures like docks. If a bridge, pier, or other structure is hit, the transportation of goods, services, and people to and from recreational sites may be disrupted. The severity of the effects from a collision would depend on the duration and extent of the event. The effects from vessel collisions could be compounded if they encumbered a seasonal event, such as a coastal festival or fishing tournament. The effects of a vessel collision on recreational fishing is discussed in **Chapter 4.4.3** (Recreational Fishing).

In addition, beaches and other recreational areas could be negatively affected by a vessel collision should it result in an oil or chemical spill, which may disrupt recreational activities offshore and along the coast. The effects of spills on tourism and recreational activities are discussed in the "Unintended Releases to the Environment" section above.

4.4.6 Social Factors (Including Environmental Justice)

4.4.6.1 Resource Description

There is a strong relationship between the offshore oil and gas industry and the people and communities of the coastal regions of the five Gulf Coast States, i.e., Texas, Louisiana, Mississippi, Alabama, and Florida. The region is diverse in population, economic mix, available natural resources, and interaction with the offshore oil and gas industry. The presence of environmental justice populations, or minority or low-income populations, warrants added attention to identify if they experience disproportionate environmental impacts, including human health and social and economic consequences. The oil and gas industry is widespread through the region, but its density and composition vary geographically. This chapter serves to describe the holistic and interconnected nature of human activities in the area and their interactions with offshore oil and gas.

The petroleum industry as a whole in the Gulf of Mexico region has matured over nearly a century and is well-developed, expansive, extensive, and deeply intertwined in the regional communities and economies of the five Gulf Coast States. The industry involves onshore, State offshore, and Federal OCS exploration, development, and production. Industries that support Federal OCS oil and gas development, such as shipyards, fabrication yards, transportation, communications, supply, and others, also support other industries and/or oil and gas development onshore, in State waters, and elsewhere around the globe. This infrastructure is described in **Chapter 2** and **Chapter 4.4.1** (Land Use and Coastal Infrastructure). Pipelines mix OCS and non-OCS oil and gas as they transport it to petrochemical plants and other infrastructure where it is stored, processed, or used with product from elsewhere. Teasing out the Gulf of Mexico OCS oil- and gas-related effects from the effects of other oil and gas activities and other industries is difficult, if not impossible. For example, when oil prices fall and stay down, then gasoline prices drop, positively affecting individuals and businesses who buy fuel. When oil prices remain low for many months, oil- and gas-related companies start trimming costs by reducing the number of employees and seeking other efficiencies. In the communities that support this industry, laid-off employees and contractors with no new contracts no longer have income to make purchases. Businesses where workers would normally spend their money begin to suffer. Also, when necessary, people begin moving out of the area to find other work, leading to a negative effect on the housing market, depressing real estate prices as the number of units available for rent or sale outgrows the demand. A negative effect for some (i.e., oilfield workers, oil-related businesses, sellers, and landlords) becomes a positive effect for others (i.e., businesses that depend on low fuel prices, buyers, and renters). This is just one example of a process unrelated to the effects of OCS oil- and gas-related activities leading to dual ripple impacts (negative and positive) through communities and illustrates the complexity of the socioeconomic framework. Environmental justice populations (i.e., minority populations and low-income populations, as defined in Executive Order 12898) may be particularly vulnerable to these changes if they have unequal access to social and financial resources in the community or if they have unique relationships with the environment, as was discussed **Chapter 4.4.4** (Subsistence Fishing).

The area of interest for social factors analysis is the 133 coastal and near-coastal counties and parishes in the five Gulf Coast States, as illustrated in **Figure 4.4.6-1**. These counties and parishes are grouped into 23 EIAs. **Chapter 2** and **Chapter 4.4.7** (Economic Factors) discuss the methodology behind the selection of these counties and parishes and the employment of EIAs. **Chapter 4.4.1** (Land Use and Coastal Infrastructure) discusses the distribution of the industry across the area. This geographic area possesses a culturally and racially diverse population and relationship to the petroleum industry. Some counties and parishes are more closely connected to the offshore oil and gas industry than others, including Harris County, Texas, which holds the largest number of oil- and gas-related companies and associated support infrastructure, and Lafourche Parish, Louisiana, where the largest OCS-related service base, Port Fourchon, is located. Conversely, coastal Florida, except for Bay County in the panhandle and the area immediately around Tampa Bay in Hillsborough County, have little infrastructure directly related to the offshore oil and gas industry.

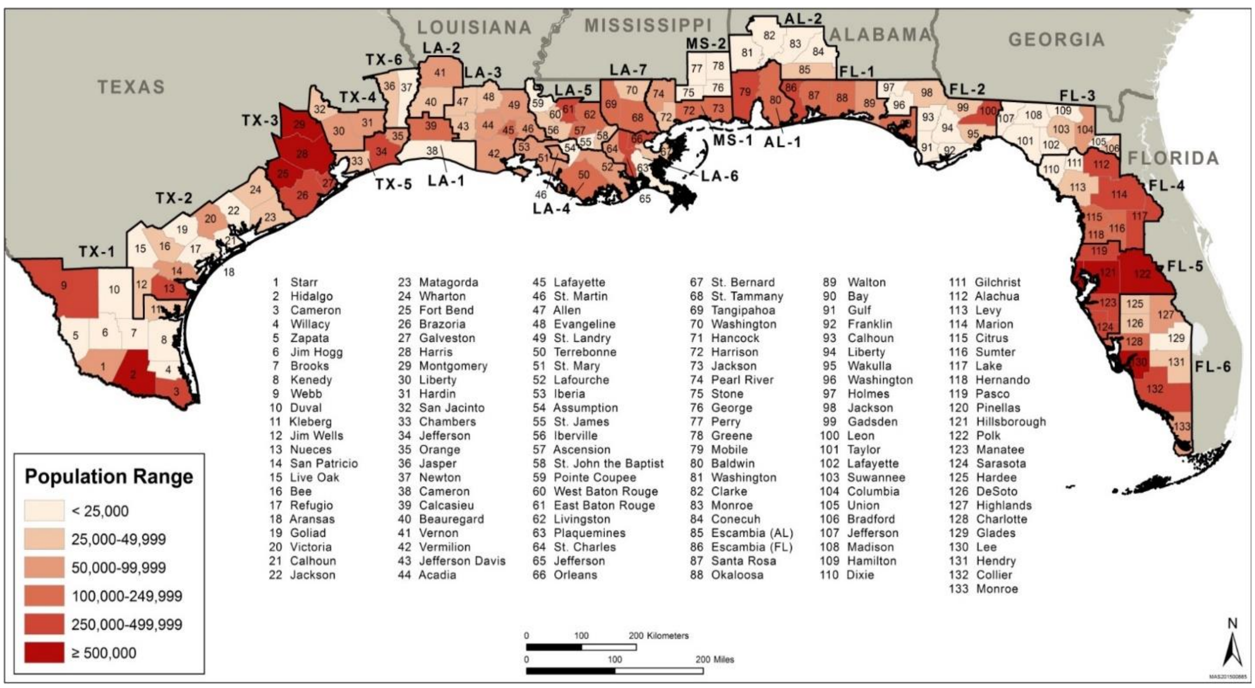


Figure 4.4.6-1. Population of BOEM's Economic Impact Areas in the Gulf of Mexico.

Nationally, there are 23 states in the continental U.S. with coastline. Fifty-two percent of the U.S. population lives in coastal counties or parishes, which occupy only 20 percent of the land, giving these areas high population densities, i.e., the number of persons per square mile that lives in a geographically defined area (Crossett et al. 2013). Population in the coastal regions of the Gulf Coast States increased 54 percent from 1970 through 2010 to a total of 28,802,699 (NOAA 2020j).

Population ranges in the counties/parishes of interest are provided in **Figure 4.4.6-1**. During that time period, the largest percentage increases were in Florida (178%) and Texas (130%), with Mississippi (59%), Alabama (44%), and Louisiana (27%) trailing (Crossett et al. 2013). In Louisiana, these numbers hide the shifting distribution of population within parishes, where populations are becoming more concentrated towards the north end of coastal parishes as residents move away from the coast with its problems of land loss, flooding, and loss of population and infrastructure (Austin et al. 2014b). 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 high population density: Harris County (Houston, Texas); and Orleans and Jefferson Parishes (Louisiana).

The racial and ethnic composition of the analysis area reflects both historical settlement patterns and current economic activities. South Texas was part of Mexico; today, Hispanics remain the dominant group. In that area, many work in farming, tending cattle, or in low-wage industrial jobs. Moving east along the coast, by east Texas the size of the African American population increases, and there is a more diversified racial mix, indicating more urban and diverse economic pursuits. Louisiana, once part of France, retains Cajun and French-speaking populations. In Louisiana, Mississippi, Alabama, and northern Florida, African Americans outnumber Hispanics, reflecting the area's history of slavery. North-central Florida has relatively low numbers of minorities, while southern Florida has larger Hispanic populations, illustrating, in part, the proximity of Cuba and Puerto Rico. The average percentage of minority residents throughout the area of analysis 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. **Figure 4.4.6-2** illustrates the distribution of ranges of minority populations in Texas and Louisiana in relation to oil- and gas-related infrastructure, and **Figure 4.4.6-3** illustrates the distribution of ranges of minority populations in Mississippi, Alabama, and Florida in relation to oil- and gas-related infrastructure. 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 (U.S. Census Bureau 2013a).

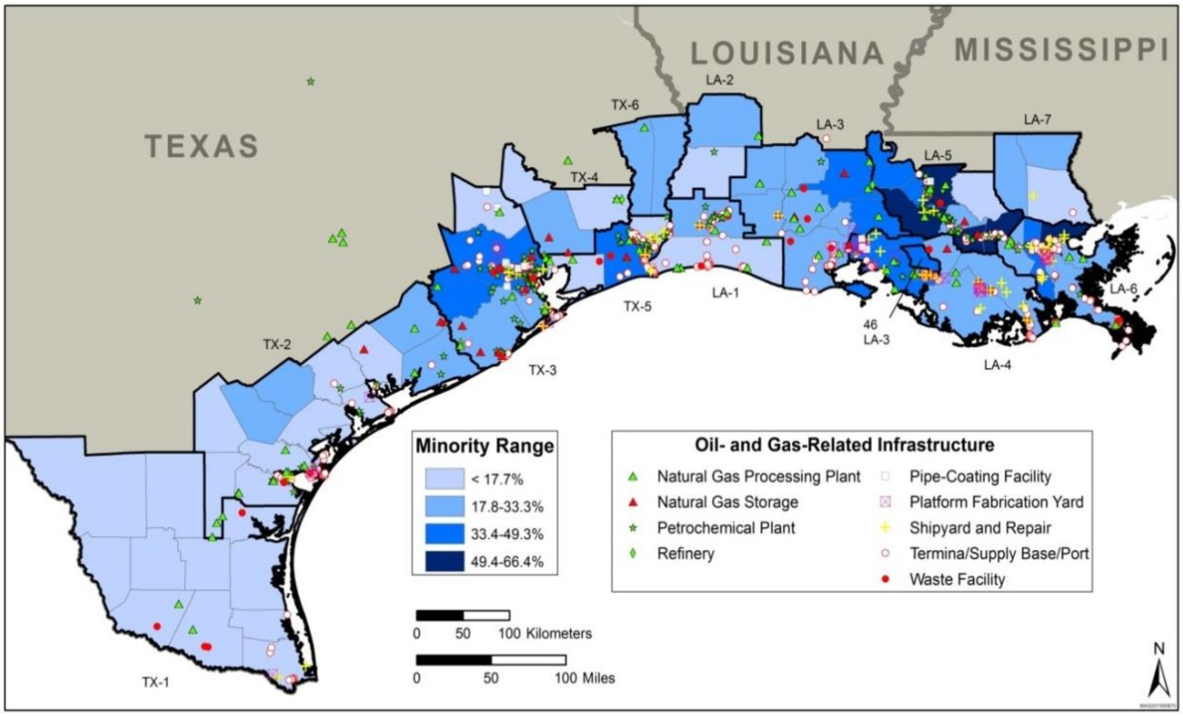


*Figure 4.4.6-2. Percentage of Minority Populations in Texas and Louisiana in Relation to Oil- and Gas-Related Infrastructure (reprint of **Figure 4.4.4-2**).*

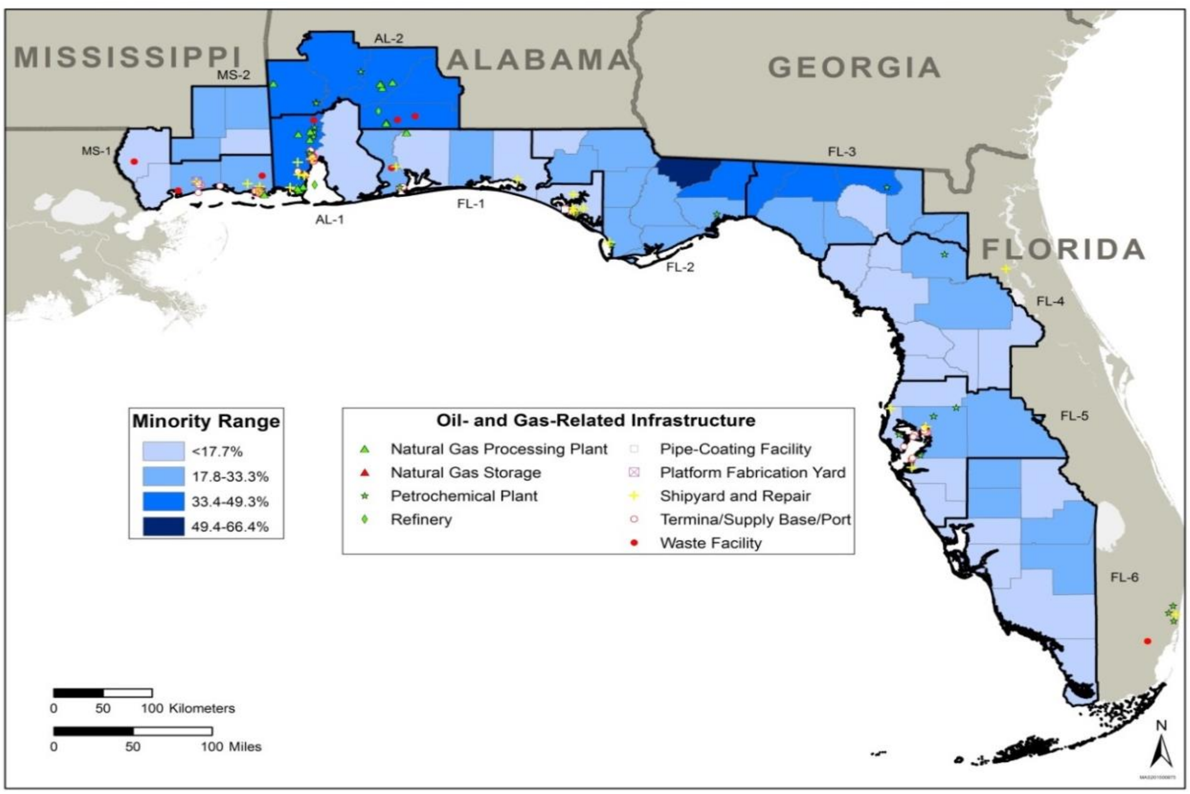


*Figure 4.4.6-3. Percentage of Minority Populations in Mississippi, Alabama, and Florida in Relation to Oil- and Gas-Related Infrastructure (reprint of **Figure 4.4.4-3**).*

Figure 4.4.6-4 illustrates the percentage of population below poverty levels in Texas and Louisiana, and **Figure 4.4.6-5** illustrates the percentage of population below poverty levels in Mississippi, Alabama, and Florida. Within the 133 counties/parishes, 104 counties/parishes have poverty levels above the national average of 14.5 percent. The highest concentration of poverty is in the south Texas EIA (TX-1) where 8 out of 11 counties have more than 30 percent of their population living below the national poverty level. In total, both the highest and lowest poverty rates are in Texas, in Willacy (40%) and Fort Bend Counties (8.4%), respectively (U.S. Census Bureau 2013b; 2013c). The presence of these racial and ethnic minority and low-income populations justifies attention to environmental justice concerns.

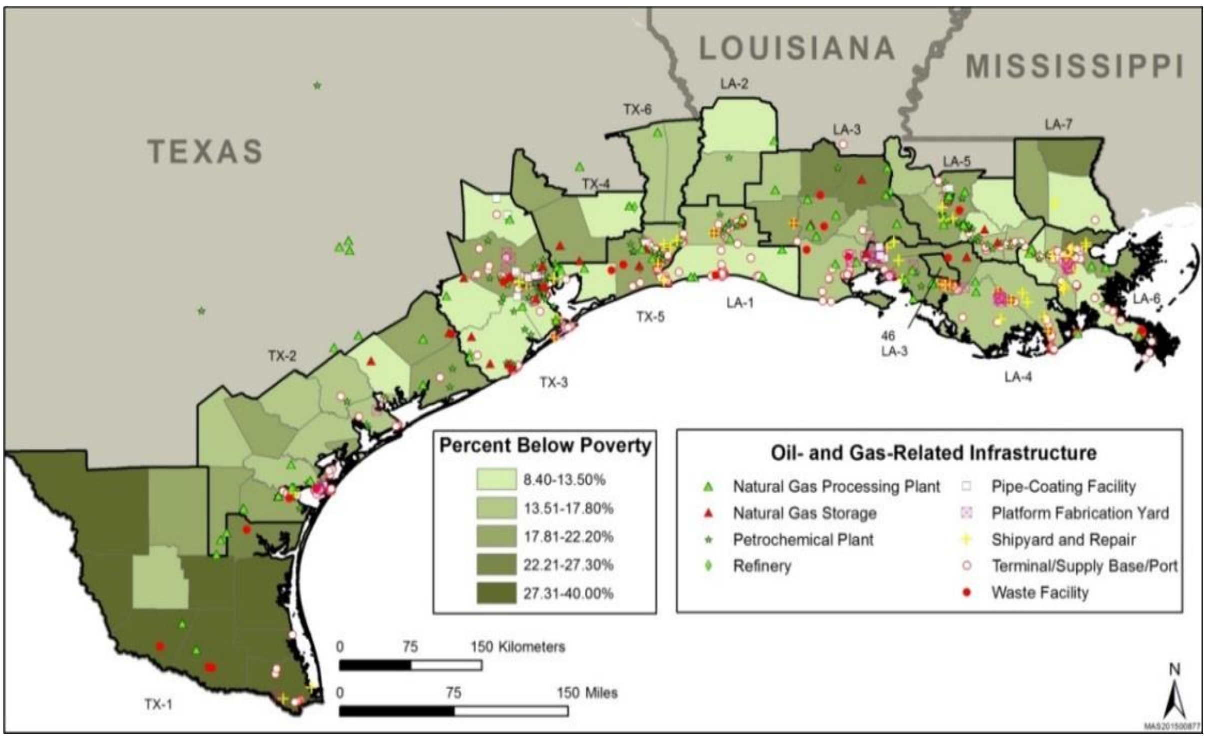


Figure 4.4.6-4. Percentage of Population Below Poverty in Texas and Louisiana (reprint of ***Figure 4.4.4-4****).*

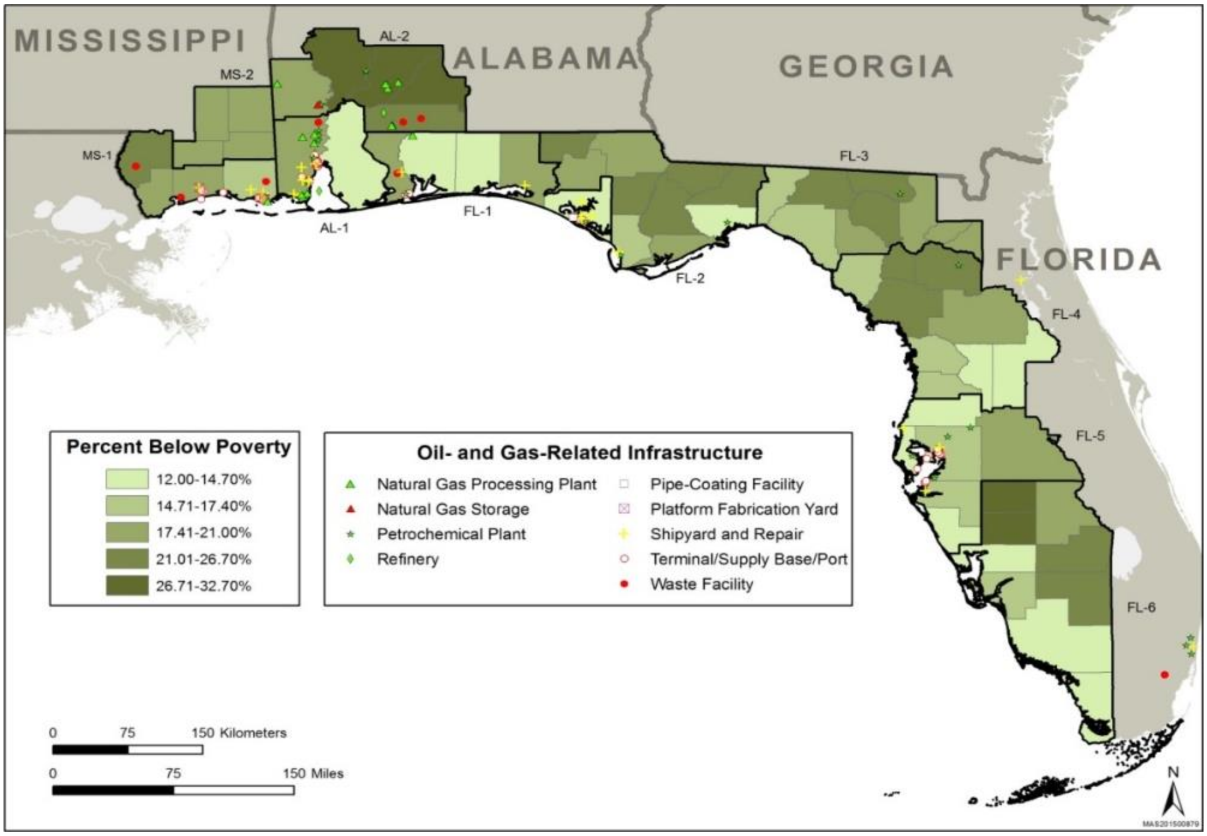


*Figure 4.4.6-5. Percentage of Population Below Poverty in Mississippi, Alabama, and Florida (reprint of **Figure 4.4.4-5**).*

Natural Processes and Events

There are many natural events and processes that can affect coastal populations. Many of these events and processes are influenced by human activity in terms of their extent, duration, or impact, though it is beyond the scope of this analysis to trace all of those connections. These natural events and processes include, but are not limited to, the following: microorganisms; habitat degradation; saltwater intrusion; sedimentation of rivers; sediment deprivation; river or rainfall flooding; barrier island migration and erosion; fish kills; red tide; coastal erosion/subsidence; sea-level rise; coastal storms; and climate change.

Microorganisms in the Gulf of Mexico

Harmful microorganisms in GOM waters can cause challenges for coastal living. Red tide, cyanobacteria, and vibrio, among others can pose dangers for humans and other animals who come into contact with or ingest them, causing disruptions in fishing and water and beach access. This can interfere with people's use and enjoyment of the natural environment and contribute to negative effects on GOM coastal populations. While these are naturally occurring microorganisms, their distribution and impact on people can be altered by human activity. For example, when the U.S. Army Corps of Engineers opened the Bonnet Carré Spillway in 2019, the record amount of Mississippi River water pushed into the Mississippi Sound created harmful algae blooms, closing all of the Mississippi beaches and some additional waters to swimming and fishing, killing dolphins and disrupting economies and livelihoods (Lee 2019; Sharp 2019; Weatherly 2019b).

Loss of Coastal Lands and Bottom Disturbance

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 of coastal lands 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 coastal development.

Saltwater intrusion resulting from land loss, river channelization, and canal dredging is a major cause of coastal habitat deterioration (Cox et al. 1987; Frayer et al. 1983; Tiner Jr. 1984). 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 (Cox et al. 1987; White and Kaplan 2017).

When degradation of oyster reefs occurs, it may negatively affect people and communities by decreasing the number of oysters that are available for harvest for 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 ecosystems depend. The long-term impacts of the *Deepwater Horizon* explosion, oil spill, and response on oyster populations as well as the impacts of State restoration projects are still unknown, but there is evidence that there are ongoing negative effects (Austin et al. 2014b). Barrier islands are also important for fishing, but the barrier islands' natural migration has been disrupted by development and transportation, including construction on the islands and the dredging of ship channels. Barrier island restoration is one of the focal areas of the Louisiana Coastal Master Plan (Coastal Protection and Restoration Authority of Louisiana 2017). This interaction of man-made and natural processes is one of the challenges faced in the region.

Users of coastal waters are diverse, from the relatively or very affluent for whom the waters might provide recreation, the source of their wealth, or both, to low-income and minority groups that are dependent on coastal resources for their livelihoods, cultures, and low-cost recreation. Several ethnic minority and low-income groups rely substantially on these resources. Hemmerling and Colten (2003) evaluate environmental justice considerations for south Lafourche Parish, and Hemmerling and Colten (2017) offer an extended discussion of environmental justice in Lafourche, Jefferson, and St. Bernard Parishes, finding that distribution of onshore infrastructure and associated risks of habitat degradation raise potential concerns for subsistence fishers. Austin et al. (2014a, 2014b) offer a discussion of coastal communities before and after the 2010 *Deepwater Horizon* explosion and oil spill, with particular discussions on minority resource dependence in Bayou La Batre, Alabama; Biloxi, Mississippi; and Plaquemines and Terrebonne Parishes, Louisiana, noting that the informal, largely undocumented nature of subsistence resource use makes it difficult for users to be reimbursed for losses in the case of environmental damage or disruption. Refer to **Chapters 4.4.2** (Commercial Fisheries), **4.4.3** (Recreational Fishing), and **4.4.4** (Subsistence Fishing) for additional discussion on commercial, recreational, and subsistence fishing.

Coastal land loss from erosion, subsidence, sea-level rise, and storm surge also affects the larger society as a whole, with significant land loss occurring in coastal areas, especially Louisiana. Louisiana has created a Coastal Master Plan focused on resolving the land loss crisis (Coastal Protection and Restoration Authority of Louisiana 2017). Land loss affects people and communities by impacting residential areas as well as local businesses and public infrastructure. **Figure 4.4.6-6** shows the amount of land that coastal Louisiana has lost from 1932 to 2010. **Figures 4.4.6-7 and 4.4.6-8** illustrate scientists' projections for future land loss in Louisiana. The moderate scenario assumes more mitigating measures, and the less optimistic scenario shows the projected impact if extensive mitigating measures are not instituted.

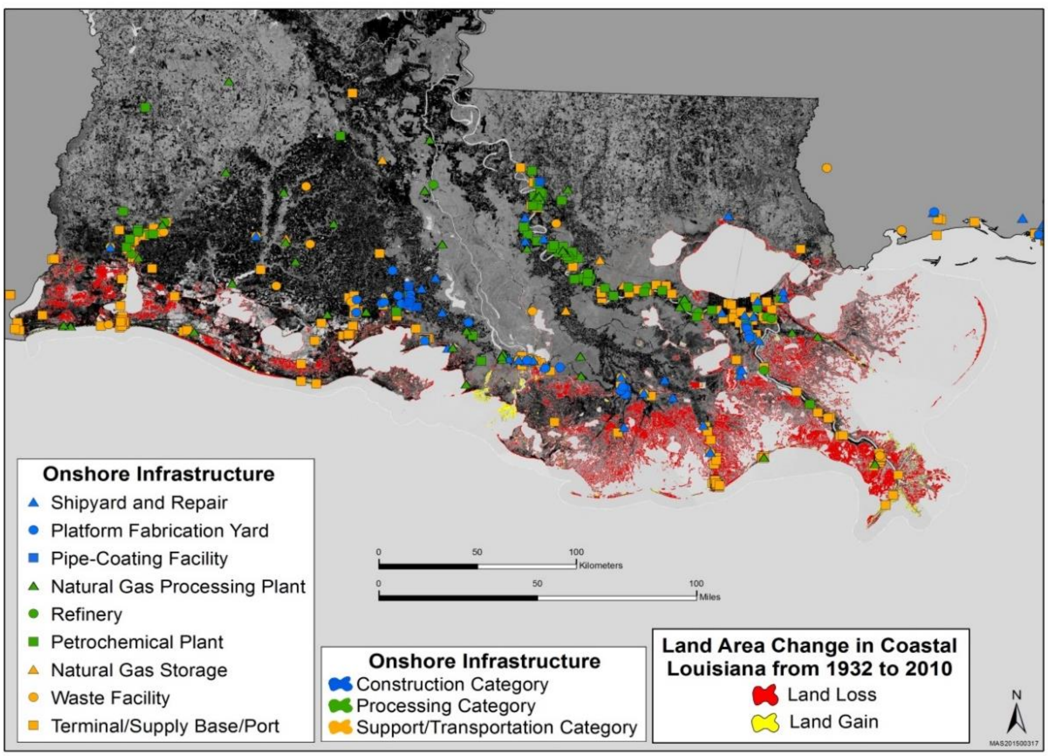


Figure 4.4.6-6. Historical Land Loss in Louisiana, 1932-2010 (reprint of ***Figure 4.4.1-8****).*

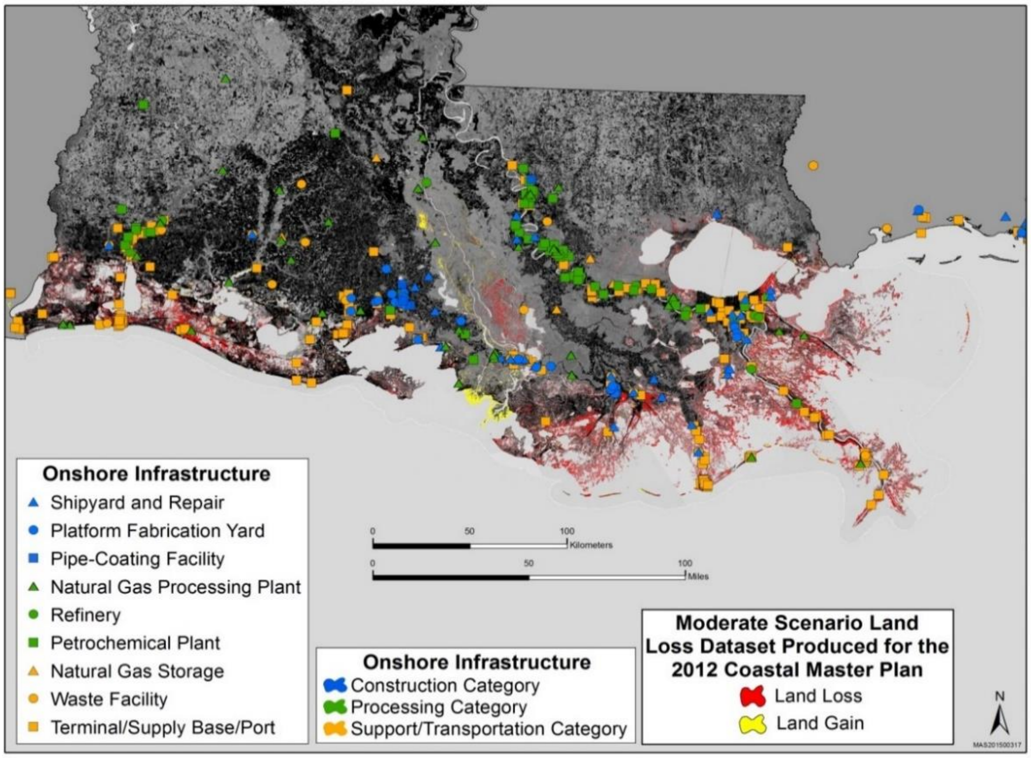


Figure 4.4.6-7. Moderate Scenario: Projected Land Loss in Louisiana (reprint of ***Figure 4.4.1-9****).*

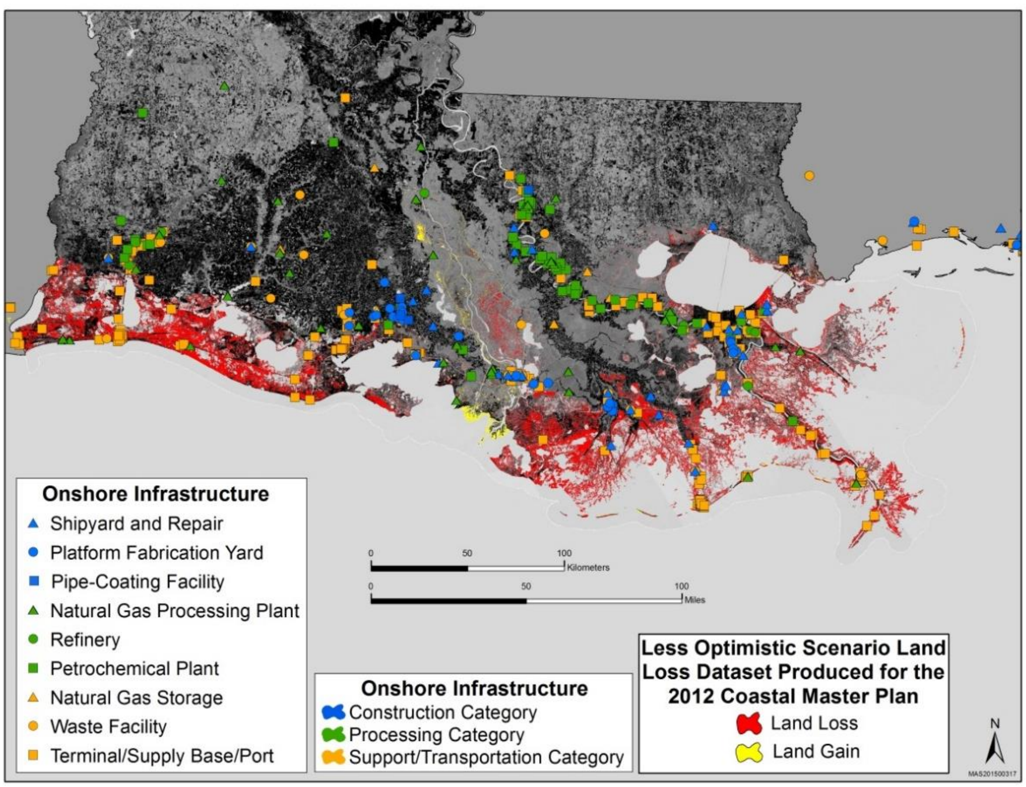


Figure 4.4.6-8. Less Optimistic Scenario: Projected Land Loss in Louisiana (reprint of ***Figure 4.4.1-10****).*

As evident from these visual depictions, coastal land loss is one of the greatest threats to the stability and future of coastal populations. Louisiana’s 2017 Coastal Master Plan discusses the urgency of the land loss crisis (Coastal Protection and Restoration Authority of Louisiana 2017) and more recently, the State has referred to the situation as an “existential crisis” (Louisiana's Strategic Adaptations for Future Environments 2019).

Restoration projects will also impact habitats, communities, and residents. Depending on their scale, they may impact large or small areas and may restore the area in ways that will replace uses lost to coastal erosion or may remove areas from traditional uses. The outcomes of Louisiana’s 2017 Coastal Master Plan, and future iterations of that plan, are unknown because funding, schedules, and designs have not been identified for the listed projects; it is not certain that listed projects, if not built, will be included in the next iteration of the plan; and the outcomes of those projects, if built, are not known. While Louisiana is the Gulf Coast State with a comprehensive Master Plan for coastal restoration, all five Gulf Coast States have received and will continue to receive money through the *Deepwater Horizon* settlement process, some of which must be used on coastal restoration. Because these restoration programs are still new, their long-term impacts are unknown.

Hurricanes and Tropical Storms

Hurricanes, tropical storms, and other wind-driven tidal or storm events are natural occurrences along the Gulf of Mexico coastal zone. How they are experienced, however, varies depending on their physical characteristics (i.e., size, timing, and location of landfall) and the social features of the communities in their path (including socioeconomic composition, built environment, and prior experience with hurricanes). The intensity and frequency of hurricanes and tropical storms in the GOM over the last 15 years has greatly impacted the physical system of protective barrier islands, beaches, and dunes and associated wetlands along the Gulf Coast, as have efforts at restoration following these storms. They have also had considerable economic and social impact. The Gulf Coast of Texas, Louisiana, Mississippi, Alabama, and Florida have experienced multiple hurricanes: Ivan (2004); Katrina and Rita (2005), Humberto (2007); Dolly, Gustav, and Ike (2008); Isaac (2012); Harvey, Irma, and Nate (2017); and Barry (2019). While these storms are a fact of life, they can be unpredictable in path and intensity, posing a challenge for communities. For example, Hurricane Michael, in 2018, was the strongest documented storm to make landfall on the Florida panhandle (NOAA 2018a). For Hurricane Barry and Tropical Storms Imelda and Nestor in 2019, their destructiveness increased because of their slow movement, itself tied to climate change, as described below (Masters 2019). While communities have centuries, or millennia, of experience with hurricanes, shifts in hurricane behavior can decrease the utility of community knowledge and preparedness, as can changes or inequities in the built environment, social services, or risk messaging. For example, while Hurricane Katrina made landfall in southern Louisiana in Plaquemines Parish and in Hancock County, Mississippi, and the storm surge was the highest across the Mississippi and eastern Alabama coasts, the city of New Orleans flooded due to levee failures (National Weather Service 2016). Had the levees not failed, New Orleans would have been spared much of the damage and loss of life.

Houston experienced five nationally declared flooding disasters between 2015 and 2017. Related to Hurricane Harvey, the largest of these disasters, research indicates that minorities and individuals with disabilities have disproportionately greater exposure to environmental hazards (Chakraborty et al. 2019) and lesser access to environmental benefits, although the latter has seen some improvement over time due to with shifting residence patterns (Elliott et al. 2019). During Hurricane Harvey, those who engaged in pre-storm mitigation at their homes experienced faster recovery and suffered fewer health and stress-related consequences (Grineski et al. 2019). The Houston-Galveston area, however, does not have enough shelter capacity to serve residents with housing and transportation needs (Karaye et al. 2019). Baer et al. investigated attitudes towards hurricane evacuation in Galveston, Texas, reporting that people chose not to evacuate either because they did not believe the reports of the potential dangers or they understood the reports and deemed evacuation more hazardous (Baer et al. 2019).

Lessons learned from previous hurricanes are shaping local and national policies and planning, though the application and effectiveness are uneven. Planning and zoning are often aimed at reducing future risk. 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. However, how planning and mitigation are applied and effective in the case of storms varies. The Harvey Data Project (Civis Analytics et al. 2019), a data collection and analysis project, provides details on the location and scale of Hurricane Harvey damage in Houston and develops a new methodology for understanding storm damage that the city intends to use in recovery from future flood events. This report notes that 56 percent of households directly impacted by Harvey flooding were not in a Federal Emergency Management Agency (FEMA) flood zone; that the impacts were very unevenly distributed, resulting in highly at-risk areas for recovery; and that official techniques significantly underestimate damage, particularly damage suffered by more vulnerable populations. In Louisiana, Davis (2008) notes that State coastal planning places responsibility for specific plans on local governments that do not have authority or resources to carry it out. Colten (2019) details how human adaptation to climate change in southern Louisiana has been disjointed and focused on short-term solutions, leading to poor adaptation at the larger scale and longer term that will lend itself to poor disaster outcomes. Similarly, in Louisiana, planning for flooding often rests at the level of local community organizations that can favor development, regardless of flood risk, leading to increasingly costly and destructive flood events (Colten and Grismore 2018). DeYoung et al. (2019) studied well-being and disaster preparedness among individuals in Cambodian and Laotian immigrant communities along the Alabama, Mississippi, Florida, and Louisiana coasts. They found that these communities have unique vulnerabilities tied to their histories and composition, with elders being particularly vulnerable; sense of community was positively correlated with a sense of well-being; and confidence in preparedness, ability to cope with a financial crisis, and trust in local government disaster response were all positively correlated with preparedness.

Within the Gulf Coast States, one of the most striking examples of application of post-hurricane lessons learned is with the State of Louisiana's coastal planning. According to a U.S. Geological Survey 5-year, post-Katrina survey, the wetland loss in Louisiana from 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). This, among other factors, encouraged Louisiana to codify its coastal planning by creating Louisiana's Coastal Protection and Restoration Authority (CPRA) in December 2005 and publish a series of *Comprehensive Master Plan for a Sustainable Coast*, the first of which was a 50-year, $50 billion plan for coastal restoration and storm surge protection, which was published in 2007 (Coastal Protection and Restoration Authority of Louisiana 2007).

Climate Change

Climate change is altering multiple facets of life in the area of analysis. Masters (2019) notes that the impacts of climate change, especially warmer ocean temperatures, are making slow-moving storms more common and more damaging, as they can sit over one location for longer periods of time, increasing the amount of participation seen in an area. It also contributes to sea-level rise, one factor in the loss of coastal lands felt across the Gulf of Mexico, but most acutely in Louisiana.

How climate change impacts communities is uneven and depends on many factors, though research is still ongoing to understand the impacts and variation. Hardy et al. (2018) discusses that communities face varied and varying exposure to and impacts from climate change due to how their dynamic social and economic situations do or do not make them vulnerable to these changes. Beyond the physical characteristics of place, they identify four social and economic factors that influence community vulnerability to climate change, i.e., specifically, access to resources, culture, governance, and information. They emphasized that, to be successful, attempts to reduce or understand vulnerability to a given hazard must consider how these four factors interact with exposure, sensitivity, and adaptive capacity. The Fourth National Climate Assessment (U.S. Global Change Research Program 2018) emphasizes that climate change brings new risks to communities but that the impacts are unevenly distributed, with already vulnerable groups more likely to feel negative impacts. Indigenous peoples are among those groups with an increased likelihood of experiencing negative impacts, including impacts to their livelihoods and economies, and physical, mental, and indigenous values-based health. Attempts at adaptation may be blocked by preexisting institutional barriers and a lack of published information on these resources. Ongoing attempts to develop Tribal sovereignty and cultural and language revitalization may be particularly threatened by climate change (Dupigny-Giroux et al. 2018; Jantarasami et al. 2018).

Dahl et al. (2017a, 2017b) analyzed the rates of socioeconomic vulnerability and three projections of sea-level rise to identify communities that, without intervention, would experience effective inundation (inundations regular enough to disrupt normal functioning) and would have a high percentage of residents lacking the means to respond. They concluded that most of the south Louisiana and east Texas coasts would fit into this category by 2035 in the intermediate low scenario. In the intermediate high scenario, additional socially vulnerable communities in central Texas, southern Louisiana, eastern Mississippi, western Alabama, and the Gulf Coast of Florida would experience effective inundation. This analysis adds to the previous analysis by expanding their consideration of impacts to include social and community impacts and by considering an objective measure – effective inundation – that impacts daily life and economic function.

Sea-level rise is expected to significantly shift U.S. population distribution. Using a scenario of 1.8-m (5.9-ft) sea-level rise between 2010 and 2100, Hauer predicts that, of the 50 states, Florida and Louisiana are the U.S. states likely to lose the most population from sea-level rise-induced migration (2.5 million and 0.5 million, respectively), with Texas likely to gain the most population (nearly 1.5 million), while Alabama and Mississippi will experience slight gains (Hauer 2017). This research emphasizes that the population movement will be distributed to all states and that receiving communities may not be prepared, worsening impacts. Robinson et al. (2020) build on this and other research to develop a modeling framework under the same scenario to better account for population distribution changes resulting from sea-level rise-induced migration coupled with migration to coastal areas that would be routed to other areas. Therefore, their findings indicate that, while all states will be impacted, large population centers and currently less desirable areas located near desirable coastal areas will also see increases in population. In the area of analysis, they expect inland urban areas and near-coastal areas in Florida, Mississippi, and Louisiana to see additional gains in population. This kind of population movement would have significant impacts on the coastal communities and how they interact with the offshore oil and gas industry by altering community function and changing the distribution of populations, markets, and available labor.

Specific to the five Gulf Coast States, a study conducted by Elisaveta 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 GOM 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 (Elisaveta et al. 2015).

Research with a State-recognized Tribe in Terrebonne Parish, Louisiana, indicates that Tribal communities are particularly susceptible to harms from environmental change because the environment is connected to cultural knowledge tied to health and well being, and separation from or alteration of that environment can therefore threaten the knowledge and its contribution to health and well being (Billiot et al. 2019). The authors suggest that this is further evidence that marginalized communities or communities that rely more closely on the land will be more susceptible to climate change and its impacts.

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 GOM 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).

Coastal Louisiana, with its additional pressures of coastal land loss and flooding, offers clear illustrations of these processes. Colten et al. (2018) explain that, in southern Louisiana, while mobility was a key practice after hurricanes and oil spills in the past, those were different economic, social, and ecological circumstances. Residents currently resisting migration, especially forced migration in the face of large-scale coastal restoration projects, do so for multiple reasons, including their histories of traumatic relocations, their attachment to place, economic exigencies, and in protest of Louisiana's history of discriminating against disadvantaged populations and rural areas in its protection and restoration decisions. The authors additionally note that the State has, at the time of publication, no plan to work with communities impacted by coastal restoration and that, as people leave, the conditions will continue to deteriorate for those who stay. Simms (2017) emphasizes the livelihood, cultural, and social connections to place, including practices that increase resilience in disaster, which could be destroyed in forced or unplanned migrations. At the time of this research, policy discussions did not take these practices into account; this will likely have detrimental effects on the populations and cultures of southern Louisiana (Simms 2017). Since that time, in recognition of the challenges faced in southern Louisiana and the need for holistic, community-based adaptation and risk planning, the State, through LA SAFE, conducted a series of community meetings in coastal communities and combined the results with scientific data on expected coastal changes and planning expertise to produce a compilation of community-based adaptation strategies (Louisiana's Strategic Adaptations for Future Environments 2019). The State is also managing a voluntary resettlement program for current and former residents of Isle de Jean Charles, a rapidly eroding island whose residents are primarily of Tribal ancestry, to provide them safe housing inland, away from storm and land loss threats (State of Louisiana and Isle de Jean Charles Resettlement Program 2019). Research on coastal planning in Louisiana found that participatory modeling can be used successfully as a tool to incorporate traditional ecological knowledge in coastal restoration planning and as a way to increase participation from local residents and build their trust in the State, its agents, and the process (Hemmerling et al. 2019).

As a specific example associated with climate change, the Mississippi River experienced a historic high-water event during 2019. This disrupted trade on the river. Due to the high water, in

2019, the U.S. Army Corps of Engineers opened the Bonnet Carré Spillway twice for a total of 123 days; both are historic events (USACE 2019). These openings released trillions of gallons of freshwater into Lake Pontchartrain and, from there, the Mississippi Sound, creating algae blooms, closing all Mississippi beaches and some additional waters to swimming and fishing, and killing dolphins. This persisted throughout the summer, disrupting livelihoods and tourism, and raising fears of impacts similar to the *Deepwater Horizon* oil spill (Lee 2019; Sharp 2019; Weatherly 2019b). The impacts of these losses were declared a catastrophic regional fishery disaster, making the impacted fishing communities eligible for Federal relief funds (DOC 2019). The lasting impacts of this situation are still unknown.

Coronavirus

During winter 2019-2020 a novel coronavirus and associated disease, COVID-19, originated in Wuhan Province, China. It quickly spread around the globe, attaining pandemic proportions by March 11, 2020, after which a national state of emergency in the U.S. was declared on March 13, 2020 (Taylor 2020). Many of the five Gulf Coast States or jurisdictions within them declared stay-at-home orders (Kaiser Family Foundation, 2020) and some have declared mandatory quarantine periods for visitors. This is a rapidly developing situation. During the pandemic, information was available on a CDC website (CDC 2020). As travel and industry slowed, first in China, and then around the globe, demand for oil fell, and an oil war between Saudi Arabia and Russia kept production high, leading oil prices to fall precipitously over spring 2020 (Stickney 2020). Appearance of COVID-19 on oil platforms in the Gulf of Mexico by April 8, 2020, led to increased questions about how the industry will face this, coupled with the pandemic and oil price collapse (Sneath 2020). How the situation will develop is unknown, but it will likely have diverse, long-lasting impacts on the five Gulf Coast States and has the potential to alter baseline conditions. BOEM will continue to monitor the situation and seek the best information available on the impacts of the pandemic.

4.4.6.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and social factors (including environmental justice). **Figure 4.4.6-9** provides a synopsis of the IPF categories that currently affect or have the potential to affect social factors in the Gulf of Mexico OCS. Following **Figure 4.4.6-9** is a summary of those potential effects on social factors, as well as a brief discussion of the IPF categories identified in **Figure 4.4.6-9** that are not likely to affect social factors, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors including, but not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to social factors, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

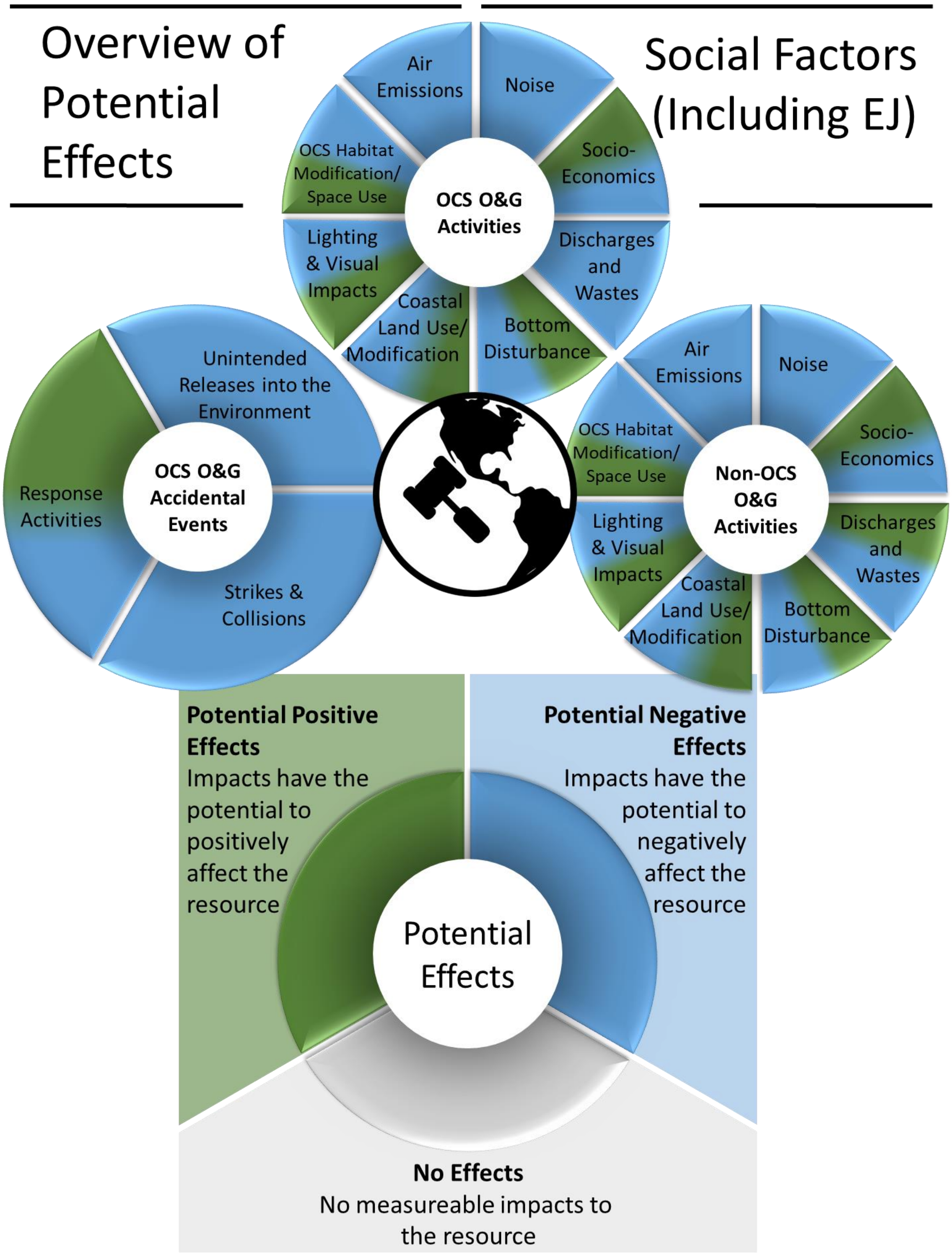


*Figure 4.4.6-9. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Social Factors (Including Environmental Justice). Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (EJ = environmental justice, O&G = oil and gas)*

4.4.6.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.6-9 highlights the IPF categories of other, non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect social factors in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions from non-OCS oil- and gas-related activities can have negative effects on social factors and environmental justice. Air pollutants are released by human activity (i.e., industrial activity, combustion engines, agriculture, and consumer products), and many can also be released by non-human activity (i.e., forest fires, high winds, natural seeps, decay of solid waste, and lightning) and include those regulated under NAAQS, hazardous air pollutants, and greenhouse gases. Fossil fuel combustion can contribute to smog, acid rain, and hazardous air pollutants that can cause cancer or other adverse health effects (USEPA 2013a; 2019b; Wilson et al. 2019b). These releases can negatively affect human health, degrade habitats of culturally and economically significant plant and animal species, damage cultural and archaeological resources, impede visibility, contribute to ocean acidification, and impact weather, climate, and manmade materials. Refer to **Chapter 4.1** (Air Quality), **Chapter 4.3** (Biological Resources and Habitats), **Chapter 4.5** (Cultural, Historical, and Archaeological Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional details on air quality and the effects of air quality on resources. Communities, and especially environmental justice communities, which rely on these resources for their sense of place, culturally significant practices, or income, may be particularly vulnerable. Refer to **Chapters 2, 4.1, and 5**, and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for details on the regulations that limit air emissions for non-OCS oil- and gas-related activities.

Discharges and Wastes (Chapter 2.2.2)

Discharges and wastes can have both negative and positive effects on social factors and environmental justice. Point- and nonpoint-source pollution of liquid and solid waste (including plastics) from multiple sources (i.e., industrial, agricultural, and urban) can pollute the air and water used by people, causing acute and chronic effects, and can contaminate the habitat of species used for subsistence, including subsistence fishing, making them unavailable or unsafe for use by environmental justice and other communities. This is discussed in additional detail in **Chapter 4.1** (Air Quality), **Chapter 4.2** (Water Quality), and **Chapter 4.4.4** (Subsistence Fishing). Closure of areas to recreational use or fishing can prevent use of these areas, while protecting human health. Not all health advisories and fishing closures are followed due to poorly disseminated advisories, unclear communication of the advisories and associated risks, language barriers, and unwillingness or inability to follow advisories, leading to potential human health effects. Onshore waste disposal involves transportation routes and waste management facilities, which, while necessary, can be perceived as negative by neighbors and can involve noxious or unpleasant odors, concerns about human health effects from allowed or accidental releases, and reduced property values. Siting decisions for some past waste management facilities placed them near environmental justice communities, causing lasting disproportionate effects on these communities. Impacts from discharges and wastes from oil and gas activity in State waters are similar to those from OCS oil- and gas-related activity, except that, being closer to shore, physical effects felt by communities are expected to be proportionally stronger. These effects, including negative effects on water quality from point- and nonpoint sources of contaminants and contribution to onshore waste disposal are described in detail below (refer to the "Discharges and Wastes" section in **Chapter 4.4.6.2.2**, Potential Effects from Routine OCS Oil- and Gas-Related Activities). Conversely, dredged material disposal often benefits surrounding land by shoring up areas undergoing subsidence and making improvements that can be used for parks, recreation, and fishing (refer to **Chapter 4.4.1**, Land Use and Coastal Infrastructure; and **Chapter 4.4.5**, Tourism and Recreational Resources).

Bottom Disturbance (Chapter 2.3.2)

Bottom disturbance from activities such as dredging, trawling, and marine construction can have negative effects on social factors and environmental justice. It can disrupt habitat (through turbidity and sedimentation or physical displacement) for species, including oysters and other shellfish, making them unavailable for consumption or commerce. Conversely, the installation of production structures related to State oil and gas activities, as well as artificial reef placement could enhance reef fish habitat and thus improve fishing and diving opportunities by congregating some fish populations near the structures. Accessible fishing structures can lead to an increase in availability of fish for consumption, commerce, and recreational experience. Additional detail is available in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), **Chapter 4.4.4** (Subsistence Fishing), **Chapter 4.4.5** (Tourism and Recreational Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.2)

Anthropogenic noise from non-OCS oil- and gas-related sources, including State oil and gas activities, industrial activity, and construction, can negatively affect animal behavior (refer to **Chapter 4.3**, Biological Resources and Habitats). Although sound from non-OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by non-OCS oil- and gas-related activities may negatively affect commercial, recreational, and subsistence fishing (refer to **Chapter 4.4.2** [Commercial Fisheries], **Chapter 4.4.3** [Recreational Fishing], and **Chapter 4.4.4** [Subsistence Fishing]) through decreased landings.

Coastal Land Use/Modification (Chapter 2.5.2)

Coastal land use can have positive or negative effects on social factors and environmental justice. Coastal land is a limited resource; decisions about its use would necessarily preclude certain other uses. For example, a given piece of land cannot be both a nature preserve and an industrial park. The importance of coastal lands, particularly wetlands, is recognized and decisions about coastal land use are regulated by local, State, and Federal zoning, ordinances, regulations, and laws.

Even within this legal structure, use decisions can be controversial and simultaneously considered positive by some stakeholders and use groups, and negative by others.

Land development, whether residential, commercial, or agricultural, and the zoning ordinances or planning documents that constrain or promote it can have negative and positive effects on people, habitats, and the environment, depending on how they stand to benefit or not from various proposed projects. For example, when highway systems (local, State, or Federal) and port facilities are expanded, there is a tradeoff between the benefits of expansion and the potential negative effect to the local environment, people, and communities. Industrial development is tied to key industries. River channelization and dredging of other waterways also contribute to effects for local populations, especially low-income and minority populations who may have traditionally fished and tended oyster beds negatively affected by the disruption of the natural balance of the delicate ecosystem.

Additionally, processes including coastal storms, flooding and drought, sea-level rise, subsidence, barrier island migration and erosion, and climate change can all effect the availability and condition of coastal lands. Environmental justice communities may be particularly sensitive to changes in coastal land use, either positive or negative, because they may have culturally significant practices that rely on the use of coastal lands or they may lack the financial resources to travel or otherwise replace lost use.

Ongoing for decades, population movement from rural to urban areas continues to effect people and communities, involving demographic shifts as people move into or out of the more densely populated areas. Effects that result include development and associated 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 and the natural resources on which they may depend. As rural communities are depopulated and population shifts to larger communities and urban areas, this places strains on public infrastructure in both the growing and shrinking communities.

Other human activities that also have effects 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 effects to the residents, community, and environment could result. Environmental management is also critical. In recent years Louisiana has experienced increased releases of toxic chemicals from petrochemical plants, increasing the hazards to which nearby communities are exposed (Schleifstein 2019b). The State's Department of Environmental Quality's budget and staffing have also been significantly reduced, raising questions about the agency's ability to enforce environmental regulations (Schleifstein 2019a). This may also raise environmental justice concerns, depending on the composition of the surrounding neighborhoods.

Lighting and Visual Impacts (Chapter 2.6.2)

Lighting and visual impacts can have positive or negative effects on social factors and environmental justice. While lighting can be installed for public safety and to facilitate nighttime industrial work, enjoyment of outdoor spaces, and fishing after dark, creating positive effects, it can also contribute to light pollution and be disruptive to certain species and other human uses of nighttime spaces, such as recreation (including star-gazing, camping, fishing). Lighting and visual impacts from offshore oil and gas activity in State waters, including lighting installed for working and navigational safety, can create positive effects for the oil and gas industry but it can also contribute to light pollution, creating negative effects for certain species or communities in the area and possibly disrupting the sense of place of a community or its cultural, historic, and archaeological resources. Visual impacts from State offshore oil and gas infrastructure are subjective and vary in space and time (Bounds 2012; Nassauer and Benner 1984; NPS 2001). These effects are similar to lighting and visual impacts from OCS oil- and gas-related activity, as described below (refer to the "Lighting and Visual Impacts" section in **Chapter 4.4.6.2.2**, except that, being closer to shore, effects felt by communities are expected to be proportionally stronger. Changes that involve physical development, creating visual impacts, may also visually alter the subjective experience and sense of place of a community and any cultural, historic, and archaeological resources, if present. This may be particularly disruptive to environmental justice communities and areas that rely on their sense of place or cultural resources for community identity or as a draw for recreation and tourism. Refer to **Chapter 4.5** (Cultural, Historical, and Archaeological Resources) for additional information.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

Offshore space use can negatively and positively affect communities and society in the area of interest. There are many competing interests for offshore land and water, including commercial and recreational fishing (which at times compete both with each other and with other uses), aquaculture, State offshore oil and gas and renewable energy, marine minerals (including sediment for coastal restoration projects), coastal restoration projects, military activities, transportation, tourism and recreation, protected areas (including cultural resources, marine protected areas, critical habitat), and other industries. The temporality and temporary nature of certain uses may allow for multiple uses to take place in the same area at different points in time, such as military activities and recreational boating, which can both be transitory. However, in cases where structures remain in place for long periods of time or nonrenewable resources are extracted, a gain for one interest group, such as proponents of renewable energy projects, may be a loss to another interest group, such as commercial fishers who rely on trawling. Additionally, processes including coastal storms, flooding and drought, sea-level rise, ocean acidification, barrier island migration and erosion, underwater mudslides, and climate change can all affect the condition of OCS lands and waters.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Socioeconomic drivers have arguably the largest effect on social factors and environmental justice, both positive and negative. Events and processes associated with socioeconomic changes and drivers are diverse and all-encompassing, in essence, all of social and economic life. They include changes to demography; migration; local and global economies; government programs and expenditures, including military, public health, education, environmental management, and enforcement; size, composition, and distribution of key industries, including fishing, tourism and recreation, and the petrochemical industry; workforce structure; and culture, social structure, and preferences. For example, 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. Some effects of this, such as a reduction in housing prices, may be positive for some parts of the community, such as renters. In an economic boom, jobs become more available, people and local governments have more money to spend, and communities see direct, indirect, and induced economic effects. Some aspects of this may be negative for portions of the community, such as low-income renters who may find themselves prices out of housing markets. As another example, one factor youth consider in their career choices is the local availability of training programs or opportunities. Founding or closure of a program, therefore, may have long-term effects on both the opportunities available for local residents and the numbers of workers present for industry to hire. These changes may be particularly strongly felt by environmental justice communities who may not have the financial or social resources to take advantage of potentially positive changes or mitigate negative ones.

Revenues from oil programs in State lands and waters have produced several positive effects, and the steady stream of oil exploration and development have produced positive effects that include increased funding for infrastructure, higher incomes, better health care, and improved educational facilities. Texas, for example, has historically used oil and gas revenues on State lands to equalize education district disparities across the State. Offshore leasing in shallow waters has been in a general decline, reducing revenues to the states. Louisiana is additionally facing increasing fiscal responsibility to plug growing numbers of wells abandoned by bankrupt oil and gas companies, a situation worsened by a State agency in charge of regulating the oil and gas industry that has not fulfilled its legal obligations (Schleifstein 2020). With industry volatility associated with COVID-19 and the oil price war, it is not certain how this situation will unfold, but it is likely the state's responsibilities will grow.

The status of a community's educational system may be a positive or negative benefit to the residents, depending on the quality of the educational facilities and infrastructure, teacher-to-student ratios, standardized test scores, amount and extent of busing across cities and towns, and availability of special education services in the public schools (FSG Inc. 2011; National Education Association 2020). The status of higher education, trade schools, community or junior colleges, colleges, and universities in an area may also be a positive or negative influence on the area. Closures or reductions in programs, particularly in smaller or underserved communities, can lead to job losses and loss of opportunity for residents who may not be able to travel to study elsewhere. Development of new programs may offer increased opportunities, particularly if they contribute to requirements for locally or regionally available jobs. The status of these institutions may also influence what companies choose to relocate to the area if they need a specially trained workforce.

Public health and family support services systems, namely their availability, proximity, and quality (CommonHealth ACTION 2015), are also extremely important. 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. The quality and accessibility of these government services contribute to the opportunities available to residents and businesses or other organizations in these areas, and therefore contribute to decisions about entering, staying in, or leaving these communities.

The contraction and expansion of key industries contribute to the economies, onshore and offshore land use, visual impacts, and subjective experience of living in the area. As industries expand and contract, they may compete directly or indirectly for land, workers, public perception, and government funding or assistance. Competition for workers is recognized as a significant challenge for industries, particularly those with unpredictable or cyclical employment needs, such as oil and gas and shipbuilding and fabrication (Austin et al. 2002a; Austin and Woodson 2014; McGuire et al. 2014).

4.4.6.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.6-9 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect social factors in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

Air emissions and pollution from routine OCS oil- and gas-related activities are highly regulated and monitored under the NAAQS. However, air emissions from routine OCS oil- and gas-related activity can have negative effects on social factors and environmental justice. Air pollutants released from OCS oil- and gas-related activities, including fossil fuel combustion and venting, can contribute to smog and acid rain, and hazardous air pollutants that can cause cancer or other adverse health effects (USEPA 2013a; 2019b; Wilson et al. 2019b). In addition to human health concerns, these releases can degrade habitats of culturally and economically significant species and damage cultural and archaeological resources. Communities, and especially environmental justice communities, that rely on these resources for their sense of place, culturally significant practices, as a food source, or for income may be particularly vulnerable. Refer to **Chapter 4.1** (Air Quality), **Chapter 4.3** (Biological Resources and Habitats), **Chapter 4.5** (Cultural, Historical, and Archaeological Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b) for additional details on air quality and the effects of air quality on resources. Refer to **Chapters 2, 4.1, and 5**, and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for details on the regulations that limit air emissions for OCS oil- and gas-related activities.

Discharges and Wastes (Chapter 2.2.1)

Discharges and wastes from routine OCS oil- and gas-related activity, although highly regulated, can have a negative effect on social factors and environmental justice. This includes negative effects on water quality from drilling discharges and produced waters that can degrade habitat, including that of species used commercially, recreationally, and for subsistence. This is discussed in additional detail in **Chapter 4.1** (Air Quality), **Chapter 4.2** (Water Quality), and **Chapter 4.4.4** (Subsistence Fishing). Some waste from OCS oil- and gas-related activity can be disposed onshore in permitted facilities (refer to **Chapter 4.4.1**, Land Use and Coastal Infrastructure). This involves transportation routes and waste management facilities which, while necessary, are perceived as negative by neighbors and can involve noxious or unpleasant odors, concerns about human health impacts from allowed or accidental releases, and reduced property values. Siting decisions for some past waste management facilities placed them near environmental justice communities, causing disproportionate effects to these communities.

Bottom Disturbance (Chapter 2.3.1)

Bottom disturbance from OCS oil- and gas-related activities, including that resulting from dredging and installation and decommissioning of platforms, pipelines, cables, and other structures, can have negative effects on social factors and environmental justice. It can disrupt habitat (through turbidity and sedimentation or physical displacement) for species, including oysters and other shellfish, making them unavailable for consumption or commerce. Conversely, OCS oil- and gas-related structures could have positive effects by enhancing reef fish habitat and thus improving some fishing and diving opportunities by congregating fish populations near the structures and making them easily available for consumption, commerce, and recreational experiences. Additional detail is available in **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), **Chapter 4.4.4** (Subsistence Fishing), **Chapter 4.4.5** (Tourism and Recreational Resources), and BOEM's Biological Environmental Background Report (BOEM 2021b).

Noise (Chapter 2.4.1)

Anthropogenic noise from OCS oil- and gas-related activities, including transportation and industrial activity, can negatively affect animal behavior (refer to **Chapter 4.3**, Biological Resources and Habitats). Although sound from OCS oil- and gas-related activities is not expected to have population-level effects to fish and invertebrates (refer to **Chapter 4.3.4**, Fish and Invertebrates), anthropogenic sound caused by OCS oil- and gas-related activities may negatively affect commercial, recreational, and subsistence fishing (refer to **Chapter 4.4.2** [Commercial Fisheries], **Chapter 4.4.3** [Recreational Fishing], and **Chapter 4.4.4** [Subsistence Fishing]) through decreased landings.

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land use from routine OCS oil- and gas-related activities can have positive or negative effects on social factors and environmental justice. As discussed above in non-OCS oil- and gas-related effects, coastal land use can be controversial and involves many diverse stakeholder groups. The shape, size, and impact of associated infrastructure varies on the landscape, so these effects are not equally distributed across the area of interest but are predominantly concentrated around centers of the oil and gas industry, as described in **Chapter 4.4.1** (Land Use and Coastal

Infrastructure). For example, a given piece of land cannot be both a recreational area and an oil refinery. Building a refinery on a coastal parcel could have a positive effect for the workers in the OCS oil and gas industry and the local economy in the area; however, the land where the refinery was built is no longer available for recreational or subsistence uses, negatively affecting people who may have used the land for those uses previously and preventing economic gains associated with recreation, subsistence, or any other potential use on that land. Environmental justice communities may be particularly sensitive to changes in coastal land use as they may have special uses of those lands and be less likely to benefit from development.

Lighting and Visual Impacts (Chapter 2.6.1)

Lighting and visual impacts can have positive or negative effects on social factors and environmental justice. The OCS oil- and gas-related lighting is installed for working and navigational safety, creating positive effects for the oil and gas industry; however, it can also contribute to light pollution, creating negative effects for certain species or communities in the area. The OCS oil- and gas-related lighting may disrupt the sense of place of a community or its recreational, cultural, historic, and archaeological resources and economically or culturally significant species. Environmental justice communities may be particularly sensitive to these disruptions if they have culturally significant relationships with those resources or are dependent on income associated with them. Refer to **Chapter 4.5** (Cultural, Historical, and Archaeological Resources) for additional information. Although these impacts are similar to those described above in the "Lighting and Visual Impacts" section in **Chapter 4.4.6.2.1**, given the smaller amount of infrastructure associated with OCS oil and gas than all other human uses, the effects of OCS oil- and gas-related lighting would be much more limited in extent and scope.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

The OCS oil and gas offshore space use can have negative and positive effects on social factors and environmental justice. These effects are similar to the "Offshore Habitat Modification/Space Use" section in **Chapter 4.4.6.2.1** but are limited to the placement and removal of OCS oil- and gas-related infrastructure. While placement of OCS oil and gas infrastructure prevents competing uses of those areas, such as fish trawls, it provides additional locations for recreational fishing. The OCS oil and gas structure removal, however, eliminates or alters potential recreational fishing locations but increases areas where commercial trawlers may operate. Therefore, the effects of structure removal can be viewed as both negative (e.g., commercial and recreational anglers) or positive (e.g., commercial fishing).

Socioeconomic Changes and Drivers (Chapter 2.8.2)

The OCS oil- and gas-related activities have the potential to both negatively and/or positively effect social and economic factors. They also vary in space and time, occur in varying degrees of intensity, can have simultaneous positive and negative effects or be one or the other depending on the specifics of any given situation, and are experienced at multiple, overlapping levels, including industry workers, support industry workers, families of workers, and the individuals and institutions that make up the communities at large. Issues related to this impact-producing factor are broad. They include, but are not limited to, employment stability, wages and opportunities for advancement, economic and non-economic rewards in exchange for work (benefits and satisfaction), economic and career opportunity, work scheduling patterns, industry cycles and fluctuations in OCS oil- and gas-related activity levels, industry-driven demographic shifts (in-migration and out- migration), and commuter and truck traffic.

Industry Volatility

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 to changes in oil and gas commodity 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 OCS 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, 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. Scott (2018) describes how important and influential the extraction, refining, and pipeline sectors of the oil and gas industry are for the State of Louisiana. While the residents and communities of Louisiana enjoy unquestionable economic benefits, they also are most impacted by fluctuation in OCS oil- and gas-related activity levels and oil and gas prices. For example, when measured in growth per capita personal income, before the oil price crash of the 1980s, Louisiana was the third fastest growing state in the U.S.; however, after the crash it became the third slowest (Austin et al. 2008). The impact of the crash on the other four Gulf Coast States was statistically indistinguishable from the rest of the Nation. Since that time, some areas that were particularly hard hit have increased financial planning and economic diversification, with mixed results; simultaneous downturns in oil and gas and other industries could still create shocks (Austin et al. 2002a), including after the *Deepwater Horizon* explosion and oil spill in 2010 (Austin et al. 2014b). Shortfalls and fluctuations are often felt hardest by environmental justice communities that lack equal access to the social and financial resources necessary to successfully adapt to these changes. Hemmerling et al. (2020) also examine the relationship between the oil and gas industry and communities, noting that, while it has positive economic impacts, it has also increased community vulnerability to economic fluctuations.

Industry Sectors

Sectors of the offshore oil and gas industry vary in many respects, including composition, work schedule and requirements, benefits and perceived desirability, and distribution along the Gulf Coast. 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 GOM, and it is likely to continue experiencing benefits from continued offshore oil and gas activity (Scott 2018), thus concentrating impacts. Austin et al. (2002a) and Austin et al. (2002b) describe the differences in sectors 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 as it is more easily affected by fluctuations in oil and gas prices.

The shape, size, and impact of these industries on the landscape also varies. Hemmerling and Colten (2017) identified potential geographic and demographic impacts of OCS oil- and gas-related hazards on minority and low-income populations in three coastal Louisiana parishes using GIS techniques to integrate locations of OCS oil- and gas-related activities, census data, and transportation data from the early 2000s. The study considered the locations of residences and key subsistence resources. The authors concluded that there was very little evidence of systematic environmental injustice in the siting procedures of various oil-related industries. In most cases, the demographic makeup of the community changed after the facilities were constructed, either increasing or reducing the percentage of minorities in the area. The authors noted environmental justice concerns, especially ensuring residents' access to accurate and up-to-date data about neighborhood and environmental health risks for informed decisionmaking about their residence, subsistence, and cultural activities.

Of industries that support the offshore oil and gas industry, shipbuilding and fabrication has one of the largest physical footprints in the Gulf of Mexico region. Though shipbuilding existed in the region long before the oil and gas industry and also services fishing, bluewater and brownwater transportation, and military and security forces, oil and gas has featured in its development and has influenced its current composition. Priest and Lajaunie (2014) describe the development of the shipbuilding and fabrication industry, the role it played in the growth of offshore oil and gas, its distribution across the coast, and its composition by 2005. Austin and Woodson (2014) describe seven key shipbuilding communities that are illustrative of the industry's diversity across the coast from Texas to Alabama. McGuire et al. (2014) focus on the composition of the industry, its workforce, its role in development plans and programs, risk, and the influence of hurricanes.

Community Composition and Perspectives

The impacts of the industry and its support industries are interpreted and lived differently depending on the composition of the communities experiencing the impacts. For example, noneconomic rewards or detriments associated with work, including status and social standing, will vary in relative importance compared to other available options and how the industry is perceived. Austin and Woodson (2014) and Austin et al. (2002b) describe this for the shipbuilding and fabrication industry and note the desire of parents in these industries and in offshore oil and gas that their children not follow them into their chosen professions. Austin and Woodson (2014) illustrate that the industry mix is one factor that workers consider when defining their employment preferences, and Austin et al. (2002b) add that availability of training options is one thing teens consider when thinking about future careers. This availability is, in part, determined by the communities themselves and has continued effects on the distribution and availability of trained workers for employers to hire. Economic development officials consider industry needs when lobbying for educational programs, and planners and elected officials have been working to diversify economies since the oil bust of the 1980s (Austin et al. 2002). Communities that have successfully diversified are less likely to experience widespread negative consequences from volatility in oil and gas.

Similarly, community members can differ on the desirability of additional industrial development. These differences can be contentious, and complicated issues and members of communities may disagree, both among themselves and with planners and elected officials. Environmental justice communities may be particularly vulnerable to these changes, as their needs and preferences are less likely to be consulted by planners and developers and they may lack financial and social resources necessary to positively adapt to the changes (e.g., refer to (Maantay 2002).

4.4.6.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.6-9 highlights the IPF categories of accidental events associated with oil- and gas-related activities on the OCS that could potentially affect social factors in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Releases into the environment could have negative effects on social factors and environmental justice, particularly on coastal communities and communities with close ties to coastal resources. Accidental or emergency release of air pollutants on platforms could pose a hazard to helicopters (BSEE 2015a), which could result in a crash, as well as pose a hazard to nearby humans and animals through elevated air emissions, though the duration is expected to be temporary. Refer to **Chapter 4.1** (Air Quality) for additional discussion. When oil is spilled in offshore areas, much of the oil volatilizes or is dispersed by currents, so it has a low probability of contacting coastal areas but may negatively affect offshore activities such as fishing, recreation, or transportation, depending on the timing, by not allowing these activities to take place in the affected area or negatively affecting the health or survival of the fish or other organisms in the area of the spill.

Oil spills that occur in coastal or nearshore waters have a greater chance of directly affecting local populations. Similarly, the effects of chemical and drilling-fluid spills depend on the location and timing of the spill, with spills closer to shore increasing the likelihood of negative effects to coastal communities. Effects of spills in coastal waters could include habitat degradation of sought-after fish, contaminated catch, inability to fish or recreate in the affected area, and closure of ports or vessel traffic lanes, resulting in the inability to leave port to fish. A spill that occurs during the open season for a fishery or in a major transportation lane, for example, would have more negative consequences than one that takes place during the off season or in a low-traffic area because the health or habitat of the fish, as well as the fisher’s ability to pursue the fish, could both be negatively affected, resulting in a reduction of catch for commercial, recreational, or subsistence fishers. For more detail on the biological effects of oil spills to fish and invertebrates, refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM’s Biological Environmental Background Report (BOEM 2021b). Refer to **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3**

(Recreational Fishing), **Chapter 4.4.4** (Subsistence Fishing), and **Chapter 4.4.5** (Tourism and Recreational Resources) for the effects of oil spills on fishing, tourism, and recreation.

Most small-scale oil spills are short in duration and have transitory effects, including area closures and fish advisories. Larger spills could result in larger closures and more fish advisories over a greater area for a longer time period. Effects of an oil spill can be compounded if the spill impedes time-limited processes such as fishing seasons or cultural events, such as fleet blessings. Environmental justice and subsistence populations and Tribes may have additional vulnerabilities due to their particular circumstances or specificities of resource use.

Response Activities (Chapter 2.9.2)

Spill response can have both negative and positive effects on social factors and environmental justice. It can disrupt normal social and economic functioning, creating disruption and loss. Institutions may be unable to fulfill their normal functions because of their attention to the spill response. Accidental events involve varying degrees of spill response and containment, from short-term response involving only a few people and a limited geographic area to those affecting more than one county or parish with impacts lasting up to 1 year. Associated activities could affect facets of the community differently. Businesses and individuals involved in response (other than the responsible party) could see economic gain, while those whose livelihoods or business plans are disrupted by the spill, and its cleanup would need to adjust their plans and could see losses (Austin et al. 2014a, 2014b). Were cultural events to be disrupted, the losses could be both social and economic, and impact a more varied segment of the population, depending on the nature of the event, including participants, presenters, vendors, government institutions, and nonprofit religious organizations. For those workers involved in spill response, however, there can be positive economic gains, as well as economic gains for surrounding hotels and restaurants that gain business from the response, though others may see losses. The effects of a spill on a particular community can depend 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 (Austin et al. 2014a). Refer to the *Gulf of Mexico Catastrophic Spill Event Analysis* technical report (BOEM 2021d) for additional discussion.

Strikes and Collisions (Chapter 2.9.3)

Vessel collisions could have negative effects on social factors and environmental justice. Collisions may affect local populations as they can result in oil or chemical spills, as discussed above, and may interrupt fishing, transportation, and cultural activities along waterways or adjacent roadways. Their impacts would be compounded if they impeded time-limited processes such as fishing seasons or cultural events, such as fleet blessings. Commercial, recreational, and subsistence fishing could be particularly affected by vessel collisions if the collision occurred on inland waterways and disrupted the flow of vessels coming from and going to port (refer to **Chapter 4.4.2** [Commercial Fisheries], **Chapter 4.4.3** [Recreational Fishing], **Chapter 4.4.4** [Subsistence Fishing]). Vessel collisions in coastal waters may involve other vessels or stationary structures like bridges and docks. If a bridge, pier, or other structure is hit, it could disrupt the transportation of goods, services, and people to and from work and schools. The severity of the effects would be dependent on the location of the vessel collision, the size of the vessels involved, and whether the collision involves a bridge, pier, or other structure. Refer to **Chapter 4.4.1**, Land Use and Coastal Infrastructure, for additional information.

4.4.7 Economic Factors

4.4.7.1 Resource Description

Economic factors are factors that explain and quantify the human behaviors that determine the positive and negative effects that may arise from both OCS oil- and gas-related activities and non-OCS oil- and gas-related activities. Offshore oil- and gas-related 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.

Economic Impact Areas

BOEM aggregates 133 counties and parishes from the five Gulf Coast States into 23 EIAs based on economic and demographic similarities among counties and parishes (Varnado and Fannin 2018). Much of BOEM's socioeconomic analyses focus on these EIAs since many of the positive and negative effects related to OCS oil and gas leasing in the Gulf of Mexico are concentrated in these EIAs. These EIAs also serve as consistent units for which to present economic and demographic data. **Figure 4.4.7-1** shows a map of the EIAs in the GOM region. For more information on EIAs, refer to **Chapter 2.5**.

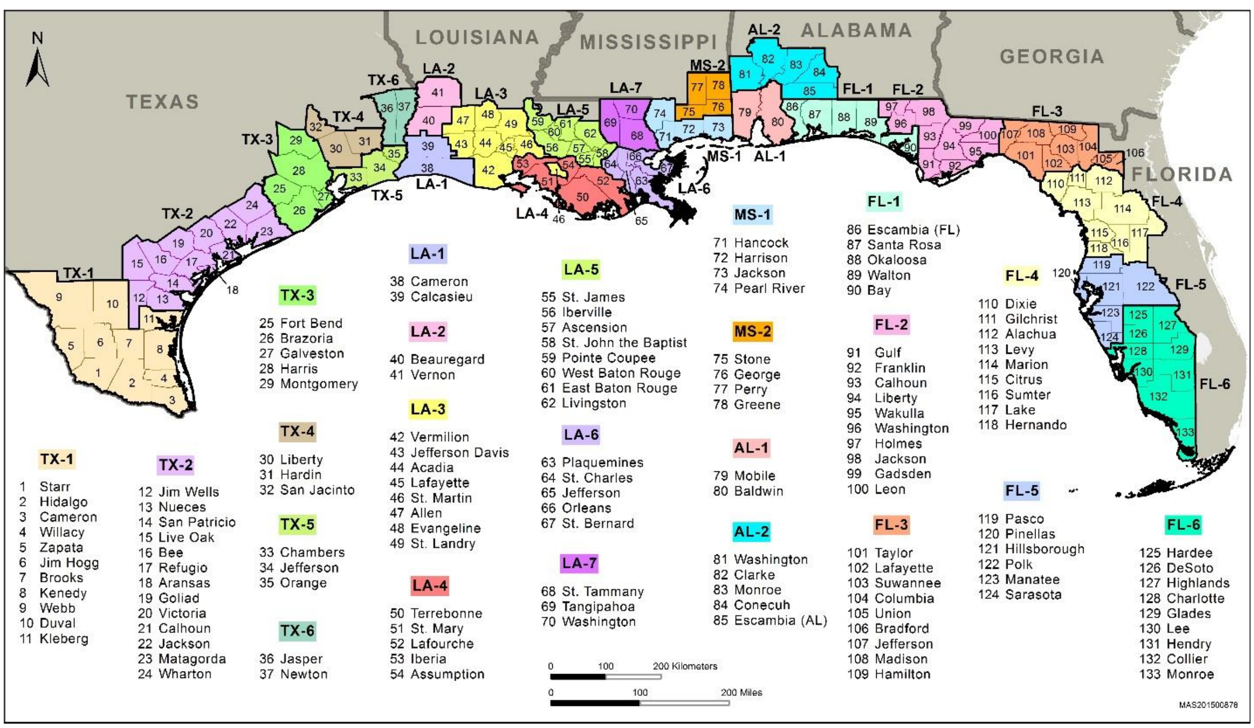


*Figure 4.4.7-1. Economic Impact Areas in the Gulf of Mexico Region (reprint of **Figure 2.5-1**).*

Economic and Demographic Data

BOEM measures baseline economic conditions in the Gulf of Mexico region by utilizing economic data provided by Woods & Poole Economics, Inc. These data provide baseline and projected economic information for both OCS oil- and gas-related activity and non-OCS oil- and gas-related activity in the GOM region. These data are derived from historical local, regional, and national data, as well as likely changes to economic and demographic conditions. 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. BOEM acknowledges that these data are not comprehensive but provide reasonable projections based on future possible projects and actions.

The Woods & Poole Economics, Inc. data include county-level economic and demographic data for prior years, as well as forecasts through 2050. BOEM aggregates these data by EIA for select socioeconomic variables, including population, employment, gross regional product, labor income, median age, sex, and race composition. According to Woods and Poole Economics, Inc. (2020) (displayed in **Table 4.4.7-1**), the largest EIAs in 2018 (presented in descending order of gross regional product) were TX-3 (which includes Houston and Galveston), FL-5 (which includes Tampa), LA-6 (which includes New Orleans), FL-6 (which includes Fort Myers), LA-5 (which includes Baton Rouge) and TX-1. The smallest EIAs (presented in ascending order of gross regional product) were MS-2, TX-6, LA-2, TX-4, and AL-2. The forecasts from Woods & Poole Economics Inc. (2020) for future years are presented in **Table 4.4.7-2** below.

Table 4.4.7-1. Economic and Demographic Information for BOEM's Economic Impact Areas in 2018.

EIA	Population[1]	Employment[1]	Gross Regional Product (thousands, 2012 dollars)[1]	Labor Income (thousands, 2012 dollars)[1]	Median Age[2]	Male Percent[2]	White[2]	Black[2]	Hispanic[2]	Native American[2]	Asian[2]
Texas TX-1	1,721,132	793,046	47,781,662	28,593,311	32.1	49.1%	6.6%	0.5%	92.0%	0.1%	0.8%
Texas TX-2	759,782	435,780	37,838,460	20,387,991	39.4	50.1%	36.1%	4.7%	57.1%	0.3%	1.8%
Texas TX-3	6,785,492	4,186,620	435,704,225	284,473,635	36.2	49.6%	35.8%	17.5%	38.0%	0.3%	8.5%
Texas TX-4	172,249	56,931	3,493,121	2,134,305	39.8	49.5%	72.8%	8.4%	17.6%	0.5%	0.8%
Texas TX-5	381,027	214,719	29,151,353	12,368,871	36.5	50.8%	52.4%	25.4%	18.7%	0.4%	3.1%
Texas TX-6	49,618	17,924	1,470,093	629,561	42.4	50.0%	75.2%	17.6%	6.0%	0.6%	0.6%
Louisiana LA-1	210,080	146,167	16,451,887	8,417,661	38.4	48.9%	68.8%	25.4%	3.8%	0.5%	1.4%
Louisiana LA-2	86,113	38,203	2,854,011	1,889,493	34.1	52.2%	75.9%	14.0%	7.0%	1.3%	1.8%
Louisiana LA-3	591,817	324,217	23,178,547	14,084,815	37.1	49.1%	68.0%	26.6%	3.6%	0.4%	1.3%
Louisiana LA-4	352,151	189,296	15,704,818	9,510,840	38.6	49.1%	67.3%	23.2%	4.9%	3.1%	1.5%

Louisiana LA-5	850,504	542,554	55,015,676	29,311,309	37.8	48.5%	55.9%	37.2%	4.3%	0.3%	2.3%
Louisiana LA-6	948,067	637,637	60,101,165	33,433,715	37.2	48.1%	45.5%	40.3%	10.2%	0.4%	3.6%
Louisiana LA-7	438,470	225,763	14,345,609	10,710,510	38.5	48.6%	73.2%	20.1%	5.0%	0.5%	1.3%
Mississippi MS-1	452,648	231,955	18,560,335	10,314,146	40.3	49.1%	70.3%	21.2%	5.6%	0.5%	2.4%
Mississippi MS-2	68,484	22,115	1,201,265	717,114	38.3	51.7%	79.9%	16.9%	2.2%	0.4%	0.5%
Alabama AL-1	631,779	354,793	24,538,313	15,099,393	40.6	47.9%	66.7%	27.0%	3.6%	0.9%	1.9%
Alabama AL-2	110,390	50,212	3,912,902	1,998,376	42.9	48.8%	57.7%	37.0%	1.9%	2.9%	0.5%
Florida FL-1	958,814	541,893	40,424,389	25,111,082	39.8	50.1%	75.0%	14.0%	6.8%	0.8%	3.3%
Florida FL-2	514,463	282,509	20,055,347	12,404,325	41.1	50.0%	61.6%	29.0%	6.2%	0.5%	2.6%
Florida FL-3	235,111	91,382	6,132,037	3,559,820	41.9	54.0%	70.6%	21.5%	6.6%	0.5%	0.8%
Florida FL-4	1,529,702	666,313	43,305,151	26,276,225	48.6	48.5%	73.7%	11.3%	11.9%	0.4%	2.7%
Florida FL-5	4,481,380	2,519,558	198,095,274	120,485,593	46.0	48.5%	64.7%	12.0%	19.5%	0.3%	3.4%
Florida FL-6	1,618,561	845,787	59,946,306	37,590,747	46.7	49.6%	66.8%	8.0%	23.2%	0.3%	1.7%

Note: EIA = economic impact area
[1] Economic Variables
[2] Demographic Variables
Source: Woods & Poole Economics, Inc. 2020

Table 4.4.7-2. Economic and Demographic Information for BOEM's Economic Impact Areas in 2050.

EIA	Population[1]	Employment[1]	Gross Regional Product (thousands, 2012 dollars)[1]	Labor Income (thousands, 2012 dollars)[1]	Median Age[2]	Male Percent[2]	White[2]	Black[2]	Hispanic[2]	Native American[2]	Asian[2]
Texas TX-1	2,593,012	1,516,848	118,433,986	74,090,447	39.8	49.3%	3.8%	0.4%	94.9%	0.0%	0.8%
Texas TX-2	843,789	572,382	58,689,281	33,393,298	41.4	50.8%	24.6%	5.2%	67.2%	0.3%	2.8%
Texas TX-3	10,209,777	6,969,351	942,208,319	611,072,387	39.3	49.1%	20.5%	14.4%	49.1%	0.3%	15.7%
Texas TX-4	208,969	74,846	4,886,144	3,576,906	42.7	49.6%	60.2%	8.3%	29.6%	0.5%	1.5%
Texas TX-5	417,234	283,071	38,433,011	19,923,106	41.6	52.1%	37.0%	22.3%	36.2%	0.4%	4.1%
Texas TX-6	49,920	20,190	1,956,415	901,173	45.3	50.2%	61.5%	23.6%	13.1%	0.7%	1.2%
Louisiana LA-1	230,384	204,890	29,083,094	14,645,929	42.3	49.0%	64.8%	26.2%	5.6%	0.6%	2.8%
Louisiana LA-2	88,339	45,936	3,520,390	3,053,372	37.5	52.3%	71.0%	13.7%	11.1%	1.3%	3.0%
Louisiana LA-3	672,313	441,499	35,334,005	23,837,453	42.3	49.7%	63.6%	28.7%	5.3%	0.4%	2.0%

Louisiana LA-4	361,648	224,151	22,853,908	14,114,929	43.2	49.3%	57.8%	24.3%	10.7%	4.3%	2.9%
Louisiana LA-5	1,027,518	791,640	98,293,173	52,494,983	44.3	49.2%	50.6%	39.7%	6.1%	0.2%	3.4%
Louisiana LA-6	836,160	657,883	79,556,351	44,040,069	40.9	48.7%	34.5%	41.1%	18.4%	0.4%	5.6%
Louisiana LA-7	581,353	393,912	32,352,213	21,946,719	43.1	48.6%	66.0%	22.2%	9.0%	0.5%	2.3%
Mississippi MS-1	496,055	274,896	26,035,029	15,289,993	43.5	49.2%	63.5%	23.5%	9.4%	0.4%	3.2%
Mississippi MS-2	80,352	28,121	2,008,028	1,178,237	42.9	52.7%	75.1%	20.7%	3.0%	0.4%	0.9%
Alabama AL-1	740,089	496,878	41,861,938	25,738,979	44.3	47.9%	63.1%	26.8%	6.0%	0.8%	3.4%
Alabama AL-2	104,464	56,462	5,014,570	2,749,850	48.5	50.2%	50.4%	41.4%	3.3%	3.8%	1.1%
Florida FL-1	1,240,698	824,962	66,382,290	48,113,053	44.3	51.8%	69.7%	15.9%	9.3%	0.5%	4.6%
Florida FL-2	613,400	379,190	33,569,101	20,922,130	47.6	51.9%	54.5%	35.0%	6.3%	0.4%	3.8%
Florida FL-3	287,116	117,620	8,647,769	5,325,920	45.3	56.1%	65.5%	24.2%	8.4%	0.4%	1.5%
Florida FL-4	2,410,083	1,142,130	91,240,918	58,537,196	53.5	50.2%	66.6%	13.1%	15.9%	0.3%	4.1%
Florida FL-5	6,066,018	3,726,800	390,661,826	235,210,811	47.8	49.0%	45.8%	14.2%	32.6%	0.2%	7.2%
Florida FL-6	2,482,405	1,403,276	138,760,179	86,760,345	51.1	50.0%	50.1%	9.8%	37.8%	0.2%	2.1%

Note: EIA = economic impact area.

[1] Economic Variables

[2] Demographic Variables

Source: Woods & Poole Economics, Inc. 2020.

Offshore Oil and Gas Industry

The offshore oil and gas industries operate within existing local socioeconomic frameworks, as well as in the context of various dynamic market forces. The offshore energy industry in the Gulf of Mexico extracts oil, natural gas, and natural gas liquids, 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. BOEM relies on several data sources for information concerning economic factors in the GOM region when conducting environmental assessments. Kaiser and Narra (2018) provide a robust overview of GOM oil and gas infrastructure inventories and trends, as well as operating cost data analysis and a decommissioning forecast for shallow and deepwater regions. 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; Kaplan et al. (2011a) provides background information on the oil services contract industry; and Priest and Lajaunie

(2014) and McGuire et al. (2014) provide background information on the shipbuilding and fabrication industries.

The offshore energy industry has been adaptive to volatile energy prices. For example, the oil price crash in 2014 caused slowdowns in offshore drilling activities (Beaubouef 2015) and rig construction (Odell 2015). Offshore investments then increased in 2019 after an oil price recovery in 2018, but the short-term outlook has turned unpromising again after two recent shocks (i.e., COVID-19 impacts and global oversupply) to oil markets in the first quarter of 2020 (Fitzsimmons and Sandøy 2020). However, offshore oil and gas production are generally slow 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. BOEM utilizes forecasts from industry analysts and the U.S. Department of Energy's Energy Information Administration to gauge shifts in industry activity and estimated future production levels on an ongoing basis. For example, as of August 2020, GOM offshore oil production is forecast to increase modestly from an average of 1.88 MMbbl/day in 2019 to 1.93 MMbbl/day in 2020 and then decrease slightly to 1.91 MMbbl/day in 2021 (Energy Information Administration 2020d). The expected sustained increase in GOM offshore production, despite current market conditions, is partially a result of deepwater discoveries that occurred during exploration before the 2015 price collapse (Energy Information Administration 2020a). There is potential for changes in the production forecast due to the COVID-19 pandemic, and BOEM will consider these changes in future analyses.

Office of Natural Resources Revenue Data

In addition to direct and indirect industry spending, corporate profits, and employment, OCS oil and gas leasing activity generates government revenues. Government revenues from offshore oil- and gas-related activities are generated 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. Some OCS oil- and gas-related activities are subject to partial or full royalty exemptions. The U.S. Department of the Interior's Office of Natural Resources Revenue collects these revenues and provides production, revenue, and disbursement data, including but not limited to Federal OCS oil- and gas-related activities. BOEM's "Fair Market Value" webpage describes the rental rates, royalty rates, and other terms associated with Gulf of Mexico leases (BOEM 2020a). Some OCS oil- and gas-related activities are subject to partial or full royalty exemptions. BOEM's "Royalty Relief Information" webpage provides more information regarding BOEM's royalty relief programs (BOEM 2020d).

Table 4.4.7-3 presents annual data regarding sales volumes, sales values, and government revenues received from Federal offshore energy activities in the Gulf of Mexico (ONRR 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 4.4.7-3. Sales Volumes, Sales Values, and Revenues from Offshore Oil and Gas Activities in the Gulf of Mexico.

Sales Volumes/Sales Values/Revenues	Fiscal Year 2009	Fiscal Year 2010	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Panel A: Sales Volumes 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
Panel A: Sales Volumes 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
Panel A: Sales Volumes NGL (royalty) (bbl)	38,833,183	35,291,345	44,366,261	38,612,327	36,930,555	37,108,821	43,547,877
Panel A: Sales Volumes 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
Panel A: Sales Volumes Oil (royalty) (bbl)	399,610,189	245,817,393	365,315,753	327,838,813	353,301,996	380,094,970	427,893,211
Panel A: Sales Volumes 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 Gas ($)	9,042,095,734	3,635,054,218	6265443988	3,431,037,416	3,389,367,262	3,673,721,931	3,062,140,872
Panel B: Sales Values NGL ($)	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
Panel B: Sales Values Oil ($)	22,121,036,571	20,398,834,017	34,955,160,900	35,976,794,554	37,471,600,329	38,509,764,522	26,989,786,050
Panel B: Sales Values Other Products ($)	328,166	81,819	62,776	48,488	65,859	46,065	181,361
Panel B: Sales Values Total Sales Value ($)	32,504,396,457	25,717,246,074	43,424,481,803	41,851,627,453	42,206,642,395	43,579,769,211	31,156,835,720
Panel C: Revenues Gas Royalties ($)	1,270,482,533	578,648,176	867,823,949	477,314,371	492,705,927	506,802,521	397,152,833
Panel C: Revenues NGL Royalties ($)	106,141,947	193,526,754	275,894,256	242,173,963	162,496,377	172,755,305	113,431,762
Panel C: Revenues Oil Royalties ($)	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
Panel C: Revenues Other Royalties ($)	44,168	-14,192	3,494	4,163	4,466	2,605	10,310

Sales Volumes/Sales Values/Revenues	Fiscal Year 2009	Fiscal Year 2010	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Panel C: Revenues Rents ($)	226,228,376	236,631,251	219,119,868	217,669,757	244,699,154	229,741,396	215,683,828
Panel C: Revenues Bonus ($)	1,181,075,491	979,569,294	36,751,111	663,714,729	2,675,653,773	967,365,328	642,044,899
Panel C: Revenues Other Revenues ($)	-82,772,915	119,508,488	23,807,036	31,841,893	34,646,396	46,274,075	-36,537,426
Panel C: Revenues Total Revenues ($)	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

Notes: bbl = barrel; Mcf = thousand cubic feet; NGL = natural gas liquids.

Source: Office of Natural Resources Revenue 2016.

4.4.7.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and economic factors. **Figure 4.4.7-2** provides a synopsis of the IPF categories that currently affect or have the potential to affect economic factors in the Gulf of Mexico OCS. Following **Figure 4.4.7-2** is a summary of those potential effects on economic factors as well as a brief discussion of the IPF categories identified in **Figure 4.4.7-2** that are not likely to affect economic factors, and why.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential range of effects to economic factors, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

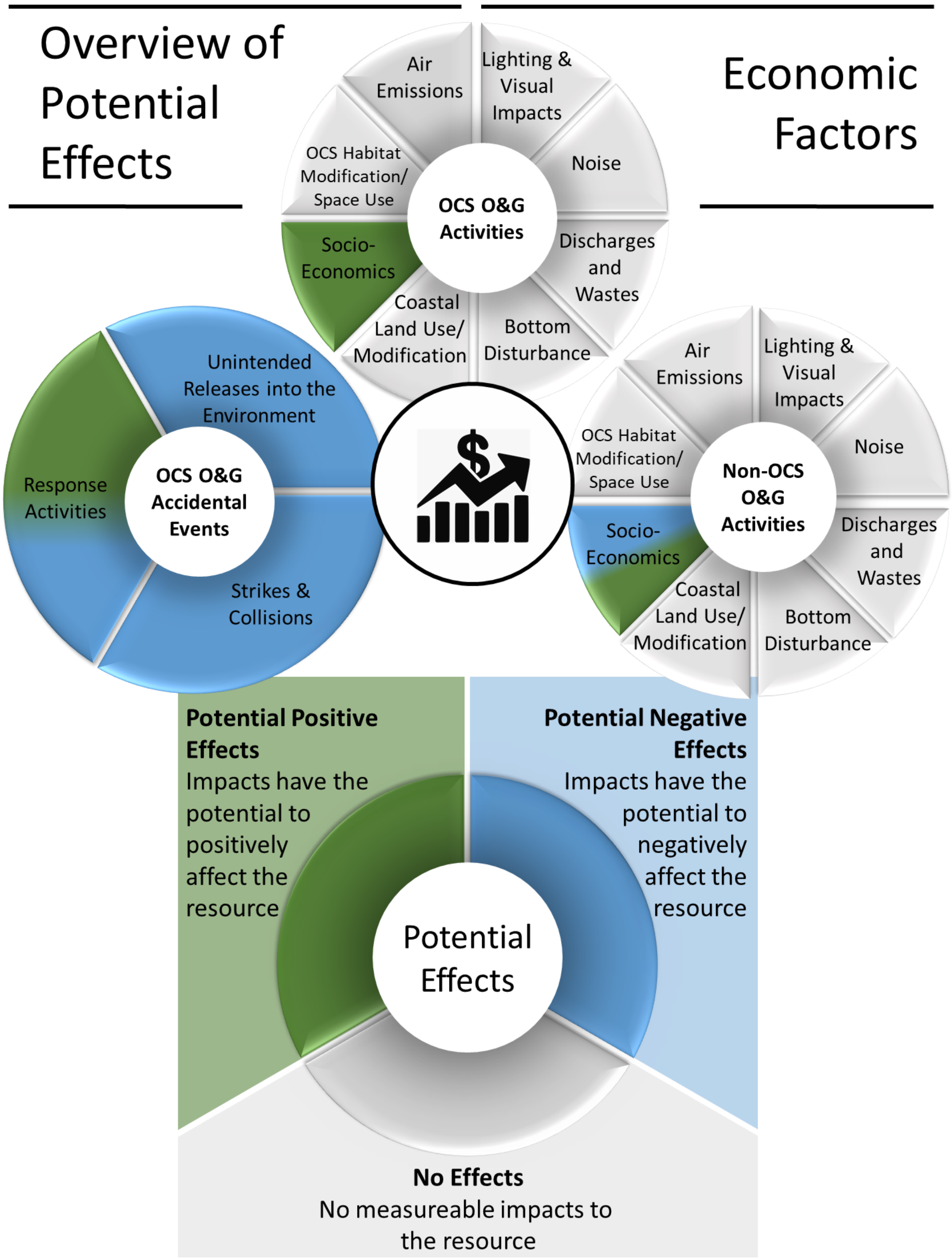


Figure 4.4.7-2. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Economic Factors. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)

4.4.7.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.4.7-2 highlights the IPF categories of non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect economic factors in the GOM region. Effects from these categories of IPFs could vary depending on the frequency, duration, and geographic extent of activities as discussed below.

Socioeconomic Changes and Drivers (Chapter 2.8.3)

Non-OCS oil-and gas-related activities in the Gulf of Mexico region occur in the context of many other socioeconomic changes and drivers, which influence regional economic factors. To examine the potential effects from future non-OCS oil- and gas-related activities, BOEM utilizes the economic and demographic projections from Woods & Poole Economics, Inc. to define the likely regional socioeconomic landscape resulting from all other future projects, actions, and trends. **Table 4.4.7-2** presents these projected data for the year 2050. These data are derived from historical local, regional, and national data, as well as likely changes to economic and demographic conditions. 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. BOEM acknowledges that these data are not comprehensive but provide reasonable projections based on future possible projects and actions.

BOEM uses these projected data to describe all expected effects from other industries and other parts of the economy on economic factors. One example is how BOEM considers the effects to the oil and gas industry. The oil and gas industry could be affected by various forces affecting supply and demand for energy products. Some of these forces include changes in U.S. onshore energy production, commodity price fluctuations, international trade flows, geopolitical developments, and widespread shifts in human behavior due to a pandemic or other social disruption. Demand for energy products is affected by a plethora of factors, including economic activity, technological developments, and government policies. For instance, the rapid expansion of U.S. onshore energy production contributed to a noticeable decline in oil prices beginning in late 2014. In 2018, the U.S. became the world’s largest producer of crude oil, also attributable to U.S. unconventional shale production (Dismukes et al. 2019). Energy supply and demand has further been affected by international developments, including policy towards Iran and decisions made by the Organization for Petroleum Exporting Countries (OPEC). Additionally, the COVID-19 global pandemic led to a negative effect on oil and gas demand in the first quarter of 2020, which was further compounded by an OPEC+ group’s disagreement on reduced production measures (Fitzsimmons and Sandøy 2020).

There are several forecasts of energy markets that incorporate the aforementioned varied factors, which BOEM employs to gauge effects that could be both positive and negative on economic conditions. For example, although economic conditions are difficult to discuss in generalizations, if domestic onshore energy production decreases, that could trigger reduced spending and revenue for affected firms. This could lead to local job losses (assuming the firm does not have domestic offshore nor international operations, which could see increased production to offset the domestic onshore declines and employees could be offered relocations to those other locations, which would not result in a net loss of jobs or revenues). However, dynamic international energy markets are intertwined with many complicated supply and demand forces seeking equilibrium; therefore, to assess what macro-economic effects could occur from domestic onshore production declines, other current global market conditions must also be assessed. In addition, what may be a positive effect for one firm or group of people, may be a negative effect for another, and those effects could change over time (even quickly), depending on the other market factors.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

Non-OCS oil- and gas-related activities occur concurrently with an expansive existing OCS oil and gas program in the GOM. BOEM measures these activities as part of the baseline economic conditions in the GOM region by utilizing economic data provided by Woods & Poole Economics, Inc., which considers historical data trends and provides forecasts of various economic variables over time, as discussed above in **Chapter 4.4.7.1** (Resource Description). The Woods & Poole Economics, Inc. data include contributions of likely activities and trends based on local, regional, and national data, as well as likely changes to economic and demographic conditions. BOEM evaluated the IPFs as defined in **Chapter 2** in light of the projections from the Woods & Poole Economics, Inc. economic data and determined that air emissions and pollution, discharges and wastes, bottom disturbance, noise, coastal land use/modification, lighting and visual impacts, and offshore habitat modification/space use are not likely to have a close causal connection to economic factors, and therefore, not likely to have reasonably foreseeable effects to any measurable degree to economic factors.

BOEM acknowledges the complex interactive web of socioeconomic effects that can occur based on each IPF, and although there is not a close causal relationship between these IPFs and economic factors, many of these IPFs could potentially effect economics depending on how they affect other resource categories (e.g., coastal habitats, fish populations) and how those effects ripple through various economic drivers such as commercial and recreational fishing, tourism and recreational industries, and coastal land use. For example, bottom disturbance could smother benthic prey in a localized area. The fish that rely on these benthic communities could be displaced, making them less available to recreational fishermen. This could result in reduced catch and fewer recreational fishing trips to areas where catches are low. This could lead to reduced revenue for charter boat captains or fishing boat rental businesses. Such reduction in catch and revenue could result in less spending by fishermen because they are not visiting certain areas and less spending by fishing-related business owners because they have less revenue, resulting in possible local economic effects. As demonstrated in this example, any causal connection between local economic effects and bottom disturbance is not even certain and attenuated at best – it is not a close causal connection.

The potential for effects on resources from the above-mentioned IPFs is discussed in detail in **Chapter 4.3.1** (Coastal Habitats and Communities), **Chapter 4.3.2** (Benthic Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), **Chapter 4.4.1** (Land Use and Coastal Infrastructure), **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), and **Chapter 4.4.5** (Tourism and Recreational Resources). The corresponding potential positive and negative effects to economics from these IPFs are also discussed qualitatively in their respective chapters and are factored into the socioeconomic changes and drivers IPF (**Chapter 2.7**). As such, the relationships of potential effects to these resources from non-OCS oil- and gas-related activities and their influence on socioeconomic aspects are captured in the analysis of the socioeconomic changes and drivers IPF (**Chapter 2.7**), which cross references to the individual resource chapters as applicable. Because these IPFs' potential effects and their possible relationships to economics are captured in the "Socioeconomic Changes and Drivers" section and are consistent with the scope of historical trends in BOEM's environmental analyses for OCS oil and gas programs in the GOM, these IPFs were determined not likely to have a close causal relationship with economic factors, and therefore, were not analyzed in further detail.

4.4.7.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.4.7-2 highlights the IPF categories associated with routine OCS oil- and gas-related activities that could potentially affect economic factors in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Socioeconomic Changes and Drivers (Chapter 2.8.2)

Routine activities arising from OCS oil- and gas-related activities could have various economic effects. Extraction of oil, natural gas liquids, and natural gas generate expenditures on various goods and services, as well as generate jobs. Routine activities could also generate corporate profits and government revenues, as well as have effects on the overall energy market. The Department of the Interior's Office of Policy Analysis estimated that United States' OCS oil- and gas-related activities supported 267,350 jobs and $30.4 billion in domestic value-added in Fiscal Year (FY) 2018 (DOI and Office of Policy Analysis 2019). The discussion below addresses the positive economic effects resulting from routine OCS oil- and gas-related activities.

Expenditure Impacts

The OCS oil- and gas-related activities could have economic effects on a variety of businesses along the OCS industry's supply chain. For example, OCS oil- and gas-related activities could 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 could also affect 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 effects, BOEM uses economic and financial models to estimate the output, value added, income, and employment associated with OCS oil- and gas-related activity. BOEM bounds model estimates by the specified forecasted activity levels, which are based on many well-informed assumptions. The models generate a time series of activity-specific industry expenditures based on the inputted lease scenario data. These estimates reflect direct effects realized by the offshore oil and gas industry, as well as spillover effects to other industries. The model then allocates these expenditures to geographic areas and applies a series of IMPLAN multipliers to estimate the economic impacts associated with these expenditures. Historically, most of these effects are geographically distributed to the Gulf of Mexico region, particularly in coastal Texas and Louisiana. The EIAs that usually experience the highest economic effects are TX-3, TX-2, LA-3, LA-4, LA-6, MS-1, and AL-1 (Price et al. 2020).

Government Revenue Impacts

The OCS oil- and gas-related activities could generate government revenues through bonus bids, rental payments, and royalty payments. Effects resulting from the generation of 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 effects of OCS oil- and gas-related activities could be 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 revenues related to 8(g) of the OCSLA (which arise due to leasing within 3 mi [5 km] of State waters), the Coastal Impact Assistance Program, and revenue sharing arising from the Gulf of Mexico Energy Security Act of 2006 (GOMESA).

Since 2007 under Phase I of GOMESA, 37.5 percent of all qualified GOM revenues are shared among the four states (i.e., Texas, Louisiana, Mississippi, and Alabama) and their coastal political subdivisions. Revenues are generated from leases in specific geographic areas defined in the Act. Additionally, 12.5 percent of revenues are disbursed to the Land and Water Conservation Fund under Phase I. The second phase of GOMESA revenue sharing started in Fiscal Year 2017, which expanded the areas that qualify for revenue-sharing. Phase II also imposes revenue-sharing caps on states and the Land and Water Conservation Fund. Overall, State revenue-sharing caps under Phase II are $375 million for Fiscal Years 2017-2019, $487.5 million for Fiscal Years 2020 and 2021, and $375 million for Fiscal Years 2022-2055. The cap will be lifted beginning in Fiscal Year 2056 (ONRR 2020a). Phase 2 of GOMESA may increase the beneficial impacts to the Bureau of Ocean Energy Management's EIAs arising from a proposed lease sale, 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).

Profit Impacts

The OCS oil- and gas-related activities 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 could 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 could 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 effects are also likely to be widespread. Recent changes in the U.S. tax law codified in the Tax Cuts and Jobs Act of 2017 (Public

Law No. 115-97, 131 Stat. 2054) reduced the corporate income tax rate and changed the rate structure, which will likely contribute positively to corporate profits.

Market Impacts

The oil, natural gas, and natural gas liquids produced due to OCS oil- and gas-related activities could meet the demands of end users of those products. Increased energy supply could put downward pressure on energy prices, although the small scale of a proposed lease sale(s) 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. The OCS oil- and gas-related activities can also contribute to U.S. policy goals of energy independence and security.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

It is important to note that OCS oil- and gas-related activities as a result of a single lease sale occur in the context of an expansive existing OCS oil and gas program in the GOM. When evaluating the IPFs as defined in **Chapter 2**, air emissions and pollution, discharges and wastes, bottom disturbance, noise, coastal land use/modification, lighting and visual impacts, and offshore habitat modification/space use are not likely to have a close causal connection or reasonably foreseeable effects to any measurable degree to economic factors. Therefore, these IPF categories were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

BOEM acknowledges the complex interactive web of socioeconomic effects that can occur based on each IPF, and although there is not a close causal relationship between these IPFs and economic factors, many of these IPFs could potentially effect economics depending on how they affect other resource categories (e.g., coastal habitats and fish populations) and how those effects ripple through various economic drivers such as commercial and recreational fishing, tourism and recreational industries, and coastal land-use. However, these IPFs are not likely to have reasonably foreseeable effects to any measurable degree from a single lease sale in the context of the existing OCS oil and gas program. For example, bottom disturbance could smother benthic prey in a localized area. The fish that rely on these benthic communities could be displaced, making them less available to recreational fishermen. This could result in reduced catch and fewer recreational fishing trips to areas where catches are low. This could lead to reduced revenue for charter boat captains or fishing boat rental businesses. Such reduction in catch and revenue could result in less spending by fishermen because they are not visiting certain areas and less spending by fishing-related business owners because they have less revenue, resulting in possible local economic effects. As demonstrated in this example, any causal connection between local economic effects and bottom disturbance is not even certain and attenuated at best – it is not a close causal connection.

The potential for effects on resources from the above-mentioned IPFs is discussed in detail in **Chapter 4.3.1** (Coastal Habitats and Communities), **Chapter 4.3.2** (Benthic Communities and

Habitats), **Chapter 4.3.4** (Fish and Invertebrates), **Chapter 4.4.1** (Land Use and Coastal Infrastructure), **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), and **Chapter 4.4.5** (Tourism and Recreational Resources). The corresponding potential positive and negative effects to economics from these IPFs are also discussed qualitatively in their respective chapters and are factored into the socioeconomic changes and drivers IPF (**Chapter 2.7**). As such, the relationships of potential effects to these resources from OCS oil- and gas-related activities and their influence on socioeconomic aspects are captured in the analysis of socioeconomic changes and drivers IPF (**Chapter 2.7**), which cross references to the individual resource chapters as applicable. Because these IPFs' potential effects and their possible relationships to economics are captured in the "Socioeconomic Changes and Drivers" section and are consistent with the scope of historical trends in BOEM's environmental analyses for OCS oil and gas programs in the GOM, these IPFs were determined not likely to have a close causal relationship with economic factors, and therefore, were not analyzed in further detail.

4.4.7.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.4.7-2 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect economic factors in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Accidental events, such as oil and chemical spills, can lead to corresponding issues with local economies. The most direct issues would likely be experienced 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. An oil spill could also disrupt 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 issues resulting from an accidental event would be determined by 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. This issue would be greatest felt in coastal Louisiana and Texas since those are the primary locations where OCS oil- and gas-related employment is concentrated. The direct effects of an oil spill on a particular industry could also ripple through that industry's supply chain; consumer spending by employees of these firms could also have effects to the broader economy. Decreased levels of offshore oil- and gas-related activities could also adversely affect 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 lead to varied impacts to 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 contributions, 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.

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 reasonably foreseeable; the impacts of catastrophic spills are discussed in the *Gulf of Mexico Catastrophic Spill Event Analysis* technical report (BOEM 2021d). Austin et al. (2014a, 2014b) are two volumes of a study on 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.

A coastal spill could have a greater effect on the localized economy than an offshore spill because coastal and nearshore waterways could be closed to vessel traffic following a spill, resulting in effects to upstream and downstream business interests from the impeded flow of commerce. Other potential effects that could ripple through the economy 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 intensity of any effects related to an event 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 effects as harshly as those who are most dependent on the waterway for transport. For more information, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Releases into the environment, such as chemical or oil spills, can affect commercial fisheries by affecting the health of fish and invertebrate populations that support commercial fishing activities, by affecting fishermen's access to those populations, or by affecting the seafood supply chain. The corresponding effects to commercial fishing would depend on the number of target species affected by the spill, the size of the oil spill, the length of time an area was closed as a result of the spill, and the types and scales of commercial fishing activities in an impacted area. Localized fishing closures could directly impact fishermen's access to fish resources and could cause them to travel farther for catch, reducing their profit from catch. For more information on the biological effects of oil and chemical spills on fish, refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Refer to **Chapter 4.4.2** (Commercial Fisheries) for more information on commercial fishing.

Oil spills can also have effects on the supply or demand for seafood. For example, an oil spill could cause seafood safety concerns, which would reduce the demand for the affected species, negatively affecting the commercial fishing industry. An oil spill could also cause certain fishermen to stop fishing to participate in the cleanup operations or for economic reasons. A large oil spill could have some longer-term economic impacts on commercial fisheries and may not be evident for several years. If the long-term effects on fish influences catch, there could be a long-term negative effect on the supply chain related to commercial fisheries. For more information on the biological effects of oil and chemical spills on fish, refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Refer to **Chapter 4.4.2** (Commercial Fisheries) for more information on commercial fishing.

Recreational fishing activity could decline if fish populations are affected by oil spills, which could cause a decline in the recreational fishing supply chain. Traveling to an unaffected substitute fishing site in a region could add additional costs to the angler. Any disruption to recreational fishing activity could also have broader economic implications to a particular geographic region. Disruptions to recreational fishing could affect boat launches, bait shops, and durable fishing equipment manufacturers. Reductions in recreational fishing could also negatively affect the various firms that supply goods and services to anglers. In addition, public perception of the effects of a spill on marine life and its extent may ultimately result in a loss of revenue for the fishing-related recreation industry. Party and charter boat recreational fisheries often have loss of income because of reduced interest in fishing when a spill has occurred. Local hotel, restaurant, bait and tackle shops, and boat rental companies associated with recreational fisheries may experience reduced sales because of the public perception of the effects of an oil spill. For more information on the biological effects of oil and chemical spills on fish, refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Refer to **Chapter 4.4.3** (Recreational Fishing) for more information on recreational fishing.

Oil spills could reduce tourism and recreational activities based on swimming, fishing, and diving because people may avoid polluted water. The effects of the spill on the local economy would depend on the size and location of the spill. A large or nearshore localized spill may have a greater effect than a small or offshore spill that does not reach land. Offshore spills could affect the economies related to fishing, diving, and boating as well as lead to reduced tourism in coastal areas based on media coverage. A coastal spill could more directly affect recreation and tourism because tourism could be reduced on oiled beaches, which can cause economic losses to both individuals and firms in the area of an oiled or closed beach. The negative effects from an oil spill would be compounded if it encumbered a seasonal event, such as a summer beach festival or fishing tournament. Refer to **Chapter 4.4.5** (Tourism and Recreational Resources) and **Chapter 4.4.3** (Recreational Fishing) for more information on tourism, recreation, and recreational fishing.

Response Activities (Chapter 2.9.2)

Potential effects related to spill response may be negative or positive for the local economy. The influx of spill response workers could contribute to filling short-term rental vacancies at hotels, apartments, and other properties that could provide housing, which could be a positive effect on land use and, by extension, on the local economies. Restaurants and hotels in the spill response area could receive an influx of demand from cleanup workers that could offset losses otherwise expected from tourism declines resulting from a spill. Refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure) and **Chapter 4.4.5** (Tourism and Recreational Resources) for additional detail.

Conversely, spill-response activities may strain local communities, resulting in the need for costly repairs or upgrades in community infrastructure. Spill response generates large quantities of waste and this can strain existing waste disposal capacity, and additional use of waterways or roadways used for the vehicles servicing spill response may result in localized increased wear and tear. The severity of spill-response effects on the local economy related to land use and coastal infrastructure would depend on the location and duration of the spill and cleanup efforts, and whether the event is a small-scale spill or a larger spill. Refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure) for additional detail.

Spill-response activities can cause negative but localized space-use conflicts for commercial fishermen at ports and offshore where fishermen would need to avoid certain fishing areas while spill response is ongoing, potentially reducing catch and profitability. To the extent that spill-response activities may affect fish and invertebrate resources, commercial and recreational fisheries supply chains also can be affected because landings may be negatively affected. In addition, an oil spill cleanup effort can cause reduced visits to beaches and use of recreational areas as well as economic losses to both individuals and firms in the area of an oiled or closed beach, or one being cleaned. For more information on the biological effects of oil and chemical spills on fish, refer to **Chapter 4.3.1** (Coastal Communities and Habitats), **Chapter 4.3.4** (Fish and Invertebrates), and BOEM's Biological Environmental Background Report (BOEM 2021b). Refer to **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), and **Chapter 4.4.5** (Tourism and Recreational Resources) for more information on fishing, recreation, and tourism.

Strikes and Collisions (Chapter 2.9.3)

Vessel collisions with each other or coastal structures could negatively affect the economy. If a vessel were to collide with a bridge, pier, or other structure, it could disrupt the transportation of goods, services, and people to and from work and schools. The collision could also result in an oil spill (discussed in the "Unintended Releases to the Environment" section above), which could negatively affect the economy. The severity of the effects that could ripple through the economy would be dependent on the location of the vessel collision, the size of the vessels involved, and whether the collision involves a bridge, pier, or other structure. For more information, refer to **Chapter 4.4.1** (Land Use and Coastal Infrastructure).

Coastal vessel collisions could disrupt the flow of vessels coming from and returning to port. For example, any impediment to fishing vessels leaving or returning to port could reduce the fish sold at market, effecting the fisher's profitability and the seafood supply chain. The recreational fishing industry could also see negative effects if boat launches are closed or charters and rentals are unable to leave from a particular location. If oil is spilled as a result of a collision, the effects would be the same as discussed above for commercial and recreational fishing, as well as for recreation and tourism. For more information, refer to **Chapter 4.4.2** (Commercial Fisheries), **Chapter 4.4.3** (Recreational Fishing), and **Chapter 4.4.5** (Tourism and Recreational Resources).

4.5 CULTURAL, HISTORICAL, AND ARCHAEOLOGICAL RESOURCES

4.5.1 Resource Description

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 a 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. These resources include any physical evidence of human habitation, occupation, use, or activity, and further include the site, location, or context in which such evidence is situated (30 CFR § 550.105). The National Historic Preservation Act of 1966 (NHPA), as amended (54 U.S.C. § 300101), includes archaeological resources among potential "historic properties," defined as any prehistoric or historic district, site, building, structure, or object included on, or eligible for inclusion on, the National Register of Historic Places (NRHP), including artifacts, records, and material remains relating to the district, site, building, structure, or object (54 U.S.C. § 300308). Traditional cultural properties and sacred sites also may be designated as historic properties. To be eligible for inclusion on the NRHP, a historic property typically must be at least 50 years old; retain the integrity of location, design, setting, materials, workmanship, feeling, and association; and meet at least one of four significance criteria (36 CFR § 60.4):

(1) be associated with events that have made a significant contribution to the broad patterns of our history; or

(2) be associated with the lives of persons significant in our past; or

(3) embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or that possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction; or

(4) have yielded, or may be likely to yield, information important in prehistory or history.

BOEM's authorities and responsibilities towards the management of cultural, historical, and archaeological resources are specified in various legislative Acts including the NHPA, NEPA, and OCSLA. In particular, Section 106 of the NHPA requires all agencies having direct or indirect jurisdiction over a federally funded or permitted undertaking to take into account the effects of that undertaking on historic properties. Additionally, Section 110 of the NHPA directs agencies to establish historic preservation programs for the identification, evaluation, and protection of historic properties, whether these properties are under the jurisdiction or control of the agency, or merely potentially affected by agency actions. These provisions of NHPA collectively establish the foundation for BOEM's regulations (30 CFR § 550.194), policies, procedures, and guidance documents

(NTL No. 2005-G07) regarding the identification, protection, and preservation of cultural and archaeological resources during agency activities. **Chapter 5.9** provides further information on BOEM's postlease Section 106 reviews.

In addition to the NHPA, the Council on Environmental Quality's regulations implementing the procedural provisions of NEPA mandate that Federal agencies assess their proposed actions' environmental impacts on cultural and historic resources (40 CFR § 1508.8). In this case, "the term 'cultural resources' covers a wider range of resources than 'historic properties,' such as sacred sites, archaeological sites not eligible for the National Register of Historic Places, and archaeological collections" (CEQ and ACHP 2013).

Finally, and in conjunction with the NHPA and NEPA, the OCSLA prohibits the Secretary of the Interior (Secretary) from issuing permits for geological exploration, which includes "the drilling of a well," if such explorations will "disturb any site, structure, or object of historical or archaeological significance" (OCSLA § 11(g), 43 U.S.C. § 1340(g)(3)). BOEM's regulations towards the protection of archaeological resources during exploration activities are codified in 30 CFR § 550.194, and further guidance on collecting and reporting archaeological data can be found in NTL No. 2005-G07.

The OCSLA (43 U.S.C. § 1346) additionally requires the Secretary to conduct environmental studies both prior and subsequent to the mineral leasing and development of areas on the OCS in order to assess, monitor, and manage impacts from these activities on the human, marine, and coastal environments. Such studies may be conducted to provide the information necessary to identify and monitor effects to historic properties located in the offshore, nearshore, and onshore environment that may be impacted by the agency's proposed activities.

Since the 1970s BOEM has identified numerous archaeological resources that either have been discovered or have the potential to be discovered on the Gulf of Mexico OCS using a combination of archival research, industry and other Federal agencies' remote-sensing surveys, BOEM-funded environmental studies, consultations, and frequent review of current scientific literature. Much of this information has been synopsized in regional and site-specific archaeological studies published through BOEM's Environmental Studies Program, which are publicly available on BOEM's website at https://www.boem.gov/environment/environmental-studies/esp-data-and-information-systems. Examples include Coastal Environments Inc. (1977a; 1977b), Pearson et al. (1986), MMS (1989), Garrison et al. (1989a; 1989b; 1989c), Pearson et al. (2003a; 2003b; 2003c), Enright et al. (2006), Church et al. (2007), Krivor et al. (2011), and Evans et al. (2013), among others.

Archaeological resources on the OCS are categorized under one of two general designations: pre-contact or historic. There are some similarities between these site types in geographic location and in the survey methodologies used to identify them, but there are also significant differences in their age, artifact composition, diagnostic evidence in remote-sensing data, and methods of data collection and interpretation during Phase II (NRHP evaluation) and Phase III (data recovery) archaeological investigations. The two site categories also reflect a general deviation of expertise within the archaeological profession at-large between prehistoric and historical archaeologists, with submerged prehistoric archaeology rapidly emerging as a robust sub-discipline of underwater archaeology specialization requiring its own theories, methods, and technologies (Dixon and Davis 2020).

Pre-Contact

The term "pre-contact" is used to distinguish Native American archaeological sites or artifacts that date prior to the arrival of Europeans in North America beginning in the late 15th century A.D. It includes sites associated with the first humans to occupy areas of the Gulf Coast that are now submerged on the OCS. 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 the present (B.P.) (Nelson and Bray 1970). Sea level in the northern GOM 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.

***Pre-contact** generally refers to archaeological sites associated with the first peoples to occupy the Americas, before the advent of written history.*

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 around 13,500 years B.P. 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. Today, however, a growing body of evidence has dispelled the "Clovis First" model with the discovery of several sites with accurate 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 5,500 B.P lie buried under as much as 40 m (131 ft) of Holocene sediments or are underwater on the OCS (Rees 2011). 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 a site or 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 (Coastal Environments Inc. 1977a; 1977b; Gagliano et al. 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 the GOM region.

Distinct prehistoric archaeological sites on the OCS are difficult to identify in wide-area, remote-sensing surveys due to their small footprint and material composition (e.g., stone, shell, wood, ceramics, etc.). Instead, archaeologists and geophysicists attempt to identify intact landforms that survived the erosional processes associated with sea-level rise and therefore may also contain intact archaeological materials. Based on their 1977 baseline study, (Coastal Environments Inc. 1977a; 1977b) proposed that paleo-landforms analogous to the types of environments 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 that the mound-building activity by prehistoric inhabitants may have occurred as early as 6,200 years B.P. (Gibson 1994; Gibson and Shenkel 1984; Russo 1992; 1994; Saunders and Allen 1994; Saunders et al. 2005). Therefore, humanmade 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 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 believed to have the potential for prehistoric site preservation are identified through archaeological and geohazard surveys, the oil and gas industry generally has chosen to avoid these areas rather than conduct further investigations. Thus, the validity of the hypothesis that the landforms identified in industry surveys are archaeological sites remains speculative until further testing can be done.

Along the coast, archaeologists have documented prehistoric sites representing the period between the Paleoindian culture and European contact. The McFaddin Beach Site (41JF50), 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 (Pearson et al. 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. A subsequent BOEM study in the Galveston and High Island areas of the northwestern Gulf of Mexico conducted remote-sensing and coring surveys of four additional areas that had been identified in industry surveys and indicated a potential presence of archaeological sites (Evans 2016). The collected cores confirmed that the paleo-landforms are preserved and had been available for exploitation by Paleoindian or Early Archaic peoples, and evidence of a shell midden or localized burning was present at two of the study sites. However, the evidence was ultimately inconclusive as to whether these features were naturally occurring or the result of human-induced modifications to the landscape.

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 the Gulf of Mexico. Solution features at the crest of these domes would have a high potential for preservation of associated prehistoric sites. The Salt Mine Valley site (16IB23) on Avery Island is a Paleoindian site associated with a salt-dome solution feature (Coastal Environments Inc. 1977a; 1977b). The shallow subsurface depth of many of these relict landforms relative to the seafloor facilitates access for further investigation and data recovery.

Historic

__Historic__ generally refers to archaeological resources occurring since the beginning of European exploration in the New World.

Historic archaeological resources on the OCS consist of historic shipwrecks, aircraft, 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 earliest shipwrecks in the Gulf of Mexico region to be identified and excavated by archaeologists are from a 1554 Spanish fleet that wrecked off Padre Island, Texas (Arnold III and Weddle 1978), and the 1559 expedition of Tristan de Luna that wrecked in Pensacola Bay, Florida (Smith 2018).

Spanish navigation in the Gulf of Mexico continued throughout the 16th and 17th centuries as the early exploratory missions expanded to include conquest and colonization. French and, to a lesser degree, English excursions into the GOM began in the late 17th century. As the European colonial empires continued to expand their North American territories into the early 19th century, the maritime character of the Gulf of Mexico developed into a complex international network of trade, transportation, privateering, and warfare. Beginning in the mid-19th century, technological advancements ushered in a transition of vessel types from exclusively wooden-hulled sailing ships to steam-powered vessels and, by the end of the century, iron and steel-hulled merchant and military craft. By the end of World War I, wooden-hulled merchant vessels had become all but extinct and were replaced by steel-hulled ships of gradually increasing size and cargo capacity. During World War II, many of these vessels ended up at the bottom of the Gulf of Mexico as a result of German U-boat attacks, primarily near the approaches to the Mississippi River. Shipwrecks from the entire span of European and American Gulf of Mexico maritime history are represented in the archaeological record, and shipwrecks in the GOM remain frequent despite centuries of technological and navigational advancements. In addition to ever-present merchant vessel losses, modern examples include commercial fishing boats, scientific research vessels, pleasure craft, drilling rigs, and other support vessels associated with the oil and gas industry.

BOEM and its predecessor agencies have commissioned multiple studies aimed at modeling and predicting areas in the Gulf of Mexico where historic shipwrecks are most likely to exist (Coastal Environments Inc. 1977a; 1977b; Garrison et al. 1989a; 1989b; 1989c; Pearson et al. 2003a; 2003b; 2003c). The Coastal Environments Inc. (1977a; 1977b) relied primarily on secondary-source literature to determine general shipwreck site distribution and identify "theoretical boundaries between zones of relatively high and relatively low occurrence of historic-period shipwreck[s]." That study concluded that two-thirds of the total number of shipwrecks in the northern GOM are likely to lie within 1 mi (1.6 km) of the shore, and most of the remainder lie between 1 and 6 mi (1.6 and 10 km) of shore. However, CEI acknowledged that these conclusions were untested and that several limitations were inherent in their source material. Published (and frequently non-scholarly) shipwreck volumes often repeat unreliable information from earlier sources, sometimes use poor translations of primary documents, and are purposefully selective in the shipwrecks they include (such as those laden with treasure) and those they omit, like small vernacular fishing and coasting vessels that are likely to be identified only in primary sources. Depending on their age, the primary sources themselves are often insufficient for identifying accurate shipwreck locations, or even the occurrence of shipwrecks. The early explorers were sailing in uncharted waters and often sank out of sight of land or near landmarks or place names that no longer are recognizable today. Many wrecks had no survivors to document even rudimentary information and were simply reported, if they were reported at all, as "lost at sea" after leaving a port and never arriving at their destination, which may have been hundreds of miles away.

Historic shipwreck reports in the archival record are also hampered by the fact that for centuries ship navigators had a limited ability to record their geographic location with any real accuracy. Sailors have long been able to accurately determine their latitude with instruments such as the astrolabe and sextant. But they could not determine their longitude with the same accuracy until the marine chronometer was invented in England in 1762, and it took several more decades before that technology became commonly used on large merchant and naval vessels. Even the development of electronic navigation aids in the early 20th century did not significantly improve the accuracy of shipwreck reporting. World War II-era shipwrecks in the Gulf of Mexico, which had the benefit of radar positioning and eye-witness testimony, have been discovered tens of miles from their reported sinking locations, including one (the German U-boat, U-*166*) found over 100 mi (161 km) from where it was reported in official records (Church et al. 2007). Not until the advent of satellite-based technology in the second half of the 20th century, such as the global positioning system (GPS), could shipwreck locations be accurately reported.

Garrison et al. (1989a; 1989b; 1989c) built on CEI's (1977a; 1977b) study by examining not just the spatial distribution of Gulf of Mexico shipwrecks but also what factors influenced that distribution, such as port development, shipping lanes, and hurricanes. Garrison et al. concurred with CEI's main conclusion that the majority of shipwrecks occurred in nearshore waters within areas of heavy marine traffic, such as the approaches and entrances to seaports and the mouths of navigable rivers and straits. However, Garrison et al. countered that CEI had underestimated the number of wrecks in open seas due to changes in the late 19th- and early 20th-century sailing routes, particularly in the eastern Gulf, and that there was a higher potential for unreported shipwrecks in high-traffic maritime lanes than had been identified by CEI. Garrison et al. further recommended an expansion of the areas in the GOM that should be considered as having the highest potential for shipwreck discoveries. Finally, Garrison et al. (1989a; 1989b; 1989c) acknowledged that CEI (1977a; 1977b) and similar studies aimed at modeling shipwreck locations "have conceptual merit but little predictive or hindcast power in the delineation of the archaeology of the OCS," and that "the [Garrison et al.] study cannot redress this lack of primary, direct archaeological observations which are necessary to construct a realistic picture of historic cultural resources on the northern Gulf OCS."

Pearson et al. (2003a; 2003b; 2003c) again revisited the concept of a probability model for shipwreck occurrence on the Gulf of Mexico OCS. Pearson et al. (2003a; 2003b; 2003c) produced a GIS-based database of over 2,000 reported Gulf of Mexico shipwrecks, adding over 600 new wrecks to the list compiled by Garrison et al. (1989a; 1989b; 1989c). Pearson et al. (2003a; 2003b; 2003c) also had the benefit of over a decade of confirmed shipwreck discoveries (or absence thereof) from oil and gas industry surveys with which to test the efficacy of Garrison et al.'s (1989a; 1989b; 1989c) model. In brief, they concluded that "there is no statistically significant difference between discovering a shipwreck in an identified high probability lease block or in finding one in a lease block not assigned a high probability of containing historic wrecks." This conclusion was based, in part, on the unreliability of reported wreck locations as well as a significant underreporting of vessel losses, particularly prior to the mid-19th century.

Instead of simply dividing the Gulf of Mexico into areas of high or low probability for shipwreck occurrence, Pearson et al. (2003a; 2003b; 2003c) improved the previous models by assigning a numerical value to each reported shipwreck location, indicating its relative location reliability. The location reliability values are as follows:

- wreck location is confirmed through physical verification (e.g., diver or remote-sensing investigations);
- a specific location is provided but has not been confirmed by direct physical investigation;
- a general location is provided in the literature (e.g., coordinates to degrees latitude and longitude, or location relative to a known landmark); and
- unreliable or vague location, such as "off the coast of Louisiana."

BOEM continues to add to the wreck database created by Pearson et al. (2003a; 2003b; 2003c), which as of May 2020 now contains approximately 2,240 reported and confirmed shipwrecks. Approximately 420 shipwrecks are confirmed locations with a reliability value of 1, and BOEM has determined that 39 of these are potentially eligible for listing on the NRHP based on remotely operated vehicle or diver investigations. Eligible or potentially eligible OCS wrecks that have been discovered include a sailing vessel from the late 17th or early 18th century based on visual dating of an assemblage of bottles on the site; numerous wooden-hulled mechant sailing vessels spanning the early 19th to early 20th centuries (Atauz et al. 2006; Brooks et al. 2016; Church and Warren 2008; Horrell and Borgens 2017); the mid-19th century sidewheel steamboats USS *Hatteras* (Enright et al. 2006; Evans et al. 2013) and SS *New York* (Gearhart II et al. 2011); and 15 of the 56 Allied merchant vessel casualties, plus U-*166,* sunk during World War II (Brooks et al. 2016; Church et al. 2007; Enright et al. 2006; Evans et al. 2013). In 2018, BOEM successfully nominated to the NRHP nine of the World War II wrecks (U-*166*, *Alcoa Puritan*, *Gulfoil*, *Gulfpenn*, *Halo, R.M. Parker, Jr.*, *Robert E. Lee*, *Sheherazade*, and *Virginia*), as well as the 20th-century steam yacht *Anona.* These vessels join the USS *Hatteras* as the only Gulf of Mexico OCS shipwrecks currently listed on the NRHP.

BOEM's database of known and reported shipwrecks is by no means exhaustive or complete. This is due to the underreporting and unreliability of shipwreck information in the historic record as discussed in CEI (1977a; 1977b), Garrison et al. (1989a; 1989b; 1989c), and Pearson et al. (2003a; 2003b; 2003c), as well as the inability of those authors to investigate every possible archival source. And despite BOEM's repeated efforts to identify areas of high probability for shipwreck occurrence on the OCS, Pearson et al.'s (2003a; 2003b; 2003c) conclusion that there is no statistically significant correlation between high-probability areas and actual shipwreck discoveries continues to be borne out. Oil and gas industry surveys to locate seafloor hazards have consistently identified historic shipwrecks in lease blocks considered "low probability" in BOEM's models, particularly in deepwater areas of the western and central Gulf of Mexico. Several of these deepwater wrecks have been subject to additional archaeological investigation by BOEM in collaboration with Federal, academic, and private partners. Examples and additional site-specific information can be found at BOEM's Virtual Archaeology Museum, which can be found on BOEM's website at https://www.boem.gov/environment/virtual-archaeology-museum.

Natural Processes and Their Influence on Archaeological Sites

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 mouths 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. Seafloor temperature in deep water is extremely cold (~4 ºC; 39 ºF), which slows the oxidation of ferrous metals and eliminates warm water wood-eating shipworms such as *Teredo navalis*. However, it is clear from recent studies that other marine organisms, including chemosynthetic species, consume wooden shipwrecks and that microbial organisms 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 fewer impacts from anthropogenic (e.g., diving, looting, and fishing trawling) and meteorological (e.g., tropical storms and hurricanes) events, there is a higher likelihood of discovering undisturbed sites in deeper waters.

Hurricane activity in the Gulf of Mexico (discussed further in **Chapter 3.3**) has directly influenced the distribution and characteristics of numerous archaeological sites. Wrecks occurring as a result of a major storm, for example, 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 (20m) of water and has been documented by MMS/BOEM (Gearhart II et al. 2011; Irion and Anuskiewicz 1999) as scattered over the ocean floor in a swath over 1,500 ft (457 m) long.

In the GOM, it is almost certain that many existing shipwrecks on the OCS can be, or have been, affected by significant storm events and hurricanes, primarily due to storm surge and seabed shifting. Studies have shown hurricane activity in the Gulf of Mexico to directly impact archaeological resources even in water depths greater than 200 ft (61 m) (Gearhart II et al. 2011; Lukens and Selberg 2004). Observed impacts to shipwrecks include hull displacement, structural damage, scouring of the surrounding seabed, and site burial due to increased sediment deposition. Shipwrecks occurring in shallow water nearer to shore, such as the Spanish wrecks of the 1554 fleet (Arnold III and Weddle 1978) and *El Nuevo Constante* (Pearson and Hoffman 1995), have been reworked and scattered by subsequent storms more often than those wrecks occurring at greater depths on the OCS. Similar patterns would be expected for future major storm events as well. The National Park Service studied sites along the Gulf Coast that were impacted by Hurricane Katrina and identified three types of damage that can occur to archaeological sites: tree throws; storm surge, scouring, and erosion; and seabed shifting (NPS 2005b). Furthermore, in 2007, MMS (BOEM's predecessor) investigated the potential impacts of Hurricanes Katrina and Rita (2005) on historic shipwrecks in the Gulf of Mexico with similar findings. Analysis of the remote-sensing surveys and diver investigations indicated that at least 3 of the 10 shipwrecks examined were affected by recent storm activity. Also, the older wrecks that had been exposed to more hurricanes and had achieved a more advanced level of equilibrium with their environment were less affected than more recent wrecks (Gearhart et al. 2011).

In addition to the direct effects of major storms discussed above, major storm events (e.g., hurricanes) can also indirectly trigger other events such as seafloor mudslides (discussed further in **Chapter 2.3.2.7**), potentially leading to secondary effects to archaeological resources by induced bottom disturbance (refer to **Chapter 4.5.2.1**).

4.5.2 Description of Potential Effects

BOEM's interdisciplinary team of subject-matter experts applied existing scientific knowledge and experience to assess the potential interactions between the IPFs identified in **Chapter 2** and cultural, historical, and archaeological resources. **Figure 4.5.2-1** provides a synopsis of the IPF categories that currently affect or have the potential to affect archaeology in the Gulf of Mexico OCS. Following **Figure 4.5.2-1** is a summary of those potential effects on archaeology as well as discussions of the IPF categories identified as not likely to affect archaeology and why. While the potential for effects to archaeological resources can likely be avoided or minimized with proper mitigation, it is important to note that any realized effects to archaeological resources are likely irreversible.

The magnitude and severity of the potential effects discussed herein could vary depending on numerous factors; therefore, impact determinations were not applied. Factors include, but are not limited to, location, frequency, and duration of the activities and/or resource; time of year; and/or the current condition of the resource. BOEM will use this preliminary identification and disclosure of the potential types of effects to archaeology, and the variables that could influence the magnitude and severity of those effects, to inform the issues and analyses to address in future NEPA analyses, consultations, or other environmental reviews associated with oil and gas leasing and development. While this document does not make impact determinations, future NEPA analyses will include such determinations.

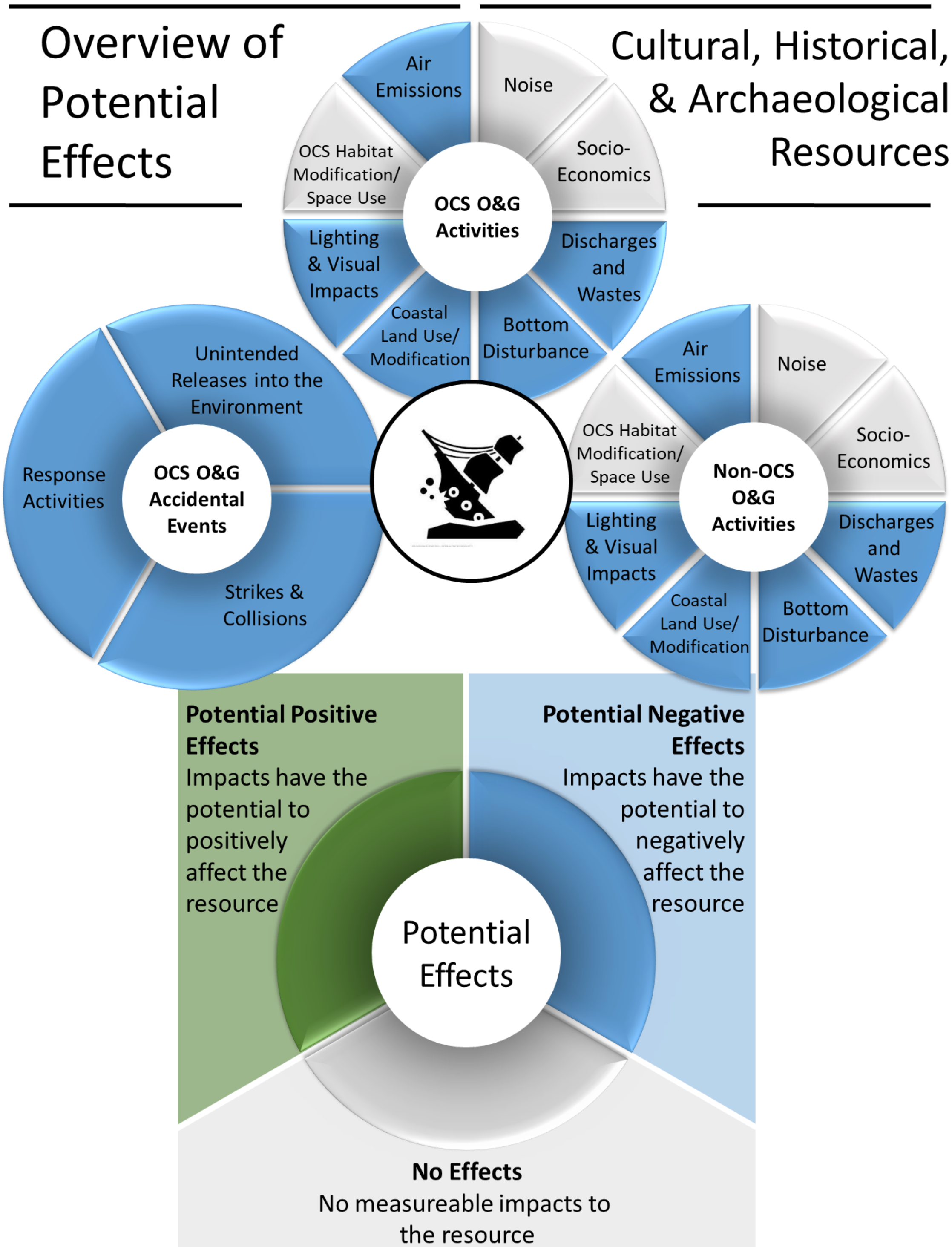


*Figure 4.5.2-1. Potential Interactions Between the Impact-Producing Factors Identified in **Chapter 2** and Cultural, Historical, and Archaeological Resources. Non-OCS oil- and gas-related activities are those that are independent of and reasonably expected regardless of whether OCS oil and gas leasing and associated activities were to occur. (O&G = oil and gas)*

4.5.2.1 Potential Effects from Non-OCS Oil- and Gas-Related Activities

Figure 4.5.2-1 highlights the IPF categories of other non-OCS oil- and gas-related activities taking place or expected in the area of analysis that could potentially affect archaeology in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent, as discussed below.

Air Emissions and Pollution (Chapter 2.1.2)

Air emissions from non-OCS oil and gas sources contribute to acidic deposition, ocean acidification, and eutrophication in the Gulf of Mexico (Caldeira and Wickett 2003; Driscoll et al. 2003; Howarth 2008; Paerl et al. 2002; Vitousek et al. 1997; Wanninkhof et al. 2015). Both CO_2 uptake and acidic deposition (wet + dry deposition) of sulfur and nitrogen can increase acidification in the Gulf of Mexico by changing the waters' pH (potential hydrogen) value (Doney et al. 2007; Echeverria et al. 2020; Paerl et al. 2002; Wanninkhof et al. 2015). Archaeological resources made of calcium carbonate (e.g., limestone and marble) and metals like steel, copper, bronze, and nickel can deteriorate faster in more highly acidic environments (Al-Hosney and Grassian 2005; Baedecker et al. 1992; Winkler 1970). Resources closer to the coastal waters (mixture of fresh and saltwater) of the Gulf of Mexico will be affected more by acidification than areas farther from the coast where water depth and the natural alkalinity of the seawater can reduce the effects of acidification (Doney et al. 2007). Terrestrial archaeological resources along the coast made of calcium carbonate (e.g., limestone and marble) and metals will deteriorate faster from the acidic deposition of sulfur and nitrogen (also referred to as acid rain) (McGee 1995; Winkler 1970).

Additionally, acidic deposition can contribute to eutrophication (Glibert 2020) (**Chapter 3.3**). Eutrophication could increase the deterioration of resources in shallow waters by disrupting the local biome (see discussion above). Conversely, the deterioration of shipwreck materials is typically slowed in low or anoxic conditions, so increased eutrophication may, theoretically, enhance shipwreck preservation in some circumstances. The USEPA, acknowledging that pollutants can harm public health and the environment, sets the National Ambient Air Quality Standards (NAAQS) for certain common and widespread pollutants. While cumulative air emissions may be reduced through the NAAQS and other mitigation regulatory requirements, any actual effects to cultural, historic, or archaeological resources resulting from or exacerbated by cumulative air emissions would likely be irreversible.

Discharges and Wastes (Chapter 2.2.2)

Non-OCS oil- and gas-related discharges and wastes that could potentially affect cultural, historical, and archaeological resources include historical chemical weapons disposal, historical industrial waste disposal, dredged material disposal, marine trash and debris, and non-OCS oil- and gas-related spills. Many of the impacts from these activities would be related to their associated bottom disturbances as described below. Chemical weapons or industrial waste containers disposed of on top of a historic shipwreck could damage the site through direct physical contact or by chemical alteration of the site's localized environment, thereby accelerating site degradation. Additionally, these containers, as well as other types of marine trash and debris that reach the seafloor, could affect the ability to accurately interpret archaeological sites in remote-sensing survey data. A concentration of non-archaeological objects on the seafloor could be misinterpreted in sonar data as a potential shipwreck (i.e., false positives) or, more likely, magnetic interference from these objects could mask or distort the magnetic signature of an underlying shipwreck buried below the mudline and prevent the accurate archaeological interpretation of magnetometer data (i.e., false negatives).

There are few relevant studies on non-OCS oil- and gas-related, oil-spill impacts to historic properties, but several studies of impacts related to the 2010 *Deepwater Horizon* oil spill and resulting spill response provide a useful example of what could result if a large spill were to occur during non-OCS oil- and gas-related activities. Studies on shipwrecks that were exposed to deposited oil within the *Deepwater Horizon* oil-spill plume displayed differences in their microbiomes and reduced biodiversity relative to unimpacted sites (Hamdan et al. 2018). Metal loss on experimental carbon steel disks placed at the study sites was increased at those sites within the spill plume, and time-series imagery indicates that the rate of metal loss on the wreck of the German U-boat U-*166* has accelerated since the spill (Mugge et al. 2019). Salerno et al. (2018) document that the release of hydrocarbons and chemical dispersant in marine environments may affect the structure of benthic microbial communities and biofilms found on artificial substrates, such as historic shipwrecks. Lab experiments were performed to determine separately the impacts of crude oil, dispersant, and chemically dispersed crude oil on the community structure and function of microorganisms in seawater and on biofilms formed on carbon steel, a common ship hull construction material. Steel corrosion was also monitored to illustrate how oil spills may impact the preservation of steel shipwrecks. The study revealed a decrease in genes associated with hydrocarbon degradation in dispersant-treated biofilms. This indicates that exposure to oil and dispersant could disrupt the composition and metabolic function of biofilms colonizing metal hulls (Salerno et al. 2018), potentially compromising the environmental equilibrium of the shipwreck and accelerating corrosion processes, as described in further detail below.

Wooden-hulled shipwrecks, which are typically older and less structurally sound than metal-hulled wrecks, are also vulnerable to potential impacts from discharged hydrocarbons or other chemicals. Research on wooden shipwreck remains has shown that both chemical and biological degradation/deterioration of wood "reduces its mechanical and physical properties" (Chang et al. 2002).

An experimental study has suggested that while the degradation of wood in terrestrial environments is initially retarded by contamination with crude oil, at later stages the biological deterioration of wood was accelerated. While different environmental constraints affect the degradation of wood in terrestrial and waterlogged environments, soft-rot fungal activity, one of the primary wood degrading organisms in submerged environments, was shown to be increased in the presence of hydrocarbons (Ejechi 2003).

In addition to the above studies, Rees et al. (2019) assessed the effects of the 2010 *Deepwater Horizon* oil spill on eight prehistoric archaeological sites on Louisiana's Gulf Coast. Crude oil and dispersant used during the response were detected in redeposited shoreline middens and intact archaeological contexts. The proximate impacts to the archaeological record include contamination of artifacts, ecofacts, and samples, with the potential to distort the results of archaeometric dating techniques including radiocarbon dating and pottery residue analysis. Effects to dating the artifacts were shown that they could be mitigated with a solvent-extraction process prior to testing.

Bottom Disturbance (Chapter 2.3.2)

Virtually all threats of adverse effects to prehistoric and historic archaeological resources within BOEM's areas of operation would be as a result of direct physical contact with and disturbance of the resource. In some cases, the nature of the disturbance may be intentionally targeted at an archaeological resource, particularly shipwrecks, such as with sport diving or treasure hunting and artifact looting. In other cases, the physical impacts to an archaeological resource may be unintentional collateral damage from more widespread bottom disturbances associated with commercial/industrial activity or seafloor maintenance projects. Regardless of the source of the bottom disturbance, the types of potential adverse effects to an archaeological resource are the same and vary only by the scale of the bottom-disturbing activity. The primary adverse effects of these activities would be the removal, reorientation, and/or destruction of the artifact assemblage or other physical components of an archaeological site. This, in turn, could result in a loss of archaeological information and inhibit the proper identification and interpretation of the site. For example, removal or destruction of diagnostic artifacts on a shipwreck such as a ship's bell, ceramics, cargo, passengers' and crews' personal effects, or structural elements of the vessel's hull could prevent a conclusive analysis of the vessel's type, age, purpose, or identity. Due to the ephemeral nature of submerged prehistoric archaeological sites on the OCS, bottom-disturbing activities could result in the complete destruction of the site or an inability to accurately resolve the site in subsequent remote-sensing surveys. If severe enough, this loss of archaeological information may minimize site integrity and prevent a determination of the site's eligibility to the NRHP or reverse a previous determination of eligibility. In all cases, these adverse effects are permanent. Archaeological sites are non-renewable resources with site-specific spatial, temporal, and physical characteristics, and each makes a unique contribution to the archaeological and historical record. Once some or all of this information is lost, it cannot be regenerated.

A secondary adverse effect from bottom disturbances is a disruption of the localized environmental conditions, which may accelerate the degradation of an archaeological site. Shipwrecks are not in a static condition; they are continuously going through a state of change – referred to as the site formation process – as their physical components (wood, metal, ceramics, organics, and other materials) deteriorate and shift locations over time. Typically, the most rapid rate of deterioration will happen in the initial years following the wrecking event when more of the shipwreck is exposed to physical, chemical, and biological forces in the water column. Over time this rate of change will decelerate as parts of the wreck are buried in oxygen-deprived sediments and as ferrous objects become encrusted in a protective concretion of iron mixed with sand and shell. Colonization of deepwater shipwrecks by certain species of sessile fauna has also been observed to induce localized artifact preservation (Etnoyer 2016). As a result, the shipwreck reaches a relative state of equilibrium with its surrounding environment. Once natural or anthropogenic events alter the environmental conditions, then this state of equilibrium is also disrupted. If the wreck is unburied, it will begin to oxidize in the water column, or direct contact from a bottom-disturbing activity may break artifacts or breach the structural integrity of the vessel's hull and expose previously protected surfaces to further degradation. For this reason, the potential consequences from a bottom-disturbing event are not limited in time to the duration of the event itself. Adverse effects to the archaeological site are likely to continue long after the initial event.

It is also important to note that, even if a bottom-disturbing activity does not directly impact an archaeological site, it could still prevent any archaeological analysis of that site, which is in itself an adverse impact. For example, if a site is buried under many feet of sediment, but a pipeline is installed on the seafloor above it, or if it is within the mooring spread of an offshore platform, then the site will not be accessible for future research without risking damage to the surrounding infrastructure and the resultant environmental consequences. As expressed in NRHP criterion (d), archaeological sites derive their significance from their potential to yield information important in prehistory or history. That significance is lost if this information cannot be studied and shared with the public.

Non-OCS oil- and gas-related activities that could result in bottom disturbance include State oil and gas exploration and development, spill response, artificial reefs, dredging related to sand borrowing or navigation channels, commercial fish trawling, renewable energy installations, military operations, mass wasting events, undersea cables, deepwater ports, recreation, and establishment of anchorage areas, buoys, and moorings. **Chapter 2.3** provides a detailed description of the range of impacts associated with these activities. Due to State jurisdictions, water depth limitations, or their role in supporting coastal infrastructure needs, many of these activities are more likely to impact historic and prehistoric archaeological resources in relatively shallow near-coastal waters (e.g., State oil and gas, artificial reefs, dredging, trawling, renewable energy, recreation, spill response, and anchor, buoy, and mooring areas). Compared with isolated point-source impacts (such as an anchor or pipeline emplacement), dredging activities have a relatively high potential for bottom-disturbing impacts from the removal of large sediment volumes over contiguous horizontal and vertical areas. In addition to direct physical contact of dredging equipment with archaeological sites in either the dredge pit or the dredged material disposal area, potential impacts also include the redepositing of artifacts into the disposal area and seabed destabilization around sites adjacent to the dredge pit.

Commercial fisheries bottom trawling similarly impacts extensive horizontal areas of the seafloor. Trawl nets that snag on shipwrecks can destroy and disperse artifacts and large sections of vessel hulls, particularly those of wooden-hulled wrecks, which are generally less structurally sound than iron or steel-hulled wrecks. Intrusive trawl netting that snags on a shipwreck and is left behind can also obscure significant sections of the site and preclude a detailed archaeological analysis. As discussed in **Chapter 2.3.2**, commercial bottom trawling is generally (though not always) conducted in water depths shallower than 200 m (656 ft); however, discarded netting can drift across the seafloor, and modern nets have been observed on historic shipwrecks in water depths over 600 m (2,000 ft).

Recreational bottom-disturbing impacts to archaeological sites include treasure hunting/looting and sport diving. Treasure hunting involves the intentional, nonscientific, usually commercial exploitation of archaeological resources for profit, and may be illegal in certain circumstances. 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* (Bowers 2008; Gearhart II et al. 2011; Irion and Ball 2001) 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 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 a remotely operated vehicle pipeline inspection (Ford et al. 2008; Horrell and Borgens 2017).

Sport diving includes private or commercial recreational diving on archaeological sites for pleasure and education. Adverse effects 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. Sport divers may, however, have a beneficial impact to archaeological sites by monitoring sites, encouraging fellow divers to protect sites, and reporting any observed adverse impacts to the appropriate State or Federal agency.

Mass wasting events, commonly known as underwater mudslides, present a somewhat unique form of bottom-disturbing impact on archaeological sites. An area of unstable sediments that have accumulated offshore the Mississippi River delta outflow is a frequent source of mass wasting events. This area also contains numerous known and reported historic shipwrecks of vessels that sank while entering or leaving the mouth of the Mississippi River. At least one of these shipwrecks, the tanker *Virginia*, which was torpedoed by a German U-boat during World War II, has moved downslope over 1,300 ft (400 m) due to repeated mudslides since the wreck was first discovered in 2001. Several other shipwrecks that have not yet been identified have also moved significant distances over the seafloor since they were first discovered during remote-sensing surveys. The impacts to these archaeological sites have not yet been studied, but an additional concern is the inability to know their exact location at any given time. The surveys that identified these wrecks are often years or decades old, and, as with *Virginia,* mass wasting events in the intervening years may have moved these wrecks hundreds or thousands of feet from their last known locations. The inability to track these movements in real-time prevents BOEM from confidently assigning avoidance mitigations during the Section 106 reviews of agency-permitted activities and introduces the potential for additional anthropogenic bottom disturbances to these sites.

Bottom disturbance impacts on archaeological resources also could occur from non-OCS oil- and gas-related spills and spill response (**Chapter 2.2.2.10**). The significant 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 looting by cleanup crews – rather than from the oil itself (Bittner 1993). As a result, cultural resources were recognized as significant early in response to the *Deepwater Horizon* oil spill, and archaeologists were embedded in Shoreline Cleanup and Assessment Technique (SCAT) teams and consulted with cleanup crews.

Any of the above activities conducted under a Federal permit or Federal funding are subject to review under Section 106 of the NHPA, and the lead Federal agency may require a pre-disturbance survey to identify any historic properties within the activity's area of potential effect, and further efforts to avoid, minimize, or mitigate any adverse effects. Activities occurring on State bottomlands are also subject to State laws and may require further review by the relevant State Historic Preservation Office.

Coastal Land Use/Modification (Chapter 2.5.2)

Coastal land disturbance as a result of sea-level rise and subsidence, erosion from saltwater intrusion and dredging of navigation canals, and tourism infrastructure can affect archaeological resources. In these instances the potential impacts to archaeological resources would be similar to those of the bottom-disturbing activities described above, whereby the physical characteristics of an archaeological site are irreversibly altered through direct contact. Coastal land disturbances are relatively less likely to impact historic shipwrecks (except for navigation canal dredging) and more likely to impact prehistoric archaeological sites or other historic buildings, sites, structures, objects, or districts. Dredging equipment or construction of tourism infrastructure may remove, disperse, or destroy features of a historic property if that property is not adequately identified and avoided prior to the bottom-disturbing activities. Sea-level rise, subsidence, and erosion may result in terrestrial historic and prehistoric sites becoming submerged and their features redistributed through wave energy.

Coastal land disturbances can also adversely affect traditional cultural properties that are defined as, "property that is eligible for inclusion in the NRHP based on its associations with the cultural practices, traditions, beliefs, lifeways, arts, crafts, or social institutions of a living community. Traditional cultural properties are rooted in a traditional community's history and are important in maintaining the continuing cultural identity of the community" (Parker and King 1992). Coastal land use or modification from development may restrict or reduce access to traditional cultural properties or permanently alter the characteristics that contribute to their traditional cultural significance. Any activities conducted under a Federal permit or Federal funding are subject to review under Section 106 of the NHPA and may require a pre-disturbance survey to identify any historic properties within the activity's area of potential effect and further efforts to avoid, minimize, or mitigate any adverse effects. Activities occurring on State bottomlands are also subject to State laws and may be subject to further review by the relevant State Historic Preservation Office. Activities occurring on land owned by a Native American Tribe are further predicated on consultation and coordination with that Tribe and (if applicable) its Tribal Historic Preservation Office.

Lighting and Visual Impacts (Chapter 2.6.2)

Visual impacts relate to a historic property's integrity of setting when considering the property's NRHP eligibility. According to the National Park Service (NPS) (2005a), "Setting often reflects the basic physical conditions under which a property was built and the functions it was intended to serve. In addition, the way in which a property is positioned in its environment can reflect the designer's concept of nature and aesthetic preferences." Physical elements that contribute to setting integrity can be natural or manmade and include topographic features, vegetation, relationships between buildings and open space, and viewsheds. Coastal property types that may have a setting dependent upon the surrounding seascape include lighthouses, fortifications, resorts, and personal residences. These same property types, and others, may have inland-facing viewsheds that are not solely dependent on the maritime landscape. Any coastal or onshore infrastructure development that introduces lighting impacts or obscures a property's associated viewshed may negatively impact its setting integrity. In the western and cental Gulf of Mexico, offshore and State oil- and gas-related activities are unlikely to introduce new visual impacts since infrastructure has existed in these areas since the 1940s and constitutes a seaward historic viewshed in its own right. Additionally, offshore oil and gas infrastructure pre-dates 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. If State oil and gas activities were to occur in areas with no existing infrastructure development, then cumulative visual impacts may ensue.

Non-OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the ongoing or expected activities not associated with OCS oil and gas development and determined that noise, offshore habitat modification/space use, and socioeconomic changes and drivers are not likely to affect cultural, historical, and archaeological resources. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

Noise (Chapter 2.4.2)

Noise from either natural or anthropogenic sources is unknown to result in physical disturbances or any other impact that might affect the NRHP eligibility of archaeological resources and so is not analyzed in detail here. In fact, acoustic data acquired during geophysical surveys (e.g., sidescan sonar and subbottom profiler) are one of the primary means of locating submerged archaeological resources. Accordingly, their use is inextricable from the proper identification, management, and avoidance of adverse impacts to archaeological sites within Federal or State jurisdictions.

Offshore Habitat Modification/Space Use (Chapter 2.7.2)

There are no effects expected to cultural, historical, and archaeological resources from offshore habitat modification/space use as it is described in **Chapter 2.7.2**, as cultural, historical, and archaeological resources are not expected to conflicting use of a shared space. Rather, effects to cultural, historical, and archaeological resources from offshore habitat modification/space use are related to the bottom disturbances associated with those activities (e.g., recreation, commercial fishing, undersea cables, military, deepwater ports, OCS sand borrowing, coastal restoration, renewable energy, and ocean dumping) and are discussed above in **Chapter 4.5.2.1** (Bottom Disturbance).

Socioeconomic Changes and Drivers (Chapter 2.8.3)

The socioeconomic changes and drivers discussed generally describe factors that influence how various communities perceive and use the ocean environment. While individual factors may have a hypothetical corresponding influence on cultural, historical, and archaeological resources, it is assumed that these factors would result in an increased or decreased occurrence of the IPFs that are described elsewhere in this chapter.

4.5.2.2 Potential Effects from Routine OCS Oil- and Gas-Related Activities

Figure 4.5.2-1 highlights the IPF categories associated with routine OCS oil and gas development that could potentially affect cultural, historical, and archaeological resources in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Air Emissions and Pollution (Chapter 2.1.1)

Air emissions and pollution from routine oil and gas operations may be a contributing factor to acidic deposition, acidification, and eutrophication in the Gulf of Mexico (Caldeira and Wickett 2003; Driscoll et al. 2003; Howarth 2008; Paerl et al. 2002; Vitousek et al. 1997; Wanninkhof et al. 2015). Routine oil and gas operations contribute to the emission of carbon dioxide (CO_2) and air pollution containing sulfur and nitrogen elements (e.g., sulfur dioxide [SO_2], nitrogen oxides [NO_X], and ammonia [NH_3]) into the atmosphere. Both CO_2 uptake and acidic deposition (wet + dry deposition) of sulfur and nitrogen can increase acidification in the Gulf of Mexico by changing the waters' pH (potential hydrogen) value (Doney et al. 2007; Echeverria et al. 2020; Paerl et al. 2002; Wanninkhof et al. 2015). Archaeological resources made of calcium carbonate (e.g., limestone and marble) and metals like steel, copper, bronze, and nickel can deteriorate faster in higher acidic environments (Al-Hosney and Grassian 2005; Baedecker et al. 1992; Winkler 1970). Resources closer to the coastal waters (mixture of fresh and saltwater) of the Gulf of Mexico will be affected more by acidification than areas farther from the coast, where water depth and the natural alkalinity of the seawater can reduce the effects of acidification (Doney et al. 2007). Terrestrial archaeological resources along the coast made of calcium carbonate (e.g., limestone and marble) and metals could deteriorate faster from acidic deposition of sulfur and nitrogen (also referred to as acid rain) (McGee 1995; Winkler 1970).

Additionally, acidic deposition can contribute to eutrophication, potentially increasing the deterioration of resources in shallow waters by disrupting the local biome (Glibert 2020). Conversely, the deterioration of shipwreck materials is typically slowed in low or anoxic conditions so increased eutrophication may, theoretically, enhance shipwreck preservation in some circumstances.

The USEPA sets the NAAQS for certain common and widespread pollutants that can harm public health and the environment and cause property damage. While potential impacts resulting from OCS oil and gas air emissions would likely be avoided or reduced through regulatory requirements and proper mitigation, any actual impacts that were to occur any actual effects to cultural, historic, or archaeological resources resulting from or exacerbated by OCS oil- and gas-related air emissions would likely be irreversible.

Discharges and Wastes (Chapter 2.2.1)

Discharges and wastes, such as drilling muds and cuttings, released from routine OCS oil and gas operations can physically impact the seafloor through sediment, trace metal, and hydrocarbon deposition, which could potentially alter an archaeological site's formation processes through physical, chemical, or biological disruption of its localized environment as described in **Chapter 4.5.2.1** (Bottom Disturbance). A small sampling and monitoring effort in the Gulf of Mexico documented that the spread of these types of discharges and wastes from routine drilling activities was limited to around 250 m (820 ft) from the drilling center point (Continental Shelf Associates Inc. 2004a). Given the limited number of wells in this sample, and that they were in similar areas and water depths, this assessment should be considered a minimum physical impact area that could potentially extend further than observed in the study. Continental Shelf Associates Inc. (2004a) estimates that these discharges can place trace metals, hydrocarbons, and suspended materials within several acres around the drilling location. Precise estimates are difficult to anticipate given the variables affecting the distribution of discharges and wastes, including depth of the well, drilling duration, grain size, and currents.

Bottom Disturbance (Chapter 2.3.1)

Routine OCS oil and gas development has many associated bottom-disturbing activities with the potential to adversely affect archaeological resources. These activities include 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; anchoring, decommissioning activities including post-removal site clearance trawling, and the masking of archaeological resources from industry-related infrastructure and debris.

Potential adverse effects associated with these activities are the same as those described in **Chapter 4.5.2.1** (Bottom Disturbance), namely the permanent loss of or damage to archaeological information from direct physical contact, a disruption of site formation processes and accelerated degradation of a site's physical components, masking of an archaeological site's acoustic or magnetic signatures in remote-sensing data as a result of ocean dumping and marine debris, and the inability to conduct further archaeological study of a site when it is shielded from access by nearby industry infrastructure.

To fulfill the requirements of Section 106 of the NHPA (36 CFR part 800) and BOEM's regulations (30 CFR § 550.194), BOEM archaeologists review all agency-permitted activities for their potential to affect historic properties and, when appropriate, take steps in coordination with operators to avoid, minimize, or mitigate any adverse effects. These steps include conducting geophysical surveys of the operator's area of potential effect to locate potential archaeological resources and requiring avoidance of potential resources or, if avoidance is not possible, further investigation to document their NRHP eligibility.

Coastal Land Use/Modification (Chapter 2.5.1)

Coastal land disturbances associated with routine OCS oil and gas development may result from the expansion or installation of coastal infrastructure such as service bases, waste disposal facilities, gas processing plants, pipeline landfalls, and navigation channels. These disturbances may occur on land or in the marine environment, and their potential impacts to archaeological sites and other historic properties would be as a result of their associated ground or seafloor disturbances or from restricted access to traditional cultural properties as described above. These activities would be subject to applicable State laws and regulations, including potential review by the relevant State Historic Preservation Office. Activities for which BOEM is the lead Federal agency or a cooperating agency for NHPA and NEPA would also be subject to additional coordination and consultation between BOEM and the relevant state, tribe, and other stakeholders in fulfillment of Section 106 of the NHPA.

Lighting and Visual Impacts (Chapter 2.6.1)

New onshore infrastructure that is developed as a result of OCS oil- and gas-related activities could introduce lighting or other visual impacts to onshore cultural, historical, or archaeological resources. Visual impacts relate to a historic property's integrity of setting when considering the property's NRHP eligibility. According to the NPS (NPS 2005a), "Setting often reflects the basic physical conditions under which a property was built and the functions it was intended to serve. In addition, the way in which a property is positioned in its environment can reflect the designer's concept of nature and aesthetic preferences." Physical elements that contribute to setting integrity can be natural or manmade and include topographic features, vegetation, relationships between buildings and open space, and viewsheds. Coastal property types that may have a setting dependent upon the surrounding seascape include lighthouses, fortifications, resorts, and personal residences. These same property types, and others, may have inland-facing viewsheds that are not solely dependent on the maritime landscape. Any coastal or onshore infrastructure development that introduces lighting impacts or obscures a property's associated viewshed may negatively impact its setting integrity.

Conversely, offshore oil and gas infrastructure is generally not considered to have visual impacts to coastal archaeological, cultural, and historic sites 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 pre-dates 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. If routine OCS oil- and gas-related activities were to occur in areas with no existing infrastructure development, then cumulative visual impacts may ensue.

Routine OCS Oil- and Gas-Related Activities Determined Not Likely to Cause Effects

BOEM evaluated each of the IPF categories that could result from the OCS oil- and gas-related activities described in **Chapter 2** and determined that noise, offshore habitat modification/space use, and socioeconomic changes and drivers are not likely to affect cultural, historic, or archaeological sites. Therefore, these IPFs were excluded from detailed analysis and would likely be scoped out of future NEPA analyses for proposed Gulf of Mexico OCS oil and gas lease sales.

Noise (Chapter 2.4.1)

Noise from either natural or anthropogenic sources is not known to result in physical disturbances or any other impact that might affect the NRHP eligibility of cultural, historical, or archaeological resources and so is not analyzed in detail here. In fact, acoustic data acquired during geophysical surveys (e.g., sidescan sonar and subbottom profiler) are one of the primary means of locating submerged archaeological resources. Accordingly, their use is inextricable from the proper identification, management, and avoidance of adverse impacts to archaeological sites within Federal or State jurisdictions.

Offshore Habitat Modification/Space Use (Chapter 2.7.1)

Space-use conflicts from routine OCS oil- and gas-related activities include seafloor emplacement of infrastructure, anchors, and seismic survey equipment. The potential impacts to archaeological resources from these activities are related to their associated bottom disturbances and have been discussed above.

Socioeconomic Changes and Drivers (Chapter 2.8.2)

The socioeconomic changes and drivers discussed generally describe factors that influence how various communities perceive and use the ocean environment. While individual factors may have a hypothetical corresponding influence on cultural, historical, and archaeological resources, it is assumed that these factors would result in an increased or decreased occurrence of the IPFs that are described elsewhere in this chapter.

4.5.2.3 Potential Effects from Accidental OCS Oil- and Gas-Related Events

Figure 4.5.2-1 highlights the IPF categories of accidental events associated with oil and gas development on the OCS that could potentially affect cultural, historic, and archaeological sites in the GOM region. Effects from these categories of IPFs could vary depending on their frequency, duration, and geographic extent as discussed below.

Unintended Releases into the Environment (Chapter 2.9.1)

Unintended releases into the environment that could impact archaeological resources include oil spills, chemical spills, pipeline failures, accidental air emissions, and trash and debris. These events could impact a cultural, historic, and archaeological site if the accidental release directly contacts the resource and alters its localized physical, chemical, or biological environment, thereby putting the site in disequilibrium with its surroundings and accelerating site decomposition. Studies on shipwrecks that were exposed to deposited oil within the *Deepwater Horizon* oil-spill plume displayed differences in their microbiomes and reduced biodiversity relative to unimpacted sites (Hamdan et al. 2018). Metal loss on experimental carbon steel disks placed at the study sites was increased at those sites within the spill plume, and time-series imagery indicates that the rate of metal loss on the wreck of the German U-boat U-*166* has accelerated since the spill (Mugge et al. 2019). Marine trash and debris may also damage an archaeological site and its associated artifacts and result in a loss of diagnostic information or introduce modern material that masks the acoustic or magnetic signature of the archaeological site in remote-sensing surveys. Each of these scenarios is discussed in more detail above in **Chapter 4.2.5.1** (Discharges and Wastes).

Response Activities (Chapter 2.9.2)

Spill response activities such as dispersant use, chemical cleaning agents, mechanical removal, and exposure to oil itself could affect cultural, historic, and archaeological resources. Following the 2010 *Deepwater Horizon* oil spill in the Gulf of Mexico, Salerno et al. (2018) documented that the release of hydrocarbons and chemical dispersant in marine environments may affect the structure of benthic microbial communities and biofilms found on artificial substrates, such as historic shipwrecks. Lab experiments were performed to determine separately the impacts of crude oil, dispersant, and chemically dispersed crude oil on the community structure and function of microorganisms in seawater and on biofilms formed on carbon steel, a common ship hull construction material. Steel corrosion was also monitored to illustrate how oil spills may impact the preservation of steel shipwrecks. The study revealed a decrease in genes associated with hydrocarbon degradation in dispersant-treated biofilms. This indicates that exposure to oil and dispersant could disrupt the composition and metabolic function of biofilms colonizing metal hulls (Salerno et al. 2018), potentially compromising the environmental equilibrium of the shipwreck and accelerating corrosion processes.

Research also has shown, using wooden shipwreck remains as an example (often the oldest and most fragile), that both chemical and biological degradation/deterioration of wood "reduces its mechanical and physical properties" (Chang et al. 2002). During long-term exposure to submerged conditions, all wooden artifacts (including the ship hull) contain microorganisms that can breakdown and/or alter the cellular components of wood, resulting in the hydrolytic leaching of starches and sugars, ultimately making the wood more porous and decreasing its structural stability (Hamilton 1999). Over time and given the right environmental conditions, waterlogged wood often becomes increasingly fragile and is dependent on surrounding water and lignin (found in the cell walls) to support the shape of the wood (Jordan 2001). In certain environmental conditions (e.g., low oxygen or low temperatures), the bacterial and chemical degradation of submerged wood can be very slow, resulting in the survival of wooden shipwreck elements for hundreds and sometimes thousands of years (Jordan 2003). An experimental study has suggested that while the degradation of wood in terrestrial environments is initially retarded by contamination with crude oil, at later stages the biological deterioration of wood was accelerated (Ejechi 2003). While there are different environmental constraints that affect the degradation of wood in terrestrial and waterlogged environments, soft-rot fungal activity, one of the primary wood-degrading organisms in submerged environments, was shown to be increased in the presence of hydrocarbons (Ejechi 2003).

Spill-response activities may also impact coastal archaeological sites. 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. Rees et al. (2019) assessed the effects of the 2010 *Deepwater Horizon* oil spill on eight prehistoric archaeological sites on Louisiana's Gulf Coast. Crude oil and dispersant used during the response were detected in redeposited shoreline middens and intact archaeological contexts. The proximate impacts to the archaeological record include contamination of artifacts, ecofacts, and samples, with the potential to distort the results of archaeometric dating techniques, including radiocarbon dating and pottery residue analysis. Effects to dating the artifacts were shown that they could be mitigated with a solvent-extraction process prior to testing.

Strikes and Collisions (Chapter 2.9.3)

Accidental vessel collisions that occur offshore are very serious events that often lead to the loss of human life. The very fact of the presence of archaeological resources like shipwrecks demonstrates tangibly the risk inherent with navigating open waters. In 2018, for example, there were 319 collision incidents reported worldwide among commercial vessels over 100 gross tons (Allianz Global Corporate & Specialty SE 2019), none of which were in the GOM. A total of 46 vessels of this type were reported lost from all causes in 2018, which represents a significant decrease from what had been a rolling 10-year average of 104 losses per year (Allianz Global Corporate & Specialty SE 2019). Impacts to shipwrecks from vessel collisions could include direct physical damage to the resource from collision debris or secondary impacts from the release of pollutants that contact the shipwreck. These potential effects were discussed in the **Chapter 4.5.2.3** "Bottom Disturbance" and "Unintended Releases into the Environment" sections above.

CHAPTER 5

POSTLEASE PERMITTING AND APPROVAL PROCESSES

What is in This Chapter?

- An overview of BOEM and BSEE's regulatory review and approval processes for OCS oil- and gas-related activities.
- Flow diagrams outlining the general review processes and BOEM/BSEE interagency coordination for the various types of postlease plans and permit applications.
- Summarized relevant consultation requirements with other Federal and State agencies and where NEPA review is conducted throughout all phases of the oil and gas lifecycle.

Key Points

- BOEM conducts environmental reviews at all four stages of the OCSLA leasing process, including postlease activities.
- BOEM coordinates closely with BSEE and other key agencies when permitting/authorizing postlease activities.
- All plans for OCS oil- and gas-related activities (e.g., exploration and development plans, pipeline applications, geological and geophysical activities, and structure-removal applications) go through rigorous BOEM review and approval to ensure compliance with established laws and regulations.

5 POSTLEASE PERMITTING AND APPROVAL PROCESSES

5.1 INTRODUCTION

BOEM and BSEE's permitting programs must be carried out in full compliance with NEPA and all other applicable environmental statutes, regulations, and guidance, as well as each Bureau's implementing regulations, giving decisionmakers an understanding of the environmental consequences of the Bureaus' actions. This chapter outlines and summarizes those processes and illustrates how BOEM and BSEE work closely to ensure that permitted operations are adequately evaluated for compliance with environmental standards and requirements to prevent or reduce the likelihood of any damage to natural resources, property, or the environment. This chapter is not intended to be exhaustive, authoritative, or to replace or supersede any applicable statutes, regulations, or other guidance on these processes.

5.1.1 BOEM and BSEE's Responsibilities and Environmental Coordination

"Postlease" activities are oil- and gas-related activities that occur after authorization of an existing lease under the Outer Continental Shelf Lands Act (OCSLA).

The primary functions of BOEM and BSEE are illustrated in **Figure 5.1.1-1**. The functions of BOEM include leasing, exploration and development plan administration, geological and geophysical permitting, environmental studies, NEPA analysis, resource evaluation, economic analysis, marine minerals, and renewable energy development. BOEM reviews and approves plans for OCS oil and gas exploration and development. BOEM's regulations pertaining to oil, gas, and sulphur leasing are found in 30 CFR parts 550, 551, and 556 (except those aspects that pertain to drilling).

The BSEE regulates oversight of worker safety, emergency preparedness, environmental compliance, and conservation of resources. The BSEE Environmental Compliance Division provides regulatory oversight that is focused on compliance by operators with all applicable environmental regulations, as well as oversight for lessee and operator obligations under OCS leases. The BSEE inspectors issue Incidents of Non-Compliance and have the authority to impose sizeable civil penalties for regulatory infractions. In some cases, criminal penalties are also available. The BSEE regulations for oil, gas, and sulphur operations are specified in 30 CFR parts 250 (Oil and Gas and Sulfur) and 254 (Oil Spill Response Plan [OSRP]).

The BSEE serves as a cooperating agency on most BOEM-initiated NEPA documents. Formal plans or applications must be submitted by operators to BOEM for review and approval before any project-specific, postlease activities can begin. BOEM performs NEPA analyses when operators submit permit applications for pipeline installations or modifications, structure removals (including pipelines), structure installations or modifications, and applications for permits to drill, and applies mitigations to the permit approvals to minimize impacts on OCS resources. The BSEE then performs NEPA coordination activities, which involve reviewing the operators' permit applications and the associated Bureau of Ocean Energy Management's NEPA analyses to ensure that the OCS activities described in the permit applications match those described in the operators' associated plans, and that the Bureau of Ocean Energy Management's NEPA analyses were properly performed. If BOEM analyzed the proposed activities under a site-specific environmental assessment, BSEE would, if appropriate, generate a Finding of No Significant Impact (FONSI).

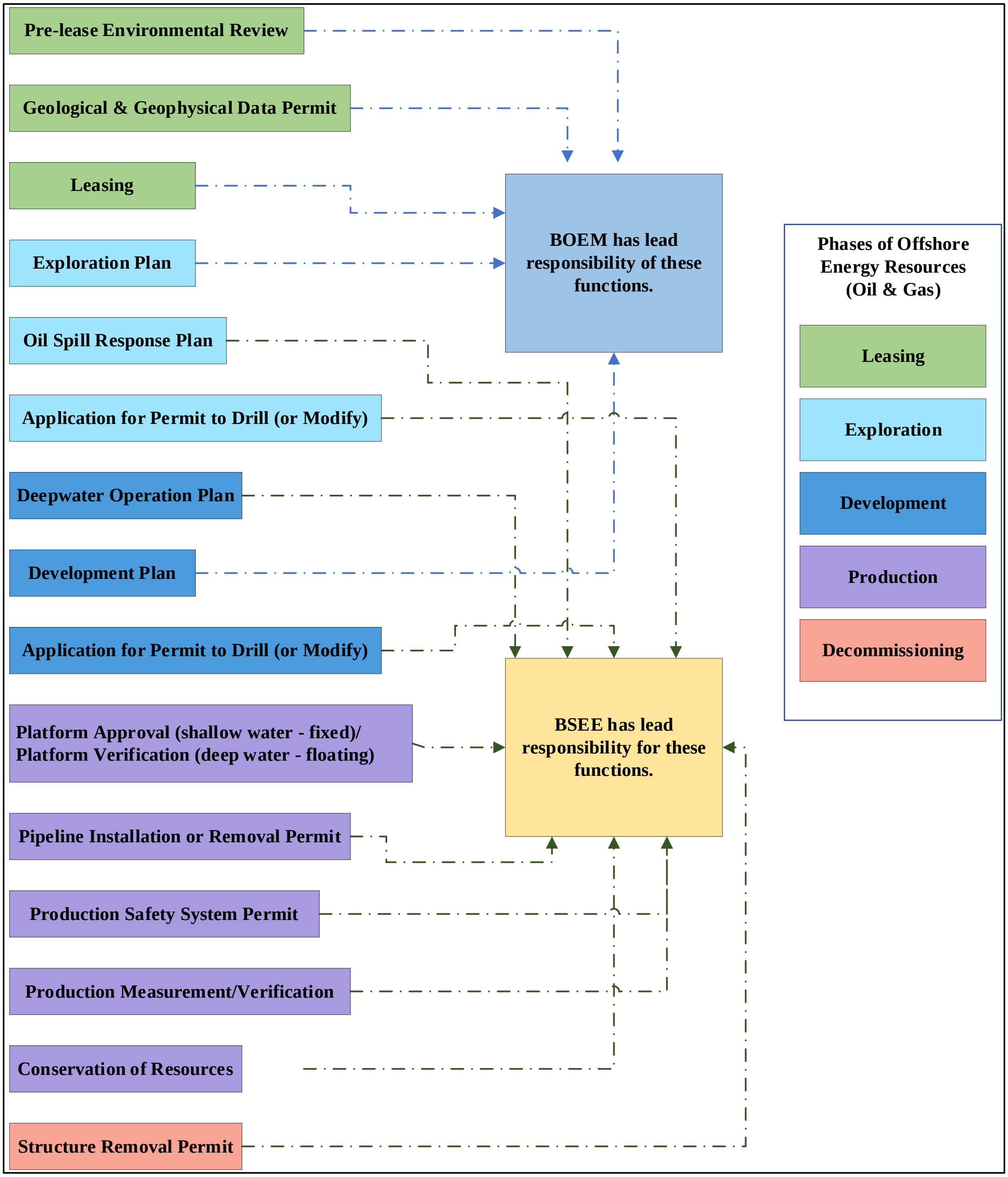


Figure 5.1.1-1. Responsibilities and Functions of BOEM and BSEE for Permitted Activities under the OCSLA in the Gulf of Mexico.

5.2 WHEN DO OPERATORS APPLY FOR PERMITS/APPROVALS?

Once a company acquires a lease in the GOM through the competitive bidding process, it would submit various plans to develop mineral resources on the OCS throughout the phases outlined in **Figure 5.1.1-1**.

The types of postlease plans and permit applications include

- G&G activities (also can be submitted in prelease);
- exploration plans (EPs) and development operations coordination documents (DOCDs) (CPA and WPA);
- development production plans (DPPs) (EPA);
- pipeline installation and decommissioning applications;
- structure removal applications; and
- certain ancillary activities.

BOEM also reviews and processes applications for rights-of-use and easement (RUEs). Rights-of-use and easement are granted to operators to construct or maintain platforms and other installations at OCS sites on which the operator does not have an OCS lease, if the proposed activities would facilitate the development of leased resources. Prior to granting an RUE request, BOEM must review and approve a plan outlining the proposed activities to ensure that these activities conform to sound conservation practices and are carried out in a safe and environmentally sound manner to prevent harm or damage to any natural resource or human, marine, or coastal environment. In FY 2019, BOEM received 24 RUE requests and completed 15 reviews. BOEM anticipates receiving approximately the same level of requests over the next few years. BOEM NTL No. 2015-N06 clarifies policy on requirements for RUE requests pursuant to the regulations set forth in 30 CFR part 550 subpart A. For BOEM to grant a RUE request for installation, the proposed activities by OCS lessees are also subject to the plans approval process and the requirements set forth in 30 CFR part 550 subpart B as discussed in subsequent sections of this chapter.

Activities covered under these categories are coordinated by BOEM's Office of Environment for applicable environmental reviews. Proposed activities are evaluated at the site-specific level, and tiering from programmatic NEPA documents, as well as consultation with cooperating agencies, are utilized in the NEPA process. **Figure 5.2-1** illustrates the relationships that exist between the tiering of NEPA documents and consultations as applied to site-specific activity proposals, and these are discussed throughout subsequent sections of this chapter. The three types of site-specific environmental reviews (SSERs) conducted for postlease activities are categorical exclusion reviews with analysis (CERAs), site-specific environmental assessments (SEAs), and environmental impact statements (EISs). Based on these reviews, BOEM applies conditions of approval (COAs) as required.

Geospatial Analysis

Geospatial analysis is widely used by BOEM to create, map, and analyze customized features and in performing NEPA determinations and reviews for proposed offshore oil and gas activities submitted by operators on the Gulf of Mexico OCS. BOEM uses Technical Information Management Systems (TIMS) components and GIS mapping technologies in conducting NEPA analyses of proposed activities, which allows BOEM to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of various types of maps and reports. The use of these geospatial tools enables NEPA coordinators and subject-matter expert reviewers to map and zoom into the predefined area of interest and identify site-specific resources that may be affected by specific actions proposed by operators on the Gulf of Mexico OCS. With the aid of geospatial resources, NEPA coordinators and subject-matter experts can make accurate NEPA determinations and apply necessary mitigations for proposed site-specific activities.

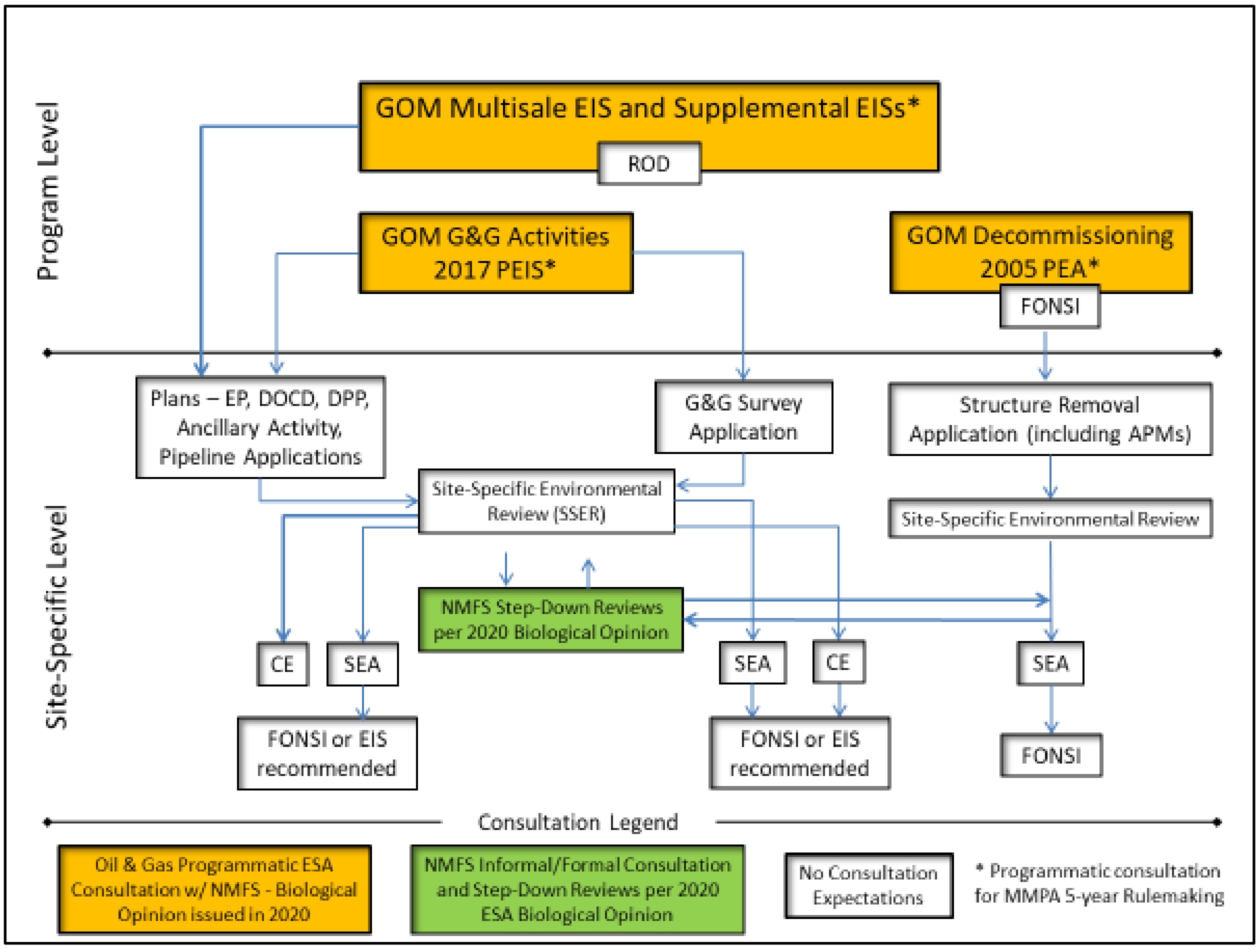


Figure 5.2-1 Programmatic to Site-Specific NEPA Tiering in the Gulf of Mexico and Consultations (FPSO = floating production, storage, and offloading facility; PEIS = programmatic environmental impact statement).

The following activities require the preparation of an SEA:

- G&G activities proposing bottom-disturbing activities or the use of airguns;
- proposed surface location within or near areas of high biological sensitivity including
  - the 4-Mile Zones of the East and West Flower Garden Banks and
  - the 3-Mile Zone of the Stetson Bank;
- drilling of wells in water depths >500 ft (152 m) using a subsea BOP or surface BOP on a floating facility;
- anticipated hydrogen sulfide (H_2S) concentration >500 parts per million (ppm) in the formation;
- EPA plans and pipelines;
- use of new or unusual technology (NUT);
- naturally occurring radioactive material (NORM) disposal;
- pipeline to shore, pipeline in a No Activity Zone, and pipeline carrying products with H_2S concentration >500 ppm;
- structure removals (explosive and nonexplosive); and
- any extraordinary circumstance triggered as defined in 43 CFR § 46.215.

– Notices to Lessees and Operators (NTLs) provide clarification, description, or interpretation of a regulation; guidance on the implementation of a lease stipulation or regional requirement; or convey administrative information.
– Conditions of approval (COAs) become part of approved postlease authorizations and include environmental protections, safety precautions, and regulatory requirements by law, as well as the requirements of other agencies having jurisdiction.

Measures to minimize potential impacts are an integral part of the OCS Oil and Gas Program. These measures are implemented through lease stipulations, operating regulations, NTLs, and project-specific requirements or COAs that are applied to all plans for OCS oil- and gas-related activities (e.g., exploration and development plans, G&G permit applications, pipeline permit applications, and structure-removal permit applications).

A current listing of the Gulf of Mexico Regional Office's NTLs is available at BOEM's and BSEE's websites at https://www.boem.gov/about-boem/archived-notices-lessees-and-operators and https://www.bsee.gov/guidance-and-regulations/guidance/notice-to-lessees, respectively.

Chapter 6 discusses a suite of "Commonly Applied Mitigating Measures" that BOEM and BSEE consider and apply as necessary at the postlease stage. Existing mitigating measures must be incorporated and documented in plans submitted to BOEM, and operational compliance of the mitigating measures is enforced through BSEE's onsite inspection program. These measures, as well as the additional measures discussed in **Chapter 6**, address concerns such as endangered and threatened species, geologic and manmade hazards, military warning and ordnance disposal areas, archaeological sites, air quality, oil-spill response planning, benthic communities, marine minerals, artificial reefs, operations in H_2S prone areas, and shunting of drill effluents in the vicinity of biologically sensitive features.

5.2.1 Extraordinary Circumstances for Regulated Activities

The Council on Environmental Quality (CEQ) regulations at 40 CFR § 1508.4 require agency procedures to provide for extraordinary circumstances in which a normally categorically excluded action may have a significant environmental effect and require additional analysis and action. At 43 CFR § 46.215, the extraordinary circumstances under which actions otherwise covered by a categorical exclusion (CE) require analyses under NEPA at the environmental assessment level are listed below.

Extraordinary circumstances exist for individual actions within CEs that may meet any of the criteria listed in paragraphs (a) through (l) below:

(a) have significant impacts on public health or safety;

(b) have significant impacts on such natural resources and unique geographic characteristics as historic or cultural resources; park, recreation, or refuge lands; wilderness areas; wild or scenic rivers; national natural landmarks; sole or principal drinking water aquifers; prime farmlands; wetlands (Executive Order 11990); floodplains (Executive Order 11988); national monuments; migratory birds; and other ecologically significant or critical areas;

(c) have highly controversial environmental effects or involve unresolved conflicts concerning alternative uses of available resources (NEPA § 102(2)(E));

(d) have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks;

(e) establish a precedent for future actions or represent a decision in principle about future actions with potentially significant environmental effects;

(f) have a direct relationship to other actions with individually insignificant but cumulatively significant environmental effects;

(g) have significant impacts on properties listed, or eligible for listing, on the National Register of Historic Places;

(h) have significant impacts on species listed, or proposed to be listed, on the list of endangered or threatened species or have significant impacts on designated critical habitat for these species;

(i) violate a Federal law, or a State, local, or Tribal law or requirement imposed for the protection of the environment;

(j) have a disproportionately high and adverse effect on low-income or minority populations (Executive Order 12898);

(k) limit access to and ceremonial use of Indian sacred sites on Federal lands by Indian religious practitioners or significantly adversely affect the physical integrity of such sacred sites (Executive Order 13007); and

(l) contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area or actions that may promote the introduction, growth, or expansion of the range of such species (Federal Noxious Weed Control Act and Executive Order 13112).

BOEM has adopted the entire list of the DOI's extraordinary circumstances and has integrated them into its NEPA program to account for specialized concerns related to the level and types of activities and the site-specific ecosystems and environmental resources where actions are proposed.

Operators acquiring an OCS lease are required to explore or develop their leases within a certain timeframe (based on water depth) or relinquish them back to the Federal Government. A lease requires OCS plans to be submitted in follow up, but the outcome of the approval process is not guaranteed.

The site-specific environmental review process that BOEM utilizes for the NEPA review of EPs, DOCDs, and DPPs is designed to identify all of the extraordinary circumstances that could apply to any of these plan types. There are four main bases that may trigger extraordinary circumstances during site-specific environmental reviews (**Table 5.2.1-1**):

- physical – pertaining to the physical environmental setting;
- biological – pertaining to the biological environmental setting;
- spatial – pertaining strictly to where on the OCS an action is proposed; and
- situational – pertaining to specific attributes of what is being proposed.

Table 5.2.1-1. Extraordinary Circumstances* and Site-Specific EA Triggers for OCS Plans.

43 CFR § 46.215(a) Have significant impacts on public health or safety?

Basis	Extraordinary Circumstance and Conditional Attributes	Always Required	Analyst Review
Physical	EP, DOCD, or DPP with product containing H_2S concentrations greater than current threshold (>500 ppm)	X	-
Situational	Floating MODU with surface BOP	X	-
Situational	MODU with subsea BOP	X	-

43 CFR § 46.215(b) Have significant impacts on such natural resources and unique geographic characteristics… and other ecologically significant critical areas?

Basis	Extraordinary Circumstance and Conditional Attributes	Always Required	Analyst Review
Biological	Permanent EP/DOCD infrastructure within 4 mi (6 km) of the Flower Garden Banks National Marine Sanctuary	X	-
Biological	Permanent EP/DOCD infrastructure within 3 mi (5 km) of Stetson Bank	X	-
Biological	Bottom disturbance within a Live Bottom Stipulation block (Pinnacle Trend)	-	X
Biological	Bottom disturbance within a Live Bottom Stipulation block (low relief)	-	X
Biological	Bottom disturbance within a Live Bottom Stipulation block (topographic feature)	-	X
Biological	Bottom disturbance within a block containing potentially sensitive biological features	-	X
Spatial	EP and DPP in the Eastern Planning Area	X	-

43 CFR § 46.215(d) Have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks?

Basis	Extraordinary Circumstance and Conditional Attributes	Always Required	Analyst Review
Situational	Proposed new or unusual technology deployment	-	X

43 CFR § 46.215(f) Have a direct relationship to other actions with individually insignificant but cumulatively significant environmental effects?

Basis	Extraordinary Circumstance and Conditional Attributes	Always Required	Analyst Review
Situational	DOCD proposing an FPSO	X	-

43 CFR § 46.215(h) Have significant impacts on species listed, or proposed to be listed, on the listed species or have significant impacts on designated critical habitat for these species?

Basis	Extraordinary Circumstance and Conditional Attributes	Always Required	Analyst Review
Situational	Plan revision with an ancillary activity deploying airgun(s)	X	-

* Not all extraordinary circumstances in 43 CFR § 46.215 apply to OCS oil- and gas-related activities.

BOP = blowout preventer; EP = exploration plan; DOCD = development operations coordination document; DPP = development production plan; FPSO = floating production, storage, and offloading facility; km = kilometer; mi = mile; MODU = mobile offshore drilling unit; ppm = parts per million.

5.2.2 Categorical Exclusions and Categorical Exclusion Reviews

The categorical exclusions (CEs) processed by BOEM's Office of Environment are called categorical exclusion reviews with analysis (CERAs). This terminology reflects the environmental review process that goes into a categorical exclusion determination for an operator-proposed activity submitted to the Environmental Operations Section. The CERAs ensure that all applicable environmental reviews are performed for the proposed action and that any necessary COAs are applied. Although a NEPA document is not created for a proposed activity with a NEPA determination of CERA, all applicable environmental reviews are performed and required COAs are applied.

"Categorical exclusion" means a category of actions that do not individually or cumulatively have a significant effect on the human environment and that have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (40 CFR § 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required (40 CFR § 1508.4).

BOEM evaluates the potential of proposed activities to cause impacts on the environment. According to 30 CFR § 580.30, activities that typically would not cause significant environmental impacts and would be considered CEs are listed below:

BOEM and BSEE Categorical Exclusions

Permit and Regulatory Functions (516 Departmental Manual 15.4 C)

(1) Issuance and modification of regulations, orders, standards, Notices to Lessees and Operators. Guidelines and field rules for which the impacts are limited to administrative, economic, or technological effects and the environmental impacts are minimal.

(2) Approval of production measurement methods, facilities, and procedures.

(3) Approval of off-lease storage in existing facilities.

(4) Approval of unitization agreements, pooling, or communitization agreements.

(5) Approval of commingling of production.

(6) Approval of suspensions of operations and suspensions of production.

(7) Approval of lease consolidation applications, lease assignments or transfers, operating rights, operating agreements, lease extensions, lease relinquishments, and bond terminations.

(8) Administration decisions and actions and record keeping such as

(a) approval of applications for pricing determinations under the Natural Gas Policy Act,

(b) approval of underground gas storage agreements from a presently or formerly productive reservoir,

(c) issuance of paying well determinations and participating area approvals, and

(d) Issuance of drainage determinations.

(9) Approval of offshore geological and geophysical mineral exploration activities, except when the proposed activity includes the drilling of deep stratigraphic test holes or uses solid or liquid explosives.

(10) Approval of an offshore lease or unit exploration or development/production plan or a development operation coordination document in the central or western Gulf of Mexico (30 CFR § 250.2) except those proposing facilities: (a) In areas of high seismic risk or seismicity, relatively untested deep water, or remote areas; or (b) within the boundary of a proposed or established marine sanctuary, and/or within or near the boundary of a proposed or established wildlife refuge or areas of high biological sensitivity; or (c) in areas of hazardous natural bottom conditions; or (d) utilizing new or unusual technology.

(11) Approval of minor revisions of or minor variances from activities described in an approved offshore exploration or development/production plan, including pipeline applications.

(12) Approval of an Application for Permit to Drill (APD) for an offshore oil and gas exploration or development well, when said well and appropriate mitigating measures are described in an approved exploration plan, development plan, production plan, or development operations coordination document.

(13) Preliminary activities conducted on a lease prior to approval of an exploration or development/production plan or a development operations coordination plan. These are activities such as geological, geophysical, and other surveys necessary to develop a comprehensive exploration plan, development/production plan, or development operations coordination document.

(14) Approval of sundry notices and reports on wells.

(15) Rights-of-ways, easements, temporary use permits, and any revisions thereto that do not result in a new pipeline corridor to shore.

BOEM's use of CEs has been an integral part of the NEPA compliance process for proposed activities in the GOM. The use of CEs for NEPA analysis is evaluated by the CEQ. The CEQ does not render a judgment about whether or not CEs are adequate but simply calls for BOEM to "Review the use of categorical exclusions for Outer Continental Shelf oil and gas exploration and development in light of the increasing levels of complexity and risk—and the consequent potential environmental impacts associated with deepwater drilling and to determine whether to revise these categorical exclusions" (Greczmiel et al. 2010).

The CEs commonly used under the division of responsibilities between BOEM and BSEE are shown in **Table 5.2.2-1**. (Refer to the number of the CE provided in the list above.)

Table 5.2.2-1. Application of Categorical Exclusions 516 DM 15.4.C(1) through 516 DM 15.4.C(15) Between BOEM and BSEE.

Categorical Exclusion	BOEM Uses	BSEE Uses	Both May Use
C (1)	-	-	X
C (2)	-	X	-
C (3)	-	-	X
C (4)	-	X	-
C (5)	-	X	-
C (6)	-	X	-
C (7)	X	-	-
C (8)	-	-	X
C (9)	X	-	-
C (10)	X	-	-
C (11)	-	-	X
C (12)	-	X	-
C (13)	X	-	-
C (14)	-	X	-
C (15)	X	-	-

Categorical Exclusions Used by BOEM

- CE C (7) applies to leasing and lease management.
- CE C (9) applies to certain prelease G&G activities.
- CE C (10) is the base for NEPA compliance for approvals of exploration (EP) and development (DOCD) activities contained in the Gulf of Mexico OCS in both the CPA and WPA.
- CE C (11) applies to minor revisions to EPs and DOCDs, and pipeline applications.
- CE C (13) applies to certain postlease G&G activity (ancillary).
- CE C (15) applies to initial pipeline applications.

5.2.3 Exploration and Development Plans

To ensure compliance with the OCSLA, other laws, applicable regulations, and lease provisions, and to enable BOEM to carry out its functions and responsibilities, formal plans (30 CFR §§ 550.211 and 550.241) with supporting information must be submitted for review and approval by BOEM before an operator may begin exploration, development, or production activities on any lease. **Table 5.2.3-1** summarizes the number of EPs and DOCDs submitted to and processed by BOEM from 2016 to 2019.

Table 5.2.3-1. EPs and DOCDs Submitted to and Processed by BOEM from 2016 to 2019.

Fiscal Year	# EPs Submitted	# DOCDs Submitted	# EPs Requiring Revisions	# DOCDs Requiring Revisions	Average Review Days for All EPs Submitted*	Average Review Days for All DOCDs Submitted*	# EPs Approved	# DOCDs Approved
2016	114	70	74	47	49	94	119	94
2017	88	125	58	85	66	96	84	94
2018	81	133	47	97	48	92	76	128
2019	95	162	60	100	57	84	82	154

* Number of review days from submittal to approval, including days in the Request for Information status for plans that require additional information.

DOCD = development operations coordination document; EP = exploration plan.

Supporting environmental information, archaeological reports, biological reports (monitoring and/or live-bottom survey), and other environmental data determined necessary must be submitted with an OCS plan. This information provides the basis for an analysis of both offshore and onshore impacts that may occur as a result of the proposed activities. BOEM may require additional specific supporting information to aid in the evaluation of the potential environmental impacts of the proposed activities. In addition, BOEM can require an amendment of an OCS plan based on inadequate or inaccurate supporting information.

The OCS plans are reviewed by subject-matter experts that include, but are not limited to, geologists, geophysicists, engineers, biologists, archaeologists, air quality specialists, water quality specialists, oil-spill specialists, NEPA coordinators, and/or environmental scientists. The plans and accompanying information are evaluated to determine whether any seafloor or drilling hazards are present; that air and water quality issues are addressed; that plans for hydrocarbon resource conservation, development, and drainage are adequate; that environmental issues and potential impacts are properly evaluated and mitigated; and that a proposed action is in compliance with NEPA, the CZMA, BOEM's operating regulations, and other requirements. Federal agencies, such as the Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), USEPA, U.S. Navy, U.S. Air Force, U.S. Army Corps of Engineers (USACE), Native American Tribes, and United States Coast Guard (USCG), may be consulted if the proposal has the potential to impact areas under their jurisdiction. Each Gulf Coast State has a designated agency that coordinates the State's federally approved Coastal Management Program (CMP). The State agency reviews the proposed activity for Federal consistency. The OCS plans requiring EAs are also made available to the general public for comment through BOEM's New Orleans Office's Public Information Office and on BOEM's website at https://www.boem.gov/oil-gas-energy/accessing-seas.

In response to deepwater activities in the GOM, BOEM's predecessor (the Minerals Management Service [MMS]) developed a comprehensive strategy to address NEPA compliance and environmental issues in the deepwater areas. A key component of that strategy was the completion of a Programmatic EA to evaluate the potential effects of deepwater technologies and operations (Regg et al. 2000). As a supplement to the deepwater Programmatic EA, MMS prepared a series of technical papers that provide a summary description of the different types of structures that may be employed in the development and production of hydrocarbon resources in the deepwater areas of the GOM (Regg et al. 2000). Information in the deepwater Programmatic EA and technical papers was used in the preparation of this report.

On the basis of BOEM's reviews of an OCS plan, the findings of the proposal-specific environmental review (CERA, EA, or EIS), and other applicable BOEM studies and NEPA documents, the OCS plan is approved or disapproved by BOEM, or modified and resubmitted for further analyses and decision. Although few OCS plans are ultimately disapproved, many are amended or have conditions of approval applied prior to approval to fully comply with BOEM's operating regulations and requirements or other Federal laws to address the reviewing agencies' concerns or to avoid potential hazards or impacts to environmental resources. Refer to **Chapter 6** for a review of commonly applied mitigating measures.

5.2.3.1 Exploration Plans

An exploration plan (EP) must be submitted to BOEM for review and approval before any exploration activities, except for preliminary activities (such as hazard surveys or geophysical surveys), can begin on a lease.

An exploration plan (EP) must be submitted to BOEM for review and approval before any exploration activities, except for preliminary activities (such as hazard surveys or geophysical surveys), can begin on a lease.

The EP describes exploration activities, drilling rig or vessel, proposed drilling and well-testing operations, environmental monitoring plans, and other relevant information, and it includes a proposed schedule of the exploration activities. Guidelines and environmental information requirements for lessees and operators submitting an EP are addressed in 30 CFR § 550.211 and are further explained in BOEM NTL No. 2022-G01, "Shallow Hazards Program," and BOEM NTL No. 2009-G27, "Submitting Exploration Plans and Development Operations Coordination Documents." In addition, BOEM NTL No. 2008-G04 provides guidance on information requirements and establishes the contents for OCS plans required by 30 CFR part 550 subpart B. BOEM NTL No. 2015-N01, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS for Worst Case Discharge and Blowout Scenarios," outlines information requirements for oil-spill response activities that may be required for the proposed activities.

After receiving an EP, BOEM's Office of Leasing and Plans determines if the plan is complete and adequate before submitting for technical and environmental reviews. Once a plan has been submitted, BOEM evaluates the proposed exploration activities for potential impacts relative to geohazards and manmade hazards (including existing pipelines), archaeological resources, endangered species, sensitive biological features, water and air quality, oil-spill response, State CZMA requirements, and other uses (e.g., military operations) of the OCS. In addition, the EP is reviewed for compliance with all applicable laws and regulations.

The regulatory requirements for EPs are 15 working days for a plan to proceed to a "deemed submitted status." At this time, it has been determined that the submitted information is sufficiently adequate and there are no requests for information. Within 2 working days after a plan has been deemed submitted, BOEM sends a public information copy of the plan to the following:

- the Governor and CZMA agency of each affected State;
- BOEM's website;
- the www.regulations.gov website for 10 days when an EA is required;
- NMFS; and
- other applicable Federal agencies (e.g., FWS [Denver] for air emissions within 200 km (124 mi) of the Breton Sound Area, USEPA when the activity is located east of 87.5 degrees longitude, and the USACE for an activity near an ODMDS or significant sediment resource).

After an EP has been deemed submitted, the regulatory due date for final NEPA action is an additional 30 calendar days. At this time an EP is either approved, disapproved, or placed into modification required status.

Figure 5.2.3-1 outlines the general NEPA review process for a typical EP once it is submitted to BOEM. A NEPA site-specific environmental review (SSER) is generated and completed for each plan. As a result of the SSER, a determination is made whether a CE can be applied or whether additional NEPA analysis in the form of an EA or EIS would be required for the proposed activity. The CEs are "a category of actions which do not individually or cumulatively have a significant effect on the human environment and for which, therefore, neither an environmental assessment nor an environmental impact statement is required" (40 CFR § 1508.4). A categorical exclusion if applicable would still require applicable environmental reviews and is referred to as a categorical exclusion review with analysis (CERA). In the event an action cannot be categorically excluded, an EA is required and is prepared by BOEM's Office of Environment, Environmental Operations Section. The SSER is based on the best available information, which may include the geophysical report (for determining the potential for the presence of deepwater benthic communities); archaeological report; air emissions data (spreadsheets); waste and discharge data (tables); live bottom survey and report; biological monitoring plan; and recommendations by the affected State(s), the Department of Defense, FWS, NMFS, and/or internal BOEM offices. As part of the CZMA review process, each initial EP must contain a Consistency Certification and the necessary data and information for the applicable State(s) to determine that the proposed activities comply with the enforceable policies of that State(s)' approved CMP and that such activities will be conducted in a manner that is consistent with the CMP (16 U.S.C. § 1456(c)(3)(A) and 15 CFR § 930.76)

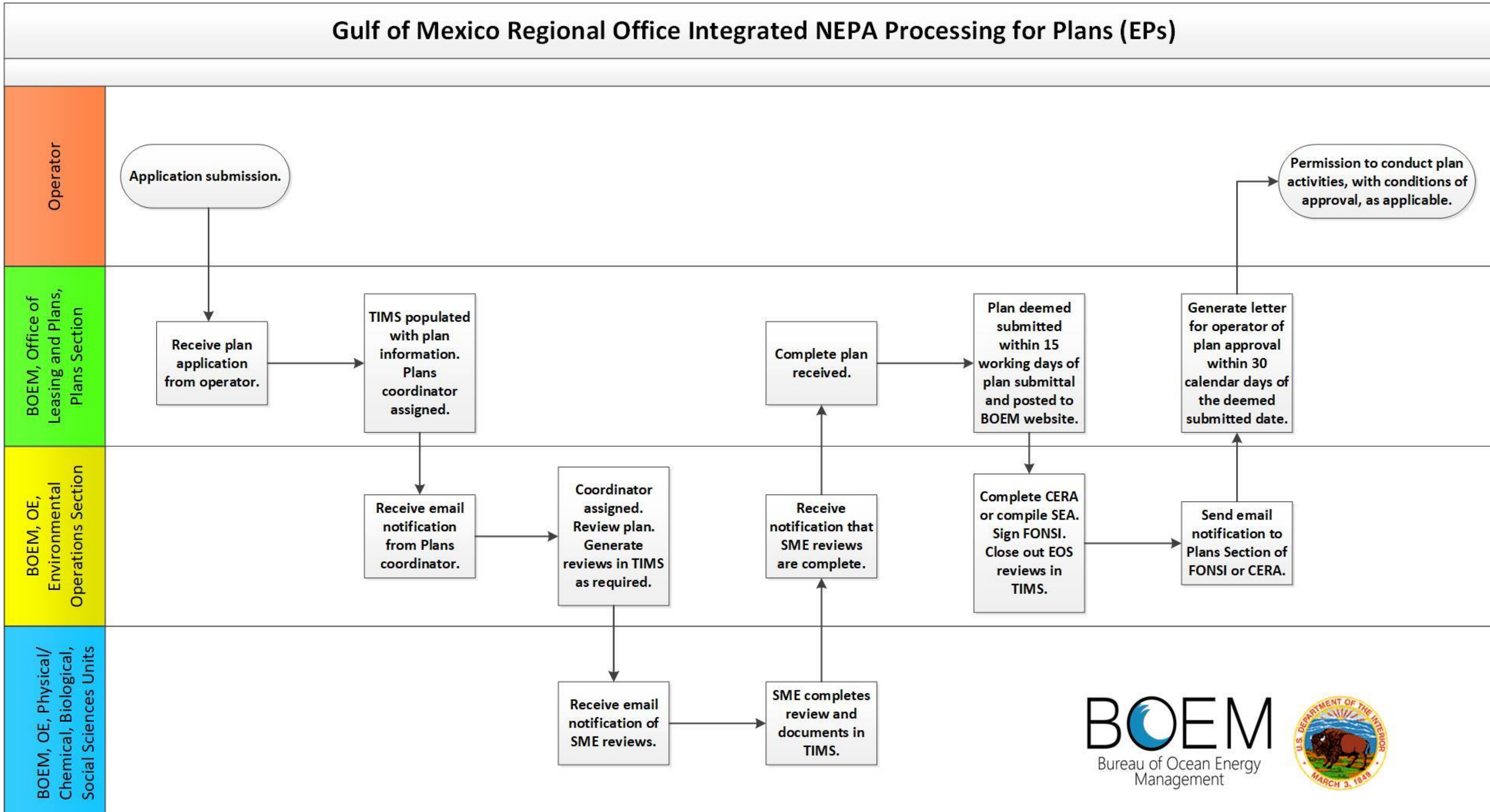


Figure 5.2.3-1. Integrated NEPA Processing Flow Diagram for Typical Exploration Plans.

If the EP is approved, and prior to conducting drilling operations, the operator is required to submit and obtain approval for an APD. The APD application process is managed by BSEE. An APD is submitted to BSEE for review and approval to conduct drilling activities on the OCS pursuant to Subpart D of the OCSLA regulations (30 CFR §§ 250.410-418). In addition to supplemental information, the regulations also require the well in the APD to be linked to a well initially proposed in an EP, DOCD, or DPP submitted by industry and approved by BOEM. When an APD is submitted, BSEE's Office of Environmental Compliance reviews BOEM's associated NEPA analysis for the associated plan to ensure that it adequately addressed the specific well and activities proposed in the APD.

5.2.3.2 Deepwater Operations Plans

In 1992, MMS formed an internal Deepwater Task Force to address technical issues and regulatory concerns relating to deepwater (>1,000 ft; 305 m) operations and projects utilizing subsea technology. Based on the Deepwater Task Force's recommendation, BSEE NTL No. 2000-N06 was developed and was later incorporated into 30 CFR part 550 subpart B. The revisions to subpart B were finalized on August 30, 2005, and require operators to submit a deepwater operations plan (DWOP) for all operations in deep water (400 m [1,312 ft] or greater) and all projects using subsea technology. DeepStar, an industry-wide cooperative workgroup focused on deepwater regulatory issues and critical technology development issues, worked closely with MMS' Deepwater Task Force to develop the initial guidelines for the DWOP. The DWOP requirement was established to address regulatory issues and concerns that were not addressed in MMS' then-existing regulatory framework, and it was intended to initiate an early dialogue between MMS and industry (now a BSEE function) before major capital expenditures on deepwater and subsea projects are committed. Deepwater technology has been evolving faster than MMS' (now BOEM/BSEE) ability to revise OCS regulations; the DWOP was established through the NTL process, which provides for a more timely and flexible approach to provide guidance on regulatory requirements and keep pace with the expanding deepwater operations and subsea technology.

The DWOP does not replace but supplements other submittals required by the regulations, such as the Bureau of Ocean Energy Management's EPs, DPPs, and DOCDs. With the large increase in deepwater plans and operations in the GOM, DWOPs are generally submitted for development projects that would use nonconventional production or completion technology, regardless of water depth. If an operator is unsure whether or not their proposed activity would be considered nonconventional, they are required to contact BSEE for guidance. The BSEE, through its Technical Assessment Section, is responsible for evaluating projects that propose the use of nonconventional technology.

The DWOP is intended to address the different functional requirements of production equipment in deep water, particularly the technological requirements associated with subsea production systems, and the complexity of deepwater production facilities. The DWOP provides BSEE with information specific to deepwater equipment issues to demonstrate that a deepwater project is being developed in an acceptable manner as mandated in the OCSLA, as amended, and BSEE's operating regulations at 30 CFR part 250 subpart B. The BSEE reviews deepwater development activities from a total system perspective, emphasizing operational safety, environmental protection, and conservation of natural resources. The DWOP process is a phased approach that parallels the operator's state of knowledge about how a field would be developed. A DWOP outlines the design, fabrication, and installation of the proposed development/production system and its components. In addition, a DWOP will include structural aspects of the facility (i.e., fixed, floating, or subsea); station-keeping (includes mooring system); wellbore, completion, and riser systems; safety systems; product removal or offtake systems; and hazards and operability of the production system. The DWOP provides BSEE with the information to validate that the operator has designed and built sufficient safeguards into the production system to prevent the occurrence of significant safety or environmental incidents. The DWOP, in conjunction with other associated permit applications, provides BSEE the opportunity to assure that the production system is suitable for the conditions in which it would operate.

The BSEE reviewed several industry-developed, recommended practices that address various aspects of mooring systems and risers for floating production facilities such as riser design, mooring system design (station-keeping), and hazard analysis. Hazard analyses allow BSEE to ensure that the operator has anticipated emergencies and is prepared to address them, either through design or through the operation of equipment. Following review of these recommended practices, BSEE released clarifications of its requirements in the following NTLs: BSEE NTL No. 2009-G03, "Synthetic Mooring Systems"; BSEE NTL No. 2009-G11, "Accidental Disconnect of Marine Drilling Risers"; and BSEE NTL No. 2009-G13, "Guidelines for Tie-downs on OCS Production Platforms for Upcoming Hurricane Seasons."

5.2.3.3 Conservation Reviews

One of BOEM and BSEE's primary responsibilities is to ensure development of economically producible reservoirs according to sound resource conservation, engineering, and economic practices as cited in 30 CFR §§ 550.202(c), 550.203, 550.210, 550.296, 550.297, 550.298, 550.299, 250.204, and 250.205. Operators should submit the necessary information as part of their Initial or Supplemental EPs, DOCDs, DPPs, and the associated Conservation Information Document (CID). Conservation reviews are performed to ensure that economic reserves are fully developed and produced, and that there is no harm to the ultimate recovery of the reserves being reviewed.

CID Requirements

The CIDs must be submitted at the time of application for DOCDs of any development in water depths >400 m (1,312 ft) and must

- address development plans for all reservoirs with well penetrations with more than 15 ft (5 m) true vertical thickness net pay (30 CFR § 550.116);

- supply a statement, for each reservoir not intended to be developed, explaining the reason(s) for not developing the reservoir, including costs, recoverable reserve estimate, production profiles, and pricing assumptions; and
- include detailed analysis for bypassed reservoirs.

Any exceptions to this requirement must receive a departure request approval along with an approximate required submittal date for the CID information.

CID Data Requirements

Information must be provided for each hydrocarbon-bearing reservoir that is penetrated by a well that would meet the producibility requirements of 30 CFR § 550.115 or 30 CFR § 550.116, including

- general discussion of the overall development,
- structure and isopach maps,
- plat map,
- structural cross-section,
- well logs (including digital well log curves),
- wellbore schematics (include actual and proposed perforations),
- sidewall core or whole core,
- pressure-volume-temperature analysis,
- anticipated recoverable oil and gas reserves,
- estimates of original oil and gas in-place,
- proposed completion scenario,
- reservoir development strategies,
- enhanced recovery practices,
- reservoir simulation, and
- proposed wellbore utility chart (with CID commitments).

More detail on the above requirements can be found at 30 CFR § 550.297.

Amended CIDs

For supplemental activity proposals, an amended CID is required under the following circumstances:

- the well(s) are in an untested fault block;
- there are new sands targeted beyond the original CID;
- the location of the well(s) is in a different stratigraphic area (untested amplitude anomaly);
- the location of the well(s) may be in an area not previously drained by other wells; and
- the well(s) may penetrate deeper targets than previous well(s).

Revision of CIDs

On occasion, revisions to a submitted CID may be required. Revisions to an original CID must be approved by BSEE. The most common reasons for CID revisions are

- well problems,
- changes in structural interpretation with new seismic surveys,
- changes in interpretation based on production data, and
- drilling of new well(s) in the reservoir.

The Office of Production and Development (PD) in BSEE is responsible for evaluating and approving submitted CIDs. The Reservoir Analysis Unit, along with the Development Unit, conduct evaluations of CIDs utilizing teams consisting of engineers, geologists, and geophysicists.

5.2.3.4 Development Operations and Coordination Documents and Development and Production Plans

Before any development operations can begin on an operator's lease, a DOCD or DPP (DOCD/DPP) must be submitted to BOEM for review and decision. A DOCD/DPP describes the proposed development activities, drilling activities, platforms or other facilities, proposed production operations, environmental monitoring plans, and other relevant information; and it includes a proposed schedule of development and production activities. Requirements for lessees and operators submitting a DOCD/DPP are addressed in 30 CFR §§ 550.241 and 550.242, and information guidelines for DOCDs/DPPs are provided in BOEM NTL Nos. 2008-G04, 2009-G27, and 2010-N06.

After receiving a DOCD/DPP, BOEM performs technical and environmental reviews. BOEM evaluates the proposed activity for potential impacts relative to geohazards and manmade hazards (including existing pipelines), archaeological resources, endangered species, sensitive biological features, water and air quality, oil-spill response, State CMPs requirements, and other uses (e.g., military operations) of the OCS. In addition, the DOCD/DPP is reviewed for compliance with all applicable laws and regulations.

The regulatory requirements for DOCDs/DPPs are 25 working days for a plan to proceed to a "deemed submitted status". At that time, it is determined whether the submitted information is adequate and there are no requests for information. Within 2 working days after a plan has been deemed submitted, BOEM sends a public information copy of the plan to the following:

- the Governor and CZMA agency of each affected State;
- BOEM's website (https://www.data.boem.gov/Plans/Plans/Default.aspx);
- the www.regulations.gov website for 10 days when an EA is required;
- NMFS; and
- other applicable Federal agencies (e.g., FWS [Denver] for air emissions within 200 km (124 mi) of the Breton Sound Area; USEPA when the activity is located east of 87.5 degrees longitude; and the USACE for an activity near an ODMDS or significant sediment resource).

After a DOCD or DPP has been deemed submitted, the regulatory due date for final NEPA action is an additional 60 calendar days. At this time the DOCD or DPP is either approved, disapproved, or placed into modification required status.

Figure 5.2.3-2 outlines the general NEPA review process for a typical DOCD once it is submitted to BOEM. A NEPA review (typically an SSER) is generated and completed for each DOCD/DPP by BOEM's Office of Environment. As a result of the SSER, a determination is made whether a CE can be applied or whether additional NEPA analysis in the form of an EA or EIS would be required for the proposed activity. The environmental review is based on the best available information, which may include the geophysical report (for determining the potential for the presence of deepwater benthic communities); archaeological report; air emissions data (spreadsheets); waste and discharge data (tables), live-bottom survey and report; biological monitoring plan; and recommendations by the affected State(s), the Department of Defense, FWS, NMFS, and/or internal BOEM offices.

As part of the review process, each DOCD/DPP must contain a CZMA Consistency Certification and the necessary data and information for the applicable State(s) to determine that the proposed activities comply with the enforceable policies of the applicable State(s)' approved CMP and that such activities will be conducted in a manner that is consistent with the CMP (16 U.S.C. § 1456(c)(3)(A) and 15 CFR § 930.76).

If the DOCD or DPP is approved, and prior to conducting drilling operations, the operator is required to submit and obtain approval for an APD. The APD application is managed by BSEE as described previously in **Chapter 5.2.2.1**. The workflow of a typical DOCD or DPP submitted to BOEM is shown in **Figure 5.2.3-2.**

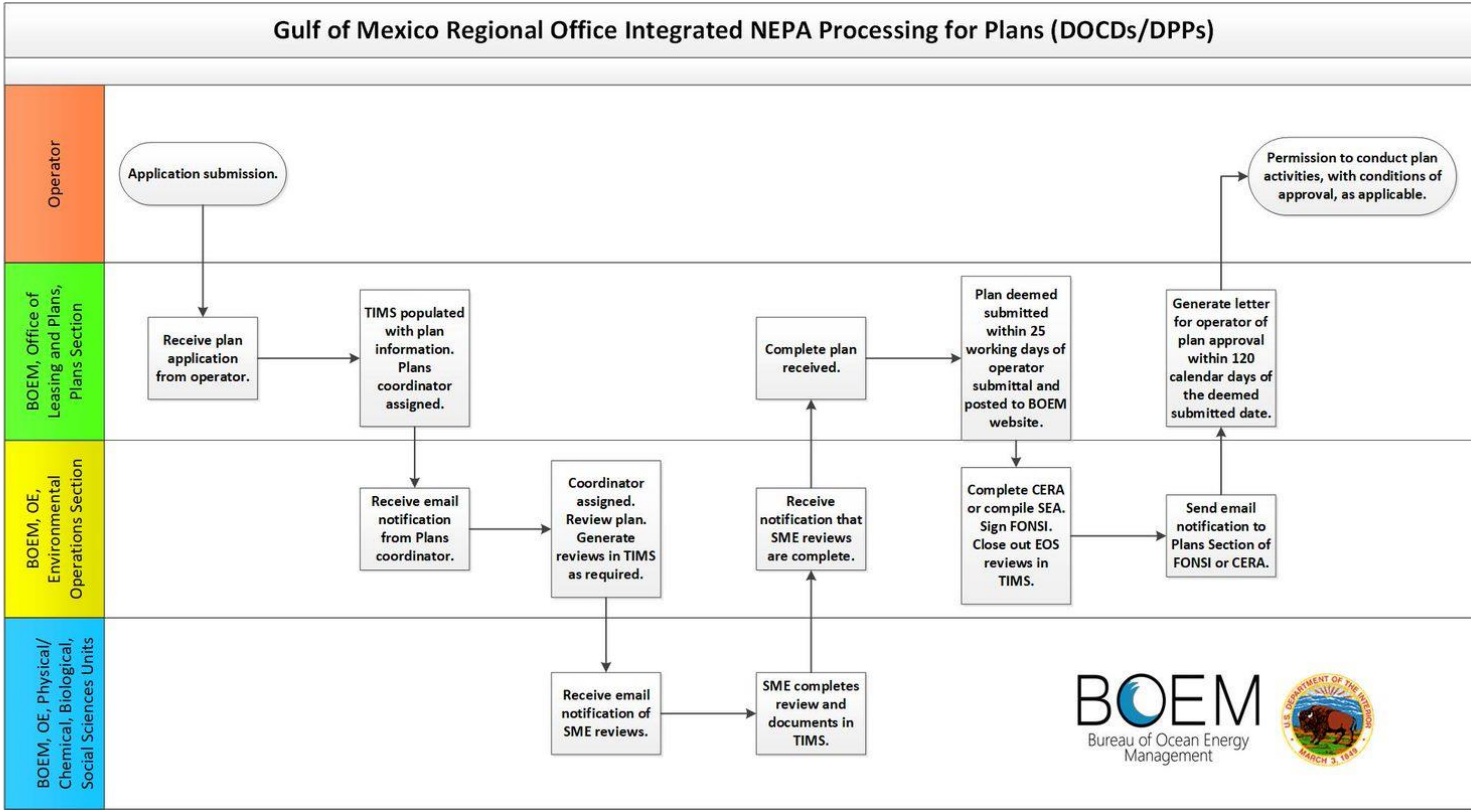


Figure 5.2.3-2. Integrated NEPA Processing Flow Diagram for Typical DOCD/DPPs New or Unusual Technologies.

Technologies continue to evolve to meet the technical, environmental, and economic challenges of deepwater development. New or unusual technologies (NUTs) may be identified by the operator in its EP, DWOP and associated DOCD/DPP, or through BOEM's plan review processes. Any plan or application that is submitted with a NUT or is determined through the NEPA environmental review process to have a NUT component must be analyzed to determine if the effects of the NUT on safety and the environment are greater than the effects using proven conventional technology. If it is determined in a NUT review that the proposed technology creates an effect greater than conventional (proven) technology, than an EA will be required for the submitted plan. Some of the technologies proposed for use by operators are actually extended applications of existing technologies and interface with the environment in essentially the same way as well-known or conventional technologies. These technologies are reviewed by BOEM for alternative compliance or departures that may trigger additional environmental review.

Some new technologies differ from established technologies in how they function or interface with the environment. These include equipment or procedures that have not been installed or used in Gulf of Mexico OCS waters. Having no operational history, they have not been assessed by BOEM through technical and environmental reviews. New technologies may be outside the framework established by BOEM's regulations and, thus, their performance (e.g., safety, environmental protection, efficiency, etc.) has not been addressed by BOEM. The degree to which these new technologies interface with the environment and the potential impacts that may result are considered in determining the level of NEPA review that would be initiated.

BOEM has developed a NUTs matrix to help facilitate decisions on the appropriate level of engineering and environmental review needed for a proposed technology. Technologies will be added to the NUTs matrix as they emerge, and technologies will be removed from the matrix as sufficient experience is gained in their implementation. From an environmental perspective, the matrix characterizes new technologies into three categories:

- technologies that may affect the environment;
- technologies that do not interact with the environment any differently than "conventional" technologies; and
- technologies about which BOEM does not have sufficient information to determine their potential impacts to the environment.

In this latter case, BOEM will receive the necessary information from operators or manufacturers regarding the technologies to make an appropriate determination on potential effects on the environment. Coordination is required with BSEE's Technical Assessment Section in evaluating proposed plans with NUT components. In addition, NMFS is generally consulted on proposals with a NUT component.

5.2.3.5 Alternative Compliance and Departures

The BSEE project-specific engineering safety review ensures that equipment proposed for use is designed to withstand the operational and environmental conditions in which it would operate. When an OCS operator proposes the use of new or unusual technology or procedures not specifically addressed in established BSEE regulations, the operations are evaluated for alternative compliance or departure determination. Any new technologies or equipment that represents an alternative compliance or departure from existing BSEE regulations must be fully described and justified before they would be approved for use. For BSEE and BOEM to grant alternative compliance or departure approval, the operator must demonstrate an equivalent or improved degree of safety and environmental protection as specified in 30 CFR § 250.141 and 30 CFR § 550.141. Comparative analysis with other approved systems, equipment, and procedures is one tool that BSEE uses to assess the adequacy of protection provided by alternative technology or operations. Actual operational experience is necessary with alternative compliance measures before BSEE would consider them as proven technology.

5.2.4 Emergency Plans

Criteria, models, and procedures for shutdown operations and the orderly evacuation of platforms and rigs for an impending hurricane have been in place in the Gulf of Mexico OCS for more than 30 years (such emergency plans are different from oil-spill response plans). Operating experience from extensive drilling activities and more than 4,000 platforms during the 50-plus years of the Gulf of Mexico OCS Oil and Gas Program have demonstrated the effectiveness and safety of securing wells and evacuating facilities in advance of severe weather conditions. Preinstallation efforts, historical experience with similar systems, testing, and the actual operating experience (under normal conditions and in response to emergency situations) are used to formulate the exact time needed to secure the wells and production facility and to evacuate it as necessary. Operators develop site-specific curtailment, securing, and evacuation plans that vary in complexity and formality by operator and type of activity. In general terms, all plans are intended to make sure the facility (or well) is secured in advance of an impending storm or developing emergency. The operating procedures developed during the engineering, design, and manufacturing phases of the project, coupled with the results (recommended actions) from hazard analyses performed, are used to develop the emergency action and curtailment plans. Evacuation and production curtailment must consider a combination of factors, including the well(s) status (e.g., drilling, producing, etc.) and the type and mechanics of wellbore operations. These factors are analyzed onsite through a decisionmaking process that involves onsite facility managers. The emphasis is on making real-time, situation-specific decisions and forecasting based on available information. Details of the shut-in criteria and various alerts are addressed on a case-by-case basis, as explained below.

Plans for shutting in production from the subsea wells are addressed as part of the emergency curtailment plan. The plan specifies the various alerts and shutdown criteria linked to both weather and facility performance data, with the intent to have operations suspended and the wells secured in the event of a hurricane or emergency situation. Ensuring adequate time to safely and efficiently suspend operations and secure the well(s) is a key component of the planning effort. Clearly defined responsibilities for the facility personnel are part of the successful implementation of the emergency response effort.

For a severe weather event such as a hurricane, emergency curtailment plans would address the criteria and structured procedures for suspending operations and ultimately securing the wellbore(s) prior to weather conditions that could exceed the design operating limitations of the drilling or production unit. For drilling operations, the plan might also address procedures for disconnecting and moving a MODU off location after the well has been secured, should the environmental conditions exceed the floating MODU's capability to maintain station. Curtailment of operations consists of various stages of "alerts" indicating the deterioration of meteorological, oceanographic, or wellbore conditions. Higher alert levels require increased monitoring, the curtailment of lengthy wellbore operations, and, if conditions warrant, the eventual securing of the well(s). If conditions improve, operations could resume based on the limitations established in the contingency plan for the known environmental conditions. The same emergency curtailment plans would be implemented in an anticipated or impending emergency situation, such as the threat of a terrorist attack.

Neither BSEE nor the USCG mandates that an operator must evacuate a production facility for a hurricane; it is a decision that rests solely with the operator. The USCG does require the submittal of an emergency evacuation plan that addresses the operator's intentions for evacuation of nonessential personnel, egress routes on the production facility, lifesaving and personnel safety devices, firefighting equipment, etc. As activities move farther from shore, it may become safer not to evacuate the facility because helicopter operations become inherently riskier with greater flight times. Severe weather conditions also increase the risks associated with helicopter operations. The precedent for leaving a facility manned during severe weather is established in the North Sea and other operating basins.

Redundant, fail-safe, automatic shut-in systems located inside the wellbore and at the sea surface, and in some instances at the seafloor, are designed to prevent or minimize pollution. These systems are designed and tested to ensure proper operation should a production facility or well be catastrophically damaged. Testing occurs at regular intervals with predetermined performance limits designed to ensure functioning of the systems in case of an emergency.

After the *Deepwater Horizon* explosion, oil spill, and cleanup, the testing requirements for well control systems came under immediate scrutiny in the DOI Secretary's *Increased Safety Measures for Energy Development on the Outer Continental Shelf* (Safety Measures Report), which was delivered on May 27, 2010 (DOI 2010). The Safety Measures Report included a recommendation of a program for immediate recertification of BOPs. As stated above, the new regulatory section at 30 CFR § 250.451(i) requires that, if a blind-shear ram or casing shear ram is activated in a well control situation where the pipe is sheared, the BOP stack must be retrieved, fully inspected, and tested.

The BSEE published the Blowout Preventer Systems and Well Control final rule (the WCR) on April 29, 2016, which enhanced BOP, well design, and well-control requirements; and incorporated certain industry consensus standards. Most of the 2016 WCR provisions became effective on July 28,

2016. Although the 2016 WCR addressed a significant number of issues that were identified during the analysis of the *Deepwater Horizon* explosion, oil spill, and response, BSEE recognized that BOP equipment and systems continue to improve technologically and that well control processes also evolve. Additionally, in April and May 2017, Executive Order 13795 and Secretarial Order 3350 directed BSEE to review specific regulations and appropriately suspend, revise, or rescind those that unduly burdened the development of domestic energy resources beyond the degree necessary to protect the public interest or otherwise comply with the law.

Following the direction of the Executive and Secretarial Orders, as well as BSEE's continued engagement with the offshore oil and gas industry, Standards Development Organizations, and other stakeholders, BSEE published the 2019 Blowout Preventer Systems and Well Control Revisions, commonly referred to as the 2019 Well Control rule (DOI and BSEE 2019). The final revised rule leaves 274 out of 342 original Well Control Rule provisions – approximately 80 percent – unchanged. Sixty-eight provisions were identified as appropriate for revision, and 33 provisions were added to improve operations on the OCS. The final rule addresses offshore oil and gas drilling, completions, workovers, and decommissioning activities. Refer to **Chapter 5.13.4** for more information on the 2019 Well Control rule and current BOP requirements.

5.2.5 Geological and Geophysical Survey Authorizations

A G&G permit must be obtained from BOEM prior to conducting off-lease geological or geophysical exploration or scientific research on unleased OCS lands or on lands under lease to a third party (30 CFR §§ 551.4(a) and (b)). Geological investigations include various seafloor sampling techniques to determine the geochemical, geotechnical, or engineering properties of the sediments. Geophysical investigations include a variety of seismic surveys that include air gun arrays, towed streamers, ocean bottom nodes (OBNs), and pressure inverted echo sounders (PIES). High-resolution geophysical surveys are also conducted and include components such as sub-bottom profilers, side scan sonars, multibeam echosounders, and magnetometers.

5.2.5.1 Ancillary Activities and Hazard Surveys

Ancillary activities, or G&G exploration and development activities conducted on lease, are defined in 30 CFR § 250.105 and 30 CFR § 550.105 with regulations outlined in 30 CFR §§ 550.207 through 550.210. Ancillary activities include geological and high-resolution geophysical, geotechnical, archaeological, biological, physical oceanographic, meteorological, socioeconomic, or other surveys; or various types of modeling studies.

Operators must notify BOEM in writing (30 CFR § 550.208) before conducting any of the following types of ancillary activities: G&G surveys for exploration and development activities including activities that involve bottom disturbance, independent of water depth, such as ocean-bottom cable surveys, node surveys, and time-lapse (4D) surveys; and those involving piston-/gravity-coring or the recovery of sediment specimens by grab-sampling or similar technique and/or any dredging or other ancillary activity that disturbs the seafloor (including deployment and retrieval of bottom cables, anchors, or other equipment).

BOEM may determine that the type of proposed ancillary activity necessitates submitting a revised EP, DPP, or DOCD plan. A NEPA review is conducted for ancillary requests that require submittal as a revised plan. An ancillary activity requiring submittal as a plan would be processed as an SEA. Operators are notified when their submitted activities do not require submittal as a revised plan and they are able to perform those activities under their lease stipulations without any further NEPA review. Submitted ancillary activities directly related to current exploration and development plans would generally require submittal as a revised plan, along with the associated NEPA reviews and SEA. **Table 5.2.6-1** illustrates the permitting authority for G&G and ancillary activities.

Table 5.2.6-1. G&G Activity, Permitting Authority, and Typical NEPA Action.

G&G Activity	On Lease	Off Lease and/or Third Party	Permitting Authority	Approval by OCS Plan	Approval by Permit Application	Typical NEPA Action
Exploration (postlease)	X	-	30 CFR part 550 subpart B	EP	-	EA or EIS
Development (postlease)	X	-	30 CFR part 550 subpart B	DOCD or DPP	-	EA or EIS
Ancillary Activities (postlease)	X	-	30 CFR part 550 subpart B	Conditional, Plan Revision	Notification	Conditional, EA
Exploration (prelease)	-	X	30 CFR part 551	None	X	EA or EIS
Scientific Research	-	X	30 CFR part 551	None	X	EA

EA = environmental assessment; EIS = environmental impact statement; DOCD = development operations coordination document; DPP = development production plan; NEPA = National Environmental Policy Act.

Ancillary G&G surveys with the potential to adversely affect endangered species require advance notice to BOEM (30 CFR § 550.208). BOEM reviews such notices to ensure that the proposed activities qualify as ancillary activities and comply with the performance standards listed in 30 CFR §§ 550.202. These performance standards require that the proposed activities, *inter alia*, do not cause undue or serious harm to the human, marine, or coastal environment. Where an ancillary activity notice fails to comply with these performance standards, BOEM may require the implementation of additional mitigating measures (such as reasonable and prudent measures identified by the Services) or require the lessee to submit an exploration plan or development and production plan before the activity would be allowed to proceed (30 CFR § 550.209).

BOEM adopted BSEE NTL No. 2009-G34, "Ancillary Activities," to provide guidance and clarification on conducting ancillary activities in BOEM's Gulf of Mexico OCS region. Operators should notify the New Orleans Office's Regional Supervisor, Office of Leasing and Plans, Plans Section, in writing 30 days in advance before conducting any of the following types of ancillary activities related to a G&G exploration or development activity:

- involving the use of an airgun or airgun array anywhere in the GOM regardless of water depth; and
- independent of water depth, involving the use of explosives as an energy source.

Additionally, BSEE NTL No. 2009-G34 clarifies that the New Orleans Office's Regional Supervisor, Office of Leasing and Plans, Plans Section, should be notified in writing 15 days in advance before conducting the following types of ***other ancillary activities***:

- involving the use of an airgun or airgun array regardless of water depth;
- involving bottom disturbance, independent of water depth, including ocean-bottom cable surveys, node surveys, and time-lapse (4D) surveys; and
- a geotechnical evaluation involving piston/gravity coring or the recovery of sediment specimens by grab sampling or similar technique and/or any dredging or other ancillary activity that disturbs the seafloor (including deployment and retrieval of bottom cables, anchors, or other equipment).

NTL No. 2009-G34 also provides guidance for each type of ancillary activity, the type and level of BOEM review, and follow-up, post-survey reporting requirements.

Geo-Hazards Assessments

Geo-hazards can have an impact on all bottom-disturbing activities proposed in the Gulf of Mexico OCS. The basic geo-hazard types are listed below.

- Seafloor Geologic Hazards
  - fault scarps, gas vents, hydrate mounds, unstable slopes, slumping, active mud gullies, crown cracks, collapsed depressions, furrows, sinkholes, mass sediment movement, surface channels, pinnacles, and reefs
- Subsurface Geologic Hazards
  - faults, gas-charged sediments, abnormal pressure zones, gas hydrates, shallow water flow, and buried channels
- Manmade Hazards
  - pipelines, wellheads, shipwrecks, ordnance, communication cables, and debris from oil and gas operations

For oil and gas and sulphur operations, shallow hazard assessments are required under 30 CFR §§ 550.214 and 50.244 and BOEM NTL No. 2022-G01, "Shallow Hazards Program," which explains the requirements for these surveys and their reports. Included in shallow hazard assessments is a structural and stratigraphic interpretation of seismic data to qualitatively delineate abnormal pressure zones, shallow free gas, seafloor instability, shallow waterflow, and gas hydrates. The primary objectives of geohazard assessments include

- identification of geo-hazards and quantification of the risks on drilling operations,
- prevention of drilling accidents by proper well site selection and well planning, and
- mitigation of drilling hazards once encountered.

Geo-hazard reviews are completed by BOEM's Office of Resource Evaluation and are used to verify that operators are aware of and mitigate for any hazards that may impact the operation.

Potential Mitigating Measures

The best mitigation for most hazards is avoidance after detection by a geophysical survey **Table 5.2.6-2** outlines other protective measure under various geologic conditions. Leaseholders are required to run geophysical surveys before drilling in order to locate potential geologic or man-made hazards (30 CFR § 250.106). In deepwater, most companies do a remotely operated vehicle (ROV) inspection of the seafloor for a pre-spud location. Companies are also required to take and analyze sediment borings for platform sites. Areas of hydrogen sulfide occurrences can be predicted, and sensors installed on drilling rigs to warn operators. Certain leases may also require archaeological surveys and live-bottom surveys to protect sensitive areas. Every application for permit to drill a well in the GOM is reviewed by BSEE geologists, geophysicists, and engineers to ensure compliance with standard drilling practices and BOEM and BSEE's regulations. All rigs and platforms are inspected by BSEE on a regular basis to ensure all equipment and procedures comply with Federal regulations for safety and environmental protection.

Table 5.2.6-2. Potential Mitigating Measures for Hazard Avoidance.

Geologic Condition	Hazard	Mitigations
Fault	Bend/shear casing Lost circulation Gas conduit	Stronger casing/heavier cement
Shallow Gas	Lost circulation Blowout Crater	Kill mud Pilot hole Circulate mud/drill slower Blow-out preventer/diverter Pressure while drilling log
Buried Channel	Jack-up leg punch through	Pre-load rig Mat support All rig legs in same type of sediment
Slump	Bend/shear casing	Thicker casing Coil/flexible pipeline
Water Flow	Erosion/washout Lost circulation	Kill mud, foam cement Pilot hole Pressure while drilling

5.2.5.2 Seismic Surveys

BOEM completed the *Gulf of Mexico OCS Proposed Geological and Geophysical Activities: Western, Central, and Eastern Planning Areas; Final Programmatic Environmental Impact Statement*

(Gulf of Mexico G&G Programmatic EIS) (BOEM 2017c). Future NEPA review would be conducted during the following stages of BOEM's oil and gas program: the evaluation of G&G permit applications (i.e., 30 CFR part 551); ancillary activities (i.e., 30 CFR §§ 550.207-210); and exploration plans (i.e., 30 CFR § 550.201(a)(6)).

Upon receiving a submitted G&G permit application, BOEM conducts a NEPA review that would result in a determination of either a CE, an EA, or an EIS in accordance with the G&G Programmatic EIS's conclusions, NEPA guidelines, and other applicable BOEM policies. When required under an approved State's CMP, proposed G&G permit activities must receive the applicable State CZMA concurrence prior to BOEM permit approval. All seismic surveys with activities that are located or extend into the EPA or crosses into Texas State waters in the WPA require CZMA concurrence. The G&G permit applications are also screened for compliance with the 2020 NMFS BiOp and are generally sent to NMFS for concurrence and application of any required conditions of approval specific to the 2020 NMFS BiOp.

Seismic surveys are performed to obtain information on surface and near-surface geology and on subsurface geologic formations. Low-energy, HRG seismic surveys collect data on surficial geology, which is used to identify potential shallow geologic or manmade hazards (e.g., faults or pipelines) for engineering and site planning for bottom-founded structures. The HRG surveys are also used to identify environmental and archaeological resources such as low-relief live bottom areas, pinnacles, benthic community habitat, and shipwrecks. High-energy, deep-penetration, common-depth-point seismic surveys obtain data about geologic formations thousands of feet below the seafloor. The 2D and 3D common-depth-point data are used to map structure features of stratigraphically important horizons in order to identify potential hydrocarbon traps. They can also be used to map the extent of potential habitat for benthic communities. In some situations, a set of 3D surveys can be run over a time interval to produce a 4D, or "time-lapse," survey that could be used to characterize production reservoirs.

5.2.5.3 Geological and Geophysical Applications

Figure 5.2.6-1 outlines the general NEPA review process for G&G permit applications once submitted to BOEM. Applications for G&G permits (non-ancillary) are submitted to the Data and Special Projects Unit of BOEM's Office of Resource Evaluation. This Unit is responsible for G&G permitting and coordinates with BOEM's Office of Environment for the processing of any required NEPA analysis. BOEM's Office of Environment determines whether an application may be processed as a CE or if an SEA is required.

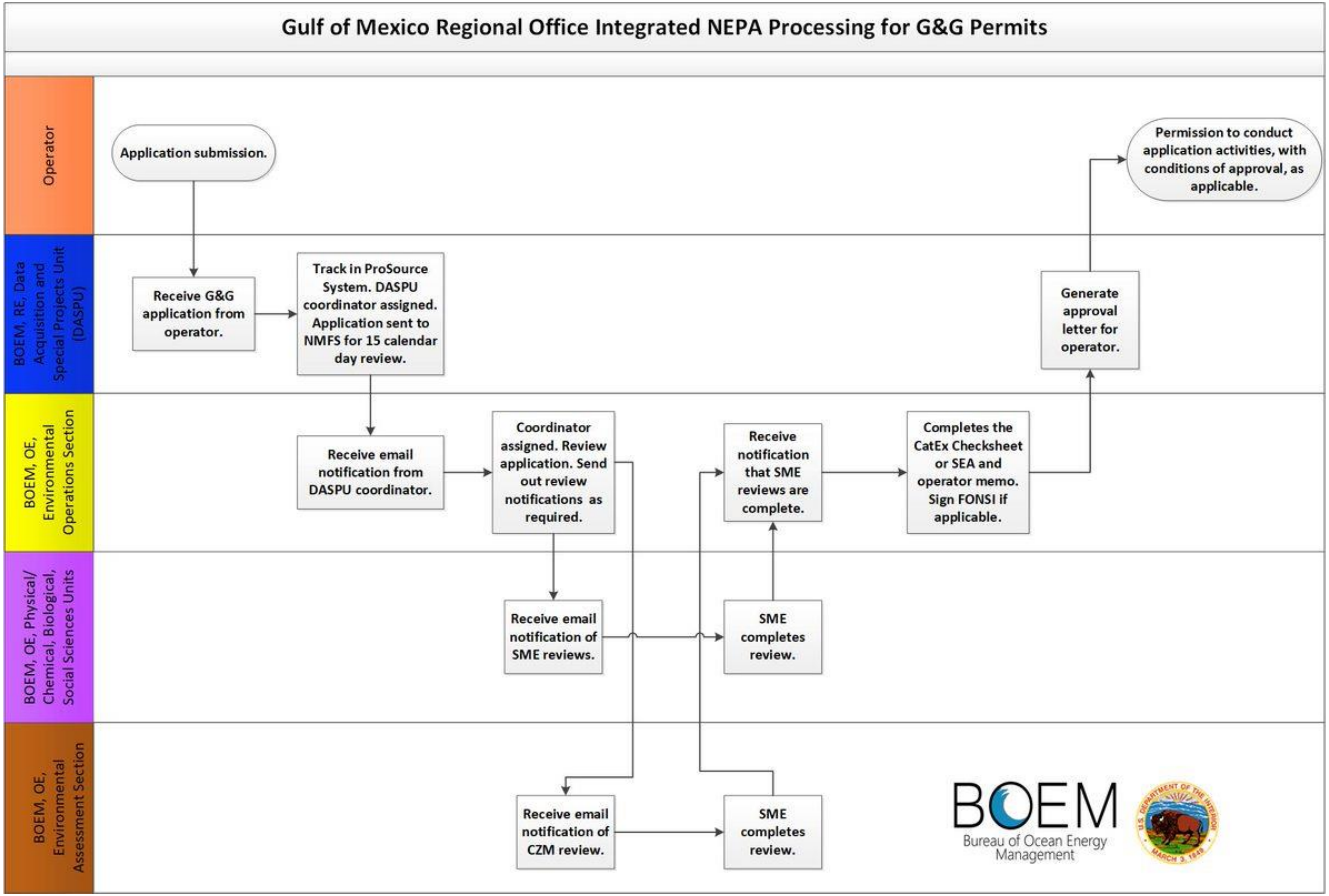


Figure 5.2.6-1. Integrated NEPA Processing Flow Diagram for Geological and Geophysical Permit Applications.

The following applications can often be processed as CEs:

(a) hard minerals sampling of a limited nature, such as shallow test drilling;

(b) water and biotic sampling, if the sampling does not adversely affect shellfish beds, marine mammals, or an endangered species or if permitted by NMFS or another Federal agency;

(c) meteorological observations and measurements, including the setting of instruments;

(d) hydrographic and oceanographic observations and measurements, including the setting of instruments;

(e) sampling by box core or grab sampler to determine seabed geological or geotechnical properties (if mitigations applied by subject-matter experts as a result of environmental reviews are not required);

(f) television and still photographic observation and measurements;

(g) shipboard hard mineral assaying and analysis; and

(h) placement of positioning systems, including bottom transponders and surface and subsurface buoys reported in Notices to Mariners.

In addition, G&G applications can be processed as CEs under 516 DM 15.4 C(9) or C(13) if the activity is for some types of geological coring, or shallow drilling (<500 ft [152 km] below the mud line).

High-Resolution Geophysical Surveys

The common types of HRG activities that are conducted in the Gulf of Mexico OCS include the following:

- Side-Scan Sonar
  - seafloor features imaged and processed to mosaics
- Multi-beam Echo-sounders
  - high-resolution bathymetric data and soil properties from backscatter
- Sub-bottom Profilers
  - image topmost sediments to assess foundation zone conditions
- High-Resolution 2D Data
  - approximately five times the resolution of deep seismic

- Magnetometer
  - detect ferrous objects such as infrastructure, pipelines, wellheads, or metallic debris

G&G Applications Requiring an SEA

An SEA is prepared for all surveys using air guns and for activities with bottom disturbances that could impact resources. The G&G applications that propose the use of airguns include seismic surveys as well as some VSP applications, which extend off lease and require a permit application. Bottom-disturbing activities that may impact resources include coring surveys (e.g., box cores, piston cores, vibracores, etc.) and seismic surveys utilizing OBNs.

Seismic surveys typically utilize towed airgun arrays. Towed streamers or OBNs are utilized as receivers. The OBNs may be deployed with tethers on the seafloor or are deployed and retrieved with remotely operated vehicles (ROVs). Often utilized also in seismic surveys are PIES. The PIES are used to complement the data collected in the survey process and are generally used along with OBNs. Seismic surveys may be 2D, 3D, or 4D. The 4D surveys introduce the element of time and generally utilize OBNs and often PIES as well. These 4D surveys are generally used in the developmental phase of operation. In addition, there are different seismic survey configurations based on information requirements.

Airguns Associated with Deep-Penetration Seismic Surveys

In an offshore seismic survey, a high-energy sound source is towed at a slow speed behind a survey vessel. The sound source typically used is an airgun array, consisting of pneumatic devices that produce acoustic output through the rapid release of a volume of compressed air. Common seismic survey types using airguns include 2D; 3D; narrow, full, and wide-azimuth surveys; PIES and pressure monitoring transponders; and borehole surveys, which are described further in **Chapter 2.4.1.1**.

Any proposed G&G activities with bottom disturbances are submitted for review (typically archaeology and benthic reviews). The completed SEA would include any applicable COAs from BOEM's Office of Environment's subject-matter experts along with all applicable mitigation resulting from other consultations. Specific mitigation and reporting requirements are determined during site-specific NEPA reviews, and some of the general programmatic requirements, as prescribed in BOEM's Gulf of Mexico G&G Programmatic EIS (BOEM 2017c), include the items below.

- Seismic Airgun Survey Protocol
  - protected species observer program expanded to include manatees and all water depths
  - passive acoustic monitoring for deep-penetration seismic in low visibility in >100-m (328-ft) isobaths (water depth)

  - passive acoustic monitoring for deep-penetration seismic in Mississippi Canyon and De Soto Canyon (24 hours)

- Non-airgun HRG Survey Protocol
- Coastal Waters Seasonal Restriction for Airgun Surveys within All OCS Waters Shoreward of the 20-m (66 ft.) Isobath between February 1 and May 31 Annually
- Guidance for Vessel Strike Avoidance
- Guidance for Marine Debris Awareness
- Avoidance of Sensitive Benthic Resources
- Guidance for Avoidance of Historic and Prehistoric Sites
- Guidance for Shallow Hazards Survey and Reporting
- Consultation In or Near National Marine Sanctuaries
- Guidance for Military Coordination
- Guidance for Ancillary Activities

If BOEM determines that additional mitigating measures are warranted through the above reviews, BOEM's authorizations to conduct G&G activities (e.g., approval letter, permit, plan, agreement, etc.) will include all required mitigation as determined in the site-specific NEPA review. Once BOEM's Office of Environment has completed its NEPA analysis (CE or SEA) and has applied all applicable conditions of approval, BOEM's Data and Special Projects Unit is notified. This Unit is responsible to issue the G&G permit requested by the applicant with all conditions of approval applied. The workflow of a typical G&G permit application submitted to BOEM is shown in **Figure 5.2.6-1**.

5.2.6 ESA and MMPA Consultations and Marine Protected Species NTLs

ESA Section 7 Consultation

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. § 1531 *et seq*.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitats they depend on. Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with FWS and/or NMFS for ESA-listed species or for designated critical habitat that may be affected by the action that is under FWS or NMFS' jurisdiction (50 CFR § 402.14(a)). If FWS or NMFS determines that an action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitats, the agency(ies) provides a reasonable and prudent alternative that allows the action to proceed in compliance with Section 7(a)(2) of the ESA.

On April 20, 2018, FWS issued its 10-year programmatic Biological Opinion for BOEM and BSEE's oil and gas activities in the GOM. The FWS Biological Opinion does not include any terms and conditions for the protection of endangered species that the Bureaus, lessees, or operators must implement. The FWS Biological Opinion also noted that any future consultations may be informal, dependent upon the likelihood of take.

On March 13, 2020, NMFS issued a Biological Opinion and related terms and conditions for oil and gas activities in the Gulf of Mexico for the protection of these species, including holding lease sales. The NMFS programmatic Biological Opinion addresses any future lease sales and any approvals issued by BOEM and BSEE, under both existing and future OCS oil and gas leases in the GOM, over a 10-year period. Applicable terms and conditions and reasonable and prudent measures from the NMFS Biological Opinion will be applied at the lease sale stage; other specific conditions of approval will also be applied to postlease approvals. The NMFS Biological Opinion may be found at https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico. The appendices and protocols may be found at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico. The Bureau of Ocean Energy Management's ESA consultation process is further discussed in the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c).

Marine Mammal Protection Act Consultation

BOEM petitioned NMFS for rulemaking under the Marine Mammal Protection Act (16 U.S.C. §§ 1361 *et seq.*) to assist industry in obtaining incidental take coverage for marine mammals due to oil and gas G&G surveys in the Gulf of Mexico. In January 2021, NMFS' Permits and Conservation Division issued final regulations governing the unintentional taking of marine mammals incidental to geophysical survey activities conducted by oil and gas industry operators in the Gulf of Mexico over the course of 5 years, pursuant to Section 101(a)(5) of the MMPA ("final MMPA rule"), which became effective on April 19, 2021. As a result, NMFS' programmatic Biological Opinion was amended on April 26, 2021, such that mitigating measures within the Biological Opinion align with, and may be imposed through, Letters of Authorizations under the final MMPA rule. BOEM's Marine Mammal Protection Act consultation process is further discussed in the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c).

Marine Protected Species Mitigation

The 2020 NMFS BiOp provides guidance for the protection of marine protected species, which is included in Appendices A, B, and C, as amended. In addition, these mitigations and their application to proposed activities in the Gulf of Mexico OCS are illustrated in **Chapter 6** under the heading of "2020 Biological Opinion Mitigations."

In addition, BSEE NTL No. 2018-G03, "Decommissioning Guidance for Wells and Platforms," 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 that allow for explosive charges up to 500 pounds, internal and external placement, and both above-mudline and below-mudline detonations.

5.2.7 Permits and Applications

After the approval of an EP or DOCD/DPP, the operator may submit a variety of applications for specific activities to BSEE and BOEM for approval. These applications include those for drilling wells; well-test flaring; temporary well abandonment; installing a well protection structure, production platforms, satellite structures, subsea wellheads and manifolds, and pipelines; installation of production facilities; commencement of production operations; platform removal and lease abandonment; and pipeline decommissioning.

5.2.7.1 Wells

The BSEE requirements for the drilling of wells can be found at 30 CFR part 250 subpart D. Lessees are required to take precautions to keep all wells under control at all times. The lessee must use the best available and safest technology (BAST) to aid in the evaluation of abnormal pressure conditions and to minimize the potential for uncontrolled well flow.

Prior to conducting drilling operations, the operator is required to submit and obtain approval for an APD. The APD requires detailed information (including project layout at a scale of 1:24,000, design criteria for well control and casing, specifications for blowout preventers, a mud program, a cementing program, directional drilling plans, etc.) to allow for BSEE's evaluation of operational safety and pollution-prevention measures. The APD is reviewed for conformance with engineering requirements and other technical considerations.

The BSEE is responsible for conducting technical and safety reviews of all drilling, workover, and production operations on the OCS. These detailed analyses determine if the lessee's proposed operation complies with all regulations and all current health, safety, environmental, and engineering standards.

The BSEE regulations at 30 CFR §§ 250.1710-1717 address the requirements for permanent abandonment of a well on the OCS. A permanent abandonment includes the isolation of zones in the open wellbore, plugging of perforated intervals, plugging the annular space between casings (if they are open), setting a surface plug, and cutting and retrieving the casing at least 15 ft (5 m) below the mudline. All plugs must be tested in accordance with the regulations. There are no routine surveys of permanently abandoned well locations. If a well(s) were found to be leaking, BSEE would require the operator of record to perform an intervention to repair the abandonment. If a well is temporarily abandoned at the seafloor, its operator must provide BSEE with an annual report summarizing plans to permanently abandon the well or to bring the well into production.

5.2.7.2 Platforms and Structures

The BSEE does a technical review of all proposed structure designs and installation procedures. All proposed facilities are reviewed for structural integrity. These detailed engineering reviews entail an evaluation of all operator proposals for fabrication, installation, modification, and repair of all mobile and fixed structures. The lessee must design, fabricate, install, use, inspect, and maintain all platforms and structures on the OCS to assure their structural integrity for the safe conduct of operations at specific locations. Applications for platform and structure approval are filed in accordance with 30 CFR § 250.901. Design requirements are presented in detail at 30 CFR §§ 250.904 through 250.909. The lessee evaluates characteristic environmental conditions associated with the operational functions to be performed. Factors such as waves, wind, currents, tides, temperature, and the potential for marine growth on the structure are considered. In addition, pursuant to 30 CFR §§ 250.902 and 250.903, a program has been established by BSEE to assure that new structures meeting the conditions listed under 30 CFR § 250.900 are designed, fabricated, and installed using standardized procedures to prevent structural failures. This program facilitates review of such structures and uses third-party expertise and technical input in the verification process through the use of a Certified Verification Agent. After installation, platforms and structures are required to be periodically inspected and maintained under 30 CFR § 250.912.

The BSEE Office of Structure and Technical Support reviews and provides permit approval for platforms and structures in the GOM OCS. Permit applications reviewed by the Office of Structure and Technical Support include new installations, modifications, structure removal, and well decommissioning.

5.2.7.3 Pipelines

Regulatory processes and jurisdictional authority concerning pipelines on the OCS and in coastal areas are shared by several Federal agencies, including DOI, the Department of Transportation (DOT), the USACE, the Federal Energy Regulatory Commission, and the USCG. Aside from the enforcement of pipeline regulations, these agencies have the responsibility of overseeing and regulating the following areas: the placement of structures and pipelines on the OCS in areas that affect navigation (i.e., fairways); the certification of proposed projects involving the transportation or sale of interstate natural gas, including OCS gas; and the right of eminent domain exercised by pipeline companies onshore. In addition, the DOT is responsible for promulgating and enforcing safety regulations for the transportation in interstate commerce of natural gas, liquefied natural gas, and hazardous liquids by pipeline. This includes, for the most part, offshore pipelines on State lands beneath navigable waters as well as pipelines on the OCS that are operated by transmission companies. The regulations are contained in 49 CFR parts 191-193 and 195. In a Memorandum of Understanding between the DOT and DOI dated December 10, 1996, each party's respective regulatory responsibilities are outlined. The DOT is responsible for establishing and enforcing design, construction, operation, and maintenance regulations, and for investigating accidents for all OCS transportation pipelines beginning downstream of the point at which operating responsibility transfers from a producing operator to a transporting operator. The DOI's responsibility extends upstream from the transfer point described above (areas of producing operator responsibility on the OCS).

The BSEE is responsible for regulatory oversight of the design, installation, modification, repair, and decommissioning of OCS producer-operated oil and gas pipelines. The BSEE operating regulations for pipelines, found at 30 CFR part 250 subpart J, are intended to provide safe and pollution-free transportation of fluids in a manner that does not unduly interfere with other users of the OCS. Pipeline applications may be for on-lease pipelines (lease term) or right-of-way pipelines that cross other lessees' leases or unleased areas of the OCS. Pipeline permit applications to BSEE include the pipeline location drawing, profile drawing, safety schematic drawing, pipe design data, a shallow hazard survey report, procedure narratives, anchor information (if applicable), and an archaeological report, if applicable.

The BSEE evaluates the design and proposed route of all OCS pipelines. Proposed pipeline routes are evaluated for potential seafloor or subsea geologic hazards and other natural or manmade seafloor or subsurface features or conditions (including other pipelines) that could have an adverse impact on the pipeline or that could be adversely impacted by the proposed operations. Routes are also evaluated for potential impacts on archaeological resources, biological communities, and significant sediment resources. The BSEE Pipelines Section is responsible for the evaluation and approval of all pipeline permit applications including installations, modifications, and removals.

NEPA Analysis for Pipeline Installations

Figure 5.2.8-1 outlines the general NEPA review process for a typical pipeline application once submitted to BSEE. Pipeline applications are forwarded by BSEE's Pipelines Section to BOEM's Office of Environment for NEPA analysis in accordance with applicable policies and guidelines. Most pipeline applications are processed as CERAs by BOEM's Office of Environment. An SEA is required in the following scenarios:

- proposal of a new pipeline corridor to shore;
- a pipeline segment is proposed in the Eastern Planning Area;
- a proposed pipeline segment(s) will carry hydrocarbons with >500 ppm of H_2S; or
- a proposed pipeline segment(s) is located in a No Activity Zone.

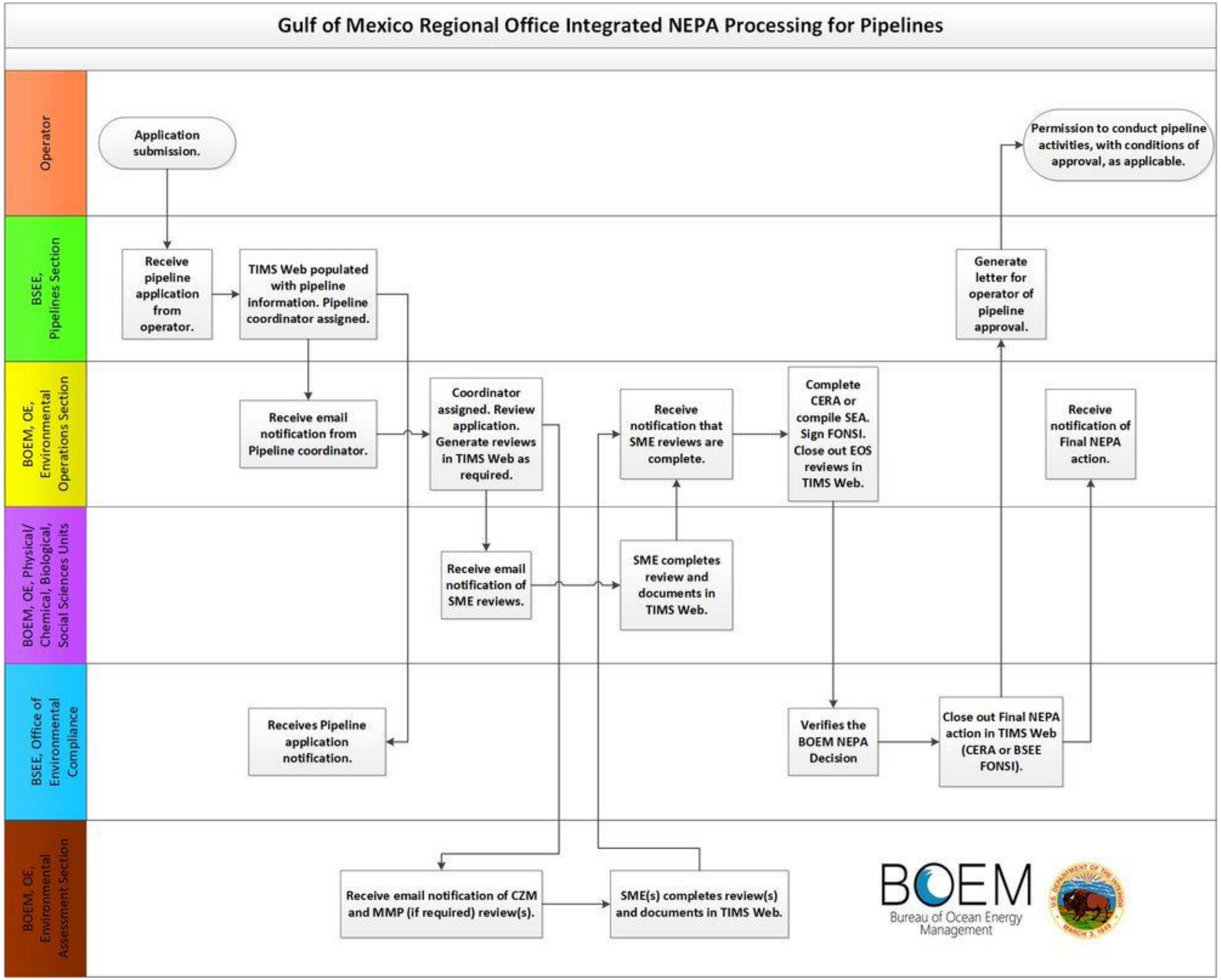


Figure 5.2.8-1. Integrated NEPA Processing Flow Diagram for Typical Pipeline Application.

Once the NEPA analysis for a proposed pipeline application is complete, BOEM's Office of Environment, Environmental Operations Section will forward the NEPA analysis with any applicable conditions of approval to BSEE's Office of Environmental Compliance for final NEPA approval. Once the final NEPA approval process is completed by BSEE's Office of Environmental Compliance, BSEE's Pipelines Section can issue the pipeline approval permit to the applicant.

Typical BOEM environmental reviews for pipeline installations include

- archaeological resources;
- biological resources (if triggered by GIS analysis of segment(s) location or water depth (>300 m; 984 ft);
- Coastal Zone Management Act (for right-of-way installations and installations that may impact significant sediment resources); and
- Marine Minerals Program (for installations that may impact significant sediment resources).

BSEE's Pipelines Section

The structural and mechanical aspects of proposed pipeline applications are evaluated by BSEE's Pipelines Section. For Federal consistency, applicants must comply with the regulations as clarified in BSEE NTL No. 2007-G20, "Coastal Zone Management Program Requirements for OCS Right-of-way (ROW) Pipeline Applications." All Gulf Coast States require consistency review of right-of-way pipeline applications as described in the clarifying NTL. The design of the proposed pipeline is evaluated for an appropriate cathodic protection system to protect the pipeline from the effects of external corrosion on the pipe; an external pipeline coating system to prolong the service life of the pipeline; measures to protect the inside of the pipeline from the detrimental effects, if any, of the fluids being transported; proposed maximum allowable operating pressure and hydrostatic test pressure of the line; inclusion and settings of all safety devices required by regulation; and protection of other pipelines crossing the proposed route. Such an evaluation includes the following: (1) reviewing the calculations used by the applicant in order to determine whether the applicant properly considered such elements as the grade of pipe to be used, the wall thickness of the pipe, de-rating factors (the practice of operating a component well inside its normal operating limits to reduce the rate at which the component deteriorates) related to the submerged and riser portions of the pipeline, the pressure rating of any valves or flanges to be installed in the pipeline, the pressure rating of any other pipeline(s) into which the proposed line might be tied, and the required pressure to which the line must be tested before it is placed in service; (2) protective safety devices such as pressure sensors and remotely operated valves, the physical arrangement of those devices proposed to be installed by the applicant for the purposes of protecting the pipeline from possible overpressure conditions and for detecting and initiating a response to abnormally low-pressure conditions; and (3) the applicant's planned compliance with regulations requiring that pipelines installed in water depths <200 ft (61 m) be buried to a depth of at least 3 ft (1 m) (30 CFR § 250.1003). In addition, pipelines crossing fairways require a USACE permit and may be required to be buried >3 ft (1 m).

Operators are required to periodically inspect pipeline routes. Monthly overflights are conducted to inspect pipeline routes for leakage. When a pipeline requires a repair, a repair plan notification and repair completion report must be submitted to BSEE for review and acceptance.

NEPA Analysis for Pipeline Decommissioning

Applications for pipeline decommissioning must also be submitted for BSEE review and approval. Decommissioning applications are evaluated to ensure that they will render the pipeline inert and/or to minimize the potential for the pipeline to become a source of pollution by flushing and plugging the ends and to minimize the likelihood that the decommissioned line would become an obstruction to other users of the OCS by filling it with uninhibited seawater and burying the ends.

Applications to decommission pipeline segments are submitted to BSEE's Pipeline Section by operators in the Gulf of Mexico OCS. These applications would generally propose decommissioning by removal or by abandonment in place. Any pipeline decommissioning application proposing abandonment in place requires a departure approval from BSEE. In some cases, depending on the logistics, a combination of these two decommissioning options are proposed. Pipeline decommissioning applications are forwarded to BOEM's Office of Environment for NEPA analysis. As is the case with installations, decommissioning applications are generally processed as CERAs.

The pipeline decommissioning process is covered in 30 CFR §§ 250.1750-1754. These sections address what is required of operators in the pipeline decommissioning process. In general, all pipelines that are approved to be decommissioned in place must be pigged, flushed, filled with uninhibited seawater, and plugged on each end. For pipelines that are approved for removal, they must be pigged and flushed with seawater prior to removal. Any departure from these removal processes must be approved by the BSEE based on the unique circumstances of the proposed action(s).

Proposed pipeline segments for decommissioning that lie within a marine minerals resource block and may potentially impact significant sediment resources areas (SSRA) must receive a Marine Minerals Program (MMP) review. The proposed activity is reviewed by MMP subject-matter experts who would either approve the application as proposed, require removal of the pipeline segment(s) (if decommissioning in place is proposed), or require alternative solutions such as partial removal of the segment(s). If the proposed activity submitted by the operator is not approved by MMP, the operator is required to submit a revised application that meets the requirements stipulated in MMP's review. An application to decommission in an SSRA, which is approved, must also receive a CZMA information review as well as a CZMA right-of-way consistency review for the applicable state(s). A CZMA right-of-way consistency letter of approval is required from the applicable state(s) for the abandonment in-place process within the designated SSRA.

In addition, BOEM's Marine Minerals Program and CZMA coordinators, BSEE's Pipelines Section, and the State of Louisiana's Office of Coastal Management and Coastal Protection and Restoration Authority are working closely to ensure that sediment resources on the OCS are made available for restoration projects by requiring the removal of decommissioned pipelines. In significant sand resource areas, BOEM's Marine Minerals Program is also coordinating with BSEE's Pipeline Section, the State of Louisiana, and applicants with regards to rerouting proposed pipelines (if necessary) when an application is submitted for emplacement to avoid the significant sediment resources if at all possible.

Once the NEPA analysis for a proposed pipeline decommissioning application is complete, BOEM's Office of Environment would forward the NEPA analysis with any applicable conditions of approval to BSEE's Office of Environmental Compliance for final NEPA approval. The BSEE Office of Environmental Compliance approves the final NEPA analysis with the recommended conditions of approval applied and notifies BSEE's Pipelines Section, which is responsible for approving the decommissioning permit submitted by the applicant.

Typical BOEM environmental reviews for pipeline decommissioning include

- archaeological resources;
- biological resources (if triggered by GIS analysis of segment location or water depth (>300 m, 984 ft);
- water quality (to evaluate USEPA compliance for the decommissioning);
- Coastal Zone Management Act (for decommissioning impacting significant sediment resources); and
- Marine Minerals Program (for decommissioning impacting significant sediment resources).

The workflow of a typical pipeline application submitted to BOEM is shown in **Figure 5.2.8-1**.

5.2.7.4 Structure Removal and Site Clearance

During exploration, development, and production operations, temporary and permanent equipment and structures are often required to be embedded into or placed onto the seafloor around activity areas. In compliance with Section 22 of BOEM's Oil and Gas Lease Form (MMS-2005) and OCSLA regulations (30 CFR § 250.1710—*Wellheads/Casings* and 30 CFR § 250.1725—*Platforms and Other Facilities*), operators need to remove seafloor obstructions from their leases within 1 year of lease termination or after a structure has been deemed obsolete or unusable. These regulations also require the operator to sever bottom-founded objects and their related components at least 5 m (15 ft) below the mudline (30 CFR § 250.1716(a)—*Permanently Plugging Wells* and 30 CFR § 250.1728(a)—*Platforms and Other Facilities*). The severance operations are generally categorized as explosive or nonexplosive.

There are, however, possible exemptions to the 1-year deadline, including the exemptions stated in 30 CFR § 250.1725, which outlines BSEE's authority to allow an offshore oil and gas structure, previously permitted under the OCSLA, to remain in place after OCS oil- and gas-related activities have ceased in order to allow the use of the structure for other energy- and marine-related activities. Specifically, 30 CFR § 250.1725 states that all platforms and other facilities must be removed within 1 year after the lease terminates unless you receive approval to maintain the structure to conduct other activities. Other activities include those supporting OCS oil and gas production and transportation, as well as other energy- or marine-related uses (including liquefied natural gas) for which adequate financial assurance for decommissioning has been provided to a Federal agency that has given BSEE a commitment that it has and will exercise authority to compel the performance of decommissioning within a time following cessation of the new use acceptable to BSEE. This authority provides opportunities to extend the life of facilities for non-OCS oil- and gas-related purposes, such as research, renewable energy production, or aquaculture before being removed.

The MMS, the predecessor agency of BOEM and BSEE, previously addressed removal operations and the potential impacts of severing methodologies (nonexplosive/explosive tools) in a Programmatic EA prepared in 1987; however, in response to advancements in decommissioning methodologies and regulatory requirements since the 1987 Programmatic EA was prepared, as well as the continued movement into more deepwater prospects (>200 m; 656 ft), MMS prepared *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (MMS 2005). This Programmatic EA serves three primary needs:

- aids in the permitting, management, and planning of future structure-removal operations;
- ensures that adequate environmental reviews are conducted on all decommissioning proposals that would help support human health and safety while simultaneously protecting the sensitive marine environment; and
- serves as a reference document to implement the “tiering” objective detailed in NEPA’s implementing regulations (40 CFR § 1502.20) (future, site-specific EAs may reference appropriate chapters of this Programmatic EA to reduce reiteration of issues and impacts, allowing analyses to focus on site-specific issues and impacts related to the removal activity).

In 1988, MMS (BOEM and BSEE’s predecessor) requested a “generic” consultation from NMFS pursuant to Section 7 of the ESA concerning potential impacts on endangered and threatened species associated with explosive-severance activities conducted during structure-removal operations. Much like the 1987 Programmatic EA, the consultation’s “generic” Biological Opinion was limited to the best scientific information available and concentrated primarily on the majority of structure removals (water depths <200 m [656 ft]). The Incidental Take Statement was therefore limited to the five species of sea turtles found on the shallow shelf. Reporting guidelines and specific mitigating measures are outlined in the Incidental Take Statement and include (1) the use of a qualified NMFS observer, (2) aerial surveys, (3) detonation delay radii, (4) nighttime blast restrictions, (5) charge staggering and grouping, and (6) possible diver survey requirements.

Emphasizing a continued need for an incentive to keep explosive weights low, MMS (BOEM and BSEE's predecessor) formally requested that NMFS amend the 1988 Biological Opinion to establish a minimum charge size of 5 pounds. The NMFS' Southeast Regional Office subsequently addressed explosive charges of ≤5 pounds in a separate, informal Biological Opinion. The October 2003 "de-minimus" Biological Opinion waives several mitigating measures of the "generic" 1988 Biological Opinion (i.e., aerial observations, 48-hour pre-detonation observer coverage, onsite NOAA personnel, etc.), reduces the potential impact zone from 3,000 ft to 700 ft (914 m to 213 m), and gives the operators/severing contractors the opportunity to conduct their own observation work.

In 1989, the American Petroleum Institute (API) petitioned NMFS under Subpart A of the Marine Mammal Protection Act regulations for the incidental take of spotted and bottlenose dolphins during structure-removal operations (i.e., for either explosive- or nonexplosive-severance activities). The Incidental Take Authorization regulations were promulgated by NMFS in October 1995 and on April 10, 1996, the regulations were moved to subpart M (50 CFR §§ 216.141 *et seq*.). Effective for 5 years, the regulations detailed conditions, reporting requirements, and mitigating measures similar to those listed in the 1988 ESA Consultation requirements for sea turtles. After the regulations expired in November 2000, NMFS and MMS advised operators to continue following the guidelines and mitigating measures of the lapsed subpart pending a new petition and subsequent regulations. At industry's prompting, NMFS released interim regulations in August 2002, which expired on February 2, 2004. Operators have continued to follow the interim conditions until NMFS promulgates new regulations (refer to **Chapter 5.2.6**).

After bottom-founded objects are severed and the structures are removed, operators are required to verify that the site is clear of any obstructions that may conflict with other uses of the OCS according to 30 CFR §§ 250.1740-1743. The BSEE NTL No. 2019-G05, "Minimum Interim Requirements for Site Clearance (and Verification) of Abandoned Oil and Gas Structures in the Gulf of Mexico," provides the requirements for site clearance. The lessee must develop, and submit to BOEM for approval, a procedural plan for the site clearance verification procedures. For platform and caisson locations in water depths of <91 m (300 ft), the sites must be trawled over 100 percent of the designated area in two directions (i.e., N-S and E-W). As an alternative, individual well-site clearances may use high-frequency (500 kilohertz) sonar searches for verification. Site-clearance verification must take place within 60 days after structure-removal operations have been conducted.

NEPA Analysis for Structure Removals and Site Clearance

A 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. **Chapter 5.2.6** describes regulations, reporting guidelines, and specific mitigating measures developed through consultation, pursuant to Section 7 of the ESA and the MMPA, concerning potential impacts on endangered and threatened species associated with explosive severance activities conducted during structure-removal operations. All of the current terms and conditions of structure- and well-removal activities are outlined in BSEE NTL No. 2018-G03, "Decommissioning Guidance for Wells and Platforms," which originally became effective on October 15, 2010, under previous BSEE NTL No. 2010-G05.

Figure 5.2.8-2 outlines the general NEPA review process for a typical structure removal application once submitted to BSEE. The BSEE Office of Structural and Technical Support receives structure-removal applications submitted from operators with proposed structure-removal activities on the Gulf of Mexico OCS. The BSEE Office of Structure and Technical Support reviews the application for completeness and compliance with 30 CFR part 250 subpart Q.

Once completeness is confirmed, the structure-removal application is sent by BSEE's Office of Structure and Technical Support to BOEM's Office of Environment for NEPA analysis and all applicable environmental reviews. All structure-removal applications require an SEA/Decision Memo document as well as a COA document.

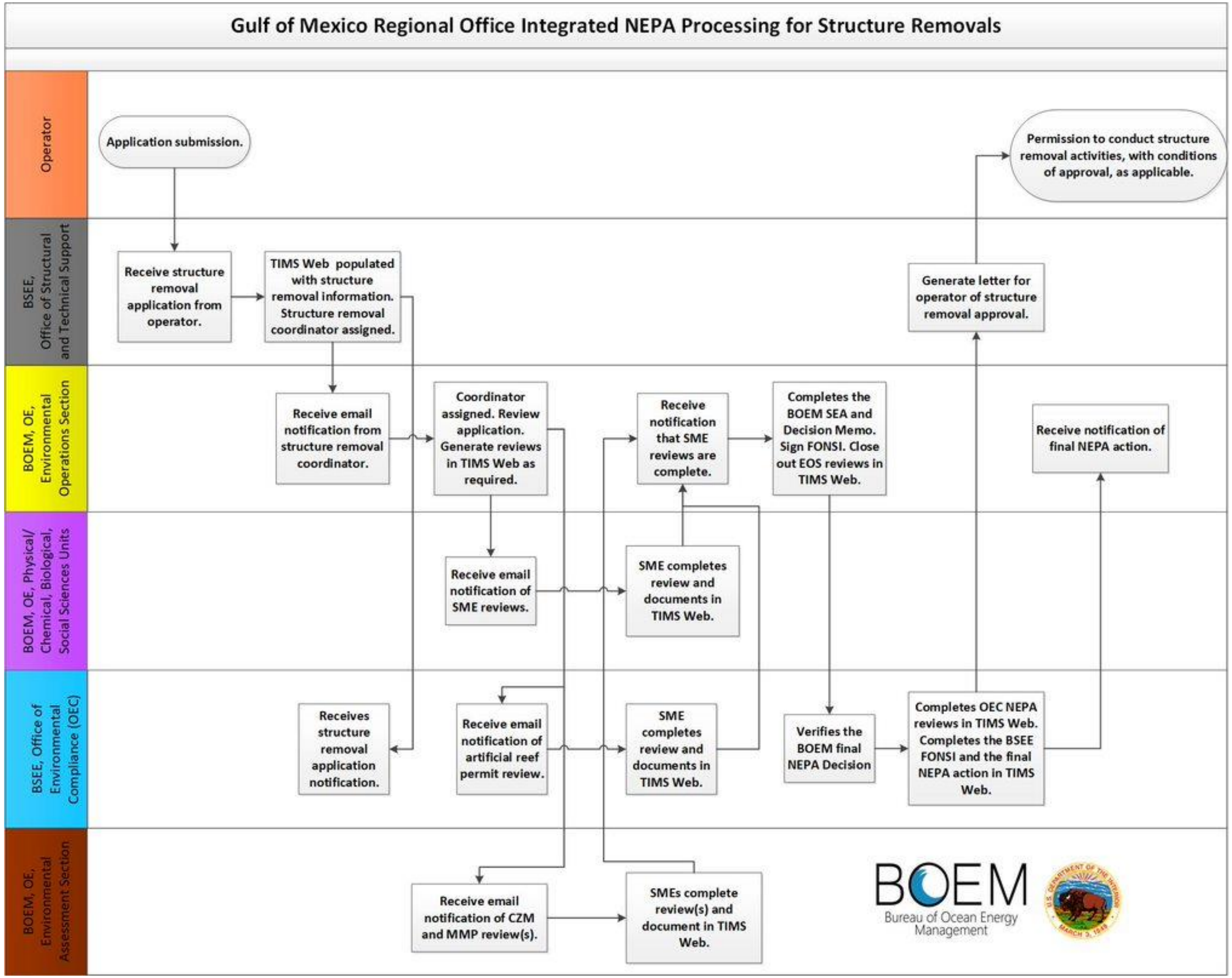


Figure 5.2.8-2. Integrated NEPA Processing Flow Diagram for Typical Structure-Removal Application.

Types of Structure Removal

Explosive Removals

Explosive removals use explosive tools such as bulk, shaped, and fracturing charges to sever tubular/structural targets during removal operations. Five blasting categories were developed based upon the specific range of charge weights needed to conduct current and future OCS structure removals.

Depending on the design of the target and other variable marine conditions, the severance charges developed under each of these categories could be designed for use in either a below-mudline (BML) or above-mudline (AML) configuration. These factors, combined with an activity location within either the shelf (<200 m; 656 ft) or slope (>200 m; 656 ft) species-delineation zone, result in 10 separate severance scenarios. The most common structure-removal blasting categories are currently located on the shelf (<200 m; 656 ft) and are the Standard Blasting BML (classified as SW-3) and Large Blasting BML (classified as SW-4). The 10 structure-removal scenarios are shown in **Table 5.2.8-1**.

Table 5.2.8-1. Blasting Categories and Associated Mitigation Scenarios.

Mitigation Scenario Number*	Net Explosive Weight (lb)	Pre-Det Surface Survey (min)	Pre-Det Aerial Survey (min)	Pre-Det PAM (min)	Animal Sightings Waiting Period (min)	Post-Det Surface Survey (min)	Post-Det Aerial Survey (min)	Post-Post-Det Aerial Survey within 1 Week
SW-1	1-10	60	N/A	N/A	30	30	N/A	No
SW-2	>10-20	90	45	N/A	30	N/A	45	No
SW-3	>20-80	90	45	N/A	30	N/A	45	No
SW-4	>80-200	120	60	N/A	30	N/A	45	No
SW-5	>200-500	150	90	N/A	45	N/A	45	No
DW-1	1-10	90	N/A	N/A	45	30	N/A	No
DW-2	>10-20	90	45	N/A	45	N/A	45	No
DW-3	>20-80	90	60	150	45	N/A	45	Yes
DW-4	>80-200	150	60	180	45	N/A	45	Yes
DW-5	>200-500	180	90	270	45	N/A	45	Yes

* All structure-removal scenarios also include a *Sargassum* habitat waiting period until visually inspected or *Sargassum* floats out of the impact zone.

Det = detonation; DW = deep water; lb = pound; min = minute; N/A = not applicable; PAM = passive acoustic monitoring; SW = shallow water;

Nonexplosive Removals

Nonexplosive removals use tools such as abrasive water jets, mechanical cutters, diamond wire cutters, and diver torching (though diver torching is now rarely used).

A structure-removal application may use any combination of the removal methods (explosive and nonexplosive) indicated in the structure-removal application. If the use of explosives is listed as an alternative, then the application is treated as an explosive removal.

Structure-removal applications generally propose transporting the removed structure to shore for disposal/salvage, but it may also propose reefing all or part of the structure, thereby utilizing BSEE's Rigs-to-Reefs program, which is discussed in **Chapter 5.3**.

NEPA Determination

BOEM typically prepares an SEA for structure removal due to post-removal site clearance activities. The following review types are frequently required in the NEPA process for structure removals:

- archaeological (always required);
- benthic communities (when required based on site-specific triggers [chemosynthetic, topographic features, and potentially sensitive biologic features]);
- artificial reef permit (if reefing is proposed);
- Marine Minerals Program (when the structure is located in an SSRA); and
- CZMA information (triggered by a required MMP review when the structure is located in an SSRA).

Structure-Removal SEA and NEPA Analysis

The Structure Removal SEA/Decision Memo and COA documents are completed by BOEM's Office of Environment. The Bureau of Ocean Energy Management's NEPA documents, which include all recommended COAs applied, are forwarded to BSEE. The BSEE Office of Environmental Compliance conducts a NEPA verification in TIMS/TIMS Web and completes their own FONSI, incorporating BOEM's recommended COAs. Lastly, the Office of Environmental Compliance notifies BSEE's Office of Structure and Technical Support, which is responsible for approving the structure-removal permit requested by the applicant of the completed final NEPA action. Typical structure-removal mitigations, in addition to any applied by BOEM, include but are not limited to

- compliance with any Biological Opinion Terms and Conditions and Reasonable and Prudent Measures;
- marine trash and debris elimination (**Chapter 6**);
- vessel strike avoidance/reporting (**Chapter 6**);
- support bases and vessel transit routes (Rice's whale area);

- slack line precautions and reporting requirement; and
- passive acoustic monitoring requirement for structure removals in water depths >200 m (656 ft).

Post-Detonation Monitoring

Post-detonation monitoring is required after a removal, at which time NMFS' marine protected species observer will conduct an aerial survey of the impact zone. The conditions of this post-detonation survey will vary depending upon the type of structure removal completed. Specific details for the different removal scenarios are shown in **Table 5.2.8-1** above.

The workflow of a typical structure-removal application submitted to BOEM is shown in **Figure 5.2.8-2**.

5.3 RIGS-TO-REEFS PROGRAM

The BSEE is responsible for permitting the placement and eventual removal of temporary oil and gas facilities on the Federal OCS. When an OCS lease expires and/or development and production operations cease, companies are obligated to decommission and remove their facilities (30 CFR § 250.1725(a)) and clear the seabed of all obstructions (30 CFR § 250.1740). The BSEE Rigs-to-Reefs program provides a means by which lessees may request a waiver of the removal requirement. Under 30 CFR § 250.1730, BSEE may grant a departure from the 30 CFR § 250.1725(a) requirement to remove a platform. Although BSEE supports and encourages the reuse of obsolete oil and gas structures as artificial reefs and is a cooperating agency in implementing the National Artificial Reef Plan, specific requirements must be met for a departure to be granted. The BSEE may allow a departure from removal requirements (30 CFR § 250.1725(a)) and applicable lease obligations provided that

- the structure must become part of a State artificial reef program that complies with the criteria in the National Artificial Reef Plan (30 CFR § 250.1730(a));
- the responsible State agency requires a permit from the USACE and must accept title and liability for the reefed structure once removal/reefing operations are concluded (30 CFR § 250.1730(a)); and
- the lessee/operator must satisfy any USCG navigational requirements for the reefed structure (30 CFR § 250.1730(b)).

All five Gulf Coast States have active artificial reef programs that develop and manage artificial reefs on the Federal OCS; however, Louisiana and Texas are the primary participants since the majority of platforms are installed offshore of these two states. Since the inception of Rigs-to-Reef, over 600 decommissioned platforms have been donated and deployed as artificial reefs in the Gulf of Mexico.

The types of Rigs-to-Reef proposals include

- reefing in place (jacket of the structure with a minimum clearance of 65 ft [20 m] below mean sea level required);
- partial reefing in place (portion of the jacket, with the remaining portion transported to and reefed in another site or transported to shore for reuse/disposal; also requires a minimum clearance of 65 ft [20m]);
- reefing in place by toppling (the structure is reefed adjacent to its current location in its current block (must provide a minimum clearance of 65 ft [20 m]); and
- removal and reefing of the jacket structure in an approved artificial reef site (the jacket is towed to the approved artificial reef site).

Generally, the deck and topsides of a structure are removed and transported to shore for disposal or re-use. The jacket (support) of the structure is the portion typically reefed. A proposal for structure reefing is submitted along with the associated structure-removal application to BSEE's Office of Structure and Technical Support. When the structure removal is sent to BOEM for NEPA analysis, an artificial reef permit review is generated by BOEM's Office of Environment. The artificial reef review is sent to BSEE's Office of Environmental Compliance, which coordinates with all applicable agencies to ensure proper permits and clearances are completed. Coordination is required with the applicable State for the location where the reefing operation is to occur, the USACE, the USCG, and occasionally other entities such as the Flower Garden Banks National Marine Sanctuary. The artificial reef review is completed with any COAs applied.

In general, regardless of reef proposal type, the resulting jacket deployment must meet the USCG and USACE navigational clearance requirements for each individually permitted reef site. Minimum navigational clearance and Private Aids to Navigation marking requirements are determined by the USCG. The State programs work with the USCG to minimize buoy marking requirements to minimize liability and maintenance costs when developing artificial reefs. The navigational clearance and buoy marking requirements vary among reef sites.

BOEM will complete the SEA/Decision Memo and COA documents and send to BSEE's Office of Environmental Compliance for final NEPA approval. Ultimately, the permit application for the structure-removal operation, along with the associated reefing, is approved by BSEE's Office of Structure and Technical Support.

5.4 Coastal Zone Management Act Consistency Review and Appeals for Postlease Activities

The CZMA places requirements on any applicant for any federally licensed or permitted activities on the OCS (i.e., OCS plans, right-of-way pipelines, geological and geophysical surveys, and decommissioning) affecting any coastal use or resource, in or outside of a State's coastal zone. The applicant must provide a consistency certification and necessary data and information for the State to determine that the proposed activities comply with the enforceable policies of the State's CMP, is approved by NOAA, and that such activities will be fully consistent with those enforceable policies (16 U.S.C. § 1456(c)(3)(A) and 15 CFR § 930.76).

Except as provided in 15 CFR § 930.60(a), State agency consistency review begins when the State receives the OCS plan or application, consistency certification, and necessary data and information pursuant to 15 CFR §§ 930.76(a) and (b). Only missing information can be used to delay the commencement of State agency review, and a request for information and data that are not required by 15 CFR § 930.76 will not extend the date of commencement of review (15 CFR § 930.58). The information requirements for CZMA purposes are found at 30 CFR §§ 550.226 and 550.260 and are discussed in BSEE NTL No. 2012-N06, "Guidance to Owners and Operators of Offshore Facilities Seaward of the Coast Line Concerning Regional Oil Spill Response Plans"; BOEM NTL No. 2008-G04, "Information Requirements for Exploration Plans and Development Operations Coordination Documents"; BOEM NTL No. 2009-G27, "Submitting Exploration Plans and Development Operations Coordination Documents"; BOEM NTL No. 2015-N01, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS for Worst Case Discharge and Blowout Scenarios"; BSEE NTL No. 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources"; and BSEE NTL No. 2007-G20, "Coastal Zone Management Program Requirements for OCS Right-of-Way Pipeline Applications."

All of the Gulf Coast States have federally approved CMPs. Requirements for the CZMA consistency information for Texas, Louisiana, Mississippi, Alabama, and Florida are given in NTL Nos. 2012-N06 (BSEE), 2008-G04 (BOEM), 2009-G27 (BOEM), 2015-N01 (BOEM), 2010-N10 (BSEE), and 2007-G20 (BSEE). In accordance with the requirements of 15 CFR § 930.76, BOEM's New Orleans Office sends copies of an OCS plan, including the consistency certification and other necessary data and information, to the designated State(s) CMP agency by receipted mail or other approved communication. In accordance with the requirements of 15 CFR § 930.60, the applicants are responsible for sending the State(s) CMP agency a copy of the application, consistency certification, and necessary data and information at the same time as the application is sent to BOEM or BSEE. If no State-agency objection is submitted by the end of the consistency review period, BOEM shall presume consistency concurrence by the CZMA State(s) (15 CFR § 930.78(b)). BOEM can require modification of a plan or application based on a State agency objection.

If BOEM receives a written consistency objection from the State, BOEM and/or BSEE will not approve any action described in the proposed activity unless (1) the operator amends the application to accommodate the objection, concurrence is subsequently received, or conclusively presumed; (2) upon appeal, the Secretary of Commerce, in accordance with 15 CFR part 930 subpart H, finds that the proposed activity is consistent with the objectives or purposes of the CZMA or is necessary in the interest of national security; or (3) the original objection is declared invalid by the courts.

The general timeline for CZMA reviews is as follows:

- OCS plans (Subpart E) – exploration, and development and production activities
  - State must notify the Federal agency and applicant within 3 months of the beginning of its consistency review of the status of its review and the basis for any further delay (15 CFR § 930.78(a)) and
  - State agency concurrence or objection must be received before or on the last day of the 6-month review period (15 CFR § 930.78(b)) and any objection must be based on enforceable policies of the CMP;
- Federal license or permit activities (Subpart D) – geological and geophysical permits, and right-of-way pipeline applications;
  - State CMP has 6 months to respond and should notify the applicant if review will go beyond 3 months; and
  - applicant and State CMP may agree to stay the 6-month period, extending it to a later date.

5.5 Marine Minerals Program

BOEM's Marine Minerals Program (MMP) is responsible for the preservation and maintenance of marine mineral resources on the Gulf of Mexico OCS. Two main focus areas of the program are ocean dredged material disposal sites and sand borrowing sites.

Dredged material is described in 33 CFR part 324 as any material excavated or dredged from navigable waters of the United States. Materials from maintenance dredging are primarily disposed of offshore on existing dredged-material disposal areas and in ODMDSs. Additional dredged-material disposal areas for maintenance or new project dredging are developed as needed and must be evaluated and permitted by the USACE and relevant State agencies prior to construction. The ODMDSs are regulated by the USEPA under the Clean Water Act and Marine Protection, Research, and Sanctuaries Act (BOEM 2020c).

NTL No. 2009-G04 addresses significant OCS sediment resources in the Gulf of Mexico. Its purpose states

> Coastal restoration, beach nourishment, and levee reconstruction are crucial to mitigate future coastal erosion, land loss flooding, and storm damage in the Gulf of Mexico, especially along coastal Louisiana. The success of that long-term effort depends on locating and securing significant quantities of OCS sediment resources that are compatible with the target environments being restored. Offshore sand resources, like upland sources, are extremely scarce where most needed. Additionally, sizable areas of these relatively small offshore sand resources are not

extractable because of the presence of oil and gas infrastructure, archaeologically sensitive areas, and biologically sensitive areas.

Proposed operator activities that are submitted to BOEM's Office of Environment and that are shown by geospatial analysis to impact an SSRA are referred to BOEM's Marine Minerals Program section. Any proposed activity could potentially impact an SSRA; however, the most common activities to impact these sites are pipeline permit applications (both installations and decommissioning). The MMP scientists determine whether operator-submitted activities are allowable as proposed. In some cases, modifications to the proposed activities are requested to protect resources. An MMP review is conducted by BOEM and documented in TIMS. The MMP reviews are also conducted whenever structure removals (decommissioning) occur in an SSRA.

New exploration and development plans rarely impact SSRAs. When they do, however, an MMP review must be conducted to determine whether the proposed activity would impact future access to the SSRA. If there are potential space-use conflicts with SSRAs, the operator is required to revise its proposed activities to meet the conditions required by MMP.

5.6 AIR QUALITY

BOEM's Air Quality Regulations for the Gulf of Mexico

The Clean Air Act (CAA), as amended, requires the USEPA to set NAAQS for six common air pollutants of concern called "criteria air pollutants." The criteria air pollutants are carbon monoxide (CO), lead (Pb), ozone (O_3), nitrogen dioxide (NO_2), particulate matter (PM), and sulfur dioxide (SO_2). The OCSLA provides the Secretary of the Interior (Secretary), acting through BOEM, with the responsibility to ensure "compliance with the NAAQS"; however the plain language also states that his authority to regulate is limited to "activities authorized under this [Act]" that "significantly affect the air quality of any State." For instance, the OCSLA itself does not require or permit the operation of vessels in support of activities under a lease.

The OCSLA's provisions on air quality provide the Secretary a much narrower authority to regulate when compared with the breadth of those authorities granted to the USEPA in the CAA. Under later amendments to the CAA, the CAA Amendments of 1990, Section 328 of the CAA clearly outlines the separate and distinct jurisdictional authority of the USEPA, limiting the applicability of USEPA's regulatory authority only to specific areas of the OCS in consultation with the Secretary (42 U.S.C. § 7627). BOEM has air quality jurisdiction in the GOM west of 87.5 degrees longitude, which encompasses the entire WPA and most of the CPA.

BOEM's regulatory authority under Section 5(a) of OCSLA is focused on the six criteria air pollutants for which the USEPA has defined NAAQS in accordance with the requirements of the CAA. The amount of any given criteria pollutant that may affect any State is influenced by two factors, the direct air emission and dispersion of the criteria pollutant, and the formation of a criteria pollutant caused by the air emissions of other pollutants. Those air pollutants that contribute to the formation of a criteria air pollutant are known as precursor air pollutants. Historically, the precursor air pollutant that BOEM has regulated (in addition to those precursor air pollutants that are themselves also criteria air pollutants) is volatile organic compounds.

For OCS air emission sources located east of 87.5 degrees longitude and within 25 mi (40 km) of the State's seaward boundaries, the USEPA regulations for these OCS areas are specified in 40 CFR part 55. For OCS air emission sources located east of 87.5 degrees longitude and more than 25 mi (40 km) from the State's seaward boundaries, the USEPA regulations for these OCS areas are specified in 40 CFR part 52. For OCS air emission sources related to activities authorized under the OCSLA and located west of 87.5 degrees longitude, BOEM's regulations for these OCS areas are specified in 30 CFR part 550. Other air emission sources that are not authorized under the OCSLA may be subject to other Federal laws and regulations.

5.6.1 BOEM Air Quality Reviews

In BOEM's regulations, EPs, DOCDs, and DPPs must include air emissions information (30 CFR §§ 550.218 and 550.249). An air quality review is required for all plans submitted for the Gulf of Mexico OCS. BOEM's regulations require a review of air emissions to determine if the projected air emissions from a facility result in onshore ambient air concentrations above BOEM's significance levels and to identify appropriate emissions controls to mitigate potential onshore air quality degradation.

BOEM uses a two-level hierarchy to evaluate potential impacts of offshore facility emission sources to onshore areas. The evaluation criteria are the exemption level and the significance level. If the proposed activities exceed the criteria at the first (exemption) level, the evaluation moves to the significance level criteria. The initial evaluation compares the worst-case air emissions of a facility's proposed activity to BOEM's exemption levels. If the proposed activity's emissions are below the exemption levels, then it is exempt from further air quality analyses.

If exemption levels are exceeded, then the second step requires air quality modeling using the Offshore and Coastal Dispersion Model or the California Puff Model. The results model potential onshore ambient air quality impacts, which are compared to BOEM's significance levels. If the significance levels are exceeded in an unclassifiable/attainment area, which is an area that meets the NAAQS, the operator would be required to apply best available control technology to the emissions source. If the affected area is designated as nonattainment, further emission reductions or offsets may be required. Currently, in BOEM's area of jurisdiction within the GOM, all areas are in attainment except for the Houston/Galveston, Texas, area for O_3 and the St. Bernard Parish, Louisiana, area for SO_2 and Pb.

BOEM air quality reviews for the Gulf of Mexico OCS are conducted by BOEM's Office of Environment's Physical and Chemical Sciences Section. Air quality subject-matter experts in the Physical and Chemical Sciences Section include meteorologists as well as multi-disciplinary physical scientists.

Operators submitting EPs, DOCDs, and DPPs in the GOM use Office of Management and Budget-approved air quality spreadsheets and Forms BOEM-0138 (for EPs) and BOEM-0139 (for DOCDs and DPPs). The forms (not part of the regulations themselves) are used by operators to report the information on air emissions required in the regulations, primarily the emissions associated with the operator's proposed plans. The air quality spreadsheets require the operator to identify the relevant types of equipment that will be used in connection with its OCS operations. The air quality spreadsheets provide emissions factors that correspond to each of the equipment types and that BOEM uses to determine the amount of emissions generated under the plan. The spreadsheets enable the operator to quantify the total emissions by type of air pollutant for all equipment included in the EP, DPP, or DOCD, and then determine whether such emissions would or would not exceed the relevant exemption levels. These air quality spreadsheets, along with submitted activity schedules (proposed activity timelines), are analyzed by BOEM's air quality subject-matter experts. This information is used along with other information submitted by the operator, such as dispersion modeling, to determine whether the proposed activity is acceptable under BOEM's regulations or whether the activity must be revised or mitigated to meet BOEM's requirements. A summary of example reporting mitigations that can be applied by BOEM air quality subject-matter experts are shown in **Chapter 6**. BSEE's Environmental Compliance Program leads verification of compliance and enforcement of environmental laws and regulations pertaining to air quality. BSEE's Environmental Compliance Program also ensures that facilities operating on the OCS are in compliance with BOEM-approved plans and related conditions of approval for air emissions.

In certain cases, proposed activities that are located <100 km (62 mi) from a Class 1 area (commonly Breton Wilderness) are recommended to be sent to FWS, who may request plume impact visual screening and analysis modeling. Also, proposed activities located between 100 and 200 km (62 and 124 mi) from a Class 1 area that have a Q/d greater than 10 (Q is sum of PM, SO_x, and NO_x emissions divided by d [the distance in km]) are forwarded to FWS in Denver for review under a cooperative agreement with BOEM. The FWS has 30 days to comment, after which concurrence with the plan as submitted is presumed by BOEM. In some cases, FWS may request that the operator submit air quality modeling for their proposed activity. For more information, refer to the *Federal Land Managers' Air Quality Related Values Workgroup (FLAG): Phase I Report—Revised (2010)* (USFS et al. 2010).

In addition to conducting air quality reviews, air quality subject-matter experts manage or participate in BOEM and BSEE environmental studies in the Gulf of Mexico OCS. The results of these environmental studies contribute knowledge to the prelease EIS documents and policies implemented for postlease activities.

5.7 Flaring/Venting

Flaring is the controlled burning of natural gas, and venting is releasing gas directly into the atmosphere without burning. The BSEE regulates flaring/venting to minimize the loss of revenue-producing natural gas resources. The BSEE regulations at 30 CFR part 250 subpart K allow, without prior BSEE approval, flaring or venting of natural gas on a limited basis under certain specified conditions. Regulations permit more extensive flaring/venting with prior approval from BSEE. Records must always be prepared by the operator for all flaring/venting, and justification must be provided for flaring/venting not expressly authorized by BSEE's regulations.

5.8 Hydrogen Sulfide Contingency Plans

The operator of a lease must request a BSEE area classification for the presence of H_2S gas. The BSEE classifies areas for proposed operations as (1) H_2S absent, (2) H_2S present, or (3) H_2S unknown.

All OCS operators must provide information about potential contact with sour hydrocarbons (contains H_2S) that could result in atmospheric H_2S concentrations above 20 ppm in their exploration or development plan. If an area is known to contain H_2S or is in an area where H_2S potential is unknown, operators are required to file an H_2S contingency plan with BSEE. This plan must include the 30 CFR part 250 requirements that are intended to ensure worker's safety at the production facility and provide contingencies for simultaneous drilling, well-completion, well-workovers, and production operations. BOEM NTL No. 2009-G31, "Hydrogen Sulfide (H_2S) Requirements," provides clarification, guidance, and information regarding BSEE's H_2S regulations at 30 CFR part 250. Expected H_2S concentrations above 500 ppm require modeling by the operator for the proposed activity.

Operators in the Gulf of Mexico OCS are required to submit H_2S information in their EP, DOCD, and DPP plans, which undergo a geological review by BOEM's Office of Resource Evaluation completed in TIMS. This review process will either confirm the operator's submitted H_2S classification or otherwise trigger a request for revisions based on BOEM data utilized to verify the operator's estimate of H_2S presence. An H_2S projection of >500 ppm requires the submittal of modeling by the operator. In addition, a projected H_2S of >500 ppm is an EA trigger and the submitted plan's NEPA determination will require the completion of an SEA prior to approval.

5.9 Archaeological Resources Regulation

Bottom-disturbing operations such as well placement, anchoring, pipeline installation and decommissioning, and structure removals, can lead to damage to any resources that reside on or are embedded within the seabed, including archaeological resources such as historic shipwrecks. The archaeological resources regulations at 30 CFR § 250.194 and 30 CFR § 550.194.

In addition to conducting reviews and applying mitigations for postlease activities, marine archaeology subject-matter experts are active in the preparation of prelease EIS documents, prelease applications (G&G), as well as developing and providing oversight of environmental studies in the Gulf of Mexico OCS. The subject-matter experts also maintain a shipwreck database and participate in numerous exploratory activities in support of BOEM's responsibilities under the National Historic Preservation Act. The marine archaeologists also provide support to BOEM decisionmakers regarding issues requiring government-to-government consultations with federally recognized Native American tribes.

5.10 Biological Resources Reviews

Proposed plan activities (i.e., EPs, DOCDs, and DPPs) and permit applications (pipeline installations and decommissionings, and structure removals) submitted by operators that receive a NEPA determination of an SEA, as well as G&G permit applications proposing bottom disturbances, or any other designation requiring an EA, will be submitted for a biological resource (benthic) review. Other triggers for a biological resource review include (1) water depths >300 m (984 ft), which triggers a deepwater benthic communities review, or (2) distance triggers from a stipulated block with known topographic, pinnacle, or potentially sensitive biological features.

These reviews are performed by biologists in BOEM's Office of Environment, Biological Sciences Unit. The Biological Sciences Unit's subject-matter experts use submitted surveys along with information available in the ArcGIS geospatial mapping tool to identify any features that may require avoidance by proposed activities. A summary of mitigations applied by the Biological Sciences Unit is available in **Chapter 6**.

Types of Benthic Reviews

- Deepwater Benthic Reviews (>300 m [984 ft]) – NTL-2009-G40. Features that could support high-density chemosynthetic communities or features or areas that could support high-density deepwater corals and other associated high-density hard bottom communities.
- Topographic Features – NTL-2009-G39. Isolated areas of moderate to high relief that provide habitat for hard bottom communities of high biomass and diversity and large numbers of plant and animal species, and support, either as shelter or food, large numbers of commercially and recreationally important fishes.
- Live Bottoms Pinnacle Trend – NTL-2009-G39. Small, isolated, low- to moderate-relief carbonate reefal features or outcrops of unknown origin or hard substrates exposed by erosion that provide surface area for growth of sessile invertebrates and attract large numbers of fish.
- Live Bottoms Low Relief – NTL-2009-G39. Seagrass communities and areas that contain biological assemblages consisting of sessile invertebrates living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where a hard substrate and vertical relief may favor the accumulation of turtles, fishes, or other fauna.
- Potentially Sensitive Biologic Features – NTL-2009-G39. Those features not protected by a biological lease stipulation that are of moderate to high relief (about 8 ft [2.4 m] or higher), provide surface area for the growth of sessile invertebrates, and attract large numbers of fish. These features would be located outside any "No Activity Zone" of any of the listed named topographic features (banks) or the 74 listed live bottom (pinnacle trend) stipulation blocks.

Triggers for the submittal of benthic reviews include proximity to features such as pinnacle trends, potentially sensitive biological features, and topographic features. Generally, topographic features are within No Activity Zones, and these include marine sanctuary areas located in the Gulf of Mexico OCS. One example is the Flower Garden Banks National Marine Sanctuary. ArcGIS is utilized to determine the proposed activities' proximity to biological features. If necessary, mitigations are applied to ensure that biological resources are protected. Examples include avoiding resources by the proper distances and the shunting of drill cuttings to the seafloor when drilling in areas adjacent to the resource.

In addition, any activity that is proposed in water depths >300 m (984 ft) triggers a deepwater benthic communities (chemosynthetic communities review in TIMS) review. In the case of a submitted OCS plan (i.e., EP, DOCD, or DPP), the deepwater designation is also a trigger for a site-specific environmental assessment NEPA determination.

BOEM's Office of Environment, Biological Sciences Unit's biologists are also responsible for coordinating cooperative agreements with other agencies. An example is the Section 7 ESA consultation, which is discussed in **Chapter 5.2.6**. Other consultation and coordination include the MMPA and essential fish habitat consultations to name just a couple. Cooperative agencies include NMFS, National Oceanic and Atmospheric Administration, FWS, and the Flower Garden Banks National Marine Sanctuary to name a few. The Biological Sciences Unit's subject-matter experts are also active in the preparation of EIS documents and numerous studies in the Gulf of Mexico OCS.

5.11 Water Quality Laws and Regulations

The CWA establishes conditions and permitting for discharges of pollutants into the waters of the United States under the NPDES. The CWA also gives the USEPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters. Accordingly, the USEPA regulates all waste streams generated from OCS oil- and gas-related activities through general permits issued by the USEPA region that has jurisdictional oversight. The general permits are typically valid for 5 years. The relevant USEPA region can also require an operator to apply for a permit for a specific activity under certain circumstances.

Role of the U.S. Environmental Protection Agency in Administering NPDES Permits

The USEPA Region 4 has jurisdiction over the eastern portion of the Gulf of Mexico OCS, including all of the EPA and a portion of the CPA off the coasts of Alabama and Mississippi (**Figure 5.11-1**). The USEPA Region 6 has jurisdiction over the rest of the CPA and all of the WPA. Each USEPA region has promulgated general permits for discharges that incorporate the 1993 and 2000 effluent guidelines for synthetic-based fluid (SBF)-wetted cuttings as a minimum.

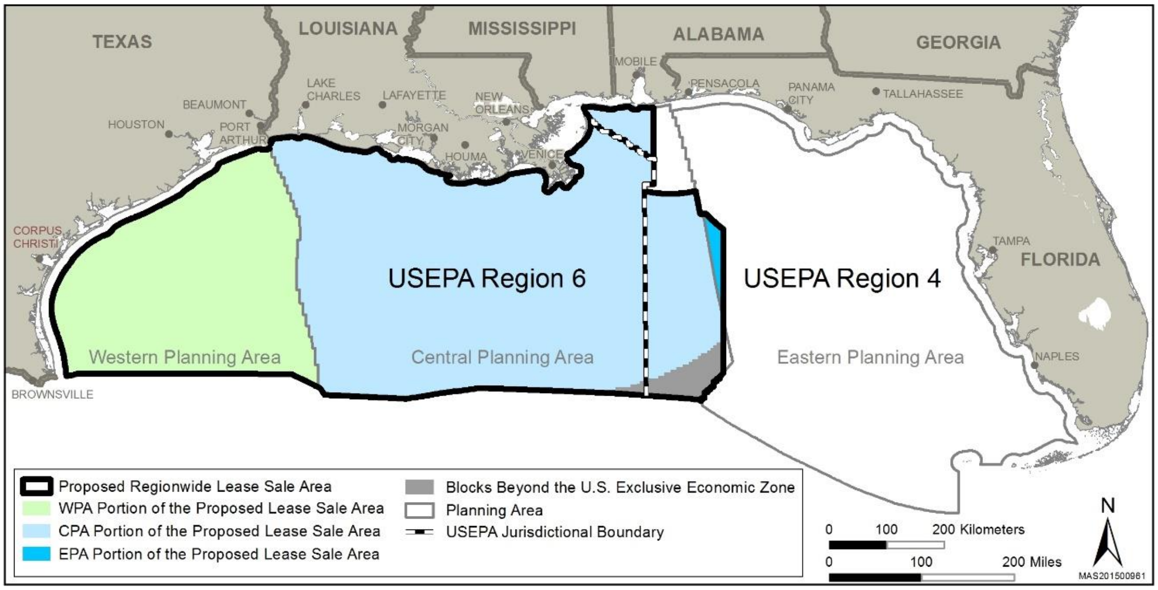


Figure 5.11-1. Boundaries for USEPA Regions 4 and 6 Overlaid with the 2017-2022 GOM Multisale EIS Proposed Lease Sale Areas.

Permits issued under Section 402 (NPDES) of the CWA for offshore activities must comply with any applicable water quality standards and/or Federal water quality criteria, as well as Section 403 (Ocean Discharge Criteria) of the CWA. Water quality standards consist of three components: the waterbody's designated uses; water quality criteria to protect those uses and to determine if they are being attained; and anti-degradation policies to help protect high-quality waterbodies. Discharges from offshore activities near State water boundaries must comply with all applicable State water quality standards.

Section 403 of the Clean Water Act requires that NPDES permits for discharges to the territorial seas (baseline to 3 mi [5 km]), contiguous zone, and ocean be issued in compliance with the USEPA's regulations for preventing unreasonable degradation of the receiving waters. Prior to permit issuance, ocean discharges must be evaluated against the USEPA's published criteria for determination of unreasonable degradation. Unreasonable degradation is defined in the NPDES regulations (40 CFR § 125.1211e) as follows:

- significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
- threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; and
- loss of aesthetic, recreational, scientific, or economic values, which is unreasonable in relation to the benefit derived from the discharge.

In order for a facility to be covered by a general NPDES permit, the operator must submit an NOI to be covered by the general permit. The USEPA developed an "electronic NOI (eNOI)" system.

The USEPA evaluates NOIs on a case-by-case basis and reserves the right to deny coverage if it is determined that the facility is ineligible or has falsified information. The NPDES permit sets minimum requirements that every allowable discharge must meet. If a waste does not meet the requirements of the permit, the permit would be considered violated and the USEPA could take an enforcement action. Discharges are monitored and the data are reported to the USEPA through discharge monitoring reports (DMRs). These reports must contain all the information required by the permit for that discharge. The USEPA now has an electronic DMR system known as "NetDMR," which is required for all facilities covered by their general permit. Failure to submit any information or monitoring results required by the permit is considered a violation.

Data from submitted NetDMRs populate the USEPA's national Integrated Compliance Information System database. The appropriate USEPA region reviews data in the Integrated Compliance Information database to identify facilities violating the permit conditions or reporting requirements. Violations are reviewed and enforcement actions are taken as deemed appropriate, particularly for serious single event violations, an ongoing pattern of noncompliance, or significant noncompliance (noncompliance for two running quarters or more). Depending on the type of violation, severity, length of violation, environmental damage, or illegal activity, the USEPA may request more information, issue a warning letter or order corrective actions, assess a penalty, or refer it to the U.S. Department of Justice or Criminal Investigation Division. The USEPA may use information, pictures, and other documentation from BSEE, BOEM, or USCG to support its enforcement cases. The public may view violations and enforcement actions in the Enforcement and Compliance History Online database (USEPA 2015a), which is updated every 30 days from the Integrated Compliance Information's database.

Water pollution associated with oil and gas activities in the Gulf of Mexico is regulated by the USEPA through the NPDES general permits in support of the CWA. Refer to BOEM's *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for more information about the CWA. During exploration and development activities for offshore oil and gas, the primary discharge types are drilling fluids, drill cuttings, various waters (e.g., bilge, ballast, fire, and cooling), deck drainage, sanitary wastes, and domestic wastes. During production activities, additional waste streams include treatment, completion and workover fluids, and produced waters. Discharges of produced sand, non-aqueous-based drilling fluids, oil-based drilling fluids, and diesel oil are prohibited. Minor additional discharges could occur from numerous sources. These discharges may include desalination unit discharges, blowout preventer fluids, boiler blowdown discharges, excess cement slurry, several types of fluids used in subsea production, and uncontaminated fresh water and salt water.

Two USEPA regional offices issue NPDES general permits in the Gulf of Mexico based on geographical location. Region 4 permits all CWA Gulf of Mexico activities beyond the territorial seas of Mississippi, Alabama, and Florida, while Region 6 permits all CWA Gulf of Mexico activities off the coast of Texas and those beyond the territorial seas of Louisiana. Each region issues general NPDES permits for discharges from new sources, existing sources, and new discharges in the "Offshore and

Coastal Subcategories of the Oil and Gas Extraction Point Source Category," as defined in the USEPA regulations at 40 CFR part 435 subpart A.

BOEM Water Quality Reviews

BOEM water quality reviews in the Gulf of Mexico OCS are conducted by the Office of Environment's Physical and Chemical Sciences Section. Water quality subject-matter experts in the Physical and Chemical Sciences Section include oceanographers as well as multi-disciplinary physical scientists.

Operators proposing activities in the Gulf of Mexico OCS submit waste and discharge information using tables in their EP, DOCD, and DPP plans according to 30 CFR §§ 550.217, 550.225, 550.248, and 550.257. **Figures 5.11-2 and 5.11-3** show uncompleted waste and discharge tables that are submitted for both discharges at the activity site and discharges to be transported to shore for disposal. The submitted tables are reviewed by water quality subject-matter experts for accuracy and completeness with regards to NPDES permit requirements. The tables submitted list both wastes that are treated and/or disposed of at the activity site, as well as those that are sent to shorebase locations for disposal. In addition, all pipelines and other appurtenances proposing abandonment in place are evaluated by water quality subject-matter experts for environmental compliance with USEPA and NPDES regulations. Pipelines, umbilicals, and jumpers that are abandoned in place may not contain chemicals or seawater containing chemicals (inhibited seawater). The abandoned pipelines, umbilicals, and jumpers are required to be pigged, flushed, and filled with pure (uninhibited) seawater according to BSEE's regulation (30 CFR § 250.1751). If any noncompliance issues are identified, they are communicated to BSEE.

TABLE 1. WASTE ESTIMATED TO BE GENERATED, TREATED AND/OR DOWNHOLE DISPOSED OR DISCHARGED TO THE GOM

Please specify if the amount reported is a total or per well amount and be sure to include appropriate units.

Projected generated waste			Projected ocean discharges		Projected Downhole Disposal
Type of Waste	**Composition**	**Projected Amount**	**Discharge rate**	**Discharge Method**	**Answer *yes* or *no***
Will drilling occur ? If yes, you should list muds and cuttings					
EXAMPLE: Cuttings wetted with synthetic based fluid	*Cuttings generated while using synthetic based drilling fluid.*	*X bbl/well*	*X bbl/day/well*	*discharge overboard*	*No*
Water-based drilling fluid					
Cuttings wetted with water-based fluid					
Cuttings wetted with synthetic-based fluid					
Will humans be there? If yes, expect conventional waste					
EXAMPLE: Sanitary waste water	*Sanitary waste from living quarters*	*X bbl/well*	*X bbl/hr/well*	*chlorinate and discharge overboard*	*No*
Domestic waste					
Sanitary waste					
Is there a deck? If yes, there will be Deck Drainage					
Deck Drainage					
Will you conduct well treatment, completion, or workover?					
Well treatment fluids					
Well completion fluids					
Workover fluids					
Miscellaneous discharges. If yes, only fill in those associated with your activity.					
Desalinization unit discharge					
Blowout prevent fluid					
Ballast water					
Bilge water					
Excess cement at seafloor					
Fire water					
Cooling water					
Will you produce hydrocarbons? If yes fill in for produced water.					
Produced water					
Please enter *individual* or *general* to indicate which type of NPDES permit you will be covered by?					
NOTE: If you will not have a type of waste for the activity being applied for, enter NA for all columns in the row.			NOTE: All discharged wastes should comply with the requirements of the NPDES permit.		

Figure 5.11-2. Table to Use for Wastes to be Treated and/or Disposed of Either Downhole or to the Gulf of Mexico.

TABLE 2. WASTE AND SURPLUS ESTIMATED TO BE TRANSPORTED AND/OR DISPOSED OF ONSHORE

please specify whether the amount reported is a total or per well

	Projected generated waste	Solid and Liquid Wastes transportation	Waste Disposal		
Type of Waste	**Composition**	**Transport Method**	**Name/Location of Facility**	**Amount**	**Disposal Method**
Will drilling occur ? If yes, fill in the muds and cuttings.					
EXAMPLE: Synthetic-based drilling fluid or mud	*internal olefin, ester*	*Below deck storage tanks on offshore support vessels*	*Newport Environmental Services Inc., Ingleside, TX*	*X bbl/well*	*Recycled*
Oil-based drilling fluid or mud					
Synthetic-based drilling fluid or mud					
Cuttings wetted with Water-based fluid					
Cuttings wetted with Synthetic-based fluid					
Cuttings wetted with oil-based fluids					
Will you produce hydrocarbons? If yes fill in for produced sand.					
Produced sand					
Will you have additional wastes that are not permitted for discharge? If yes, fill in the appropriate rows.					
EXAMPLE: trash and debris (recylables)	*Plastic, paper, aluminum*	*barged in a storage bin*	*ARC, New Iberia, LA*	*X lb/well*	*Recycled*
Trash and debris					
Used oil					
Wash water					
Chemical product wastes					
NOTE: If you will not have a type of waste, enter NA in the row.					

Figure 5.11-3. Table to Use for Wastes to be Transported to and/or Disposed of Onshore.

In addition, water quality subject-matter experts manage or participate in BOEM and BSEE environmental studies in the Gulf of Mexico OCS. The results of these environmental studies contribute knowledge to the prelease EIS documents and policies implemented for postlease activities.

5.12 Inspection and Enforcement

The OCSLA authorizes and requires BSEE to provide for both an annual scheduled inspection and a periodic unscheduled (unannounced) inspection of all oil and gas operations on the OCS. The inspections are to assure compliance with all regulatory requirements that allowed commencement of the operation.

The primary objective of an initial inspection is to assure proper installation of mobile drilling units and fixed structures, and proper functionality of their safety and pollution prevention equipment. After operations begin, additional announced and unannounced inspections are conducted. Unannounced inspections are conducted to foster a climate of safe operations, to maintain BSEE's presence, and to focus on operators with a poor performance record. These inspections are also conducted after a critical safety feature has previously been found to be defective. Poor performance generally means that more frequent, unannounced inspections may be conducted on a violator's operation.

The annual inspection examines all safety equipment designed to prevent blowouts, fires, spills, or other major accidents. These annual inspections include the inspection for the installation and performance of all facilities' safety-system components.

The inspectors follow the guidelines as established by the regulations, American Petroleum Institute Recommended Practice 14C (API RP 14C), and the specific BSEE-approved plan. The BSEE inspectors perform these inspections using a national checklist called the Potential Incident of Noncompliance list. This list is a compilation of yes/no questions derived from all regulated safety and environmental requirements.

The BSEE administers an active civil penalties program (30 CFR part 250 subpart N). A civil penalty in the form of substantial monetary fines may be issued against any operator that commits a violation that may constitute a threat of serious, irreparable, or immediate harm or damage to life, property, or the environment. The BSEE may make recommendations for criminal penalties if a willful violation occurs. In addition, the regulation at 30 CFR § 250.173(a) authorizes suspension of any operation in the Gulf of Mexico region if the lessee has failed to comply with a provision of any applicable law, regulation, or provision of a lease or permit. Furthermore, the Secretary may invoke authority under 30 CFR § 550.185(c) to cancel a nonproductive lease with no compensation. Leases on which exploration and development activities are occurring may be canceled under 30 CFR §§ 550.182 and 550.183.

5.13 Pollution Prevention, Oil-spill Regulation, and Financial Responsibility

5.13.1 Pollution Prevention

Pollution prevention is addressed through proper design and requirements for safety devices. The BSEE regulations at 30 CFR § 250.401 require that the operator take all necessary precautions to keep its wells under control at all times. The lessee is required to use the BAST in order to aid in the evaluation of conditions of abnormal pressure and to minimize the potential for the well to flow or kick. Redundancy is required for critical safety devices that will shut off flow from the well if loss of control is encountered.

In addition, BSEE's regulations at 30 CFR part 250 subparts E, F, and H require that the lessee assure the safety and protection of the human, marine, and coastal environments during completion, workover, and production operations. All production facilities, including separators, treaters, compressors, headers, and flowlines are required to be designed, installed, tested, maintained, and used in a manner that provides for efficiency, safety of operations, and protection of the environment. Wells, particularly subsea wells, include a number of sensors that help in detecting pressures and the potential for leaks in the production system. Safety devices are monitored and tested frequently to ensure their operation, should an incident occur. To ensure that safety devices are operating properly, BSEE incorporates API RP 14C into the operating regulations. The API RP 14C incorporates the knowledge and experience of the oil and gas industry regarding the analysis, design, installation, and testing of the safety devices used to prevent pollution. The API RP 14C presents proven practices for providing these safety devices for offshore production platforms. Proper application of these practices, along with good design, maintenance, and operation of the entire production facility, should provide an operationally safe and pollution-free production platform.

Also, BSEE's regulations at 30 CFR part 250 subpart J require that pipelines and associated valves, flanges, and fittings be designed, installed, operated, and maintained to provide safe and pollution-free transportation of fluids in a manner that does not unduly interfere with other uses on the OCS.

The BSEE regulation at 30 CFR § 250.300(a) requires that lessees not create conditions that will pose an unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean during offshore oil and gas operations. The lessee is required to take measures to prevent the unauthorized discharge of pollutants into offshore waters. Control and removal of pollution is the responsibility of, and at the expense of, the lessee. Immediate corrective action in response to an unauthorized release is required. All hydrocarbon-handling equipment for testing and production, such as separator and treatment tanks, is required to be designed, installed, and operated to prevent pollution. Maintenance and repairs that are necessary to prevent pollution are required to be taken immediately. Drilling and production facilities are required to be inspected daily or at intervals approved or prescribed by BSEE's District Field Operations Supervisor to determine if pollution is occurring.

Operators are required to install curbs, gutters, drip pans, and drains on platform and rig deck areas in a manner necessary to collect all greases, contaminants, and debris not authorized for discharge. The rules also explicitly prohibit the disposal of equipment, cables, chains, containers, or other materials into offshore waters. Portable equipment, spools or reels, drums, pallets, and other loose items must be marked in a durable manner with the owner's name prior to use or transport over offshore waters. Smaller objects must be stored in a marked container when not in use. Operational discharges such as produced water and drilling muds and cuttings are regulated by the USEPA through the NPDES permit program for new and existing discharges and sources (40 CFR part 435 subpart A). The BSEE may restrict the rate of drilling fluid discharge or prescribe alternative discharge methods. No petroleum-based substances, including diesel fuel, may be added to the drilling mud system without prior approval of BSEE's District Field Operations Supervisor. Under certain operating conditions, the use of a petroleum-based drilling mud system can be approved by BSEE to ensure safe operations. This approval must be documented in the permit prior to commencement of activities. If a petroleum-based drilling mud system is utilized, the system must be operated on a closed loop and all drilling mud must be transported to shore for processing. Discharge of petroleum-based drilling mud offshore is not permitted under any circumstances.

5.13.2 Worst-Case Discharge

Although a worst-case discharge (WCD) has a limited chance of occurrence, it can be experienced while drilling. In a case of insufficient drilling margin, over-pressurized formations penetrated during well construction can lead to an influx of formation fluid in the annulus at small scale and ultimately can lead to uncontrolled fluid flow and WCD.

A "worst-case discharge" is defined as the daily rate of an uncontrolled flow from all producible reservoirs into the open wellbore. The package of reservoirs exposed to an open borehole with the greatest discharge potential will be considered the worst-case discharge scenario. Shallower producible reservoirs isolated by casing and cement will not be considered in the uncontrolled flow.

Over-pressurized formations are usually naturally occurring or created due to water or gas injections in nearby wells. The WCD rate varies significantly among wells based on reservoir inflow and wellbore outflow parameters and can be evaluated in the risk assessment process. Containment of such a scenario is actually dependent on the accurate prediction of WCD rate, and consequently it can be compensated for by proper designing and holistic monitoring of the operation. The core of such a scenario is WCD rate predictions.

The WCD estimation is dependent upon several parameters accounting for reservoir inflow and wellbore outflow. Reservoir characteristics (such as permeability, porosity, pressure, and temperature) in the inflow model and wellbore parameters (such as depth, flow pattern, phase velocity, and geometry) in the outflow model play a crucial role. The permeability and porosity of a formation mainly impacts the fluid movement in the formation, which governs the rate of influx from the formation. The bottom-hole pressure and temperature set a differential condition and provides impetus to the fluid to flow from the bottom to the surface of the wellbore. An increase in temperature results in the thermal expansion of wellbore fluids in sealed annuli and can exacerbate the flow issues (Oudeman and Kerem 2006). Well depth directly influences the pressure gradient inside the annulus and consequently affects the discharge rate. Other factors, including the multiphase flow characteristics such as phase velocity, flow patterns, and geometry, also influence the WCD (Salehi et al. 2018).

The NTL No. 2015-N01 indicates that the WCD scenario should consider all hydrocarbon-bearing zones in each open-hole section as it is planned to be drilled. Accounting for changes in rock and fluid properties, multiphase flow pattern, saturation, operating pressure and temperature, and relative permeability with respect to a position over time is essential for accurate estimation of WCD. Comprehensive modeling of such a dynamic and complex scenario cannot be decoded with conventional analytical models. With the advent of modern technology, the blowout probability tends to decrease. Nevertheless, unfortunate combinations of equipment failure and geological uncertainty still regularly give rise to incidents that may lead to loss of wells, equipment, and even human life. To keep these risks to a minimum, a priori estimation of WCD through holistic modeling is necessary (Salehi et al. 2018).

The WCD is required for all plans and pipeline installation applications submitted by operators on the Gulf of Mexico OCS. The WCD is activity and site specific and is utilized along with the corresponding OSRP to evaluate the operator's capability of managing an oil spill-related accident on the OCS. The WCD scenario generally includes the following:

- no bridging;
- flow is upward through unobstructed casing and is linear; and
- there is no drill pipe in the hole.

Requirements for WCD information in Gulf of Mexico OCS plan submittals are listed below.

- As required by 30 CFR §§ 550.213 and 550.243, a plan must include a scenario for the potential blowout of the proposed well in the plan that is expected to have the highest volume of liquid hydrocarbons.
- As required by 30 CFR §§ 550.219 and 550.250, all plans must include information regarding oil spills, including the calculated volume of the WCD scenario and a comparison of the OSRP to the plan WCD.
- The plan must provide a blowout scenario for the well with the highest volume (including volume, flow rate, and duration). The WCD is compared to the corresponded OSRP to determine if it would supersede the scenario in the approved OSRP. If a plan WCD is greater than the OSRP WCD, then the OSRP may need to be revised.

The WCD submitted by operators for plans in the Gulf of Mexico OCS is evaluated by BOEM's Office of Resource Evaluation. A review is performed in which the Office of Resource Evaluation performs an evaluation of the submitted WCD information against BOEM data and the corresponding approved OSRP. If the review does not concur with the WCD as submitted by the operator, the operator may be required to revise the WCD or possibly submit a revised OSRP to BSEE for approval. An acceptable WCD is required for the completion of reviews required by the BOEM's Office of Environment's NEPA oil-spill analysis review prior to any NEPA final action approval for plans.

The WCD review includes the following:

- verification of operator-submitted analogs, assumptions, and calculations through independent analysis;
- verification of proprietary and nonproprietary data using the corporate database; and
- verification of the WCD parameters assumes a successful exploration operation as proposed.

5.13.3 Oil-Spill Response Plans

The BSEE regulations at 30 CFR part 254 require that all owners and operators of oil-handling, storage, or transportation facilities located seaward of the coastline submit an OSRP for approval. The term "coastline" means the line of ordinary low water along that portion of the coast that is in direct contact with the open sea and the line marking the seaward limit of inland waters. The term "facility" means any structure, group of structures, equipment, or device (other than a vessel), which is used for one or more of the following purposes: exploring for; drilling for; producing; storing; handling; transferring; processing; or transporting oil. An MODU is classified as a facility when engaged in drilling or downhole operations.

The regulation at 30 CFR § 254.2 requires that an OSRP must be submitted and approved before an operator can use a facility. The BSEE can grant an exception to this requirement during its review of an operator's submitted OSRP. In order to be granted this exception during this time period, an owner/operator must certify in writing to BSEE that it is capable of responding to a "worst-case" spill or the substantial threat of such a spill. To continue operations, the facility must be operated in compliance with the approved OSRP or BSEE-accepted "worst-case" spill certification. Owners or operators of offshore pipelines are required to submit an OSRP for any pipeline that carries oil, condensate, or gas with condensate. Pipelines carrying essentially dry gas do not require an OSRP. Current OSRPs are required for abandoned facilities until they are physically removed or dismantled.

The OSRP describes how an operator intends to respond to an oil spill. An OSRP may be site specific or regional (30 CFR § 254.3). The term "regional" means a spill response plan that covers multiple facilities or leases of an owner or operator, including affiliates, which are located in a similar Gulf of Mexico region. The subregional plan concept is similar to the regional concept, which allows leases or facilities to be grouped together for the purposes of (1) calculating response times, (2) determining quantities of response equipment, (3) conducting oil-spill trajectory analyses, (4) determining WCD scenarios, and (5) identifying areas of special economic and environmental importance that may be impacted and the strategies for their protection. The number and location of the leases and facilities allowed to be covered by a subregional OSRP will be decided by BSEE on a case-by-case basis considering the proximity of the leases or facilities proposed to be covered. The BSEE NTL No. 2012-N06 includes guidance on the preparation and submittal of regional OSRPs.

The Emergency Response Action Plan within the OSRP serves as the core of the BSEE-required OSRPs. In accordance with 30 CFR part 254, the Emergency Response Action Plan requires identification of (1) the qualified individual and the spill-response management team, (2) the spill-response operating team, (3) the oil-spill cleanup organizations under contract for response, and (4) the Federal, State, and local regulatory agencies that an owner/operator must notify or that they must consult with to obtain site-specific environmental information when an oil spill occurs. The OSRP is also required to include an inventory of appropriate equipment and materials, their availability, and the time needed for deployment, as well as information pertaining to dispersant use, *in-situ* burning, a WCD scenario, contractual agreements, training and drills, identification of potentially impacted environmental resources and areas of special economic concern and environmental importance, and strategies for the protection of these resources and areas. The response plan must provide for response to an oil spill from the facility, and the operator must immediately carry out the provisions of the plan whenever an oil spill from the facility occurs. The OSRP must be in compliance with the National Contingency Plan and the Area Contingency Plan(s). The operator is also required to carry out the training, equipment testing, and periodic drills described in the OSRP. All BSEE-approved OSRPs must be reviewed at least every 2 years (biennial compliance). In addition, revisions must be submitted to BSEE within 15 days whenever

- a change occurs that appreciably reduces an owner/operator's response capabilities;
- a substantial change occurs in the worst-case discharge scenario or in the type of oil being handled, stored, or transported at the facility;
- there is a change in the name(s) or capabilities of the oil-spill removal organizations cited in the OSRP; or
- there is a change in the applicable Area Contingency Plans.

Following the *Deepwater Horizon* explosion and oil spill, BSEE provided guidance regarding additional information that operators should submit regarding spill response and surface containment in light of the "worst-case" discharge calculations that are required by the regulations and clarified in BOEM NTL No. 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS," which became effective on June 18, 2010. This NTL, which has been superseded by BOEM NTL No. 2015-N01, provides clarification of the regulations requiring a lessee or operator to submit supplemental information for new or previously submitted EPs, DPPs, or DOCDs. The required supplemental information includes the following: (1) a description of the blowout scenario as required by 30 CFR §§ 550.213(g) and 550.243(h); (2) a description of their assumptions and calculations used in determining the volume of the worst-case discharge required by 30 CFR § 550.219(a)(2)(iv) (for EPs) or 30 CFR § 550.250(a)(2)(iv) (for DPPs and DOCDs); and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed. The early intervention methods could actually include the surface and subsea containment resources that BSEE announced in BSEE NTL No. 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," which states that BSEE will conduct reviews to ensure that the measures are adequate to promptly respond to a blowout or other loss of well control.

Additionally, to address new improved containment systems, BSEE NTL No. 2010-N10 became effective on November 8, 2010. This NTL applies only to operators conducting operations using subsea or surface BOPs on floating facilities. It clarified the regulations requiring that lessees and operators must submit a certification statement signed by an authorized company official with each application for a well permit, indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations (DOI and BOEMRE 2010a). The NTL also informs lessees that BSEE will evaluate whether or not each operator has submitted adequate information, demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control.

The following requirements are implemented according to BSEE's regulations at 30 CFR parts 250 and 254:

- requires immediate notification for spills >1 bbl—all spills require notification to USCG, and BSEE receives notification from USCG of all spills ≥1 bbl;
- conducts investigations to determine the cause of a spill;
- assesses civil and criminal penalties, if needed;
- oversees spill source control and abatement operations by industry;
- sets requirements and reviews and approves OSRPs for offshore facilities;
- conducts unannounced drills to ensure compliance with OSRPs;
- requires operators to ensure that their spill-response operating and management teams receive appropriate spill-response training;
- conducts inspections of oil-spill response equipment;
- requires industry to show financial responsibility to respond to possible spills (financial responsibility implementation and verification is handled by BOEM's Office of Leasing and Plans; and
- provides research leadership to improve the capabilities for detecting and responding to an oil spill in the marine environment.

BOEM receives and reviews the worst-case discharge and blowout scenarios information submitted for EPs, DPPS, and DOCDs on the OCS. BOEM also has regulatory requirements addressing site-specific OSRPs and spill response information. As required by BOEM at 30 CFR §§ 550.219 and 550.250, operators are required to provide BOEM with an OSRP that is prepared in accordance with 30 CFR part 254 subpart B with their proposed exploration, development, or production plan for the facilities that they will use to conduct their activities; or to alternatively reference their approved regional OSRP by providing the following information:

- a discussion of the approved OSRP;
- the location of the primary oil-spill equipment base and staging area;

- the name of the oil-spill equipment removal organization(s) for both equipment and personnel;
- the calculated volume of the WCD scenario in accordance with 30 CFR § 254.26(a) and a comparison of the WCD scenario in the approved regional OSRP with the WCD calculated for these proposed activities; and
- a description of the WCD to include the trajectory information, potentially impacted resources, and a detailed discussion of the spill response proposed to the WCD in accordance with 30 CFR §§ 254(b)-(d).

All OSRPs are reviewed and approved by BSEE, whether submitted with a BOEM-associated plan or directly to BSEE in accordance with 30 CFR part 254. Hence, BOEM relies heavily upon BSEE's expertise to ensure that the OSRP complies with all pertinent laws and regulations, and demonstrates the ability of an operator to respond to a WCD. The operator is also required to carry out the training, equipment testing, and periodic drills described in the OSRP. Since 1989, BSEE and its predecessor MMS has conducted government-initiated unannounced exercises that provide an economically feasible mechanism for agencies to comply with the requirements defined in 30 CFR part 254. The government-initiated unannounced exercises allow BSEE to evaluate, on a no notice basis, the response preparedness of offshore exploration and production operators. In a government-initiated unannounced exercise, BSEE and its interagency partners may focus on a number of objectives to test a specific OSRP. These objectives typically include the following:

- ability to make timely notifications to emergency officials;
- mobilize and organize staff to respond to the spill;
- plan for and implement various spill-response strategies and tactics;
- deploy and operate response equipment; and
- establish effective communications within a unified command.

Industry can also meet oil-spill exercise requirements under 30 CFR part 254 by complying with the National Preparedness for Response Program's guidelines. This Program was developed to establish a workable exercise program that meets the intent of Section 4202(a) of the Oil Pollution Act of 1990. Equipment deployment exercises most often take place in waterways adjacent to where the equipment is stored, but they may be moved if the exercise requires it. Typical deployment exercises last only a few hours and rarely longer than a day. Site-specific OSRPs are required to be submitted to BOEM with a proposed EP, DOCD, or DPP, and BOEM's regulations require that an operator must have an OSRP approved by BSEE prior to BOEM's approval of an operator-submitted EP, DOCD, or DPP.

Several NTLs and guidance documents have been issued by BOEM and BSEE that clarify additional oil-spill requirements since the occurrence of the *Deepwater Horizon* explosion, oil spill, and response. The following is a summary of these guidance NTLs.

Worst-Case Discharge and Blowout Scenario Information

BOEM NTL No. 2015-N01

BOEM issued NTL 2015-N01, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS for Worst Case Discharge and Blowout Scenarios." This NTL became effective on January 4, 2015, and explains the procedures for the lessee or operator to submit WCD and blowout scenario information for new or previously submitted EPs, DPPs, or DOCDs. This NTL supersedes BOEM NTL No. 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS." The required information to be submitted for new EPs, DPPs, and DOCDs or as a supplement to a previously submitted plan includes the following: (1) a blowout scenario as required by 30 CFR §§ 550.213(g) and 550.243(h); (2) a description of the assumptions and calculations used in determining the volume of the WCD required by 30 CFR § 550.219(a)(2)(iv) (for EPs) or 30 CFR § 550.250(a)(2)(iv) (for DPPs and DOCDs); and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed.

BOEM also issued NTL No. 2015-N01, "Frequently Asked Questions Information Sheet for Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS for Worst Case Discharge and Blowout Scenarios." This Frequently Asked Questions information sheet provides guidance intended to assist an operator's compliance with the WCD and blowout scenario information requirements pursuant to BOEM NTL No. 2015-N01 and also provides information regarding BOEM's review of the submitted information.

BSEE NTL No. 2013-N02

BSEE issued NTL No. 2013-N02, "Significant Change to Oil Spill Response Plan Worst Case Discharge Scenario." This NTL clarifies what BSEE considers to be a significant change in a WCD scenario, requiring that a revision to an OSRP be submitted. The guidance issued by this NTL states that a significant change in WCD may occur when calculating a new WCD based upon the following:

- the addition of a new facility installation or well;
- a modification to an existing facility; or
- a change in any assumptions and calculations used to determine the previously estimated WCD.

The BSEE NTL No. 2013-N02 identifies the process an owner or operator of a facility should follow to determine whether the newly calculated WCD represents a significant change. The BSEE considers a change in WCD as significant, thus requiring revision, when the process identifies the need for additional onshore or offshore response equipment beyond what is included in an approved

OSRP. Although information to make this determination is submitted to BOEM and forwarded to BSEE with a proposed EP, DOCD, or DPP pursuant to BSEE NTL No. 2013-N02, the 15-day timeframe for notification of a significant change will be enforced by BSEE as beginning no later than the date that the operator submitted an Application for Permit to Drill.

Typically, for OSRP revisions, once BSEE approves an OSRP, it must be reviewed at least every 2 years, and modifications must be submitted in accordance with 30 CFR § 254.30(a). If no modifications are deemed necessary, the owner or operator must inform BSEE in writing that there are no changes.

BSEE NTL No. 2012-N06

The BSEE also issued NTL No. 2012-N06, "Guidance to Owners and Offshore Facilities Seaward of the Coast Line Concerning Regional Oil Spill Response Plans." This NTL, which was effective on August 10, 2012, provides clarification, guidance, and information concerning the preparation and submittal of a regional OSRP for owners and operators of oil handling, storage, or transportation facilities, including pipelines located seaward of the coastline. A regional OSRP is defined as a spill response plan covering multiple facilities or leases of an owner, or operator, or their affiliates, which are located in the same BSEE region. Site-specific OSRPs submitted with Bureau of Ocean Energy Management EPs, DOCDs, or DPPs can either be prepared using the 30 CFR part 254 regulations or the guidance outlined in BSEE NTL No. 2012-N06.

Some of the clarifications and encouraged practices identified in BSEE NTL No. 2012-N06 are based upon lessons learned from the *Deepwater Horizon* oil-spill response. This NTL indicates that BSEE's review of OSRPs would be based, in part, upon information obtained during the *Deepwater Horizon* oil-spill response. For example, during the *Deepwater Horizon* oil-spill response, it was discovered that the total estimated de-rated recovery capacity for all equipment listed in the OSRP overestimated the amount of oil that could be removed from the water. The BSEE NTL No. 2012-N06 therefore states that the OSRP should be developed considering (1) a fully developed response strategy that includes the identification of the available dedicated recovery equipment as well as the actual operating characteristics of the systems associated with each skimmer and (2) the use of new technology and response systems that will increase the effectiveness of mechanical recovery tactics.

The BSEE NTL No. 2012-N06 is designed to encourage owners and operators of offshore facilities to include innovative offshore oil-spill response techniques, particularly for a continuous high-rate spill. This NTL includes requirements for the submittal of information regarding subsea containment equipment and subsea dispersant application among other provisions. The NTL also encourages the inclusion of options that would improve spill-response capabilities such as

- using remote-sensing techniques as a tool for safe night operations to increase oil-spill detection and to improve thickness determinations for ascertaining the effectiveness of response strategies;

- increasing spill-response operational time by reducing transit times to disposal locations and decontamination equipment;
- identifying sources for supplies and materials, such as fire boom and dispersants, that can support a response to an uncontrolled spill lasting longer than 30 days or for the duration of the spill response; and
- using and specifying primary and secondary communications technology and software for coordinating and directing spill-response operations systems and/or providing a common operating picture to all spill management and response personnel, including the Federal On-Scene Coordinator and participating Federal and State government officials.

BSEE NTL No. 2012-N07

The BSEE issued NTL No. 2012-N07, "Oil Discharge Written Follow-up Reports." This NTL addresses the oil discharge reports (30 CFR § 254.46(b)(2)) that are required to be submitted by a responsible party to BSEE for spills >1 bbl within 15 days after a spill has been stopped or ceases. The responsible party is required to report cause, location, volume, remedial action taken, sea state, meteorological conditions, and the size and appearance of the slick.

NTL No. 2010-N10

The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) issued NTL No. 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," which became effective on November 8, 2010. This NTL applies only to operators conducting operations using subsea or surface BOPs on floating facilities. It provides guidance stating that lessees and operators must submit a statement signed by an authorized company official with each application for a well permit indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations (DOI and BOEMRE 2010a). This NTL also informs lessees that BSEE will evaluate whether or not each operator has submitted adequate information, demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. This NTL lists the type of information that BSEE would review as follows:

- subsea containment and capture equipment, including containment domes and capping stacks;
- subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment;
- riser systems;
- remotely operated vehicles;
- capture vessels;

- support vessels; and
- storage facilities.

BOEM's NEPA Oil-Spill Analysis Review

The NEPA oil-spill analysis review was created following the *Deepwater Horizon* oil spill to enable the BOEM postlease process to track oil spill-related reviews in TIMS. New reporting requirements and reviews, such as BSEE NTL No. 2010-N06, were instituted as a result of post-spill reorganization efforts. The NEPA oil-spill analysis review was created to verify that all oil-spill information and associated reviews are completed prior to a final NEPA action being issued by BOEM's Office of Environment, Environmental Operations Section. The following reviews must be completed by BOEM before the final NEPA approval of a submitted plan:

- ***Plans Completeness Review*:** Assures that all elements of the operator's proposed activity have been submitted and the information is sufficient.
- ***Plans Oil Pollution Act Review*:** Verifies that the submitted plan is in compliance with the Oil Pollution Act and that all oil spill-related information submitted in the plan is accurate and sufficient.
- ***Oil Pollution Act's Worst-Case Discharge Verification Review*:** Assures the accuracy and completeness of oil-spill information submitted in plans as related to the WCD. The operator's WCD, which is submitted along with the plan, is verified and approved by BOEM's Office of Resource Evaluation; and the OSRP, which is approved by BSEE, is validated.
- ***NTL No. 2010-N06 Verification Review*:** Assures that the operator has complied with the requirements of NTL No. 2010-N06, which has been superseded by NTL No. 2010-N01, and defines the oil-spill response information that must be included in an operator's submitted plan such as a potential to bridge over statement, relief well drilling information and timeline, and oil-spill response capability.

5.13.4 BSEE Well Control Rule

On September 28, 2018, BSEE published revisions to the 2018 Oil and Gas Production Safety Systems Rule, which became effective on December 27, 2018 (BSEE 2018a), and on May 2, 2019, BSEE published revisions for the 2019 Well Control and Blowout Preventer Rule, which became effective on July 15, 2019 (BSEE 2019a). BOEM has independently reviewed BSEE's Final Environmental Assessment and Finding of No Significant Impact (FONSI) for the 2019 Well Control and Blowout Preventer Proposed Rule and the Final Environmental Assessment and FONSI for the 2018 Oil and Gas Production Safety Systems Rule (BSEE 2018c; 2018d; 2019c; 2019d). For purposes of this document, BOEM agrees with BSEE's conclusions that the updates in the final rule do not change or increase environmental risks from what they were under the 2016 rules. BOEM agrees with the conclusions because the changes to the rules carefully removed unnecessary burdens while leaving critical safety provisions intact, did not change the overall risks related to oil and gas activities on the OCS, and did not change the potential impacts that may result from OCS oil and gas activities in the Gulf of Mexico.

5.13.5 Spill-Response Initiatives

For more than 25 years, BSEE and its predecessors have maintained a comprehensive long-term research program to improve oil-spill response knowledge and technologies. The program is administered by BSEE's Oil Spill Preparedness Division. The major focus of the program is to improve the methods and technologies used for oil-spill detection, containment, treatment, recovery, and cleanup. The BSEE Oil Spill Response Research Program is a cooperative effort bringing together funding and expertise from research partners in State and Federal government agencies, industry, academia, and the international community. The projects funded cover numerous spill response-related issues such as chemical treating agents; *in-situ* burning of oil; research conducted at BSEE's Oil Spill Response Test Facility (Ohmsett) located in Leonardo, New Jersey; behavior of oil; decisionmaking support tools; mechanical containment; and remote sensing.

A few of BSEE's research contracts that highlight the varied types of funded research include the following:

- "In-Situ Burn Testing of California Crude Oils" (Project Number 1085) – The objective of this study is to determine the effect on an oil type's chemical and physical properties. Specifically, how these properties will affect emulsification form wave turbulence, and weathering from evaporation and photochemical reaction. Oil-spill responders need to understand how much emulsification and weathering an oil type can undergo and still be ignited for in-situ burning to be a practical remediation strategy.
- "Development of an Oil Recovery Efficiency Sensor" (Project Number 1083) – This project's objective was to develop and test an in-line flow through an oil recovery sensor (RE Sensor) to monitor in real time the percentage of oil and water in fluid recovered during oil-spill response operations. This sensor was tested at Ohmsett in June 2018 with multiple salinities and oil types. Average percentage error across all tests was 6 percent.
- "Equip GRID and GRIDSAT Tags with Accelerometers to Measure Ocean Waves" (Project Number 1080) – This program's objective is to (1) enhance the latest generation of GRID and GRIDSAT tags with 3-axis accelerometers and other equipment/technology necessary to measure wave characteristics (e.g., wave height, wave length, wave period, etc.); (2) use enhanced GRID and GRIDSAT tags to equip and test commercially available mechanical skimming units for wave characterization with accuracy within 4 inches, including choppy wave conditions as well as various sinusoidal wave conditions; (3) achieve satellite communication to transmit data for operational awareness; and (4) create a user-friendly operator interface for skimmer operations.

- "*Deepwater Horizon* Lessons Learned – Methodology and Operational Tools to Assess Future Oil Spills" (Project Number 1079) – BSEE has teamed up with NOAA to provide control and validation for surface oiling characterization efforts. The ultimate goal was to validate and quantify the capabilities of various remote-sensing systems and sensors, provide BSEE and NOAA the needed methodology and operational tools to assess future oil spills, and the ability to monitor and measure more accurately the thickness of surface oil slicks in the marine environment.

More information on these and the other awarded and completed research projects can be found on BSEE's website at https://www.bsee.gov/what-we-do/oil-spill-preparedness/oil-spill-response-research/master-list-of-oil-spill-research.

5.13.6 Incident Reporting

The MMS (BOEM's predecessor) revised operator incident reporting requirements in a final rule effective on July 17, 2006 (DOI and MMS 2006). The incident reporting rule defines what incidents must be reported, includes incidents that have the potential to be serious, and requires the reporting of standard information for both oral and written reports. As part of the incident reporting rule, BOEM's regulations at 30 CFR § 250.188(a)(6) require an operator to report all collisions that result in property or equipment damage greater than $25,000. "Collision" is defined as the act of a moving vessel (including an aircraft) striking another vessel or striking a stationary vessel or object (e.g., a boat striking a drilling rig or platform).

5.13.7 Financial Responsibility

The responsible party for covered offshore facilities must demonstrate oil-spill financial responsibility, as required by 30 CFR part 553. These regulations implement the oil-spill financial responsibility requirements of Title I of the Oil Pollution Act of 1990, as amended. Penalties for noncompliance with these requirements are covered at 30 CFR § 553.51 and in NTL No. 2008-N05, "Guidelines for Oil Spill Financial Responsibility for Covered Facilities." A covered offshore facility, as defined in 30 CFR § 553.3, is any structure and all of its components (including wells completed at the structure and the associated pipelines), equipment, pipeline, or device (other than a vessel or other than a pipeline or deepwater port licensed under the Deepwater Port Act of 1974) used for exploring, drilling, or producing oil, or for transporting oil from such facilities. BOEM ensures that each responsible party provides sufficient financial assurance for removal costs and damages resulting from the accidental release of liquid hydrocarbons into the environment for which the responsible party is liable.

BOEM's Office of Leasing and Plans, Leasing and Financial Responsibility Section is responsible for the verification of the required financial responsibility for operators with activities in the Gulf of Mexico OCS. Financial bonding is required of operators in the GOM to ensure that they are financially capable of responding to any oil-spill events or accidents related to their oil and gas operations. Plans are not approved or APDs are not issued without verification of the appropriate level of financial responsibility to cover any oil spills and/or accidents on the Gulf of Mexico OCS. On October 16, 2020, BOEM and BSEE published a notice of proposed rulemaking and request for comment on the Proposed Offshore Financial Assurance Rule. The proposed rule seeks to clarify, streamline, and provide greater transparency to financial assurance requirements (e.g., bonding) for the offshore oil and gas industry while protecting American taxpayers against high-risk decommissioning liabilities. More information on the Proposed Financial Assurance Rule can be found on BOEM's website at https://www.boem.gov/proposed-financial-assurance-rule.

5.14 Best Available and Safest Technologies (BAST)

To assure that oil and gas exploration, development, and production activities on the OCS are conducted in a safe and environmentally sound manner, 43 U.S.C. § 1347(b) of the OCSLA, as amended, requires that all OCS technologies and operations use the BAST whenever practical. The BSEE Director may require additional BAST measures to protect safety, health, and the environment, if it is economically feasible and the benefits outweigh the costs. Conformance to the standards, codes, and practices referenced in or required under the authority of 30 CFR part 250 is considered the application of the BAST. These standards, codes, and practices include requirements for state-of-the-art drilling technology, production safety systems, oil and gas well completions, oil-spill response plans, pollution-control equipment, and specifications for platform/structure designs. The BSEE conducts periodic offshore inspections and continuously and systematically reviews OCS technologies to ensure that the BAST is applied to OCS operations. The BAST is not required when BSEE determines that the incremental benefits are clearly insufficient to justify increased costs; however, it is the responsibility of an operator of an existing operation to demonstrate why application of a new technology would not be feasible. The BAST requirement is applicable to equipment and procedures that, upon failure, would have a significant effect on safety, health, or the environment, unless benefits clearly do not justify the cost (30 CFR §§ 250.107(c) and (d)).

The BAST concept is addressed in BSEE’s Gulf of Mexico OCS region by a continuous effort to locate and evaluate the latest technologies and to report on these advances at periodic Regional Operations Technology Assessment Committee meetings. A part of BSEE’s staff has an ongoing function to evaluate various vendors and industry representative’s innovations and improvements in techniques, tools, equipment, procedures, and technologies applicable to oil and gas operations (i.e., drilling, producing, completion, and workover operations). This information is provided to BSEE’s District personnel at Regional Operations Technology Assessment Committee meetings. The requirement for the use of the BAST has been, for the most part, an evolutionary process whereby advances in equipment, technologies, and procedures have been integrated into OCS operations over a period of time. Awareness by both BSEE inspectors and OCS operators of the most advanced equipment and technologies has resulted in the incorporation of these advances into day-to-day operations. An example of such an equipment change that evolved over a period of time would be the upgrading of diverter systems on drilling rigs from the smaller diameter systems of the past to the large-diameter, high-capacity systems found on drilling rigs operating on the OCS today.

Production Facilities

The BSEE regulations governing oil and gas production safety systems can be found in 30 CFR part 250 subpart H. Production safety equipment used on the OCS must be designed, installed, used, maintained, and tested in a manner to assure the safety and protection of the human, marine, and coastal environments. All tubing installations open to hydrocarbon-bearing zones below the surface must be equipped with safety devices that will shut off the flow from the well in the event of an emergency, unless the well is incapable of flowing. Surface- and subsurface-controlled safety valves and locks must conform to the requirements of 30 CFR § 50.801. All surface production facilities, including separator and treatment tanks, compressors, headers, and flowlines, must be designed, installed, and maintained in a manner that provides for efficiency, safety of operations, and protection of the environment. Production facilities also have stringent requirements concerning electrical systems, flowlines, engines, and firefighting systems. The safety-system devices are tested by the lessee at specified intervals and must be in accordance with API RP 14 C Appendix D and other measures.

5.15 Personnel Training and Education

An important factor in ensuring that offshore oil and gas operations are carried out in a manner that emphasizes operational safety and minimizes the risk of environmental damage is the proper training of personnel. Under 30 CFR part 250 subpart O, BSEE has outlined well control and production safety training program requirements for lessees operating on the OCS. The goal of the regulation (30 CFR § 250.1501) is safe and responsible OCS operations. Lessees must ensure that their employees and contract personnel engaged in well control or production safety operations understand and can properly perform their duties. To accomplish this, the lessee must establish and implement a training program so their employees are trained to competently perform their assigned well control and production safety duties. The lessee must also verify that their employees understand and can perform the assigned duties.

The mandatory Drilling Well-Control Training Program was instituted by MMS in 1979. In 1983, the mandatory Safety Device Training Program was established to ensure that personnel involved in installing, inspecting, testing, and maintaining safety devices are qualified. As a preventive measure, all offshore personnel must be trained to operate oil-spill cleanup equipment, or the lessee must retain a trained contractor(s) to operate the equipment for them. In addition, BSEE offers numerous technical seminars to ensure that operator personnel are capable of performing their duties and are incorporating the most up-to-date safety procedures and technology in the petroleum industry.

On February 5, 1997, MMS published a final rule in the *Federal Register* concerning the training of the lessee and contractor employees engaged in drilling, well completion, well workover, well serving, or production safety system operations in the OCS (DOI and MMS 1997b). The final rule streamlined the previous regulations by 80 percent, provided the flexibility to use alternative training methods, and simplified the training options at 30 CFR part 250 subpart O. Although the rule did away with many of the onerous requirements in subpart O and served as an intermediate change to the system, it did not sufficiently address the development of a performance-based training system.

On August 14, 2000, MMS published in the *Federal Register* final regulations revising 30 CFR part 250 subpart O, "Well Control and Production Safety Training" (DOI and MMS 2000). The MMS distributed the published final rulemaking to lessees, operators, and training schools. These new performance-based regulations took effect on October 13, 2000. To allow sufficient time for implementation, the rule provided a 2-year transition period from October 13, 2000, until October 15, 2002. After October 15, 2002, all lessees were required to comply with this rule.

- ***Goal of Performance Training Rule*****:** Safe and responsible OCS operations. Lessees must ensure their employees, including contractors, are trained to competently perform their assigned well control and production safety duties. This rule allows companies to focus their resources on important areas in their training program rather than sending all of their personnel to the same school program on a routine basis.
- ***Key Elements of Performance-Based Training*****:** Under this rule, schools will be free to operate but they will not receive agency approval and they will no longer be able to issue subpart O certifications. By shifting the responsibility of developing training programs to industry, lessees are free to select the type of training necessary for their employees. The BSEE will hold the lessees responsible for the success or failure of these and other training-related programs.
- ***Lessees Training Plan*****:** The lessees' training plan is the core item of BSEE's performance-based program. The plan, which does not have to be approved by BSEE, lays out the operator's training philosophy. It must specify the type, method(s), length, frequency, and content of their program. Training requirements under this rule are limited to only well control and production operations.
- ***Performance Indicators*****:** The BSEE will periodically assess lessee and contractor training programs to see how well their employees are trained. To assess programs, BSEE may use one or more of the following evaluation methods: (1) audits; (2) written tests; (3) hands-on tests; and (4) employee interviews.

5.16 Safety and Environmental Management Systems (SEMS)

The Safety and Environmental Management Systems (SEMS) is a nontraditional, performance-focused tool for integrating and managing offshore operations administered by BSEE. The purpose of SEMS is to enhance the safety of operations by reducing the frequency and severity of accidents.

Four Principle SEMS Objectives

The four principle SEMS objectives are listed below:

- focus attention on the influences that human error and poor organization have on accidents;

- continuous improvement in the offshore industry's safety and environmental records;
- encourage the use of performance-based operating practices; and
- collaborate with industry in efforts that promote the public interests of offshore worker safety and environmental protection.

On October 15, 2010, BSEE published the Final Rule for 30 CFR part 250 subpart S – "Safety and Environmental Management Systems" in the DOI and BOEMRE (2010b). This Final Rule incorporates by reference, and makes mandatory, the American Petroleum Institute's Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities (API RP 75), Third Edition, May 2004, reaffirmed May 2008. This recommended practice, including its appendices, constitutes a complete Safety and Environmental Management System. The Bureau of Safety and Environmental Enforcement's SEMS Rule requires that all operators submit performance measure data outlined in the OCS Performance Measures Program (https://www.bsee.gov/resources-and-tools/compliance/safety-and-environmental-management-systems-sems).

5.17 OFFSHORE WORKER HEALTH AND SAFETY

This chapter primarily deals with the health and safety of offshore oil and gas workers, the risks they may face, and the regulations in place to protect them. Because BOEM does not regulate the health and safety of offshore workers or enforce such regulations, a full effects analysis of the potential health and safety effects to those workers is not included in this document. However, BOEM acknowledges that these risks exist and summarizes the potential hazards below. Following the discussions of the potential hazards to offshore oil and gas workers is an overview of the regulations in place to minimize these risks.

5.17.1 Potential Health Hazards

There are several health hazards associated with oil and gas extraction activities, including diesel particulate matter, hazardous chemicals, hydrocarbon gases and vapors and low oxygen environments, H_2S, NORM, silica, fatigue, noise, and temperature extremes. Diesel engines power a variety of machinery, vehicles, and equipment used in oil and gas drilling. Workers might be exposed to harmful levels of diesel particulate matter during the operation of these engines. Workers who use hazardous chemicals during work processes might be exposed to hazardous byproducts of oil and gas drilling. The degree of potential hazard depends on individual chemical properties and toxicity, but possible hazards include chemical burns from caustic substances and inhalation of toxic vapors. All employers with hazardous chemicals in their workplaces must have labels and safety data sheets for their exposed workers and train them to handle the chemicals appropriately. Establishing effective engineering controls and work practices can reduce potential worker overexposures (OSHA 2020a).

Oil and gas wells can release H_2S and expose workers to H_2S gas. The three best practices to help prevent injury and death are active monitoring for H_2S gas, good planning, and training programs for workers. The NORM might be released from oil and gas formations. Workers at risk of exposure include those who handle pipes and equipment that might have been contaminated with NORM. Sludge, drilling mud, and pipe scales, for example, often contain elevated levels of NORM, and the radioactive materials might be moved from site to site as equipment and materials are reused. Disposal, reuse, and recycling of NORM might cause worker exposures. Workers might be exposed to respirable crystalline silica during processes that use sand, such as hydraulic fracturing (OSHA 2020a).

Workers may also experience exposure to physical risks as well as the chemical risks discussed above. Workers might experience fatigue due to long shifts and when working multiple days in a row. Oil and gas workers can be exposed to harmful noise levels during equipment operation. Well-site workers are exposed to extreme temperatures and should take precautions to stay safe (OSHA 2020a).

5.17.2 Potential Safety Hazards

Safety hazards associated with oil and gas extraction activities include vessel collisions, struck-by/caught-in/caught-between accidents, falls, confined spaces, ergonomic hazards, explosions and fires, high pressure lines and equipment, electrical and other hazardous energy, and machine hazards. The severity of the risks to offshore workers would depend on the worker's job and the amount of time the worker spends offshore. The following information on safety hazards associated with oil and gas extraction activities, as well as the guidance for workers to protect themselves, is from the Occupational Safety and Health Administration (OSHA).

Vessel and aircraft collisions could pose safety hazards to offshore oil and gas workers. Workers and equipment are required to be transported to and from well sites. Wells are often located far offshore and require traveling long distances to get to the sites. Workers might be exposed to struck-by/caught-in/caught-between hazards from multiple sources, including moving vehicles or equipment, falling equipment, and high-pressure lines. Workers might be required to access platforms and equipment located high above the ground. The OSHA requires fall protection to prevent falls from the mast, drilling platform, and other elevated equipment (OSHA 2020b).

Workers are often required to enter confined spaces such as petroleum and other storage tanks, mud pits, reserve pits and other excavated areas, sand storage containers, and other confined spaces around a wellhead. Safety hazards associated with confined space include ignition of flammable vapors or gases. Health hazards include asphyxiation and exposure to hazardous chemicals. Confined spaces that contain or have the potential to contain a serious atmospheric hazard must be classified as permit-required confined spaces, tested prior to entry, and continuously monitored. Oil and gas workers might be exposed to ergonomics-related injury risks, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures, and performing the same or similar tasks repetitively. Risk factors and the resulting injuries can be minimized or, in many cases, eliminated through interventions such as pre-task planning, use of the right tools, proper placement of materials, education of workers about the risk, and early recognition and reporting of injury signs and symptoms. Workers might be exposed to hazards from compressed gases or from high-pressure lines (OSHA 2020b).

Workers in the oil and gas industries face the risk of fire and explosion due to the ignition of flammable vapors or gases. Flammable gases, such as well gases, vapors, and hydrogen sulfide, can be released from wells and production equipment such as tanks and shakers. Ignition sources can include static, electrical energy sources, open flames, lightning, cigarettes, cutting and welding tools, hot surfaces, and frictional heat. Internal erosion of lines might result in leaks or line bursts, exposing workers to high-pressure hazards from compressed gases or from high-pressure lines. If connections securing high-pressure lines fail, struck-by hazards might be created. Workers might be exposed to uncontrolled electrical, mechanical, hydraulic, or other sources of hazardous energy if equipment is not designed, installed, and maintained properly. Further, administrative controls such as operating procedures must be developed and implemented to ensure safe operations. Oil and gas extraction workers may be exposed to a wide variety of rotating wellhead equipment, including top drives and Kelly drives, drawworks, pumps, compressors, catheads, hoist blocks, belt wheels, and conveyors, and might be injured if they are struck by or caught between unguarded machines (OSHA 2020b).

5.17.3 Regulatory Compliance

Several Federal agencies are responsible for the regulation and monitoring of offshore oil and gas worker health and safety, and those agencies have Memorandums of Understanding with DOI to ensure protections are in place to reduce risks to offshore oil and gas workers. Releases to the air and water are highly regulated and monitored to ensure that offshore workers are not exposed to high levels of discharges or emissions, and protocols and training are in place to reduce incidents offshore. Refer to **Chapters 4.1 and 4.2** and the *Gulf of Mexico OCS Regulatory Framework* technical report (BOEM 2020c) for more information on air and water quality regulations. For the purpose of the analysis included in this document, BOEM assumes operators have complied or will comply with the regulations and are following the necessary health and safety protocols to protect OCS oil and gas workers from possible health concerns or injury.

The OCSLA has conferred the U.S. Coast Guard, DOI, and OSHA with the statutory authority to promulgate regulations that address working conditions on offshore drilling platforms. Pursuant to the OCSLA, the USCG and DOI issued an extensive array of regulations applicable to occupational safety and health on the OCS. The DOI (through BSEE) regulates working conditions directly related to production platform activities and equipment. The USCG regulates production platform working conditions for safe access/egress, personal protective equipment, housekeeping, guarding of deck areas, lockout/tagout, lifesaving devices and equipment, lifeboats, firefighting equipment, fire extinguishers and systems, first-aid kits, emergency communications equipment, and commercial diving. Like BSEE, the USCG primarily regulates safety on the OCS. The OSHA regulates both health and safety standards not covered by DOI or the USCG, and OSHA cannot enforce its regulations if the working conditions are already regulated by another agency (Gurnham 2003). The National Institute for Occupational Safety and Health and other industry and safety groups work with OSHA to continuously evaluate the type and extent of chemical and other health hazards experienced by workers in the oil and gas industry.

The OCSLA granted the USCG principal safety and health authority on the OCS. By the OCSLA Amendments of 1978, Congress indicated that it expects the USCG to be the principal Federal agency on matters of safety and health. In 2002, the USCG authorized MMS (now BSEE) to conduct safety inspections onboard oil and gas platforms on the USCG's behalf. Although BSEE has some safety and health regulations, the USCG remains the primary agency with responsibility for safety and health for offshore oil and gas workers (OSHA 2010; Transportation Research Board 2013).

Under the Energy Policy Act of 2005, the OCSLA was amended and DOI was given the responsibility for regulating renewable energy on the OCS. The USCG became a cooperating agency for navigation safety and a subject-matter expert for marine safety. The BSEE does not have authority over renewable energy health and safety on the OCS (Transportation Research Board 2013).

The USCG has promulgated regulations on many occupational safety and health issues on the OCS (such as personal protection equipment, housekeeping, guarding of deck openings, Lockout Tagout, means of escape, lifesaving appliances, firefighting equipment, emergency equipment, work vests, alarm systems, emergency evacuation plans, and safety zones; 33 CFR §§ 140.1 *et seq*.), as well as on commercial diving (46 CFR part 197 subpart B). The U.S. Coast Guard diving regulations also cover diving in other locations such as diving conducted from an inspected vessel. The BSEE also has some safety and health regulations, primarily dealing with fire and explosion hazards (30 CFR §§ 250.106 *et seq*.) However, OSHA, in accordance with Section 4(b)(1) of the Offshore Safety and Health Act of 1970 (Public Law 91-596), still has responsibility for any hazardous working condition for which the USCG or BSEE has not yet promulgated a regulation. As the USCG or BSEE promulgate additional worker safety and health regulations, OSHA's application to OCS workplaces will diminish (OSHA 2010).

Both USCG marine inspectors and inspectors from BSEE conduct safety and health inspections on the OCS (33 CFR § 140.101(c) and 30 CFR § 250.130). These investigations alone do not relieve OSHA of its responsibilities. Working conditions may exist on offshore oil/gas rigs; these are addressed by OSHA standards applicable to general industry and the construction industry, for which neither the USCG nor BSEE has promulgated regulations. The OSHA and the USCG have entered into a Memorandum of Understanding, which sets forth procedures intended to avoid duplication regarding the issuance of citations for violations and regulatory overlap, while still retaining the agencies' mutual responsibilities (OSHA 2010).

5.17.3.1 BSEE-Regulated Protections for Offshore Oil and Gas Workers

Standards and regulations for operational safety and environmental protection for the exploration and development of OCS oil and gas are developed by BSEE's Office of Offshore Regulatory Programs. Through this program, offshore inspectors are continuously trained in evolving technologies for the enforcement of safety and environmental regulations offshore. The BSEE Oil

Spill Response Division oversees, develops policy, and provides guidance on oil-spill response activities. It also reviews industry oil-spill response plans for compliance with regulations. Compliance with environmental regulations and adherence to stipulations of approved leases, plans, and permits is overseen by BSEE's Environmental Enforcement Division. Permit applications are reviewed by BSEE's regional offices, and personnel from the regional offices inspect drill rigs and production facilities. Inspectors investigate accidents or incidents, can cite operators for noncompliance issues, and fine companies for regulatory infractions (Transportation Research Board 2013).

The BSEE regulates oil and gas operations on the OCS to prevent injury or loss of life under 30 CFR part 250 ("Oil and Gas and Sulphur Operations in the Outer Continental Shelf"). Rules for the health and safety of offshore workers are contained throughout the subparts of 30 CFR part 250.

- Subpart A – General requirements for health and safety, maintaining equipment, and safe work areas using the best available and safest technology. Requirements covered under Subpart A include using and maintaining cranes, qualifications for personnel and procedures for welding plans, and installing and operating electrical equipment.
- Subparts D, E, and F – Requirements for oil and gas well drilling, well completion, and well workover.
- Subpart H – Designing, installing, and operating safety equipment for oil and gas production systems.
- Subpart I – Requirements for design, construction, maintenance, inspection, and assessment of platforms and structures on the OCS.
- Subpart O – Requirements for implementing a well control and production safety training program.
- Subpart S – Requires a lessee to develop, implement, and maintain a SEMS for oil and gas operations.

The BSEE holds scheduled and unscheduled inspections of OCS oil and gas facilities and vessels to ensure worker safety as well as compliance with the terms of the lease and applicable regulations and laws. During the inspection, access to all facilities and areas listed on the lease must be provided by the operator, as well as all records of design, installation, maintenance, repairs, and investigations in the project area. As part of the inspection, BSEE examines the safety of equipment and operations based on a checklist of potential incidents of noncompliance. The checklist is formed of relevant safety and environmental regulations. Noncompliance with these regulations can result in an issuance of a citation to the operator (Transportation Research Board 2013).

5.17.3.2 USCG-Regulated Protections for Offshore Oil and Gas Workers

The USCG regulates navigation and safety of life and property on facilities and vessels that service those facilities engaged in OCS oil- and gas-related activities under 33 CFR subchapter N –

Outer Continental Shelf Activities, parts 140-147. The responsibility of enforcing requirements related to inspections and general workplace safety and health issues, such as personal protective equipment, lifesaving equipment, and firefighting equipment, are delegated to the USCG under subpart N. In 2002, safety inspections aboard oil and gas platforms were transferred to MMS (now BSEE) on behalf of the USCG in accordance with 33 CFR subpart N. The USCG and MMS (now BSEE) collaborated to develop procedures and the potential incidents of noncompliance checklist, which corresponds to the UCSG's inspection items, for personal safety inspections (Transportation Research Board 2013).

The regulations at 46 CFR Chapter I cover regulations for many OCS vessels: Subchapter I addresses general safety for personnel aboard vessels and Subchapter V addresses commercial diving from vessels under USCG jurisdiction.

The BSEE and USCG are jointly responsible for enforcing safety and environmental regulations for OCS oil and gas facilities, as outlined through their Memorandum of Agreement. This Memorandum of Agreement sets up a framework for communication and cooperation between BSEE and the USCG to avoid overlapping and duplicative regulations with regard to vessels servicing offshore oil and gas facilities. The Memorandum of Agreement, however, does not clearly address health and safety of personnel during interaction between a vessel and a facility of the OCS (Transportation Research Board 2013).

5.17.3.3 OSHA-Regulated Protections for Offshore Oil and Gas Workers

Health considerations for offshore workers are primarily covered under OSHA standards. The U.S. Department of Labor, OSHA, Directive Number CLP 02-01-047, dated February 22, 2010, establishes policies and provides guidance on OSHA's coverage of employees on vessels and at facilities located on or adjacent to U.S. navigable waters and the OCS. It primarily addresses a Memorandum of Understanding between OSHA and the USCG and the application of OSHA general industry, shipyard employment, marine terminals, longshoring, and construction standards to these situations. The OSHA coverage of occupational safety and health has not been preempted by any other Federal agency regarding oil and gas rigs that are located on U.S. navigable waters (i.e., State territorial seas or U.S. inland waters). Both the USCG and BSEE have advised OSHA by letter that they do not provide such coverage (OSHA 2010).

The General Duty Clause of the Occupational Safety and Health Act (the law that created OSHA) requires employers to provide workers with a safe workplace that does not have any recognized hazards that cause or are likely to cause death or serious injury. Exposures to hazards present in the oil and gas well drilling, servicing, and storage industry are addressed in specific standards for general industry (29 CFR part 1926). When a serious hazard exists in the workplace that is not addressed by a specific OSHA standard, Section 5(a)(l) ("General Duty Clause") of the Occupational Safety and Health Act applies. The OSHA has standards for the oil and gas industry that cover the physical work environment, powered platforms and manlifts, environmental controls, personal protective equipment, toxic and hazardous materials, materials handling and storage, fire protection and welding, large and small machinery, and electrical equipment (OSHA 2020c).

Some examples of hazards covered under general industry standards (29 CFR part 1910) include the items below.

- Subpart D – Walking surfaces and ladders
- Subpart E – Means of egress
- Subpart J – General environmental controls for confined space entry and lockout tagout
- Subpart L – Fire protection
- Subpart T – Commercial diving operations (Transportation Research Board 2013)

Maritime standards for shipyard employment are found in 29 CFR part 1915. Provisions for shipbuilding, ship repairing, and ship breaking are included in these regulations and include the items listed below.

- Subpart B – Confined and enclosed spaces
- Subpart E – Scaffolds and ladders
- Subpart F – General working conditions (Transportation Research Board 2013)

Maritime standards for marine terminal work can be found in 29 CFR part 1917. Regulations that apply to the loading and unloading of cargo or materials within the terminal area using shore-based cranes, derricks, or other cargo-handling equipment are handled under these regulations. The regulation 29 CFR part 1918 addresses rules for longshoring operations and tasks associated with working aboard vessels, accessing a vessel, and handling cargo. Regulations covering personal protective and lifesaving equipment, fire protection and prevention, fall protection, commercial diving, and cranes and derricks are covered under 29 CFR part 1926 (Transportation Research Board 2013).

In addition to regulations, OSHA has goal-based practices including process safety management and a voluntary protection program. Process safety management for operations with significant risk of hazardous chemical release, fire, or explosion are covered under 29 CFR §§ 1910.19 and 1926.64, and these regulations are set to control the release of hazardous chemicals to protect worker health and safety. These rules include procedures and management practices to prevent or reduce the consequences of toxic, flammable, explosive, and reactive liquid and gas release. This process safety management regulation is similar to the Bureau of Safety and Environmental Enforcement's SEMS, as it sets forth regulations for ensuring safe operations. The voluntary protection program is for both private industry and Federal agencies with illness and injury rates below the national average. This program implements a comprehensive health and safety management system and includes an external in-site evaluation. Employees and management must partake in yearly self-evaluations and prove the program is effective by showing injury is below the national average for a comparable workplace (Transportation Research Board 2013).

CHAPTER 6

COMMONLY APPLIED MITIGATING MEASURES

What is in This Chapter?

- A description of standard postlease mitigating measures that may be required by BOEM or BSEE as a result of the plan and permit review processes discussed in **Chapter 5**.

Key Points

- Conditions of approval are mechanisms to control or mitigate potential safety or environmental issues associated with proposed operations.
- BOEM revises applicable mitigations as needed to adaptively manage the evaluation of mitigation compliance and effectiveness.
- Operational compliance with the mitigating measures is enforced through BSEE's onsite inspection program.

6 COMMONLY APPLIED MITIGATING MEASURES

Postlease mitigating measures have been implemented for over 40 years in the Gulf of Mexico region, as they relate to OCS plans, as well as pipelines (installation and decommissioning), structure removal, and geological and geophysical applications. These mitigating measures have been amended over time to address changes in regulations, new technology, and new methods of operation. Many of these mitigating measures have been adopted as lease stipulations and incorporated into regulations and/or guidelines governing OCS oil- and gas-related exploration, development, and production activities. All plans for OCS oil- and gas-related activities (e.g., exploration and development plans, pipeline applications, geological and geophysical activities, and structure-removal applications) go through rigorous BOEM review and approval to ensure compliance with established laws and regulations (refer to **Chapter 5**). Existing mitigating measures (i.e., measures already established or agreed to by earlier authorization[s], such as through lease stipulations) must be incorporated and documented in plans submitted to BOEM. Operational compliance with the mitigating measures is enforced through BSEE's onsite inspection program.

Mitigating measures are an integral part of BOEM's program to ensure that postlease operations are always conducted in an environmentally sound manner (with an emphasis on minimizing any adverse impact of routine operations on the environment). For example, post-activity surveys are carried out to ensure that a site has been cleared of potential snags to commercial fishing gear, and pre-activity surveys seek to avoid archaeological sites and biologically sensitive areas such as pinnacles, topographic features, and chemosynthetic communities.

Some BOEM-identified mitigating measures are incorporated into OCS operations through cooperative agreements or efforts with industry and State and Federal agencies. These mitigating measures include NMFS' Observer Program to protect marine mammals and sea turtles during explosive structure removals, labeling operational supplies to track possible sources of debris or equipment loss, and development of methods of pipeline landfall to eliminate impacts to beaches or wetlands.

Site-specific mitigating measures are also applied by BOEM during plan and permit reviews. Since many of these site-specific mitigations are recurring, BOEM has developed a list of “standard” or commonly applied mitigations. The wording of a standard mitigation is developed by BOEM and may be applied whenever site-specific conditions warrant. Standard mitigation text is revised as often as is necessary (e.g., to reflect changes in regulatory citations, agency/personnel contact numbers, and internal policy). Site -specific mitigation “categories” include the following: air quality; archaeological resources; marine minerals; artificial reef material; chemosynthetic communities; Flower Garden Banks; topographic features; hard bottoms/pinnacles; military warning areas and Eglin Water Test Areas; hydrogen sulfide (H_2S); drilling hazards; remotely operated vehicle surveys; geophysical survey reviews; and general safety concerns. Site-specific mitigation “types” include the following: advisories; conditions of approval; hazard survey reviews; inspection requirements; notifications; post-approval submittals; and safety precautions. In addition to standard mitigations, BOEM may also apply nonrecurring mitigating measures that are developed on a case-by-case basis for a site-specific activity proposal.

Following a lease sale, an applicant seeks approvals to develop its lease by preparing and submitting OCS plans. The OCS plans are reviewed by BOEM and, if required based on site-specific environmental reviews, BOEM may assign conditions of approval. The conditions of approval become part of the approved postlease authorization and include environmental protections, requirements that maintain conformance with law, the requirements of other agencies having jurisdiction, and/or safety precautions.

Some examples of BOEM’s conditions of approval include the following:

- other approvals prerequisite to BOEM’s approval (e.g., the Coastal Zone Management Act);
- safety precautions (e.g., H2S present);
- post-approval submittals (e.g., surveys and interpretive reports, post activity anchor plats);
- inspection requirements (e.g., pipeline pressure testing);
- pre-deployment notifications (e.g., U.S. Department of Defense use restrictions and Military Warning Areas); and
- reduce or avoid environmental impacts on resources identified in NEPA or other laws (e.g., the National Historic Preservation Act and National Marine Sanctuaries).

BOEM revises applicable mitigations as needed to adaptively manage the evaluation of mitigation compliance and effectiveness. A primary focus of this effort is requirements for post-approval submittal of information within a specified timeframe or after a triggering event (e.g., end of operations reports for plans, construction reports for pipelines, and removal reports for structure removals).

Table 6.0.0-1 provides a list and description of standard postlease mitigating measures that may be required by BOEM or BSEE as a result of the plan and permit review processes discussed in **Chapter 5**.

Table 6.0.0-1. Commonly Applied or "Standard" Mitigating Measures (standard mitigation text is revised as needed to reflect changes in regulatory citations, agency/personnel contact numbers, and any other internal policy changes).

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
0.0		Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans or permit applications.
0.0	Marine Minerals Mitigation	Marine Minerals (Non-Recurring)	The Marine Minerals Program applies non-recurring mitigations to plans, structure removals, pipeline installations, and pipeline decommissionings that impact significant sediment resources in designated Marine Minerals Program blocks. The non-recurring mitigation applied is activity specific and describes concurrence with, or denial of, site-specific activity plans and applications based on possible impacts to significant sediment resources. For pipeline decommissioning applications, requests for departure to decommission in place are granted or denied with conditions as described in the applied non-recurring mitigation.
1.04	Vessel Traffic Mitigations	Seismic Vessels (protected species requirements)	This mitigation is still available in TIMS; however, it is now applied through the 2020 Biological Opinion, Appendix A. Refer to the 2020 Biological Opinion Mitigations in this chapter.
1.05	Vessel Traffic Mitigations	Seismic Vessels (vessel-strike avoidance/reporting)	This mitigation is still available in TIMS; however, it is now applied through the 2020 Biological Opinion, Appendix C. Refer to the 2020 Biological Opinion Mitigations in this chapter.
1.06	Vessel Traffic Mitigations	Progressive-Transport/"Hopping" (structure removals)	In accordance with the Outer Continental Shelf Lands Act (OCSLA) requirements (30 CFR § 250.1727(g)), if at any point in the decommissioning schedule, progressive-transport/"hopping" activities are required to section the jacket assembly or support material barge loading, a prior written request must be submitted and approval must be obtained from the Bureau of Safety and Environmental Enforcement's (BSEE's) Regional Supervisor, Field Operations. The applicant's request to use progressive-transport must include a detailed procedural narrative and separate location plat for each "set-down" site, showing pipelines, anchor patterns for the derrick barge, and any known archaeological and/or potentially sensitive biological features. The diagram/map of the route to be taken from the initial structure location along the transport path to each site must also be submitted with the request. If the block(s) that the applicant intends to use as "set-down" sites have not been surveyed as per NTL No. 2009-G39, "Biologically-Sensitive Underwater Features and Areas," and NTL No. 2005-G07, "Archaeological Resource Surveys and Reports," the applicant may be required to conduct the necessary surveys/reporting prior to mobilizing on-site and conducting any seafloor-disturbing activities.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
1.07	Vessel Traffic Mitigations	Seismic Vessels (notification requirements)	In accordance with 30 CFR § 550.208(b)(2), the applicant is hereby required to notify other users of the Outer Continental Shelf (OCS) before conducting the proposed ancillary activities. Prior to commencing the survey(s), the applicant must inform the operators of all leases affected by the proposed activities of when and where the applicant intends to conduct the vessel operations to ensure that proper navigation and safety protocol are observed.
2.00	Air Quality Mitigations	Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one time-only mitigation that is added to certain plans or applications.
2.05	Air Quality Mitigations	Fuel Usage or Run Time Documentation	The projected nitrogen oxides (NO_x) emissions amounts in the plan were calculated using historic (insert fuel consumption rates, run times). Maintain monthly records of the total annual (insert fuel consumption, run times) for the (specify the affected vessels or equipment) with a limit of (insert limit in gallons/year, limit in hours/year) and provide the information to the Bureau of Ocean Energy Management's (BOEM's) Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year (insert year). If no activities were conducted during a calendar year, provide a statement to that effect in lieu of the required records. If at any time during the applicant's activities these records indicate that the NO_x annual emissions may exceed the annual limit approved in your plan or the total annual (insert fuel consumption, run time) limit, the applicant must immediately prepare a revised plan pursuant to 30 CFR § 550.283 to include the recalculated emissions amounts. The applicant will not proceed with the actions that could cause the potential annual increase in emissions until the revised plan has been submitted to and approved by BOEM.
2.08	Air Quality Mitigations	Potential to Exceed SO_2 Significance Levels (flaring)	Should hydrogen sulfide (H_2S) concentrations greater than (insert number) ppm be encountered, the 3- and 24-hour sulphur oxides (SO_2) onshore ambient air concentration significance levels as prescribed by 30 CFR § 550.303(e) could be exceeded during the proposed well test flaring. Therefore, the applicant is advised that, should H_2S concentrations greater than (insert number) ppm be encountered, it shall use the graph included in its plan to determine the maximum allowable flow rate for the flaring operation. The applicant is responsible for ensuring that its maximum emission concentrations remain below the aforementioned significance levels. In accordance with 30 CFR § 250.1164(c), the applicant is hereby required to submit monthly reports that contain the following: (1) the daily volume and duration (number of hours) of each flaring episode; (2) the H_2S concentration (ppm) in the flared gas; and (3) the calculated amount of SO_2 emitted.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
2.11	Air Quality Mitigations	Using Ultra-Low Sulfur Content Fuel	As proposed, use ultra-low sulfur content diesel fuel <<sulfur concentration 0.0015% or less by weight>> while conducting these operations. Sulfur content records must be maintained on the platform and made available to authorized BSEE personnel upon request.
2.12	Air Quality Mitigations	Verification of Emissions Factors (clean burn engines)	The rating, manufacturer, and type of engine(s) proposed in the applicant's plan will be operated and maintained in accordance with the manufacturer's specifications. Using a U.S. Environmental Protection Agency (USEPA)-approved or equivalent method, perform an emissions stack test on the subject engine(s) within 60 days following installation and at least every 3 years thereafter. These tests will be performed at loads representing 25, 50, 75, and 100 percent of the rated capacity or at minimum, average, and highest operational loads to verify that the emission factors are not exceeding those used in calculating the proposed emissions in the plan. Prepare a report of the results of each stack test and submit it to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section within 45 days of the test. During engine operation, the applicant will maintain the baseline parameters (such as air-fuel ratios) established during the most recent successful stack test. The applicant must monitor and record these parameters daily to ensure consistency with those observed during the most recent successful stack test. Records of these parameters must be maintained on the platform and made available to authorized BSEE personnel upon request. In addition, the applicant must submit this information to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year <<insert year>>. If no activities were conducted during a calendar year, provide a statement to that effect in lieu of the required records.
2.13	Air Quality Mitigations	Monitoring of NO_x Emissions (catalytic converters)	The rating, manufacturer, type, and catalytic converter(s) proposed in the plan must be operated and maintained in accordance with the manufacturer's specifications. Using a USEPA-approved or equivalent method, perform an emissions stack test on the subject engine(s) and catalytic converter(s) within 60 days following installation and at least every 3 years thereafter. These tests will be performed at loads representing 25, 50, 75, and 100 percent of the rated capacity or at minimum, average, and highest operational loads to verify that the emissions factors are not exceeding those used in calculating the proposed emissions in the plan. The applicant must contact BSEE at least 30 days prior to conducting the test to determine proper protocol for the stack test and also to have BSEE's representative witness the test. Prepare a report of the results of each stack test and submit it to

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section within 45 days of the test. During operation, the applicant will maintain the baseline parameters, such as air-fuel ratios for the engine(s) and the pressure drop and temperature increase across the catalytic converter(s) established during the most recent successful stack test. The applicant must monitor and record these parameters daily to ensure they remain consistent with those observed during the most recent successful stack test. The records of these parameters will be maintained on the platform and made available to authorized BSEE personnel upon request. In addition, the applicant must submit this information to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year <<insert year>>. If no activities were conducted during a calendar year, the applicant must provide a statement to that effect in lieu of the required records.
2.15	Air Quality Mitigations	Sulfur Recovery Unit, Flaring Episodes, Production Curtailment	If a shutdown of the sulfur recovery unit necessitates diverting the acid gas stream and if the resulting increased emissions would cause the SO_2 onshore ambient air concentration significance levels as prescribed by 30 CFR § 550.303(e) to be exceeded, begin curtailing production within 6 hours of the onset of the increased emissions. If curtailment is necessary, the appropriate reduced production rate will be reached no later than 8 hours from the onset of the increased emissions and will continue until such time that normal operation of the sulfur recovery unit can resume.
2.16	Air Quality Mitigations	Monitoring of SO_2 Emissions (sulfur recovery units)	The amine unit and the <<specify name of sulfur recovery unit>> proposed in the plan must be operated and maintained in accordance with the manufacturer's specifications. Using a USEPA-approved or equivalent method, perform an emissions stack test on the subject sulfur recovery unit within 60 days following installation. This test will be performed at loads representing 25, 50, 75, and 100 percent of the rated capacity of the amine unit or at minimum, average, and highest operational loads of the amine unit to verify that the emission factors are not exceeding those used in calculating the proposed emissions in the plan. Contact BSEE's Environmental Enforcement Division at least 30 days prior to conducting the test to determine proper protocol for the stack test and also to have BSEE's representative witness the test. Prepare a report of the results of each stack test and submit it to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section within 45 days of the test.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			The applicant must monitor and record these parameters daily to ensure they remain consistent with the approved baseline parameters from the most recent successful stack test. Records of these parameters must be maintained on the platform and made available to authorized BSEE personnel upon request. In addition, the applicant must submit this information to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year <<insert year>>. If no activities were conducted during a calendar year, provide a statement to that effect in lieu of the required records.
2.17	Air Quality Mitigations	Verification of Emissions Factors (general)	The rating, manufacturer, and type of engine(s) proposed in the plan will be operated and maintained in accordance with the manufacturer's specifications. Using a USEPA-approved or equivalent method, perform an emissions stack test on the subject engine(s) within 60 days following installation and at least every 3 years thereafter. These tests will be performed at loads representing 25, 50, 75, and 100 percent of the rated capacity or at minimum, average, and highest operational loads to verify that the emission factors are not exceeding those used in calculating the proposed emissions in the plan. Contact BSEE's Environmental Enforcement Division at least 30 days prior to conducting the test to determine proper protocol for the stack test and also to have BSEE's representative witness the test. Prepare a report of the results of each stack test and submit it to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section within 45 days of the test. During engine operation, the applicant will maintain the baseline parameters (such as air-fuel ratios) established during the most recent successful stack test. The applicant must monitor and record these parameters daily to ensure consistency with those observed during the most recent successful stack test. Records of these parameters must be maintained on the platform and made available to authorized BSEE personnel upon request. In addition, the applicant must submit this information to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year <<insert year>>. If no activities were conducted during a calendar year, provide a statement to that effect in lieu of the required records.
2.18	Air Quality Mitigations	Alternative Monitoring of NO_x Emissions (catalytic converters)	Using your established baseline parameters listed below, monitor the performance of the engine(s) and catalytic converter(s) and record daily to ensure that performance remains consistent. Air-fuel ratio for engine: <<insert baseline parameters>>; pressure drop across catalytic converter: <<insert baseline

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			parameters>>; and temperature increase across catalytic converter: (insert baseline parameters). Records of these parameters must be maintained on the platform and made available to authorized BSEE personnel upon request. In addition, the applicant must submit a summary of these data to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section annually by February 1st of each year, beginning in the year <<insert year>>. The summary will report minimum, average, and maximum values for the above-listed parameters, on a monthly basis, for the year. If no activities were conducted during a calendar year, provide a statement to that effect in lieu of the required records. Notify BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section as soon as practical but no later than 24 hours after the event, whenever the engine(s) or catalytic converter(s) exceed these parameters for periods greater than a day. File a detailed report with this office within 5 days of the termination of any such event. At a minimum, this report will include a chronology of the event, NO_x emissions rates in pounds per hour, total NO_x emissions for the duration of the event, and any measures taken to regain operation within these parameters or to prevent a recurrence of similar events. If exceeding the above parameters results in increased emissions that would cause onshore NO_x concentration to exceed BOEM significance levels (30 CFR § 550.303(e)), curtail the use of the <<identify equipment associated with catalytic converter>> within 2 days of the onset of the increased emissions and continue curtailment until such time that normal operation of the catalytic converter can resume.
3.00	Archaeology Mitigations	Archaeology Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans or permit applications.
3.02	Archaeology Mitigations	Buried Channels (pipeline applications)	BOEM's review indicates that the proposed activities are in the vicinity of buried channel margin features that may contain significant archaeological resources. In accordance with 30 CFR § 250.1007(a)(5), the applicant must either (1) conduct an underwater archaeological investigation (diver and/or remotely operated vehicle [ROV] investigations) prior to commencing activities to determine whether these features represent archaeological resources or (2) ensure that the depth of the pipeline trench in the vicinity of these features does not exceed 3 ft (1 m) and that all other seafloor-disturbing actions resulting from the proposed activities avoid the subject channel margins (see the enclosed map depicting the avoidance area in the application). If the applicant conducts an underwater archaeological investigation

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			prior to commencing operations, the applicant should contact BOEM's Office of Environment and BSEE's Environmental Enforcement Branch at least 2 weeks prior to performing operations to obtain the investigation methodology. If the applicant chooses to avoid the features, then the applicant should submit anchor position plats, at a scale of 1 in = 1,000 ft with differential global positioning system (DGPS) accuracy, with your pipeline construction report required by 30 CFR § 250.1008(b). These plats must depict the "as-placed" location of all anchors, anchor chains, wire ropes, and cables on the seafloor (including sweep) and demonstrate that the features were not physically impacted by the construction activities. If the applicant chooses to avoid the features and no anchoring activities were conducted during pipeline construction, provide a statement to that effect in lieu of the required anchor position plats. This mitigation may be applied by BSEE at the post-approval stage.
3.03	Archaeology Mitigations	Buried Channels (plans)	BOEM's review indicates that the proposed activities are in the vicinity of buried channel margin features that may contain significant archaeological resources. In accordance with 30 CFR § 550.194, the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) prior to commencing activities to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions resulting from the proposed activities avoid the subject features (see the enclosed map depicting the avoidance area in the application). If the applicant conducts an underwater archaeological investigation prior to commencing operations, contact BOEM's Office of Environment least 2 weeks prior to performing operations to obtain the investigation methodology. If the applicant chooses to avoid the features, then submit an as-built map at a scale of 1 in = 1,000 ft with DGPS accuracy, showing the location of all seafloor disturbances (e.g., the rig or platform, anchors, anchor chains, wire ropes, cables, etc.) relative to these features, to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time that the applicant submits its <<specify submittal type>>.
3.04 and 3.05	Archaeology Mitigations	Magnetic Anomalies and/or Side-Scan Sonar Targets (pipeline applications – multiple features)	BOEM's review indicates that the proposed activities are in the vicinity of the unidentified <<insert magnetic anomalies, side-scan sonar targets, magnetic anomalies and side-scan sonar targets>> listed in the enclosure, features that may represent significant archaeological resources. In accordance with 30 CFR § 250.1007(a)(5), the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) prior to commencing

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
		Magnetic Anomalies and/or Side-Scan Sonar Targets (pipeline application – singular feature)	activities to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions resulting from the proposed activities avoid the unidentified features by a distance greater than that listed in the enclosure. If the applicant conducts an underwater archaeological investigation prior to commencing operations, then the applicant must contact BOEM's Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology. If the applicant chooses to avoid the features, then submit anchor position plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b). These plats must depict the "as-placed" location of all anchors, anchor chains, wire ropes, and cables on the seafloor (including sweep) and demonstrate that the features were not physically impacted by the construction activities. If the applicant chooses to avoid the features and no anchoring activities were conducted during pipeline construction, then provide a statement to that effect in lieu of the required anchor position plats. This mitigation may be applied by BSEE at the post-approval stage.
3.06 and 3.07	Archaeology Mitigations	Magnetic Anomalies and/or Side-Scan Sonar Targets (plans – multiple features) Magnetic Anomalies and/or Side-Scan Sonar Targets (plans – singular feature)	BOEM's review indicates that the proposed activities are in the vicinity of the unidentified <<insert magnetic anomalies, side-scan sonar targets, magnetic anomalies and side-scan sonar targets>> listed in the enclosure of the application, features that may represent significant archaeological resources. In accordance with 30 CFR § 550.194, the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) prior to commencing the activities to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions resulting from the proposed activities avoid the subject features by a distance greater than that listed in the enclosure of the application. If the applicant conducts an underwater archaeological investigation, then the applicant must contact BOEM's Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology. If the applicant chooses to avoid the features, submit an as-built map at a scale of 1 in = 1,000 ft with DGPS accuracy, showing the location of all seafloor disturbances (e.g., the rig or platform, anchors, anchor chains, wire ropes, cables, etc.) relative to these features to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the plan.
3.08	Archaeology Mitigations	Buried Channels (lease block survey review)	BOEM's review of the archaeological assessment indicates that there are buried channel margin features that may contain significant archaeological resources in the lease block(s). The enclosed map in the application identifies the areas to be avoided during any future development within the block(s). In accordance with

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			30 CFR § 550.194, the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions required by future exploration or development will avoid the subject features. If the applicant chooses to conduct an underwater archaeological investigation, then the applicant must contact BOEM's Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology.
3.09 and 3.10	Archaeology Mitigations	Magnetic Anomaly and/or Side-Scan Sonar Target (survey review – single feature) Magnetic Anomaly and/or Side-Scan Sonar Target (survey review – multiple features)	BOEM's review of the archaeological assessment indicates the presence of the unidentified magnetic anomaly(ies), side-scan sonar target(s), or magnetic anomaly(ies) and side-scan sonar target(s) listed in the enclosure of the application, features that may represent significant archaeological resources. In accordance with 30 CFR § 550.194, the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions required by future exploration and development avoid the unidentified features by a distance greater than that listed in the enclosure of the application. If the applicant conducts an underwater archaeological investigation, then the applicant must contact BOEM's Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology.
3.11	Archaeology Mitigations	Unsurveyed Area (plans)	Avoid impacts to the seafloor in the unsurveyed area approximately <<insert number>> feet to the <<insert direction>> of the proposed <<specify Well X, Wells X and Y, Platform X, etc.>>. This area has been identified as requiring a (insert 50-meter or 300-meter) line spacing archaeological resource survey to determine the potential for archaeological resources. BOEM has no archaeological resource assessment on file for this area and, therefore, cannot determine the potential effects to archaeological resources outside of the applicant's survey coverage. Submit an as-built map at a scale of 1 in = 1,000 ft with DGPS accuracy, showing the location of all seafloor disturbances (e.g., the rig or platform, anchors, anchor chains, wire ropes, cables, etc.) relative to the unsurveyed area to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time you submit your <<submittal type>>.
3.12 and 3.13	Archaeology Mitigations	Magnetic Anomalies and/or Side-Scan Sonar Targets	BOEM's review indicates that the proposed activities are in the vicinity of the unidentified magnetic anomaly(ies), side-scan sonar target(s), or magnetic anomaly(ies) and side-scan sonar target(s) listed in the table in the application, a feature that may represent a significant archaeological resource. In accordance

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
		(structure removals – multiple features) Magnetic Anomalies and/or Side-Scan Sonar Targets (structure removals – single feature)	with 30 CFR § 250.194(c), the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) prior to commencing activities to determine whether this feature represents an archaeological resource or (2) ensure that all anchoring operations (e.g., anchors, anchor chains, wire ropes, cables, etc.) avoid the unidentified feature by a distance greater than that listed in the table in the application. If the applicant plans to conduct an underwater archaeological investigation prior to commencing operations, then the applicant must contact BOEM's Office of Environment to obtain the investigation methodology at least 2 weeks prior to performing operations and contact BOEM's Office of Environment and BSEE's Environmental Enforcement Branch. If the applicant chooses to avoid the feature, then include in the post-removal report as-built plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, the position of anchors, anchor chains, wire ropes, and cables deployed during the structure removal relative to the feature. In addition, supply a copy of ALL vessel logs related to the removal operations (e.g., anchor handling vessels, lift boats, dive vessels, and tug boats). This mitigation may be applied by BSEE at the post-approval stage.
3.16	Archaeology Mitigations	ROV Surveys (plans)	The proposed operations are in an area designated by BOEM's Regional Director as having a high potential for the location of historic shipwrecks. In accordance with 30 CFR § 550.194(a)(2), prior to commencing the operations, conduct an ROV investigation (using video, sector-scanning sonar, or multibeam bathymetry) of the seafloor areas that could be disturbed by the operations (e.g., the rig or platform, anchors, anchor chains, wire ropes, cables, etc.) to ensure that the applicant will avoid harming potentially significant archaeological sites. The applicant must contact BOEM's Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology. The applicant must submit a report of this investigation prepared by a qualified marine archaeologist, along with an "as-placed" anchor plat and copies of the ROV video and acoustic recordings of the investigation to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the plan. If the applicant discovers any potential archaeological resource (i.e., cannot be definitively identified as modern debris or refuse) while conducting this investigation or future operations, the applicant must immediately halt any seafloor-disturbing activities and report the discovery to BOEM's Regional Supervisor, Office of Environment.
3.17	Archaeology Mitigations	Conditional Approval for ROV Surveys (plans)	Drilling permits will not be issued for proposed <<well(s) and well name(s)>> until the applicant submits an archaeological report to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section and receives approval. This report must be based on an ROV investigation (using video, sector-scanning sonar, or

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			multibeam bathymetry) of the seafloor areas that could be disturbed by the operations. The report must be prepared by a qualified marine archaeologist and must include copies of the ROV video and acoustic recordings of the investigation, along with an “as-placed” anchor plat. If the applicant discovers any potential archaeological resource (i.e., cannot be definitively identified as modern debris or refuse) while conducting this investigation, the applicant must immediately halt any seafloor-disturbing activities and report the discovery to BOEM’s Regional Supervisor, Office of Environment. The applicant must contact BOEM’s Office of Environment at least 2 weeks prior to performing this survey to obtain the investigation methodology.
3.18	Archaeology Mitigations	Buried Channels (structure removal)	BOEM’s review indicates that the proposed activities are in the vicinity of buried channel margin features that may contain significant archaeological resources. In accordance with 30 CFR § 250.194(c), the applicant must either (1) conduct an underwater archaeological investigation (diver and/or ROV investigations) prior to commencing activities to determine whether these features represent archaeological resources or (2) ensure that all seafloor-disturbing actions resulting from the proposed activities (e.g., site-clearance trawling, anchors, anchor chains, wire ropes, cables, etc.) avoid the subject features (see the enclosed map depicting the avoidance area in the application). If the applicant plans to conduct an underwater archaeological investigation prior to commencing operations, then the applicant must contact BOEM’s Office of Environment at least 2 weeks prior to performing operations to obtain the investigation methodology and contact BOEM’s, Office of Environment and BSEE’s Environmental Enforcement Branch. If the applicant chooses to avoid the features, then include in the post-removal report as-built plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, and the position of anchors, anchor chains, wire ropes, and cables deployed during the structure removal relative to these features. In addition, supply a copy of ALL vessel logs related to the removal operations (e.g., anchor handling vessels, lift boats, dive vessels, and tug boats). This mitigation may be applied by BSEE at the post-approval stage.
3.20	Archaeology Mitigations	Avoidance of Potential Archaeological Resources	BOEM’s review indicates that the proposed operations have the potential to impact submerged archaeological resources that could be in the area of potential effect, which encompasses all portions of the seafloor where bottom-disturbing activities are to occur. Before conducting any authorized, bottom-disturbing activities, the company will follow the guidance provided at http://www.boem.gov/Environmental-Stewardship/Archaeology/Gulf-of-Mexico-Archaeological-Information.aspx, which includes minimum survey recommendations, requisite certification submittals, and

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			post-activity reporting standards needed to ensure compliance with the regulations under 30 CFR § 550.194. This mitigation may be applied by BSEE at the post-approval stage.
3.21 and 3.22	Archaeology Mitigations	Side-Scan Sonar Targets (site clearance – single features) Side-Scan Sonar Targets (site clearance – multiple features)	BOEM's review indicates that the proposed activities are in the vicinity of the unidentified side-scan sonar target(s) listed in the table in the application, features that may represent significant archaeological resources. In accordance with 30 CFR § 250.194(c), the applicant must conduct an underwater archaeological investigation (diver and/or ROV investigation) under the supervision of a professional archaeologist to determine whether these features represent archaeological resources potentially eligible to the National Register of Historic Places prior to conducting site-clearance trawling activities. This mitigation may be applied by BSEE at the post-approval stage.
3.23	Archaeology Mitigations	Protection of Potential Archaeological Resources (all structure removals)	Per 30 CFR § 250.194(c) and clarified in NTL No. 2005-G07, if, during site-clearance operations the applicant discovers any object of potential archaeological significance, the applicant is required to immediately halt operations. In addition, the applicant must immediately report this discovery to BSEE's Environmental Enforcement Branch. Additional guidance will be provided to the applicant as to what steps will be needed to protect any potentially submerged archaeological resources. In order for BSEE to ensure compliance with 30 CFR § 250.194(c) and as specified under 30 CFR § 250.1743, the applicant is required to provide the trawling logs for both heavy-duty nets and verification nets, with descriptions of each item recovered. Should the applicant only pull site-clearance verification nets, the applicant must clearly state this within the body of the Site-Clearance Report. The applicant is also requested to provide the following as an appendix in the Site-Clearance Report: a CD or DVD of all digital photographs of the items recovered during the use of both the heavy-duty trawl nets and the site-clearance verification trawl nets. This mitigation may be applied by BSEE at the post-approval stage.
4.00	Artificial Reef Material Mitigations	Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans or permit applications.
4.01	Artificial Reef Material Mitigations	Louisiana (artificial reef area)	The proposed anchoring operations are located within 500 ft (152 m) of an artificial reef permit area established by the State of Louisiana. At least 2 weeks prior to conducting anchoring operations (including the use of anchors, anchor chains, and wire ropes) that could disturb the seafloor within 500 ft (152 m) of an artificial reef permit area, the applicant must contact the Louisiana Artificial Reef Coordinator to ensure that the proposed anchoring operations do not damage reefal material.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			Prior to conducting anchoring operations, the applicant must send an email to BSEE's Office of Environmental Compliance confirming that the Louisiana Artificial Reef Coordinator has been contacted. If the anchoring operations intersect or cross-over the artificial reef permit area, then submit anchor position plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, depicting the "as-placed" location of all anchors, anchor chains, wire ropes, and cables (including sweep if applicable) on the seafloor relative to the reefal material. For plans, submit the plats to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office and/or notification of platform installation date and final as-built location data as directed in 30 CFR § 250.900(e). For pipelines, submit the plats with the pipeline construction report required by 30 CFR § 250.1008(b). For structure removals, submit the plats with the post-removal report. This mitigation may be applied by BSEE at the post-approval stage.
4.021	Artificial Reef Material Mitigations	Texas (artificial reef permit area – anchoring)	The proposed anchoring operations are located within 1,000 ft (305 m) of an artificial reef permit area established by the State of Texas. At least 2 weeks prior to conducting anchoring operations (including the use of anchors, anchor chains, and wire ropes) that could disturb the seafloor within 1,000 ft (305 m) of the artificial reef permit area, contact the Texas Artificial Reef Coordinator to ensure that the proposed anchoring operations do not damage reefal material. Prior to conducting anchoring operations, the applicant must send an email to BSEE's Office of Environmental Compliance confirming that the Texas Artificial Reef Coordinator has been contacted. If the anchoring operations intersect or cross-over the artificial reef permit area, submit anchor position plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, depicting the "as-placed" location of all anchors, anchor chains, wire ropes, and cables (including sweep if applicable) on the seafloor relative to the reefal material. For plans, submit the plats to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office and/or notification of platform installation date and final as-built location data as directed in 30 CFR § 250.900(e). For pipelines, submit the plats with the pipeline construction report required by 30 CFR § 250.1008(b). For

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			structure removals, submit the plats with the post-removal report. This mitigation may be applied by BSEE at the post-approval stage.
4.03	Artificial Reef Material Mitigations	Mississippi (artificial reef area)	The proposed anchoring operations are located within 500 ft (152 m) of an artificial reef permit area established by the State of Mississippi. At least 2 weeks prior to conducting anchoring operations (including the use of anchors, anchor chains, and wire ropes) that could disturb the seafloor within 500 ft (152 m) of an artificial reef structure or an artificial reef permit area, contact the Mississippi Artificial Reef Coordinator to ensure that the proposed anchoring operations do not damage reefal material. Prior to conducting anchoring operations, the applicant must send an email to BSEE's Office of Environmental Compliance confirming that the Mississippi Artificial Reef Coordinator has been contacted. If the anchoring operations intersect or cross-over the artificial reef permit area, submit anchor position plats at a scale of 1 in = 1,000 ft with DGPS accuracy, depicting the "as-placed" location of all anchors, anchor chains, wire ropes, and cables (including sweep if applicable) on the seafloor relative to the artificial reef permit area. For plans, submit the plats to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section, at the same time you submit your End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico Region District Office and/or notification of platform installation date and final as-built location data as directed in 30 CFR § 250.900(e). For pipelines, submit the plats with your pipeline construction report required by 30 CFR § 250.1008(b). For Structure Removals, submit the plats with your Post-removal Report. This mitigation may be applied by BSEE at the post-approval stage.
4.04	Artificial Reef Material Mitigations	Alabama (artificial reef general permit area)	The proposed operations are in a General Permit Area established by the State of Alabama for the placement of artificial reef material. At least 2 weeks prior to conducting operations, contact the Alabama Artificial Reef Coordinator to ensure that the proposed operations do not damage reefal material. Prior to conducting operations, the applicant must send an email to BSEE's Office of Environmental Compliance confirming that the Alabama Artificial Reef Coordinator has been contacted. This mitigation may be applied by BSEE at the post-approval stage.
4.05	Artificial Reef Material Mitigations	Florida (artificial reef general permit area)	The proposed operations are in a General Permit Area established by the State of Florida for the placement of artificial reef material. At least 2 weeks prior to conducting operations, contact the Florida Artificial Reef Coordinator to ensure that the proposed operations do not damage reefal material. Prior to conducting operations, the applicant must send an email to BSEE's Office of Environmental

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			Compliance confirming that the Florida Artificial Reef Coordinator has been contacted. This mitigation may be applied by BSEE at the post-approval stage.
4.06	Artificial Reef Material Mitigations	Post-Reefing Survey Requirements	BOEM's review indicates that the structure proposed for decommissioning will be abandoned-in-place as an artificial reef under the Rigs-to-Reefs Program. In order to verify compliance with reefing (30 CFR § 250.1727(g)) and obstruction clearance requirements (30 CFR § 250.1740(a)(2)), the applicant is required to conduct a high-resolution sonar survey (500 kilohertz or greater) of the permitted reefal material. The applicant must design the line spacing (for side-scan) or sonar drops (for sector-scanning) and the display range to ensure that 100 percent of the material permitted under this action is covered and that it is demonstrated that the associated seabed is clear of all obstructions apart from the reefal material. For a side-scan sonar survey, the side-scan system will need to be run with 30-m (98-ft) line spacing to provide enough overlap in coverage. For a sector-scanning sonar survey, the range on the sector-scanning sonar unit shall be set no greater than 45 m (150 ft) and the survey will require enough drops to provide overlapping coverage for the entire area. The applicant is required to submit the sonar data/survey report to BSEE's Office of Environmental Compliance at the same time as the post-removal report. This mitigation may be applied by BSEE at the post-approval stage.
5.00	Chemosynthetic Communities Mitigations	Chemosynthetic Communities Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans or permit applications.
5.01	Chemosynthetic Communities Mitigations	Anchor Positioning (GPS) (plans)	Your proposed activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use a state-of-the-art positioning system (e.g., DGPS) on the anchor handling vessel to ensure that any seafloor disturbance resulting from the use of anchors (including that caused by the anchors, anchor chains, and wire ropes) does not occur within 250 ft (76 m) of such areas (see the enclosed map/Map xxx [specify map by name], submitted with the survey report, which depicts the areas). Submit plats for Well(s) <<insert number[s] or name[s]>>, which depict the "as-placed" location of all anchors and any associated anchor chains and wire ropes on the seafloor, at a scale of 1 in = 1,000 ft with DGPS accuracy, to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office to

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			demonstrate that the features were not physically impacted by these anchoring activities. This mitigation may be applied by BSEE at the post-approval stage.
5.02	Chemosynthetic Communities Mitigations	Conventional Pipeline Laying Vessels (GPS) (pipeline applications)	Your proposed pipeline construction activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use a state-of-the-art positioning system (e.g., DGPS) on the pipeline laying vessel and the anchor handling vessels to ensure that any seafloor disturbance (including that caused by anchors, anchor chains, and wire ropes) during pipeline construction activities does not occur within 250 ft (76 m) of such areas (see the enclosed map/Map xxx <<specify map by name>>, submitted with the pipeline application, which depicts the areas). Additionally, include lay barge anchor position plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b), which depict the “as-placed” location of all anchors, anchor chains, and wire ropes on the seafloor and which demonstrate that the features were not physically impacted by the construction activities. This mitigation may be applied by BSEE at the post-approval stage.
5.03	Chemosynthetic Communities Mitigations	Anchor Positioning (ROV) (plans)	Your proposed activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use an ROV to ensure that any seafloor disturbance resulting from the use of anchors (including that caused by the anchors, anchor chains, and wire ropes) does not occur within 250 ft (76 m) of such areas (see the enclosed map/Map xxx [specify map by name], submitted with your survey report which depicts the areas). Submit plats for Well(s) <<insert number[s] or name[s]>>, which depict the “as-placed” location of all anchors and any associated anchor chains and wire ropes on the seafloor, at a scale of 1 in = 1,000 ft with DGPS accuracy, along with the high-resolution ROV video on disc or removable drive, to BOEM’s Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office to demonstrate that the features were not physically impacted by these anchoring activities. The ROV video screen should show time, date, depth, heading, and location coordinates. Observational notes and a corresponding map showing the ROV heading shall also be provided. If still images are collected, include the same information in the images’ integrated data. This mitigation may be applied by BSEE at the post-approval stage.
5.04	Chemosynthetic Communities Mitigations	Conventional Pipeline Laying Vessels (ROV) (pipeline applications)	Your proposed pipeline construction activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use an ROV to ensure that any seafloor disturbance (including that caused by the anchors, anchor chains, and wire ropes) during pipeline construction activities does not occur within 250 ft (76 m)

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			of such areas (see the enclosed map/Map “xxx” <<specify map by name>>, submitted with the pipeline application, which depicts the areas). Submit lay barge anchor position plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b), which depict the “as-placed” location of all anchors, anchor chains, and wire ropes on the seafloor and which demonstrate that the features were not physically impacted by the construction activities. Additionally, submit the high-resolution ROV video on disc or removable drive. The ROV video screen should show time, date, depth, heading, and location coordinates. Observational notes and a corresponding map showing the ROV heading shall also be provided. If still images are collected, include the same information in the images’ integrated data. This mitigation may be applied by BSEE at the post-approval stage.
5.05	Chemosynthetic Communities Mitigations	Dynamically Positioned Pipeline Laying Vessels (GPS) (pipeline applications)	Your proposed pipeline construction activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use a state-of-the-art positioning system (e.g., DGPS) on the dynamically positioned pipeline laying vessel to ensure that any seafloor disturbance resulting from the pipeline construction activities does not occur within 250 ft (76 m) of such areas (see the enclosed map/Map “xxx” <<specify map by name>>, submitted with the pipeline application, which depicts the areas). Additionally, include “as-built” location plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b), which depict the location of the pipeline(s) relative to these features to demonstrate that the features were not physically impacted by the construction activities. This mitigation may be applied by BSEE at the post-approval stage.
5.07	Chemosynthetic Communities Mitigations	Anchor Positioning (GPS and ROV)	Your proposed activities are in the vicinity of areas that could support high-density deepwater benthic communities. Use a state-of-the-art positioning system (e.g., DGPS) on the anchor handling vessel and use an ROV to ensure that any seafloor disturbance resulting from the use of anchors (including that caused by the anchors, anchor chains, and wire ropes) does not occur within 250 ft (76 m) of such areas. Submit plats for Well(s) <<insert number[s] or name[s]>>, which depict the “as-placed” location of all anchors and any associated anchor chains and wire ropes on the seafloor, at a scale of 1 in = 1,000 ft with DGPS accuracy, along with the high-resolution ROV video on disc or removable drive, to BOEM’s Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office to demonstrate that the features were not physically impacted by these anchoring activities. The ROV

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			video screen should show time, date, depth, heading, and location coordinates. Observational notes and a corresponding map showing the ROV heading shall also be provided. If still images are collected, include the same information in the images' integrated data. This mitigation may be applied by BSEE at the post-approval stage.
5.08	Chemosynthetic Communities Mitigations	Well Placement Variance (plans)	There is an area capable of supporting high-density deepwater benthic communities within 2,000 ft (610 m) of the proposed well(s), also known as the chemosynthetic well parameter. The proposed well(s) is/are <<insert chemosynthetic distance parameter>> from the area capable of supporting high-density deepwater benthic communities, which in this case provides adequate protection from muds and cuttings during operations. The actual well(s) shall not be placed closer than <<CHEMO DISTANCE PARAMETER 1>> from the potential habitat (see the chemosynthetic map parameter, which depicts the area). Provide a map showing the final as-placed well(s), potential habitat, and distance of the well(s) from the potential habitat to BOEM's Regional Supervisor, Office of Leasing and Plans, Plans Section at the same time the applicant submits the End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office to demonstrate that the feature(s) were not physically impacted by the drilling activity. This mitigation may be applied by BSEE at the post-approval stage.
5.09	Chemosynthetic Communities Mitigations	Well Placement Variance – "Zero Discharge" (plans)	There is an area capable of supporting high-density deepwater benthic communities within 2,000 ft (610 m) of the proposed well(s) <<insert chemosynthetic wells parameter>>. Since this area is (insert chemosynthetic distance parameter) from your well site(s), BSEE permits the activity with the following mitigations added. • Do not move the well(s) any closer to the area capable of supporting high-density deepwater benthic communities (see chemosynthetic map parameter, which depicts the area). • Follow "zero discharge" practices (i.e., no muds or cuttings shall be discharged near the sea surface in the vicinity of the permitted activity). • In this instance, it is understood that the discharge of muds and cuttings will occur on or near the seafloor for the riserless portion of the drilling operations ONLY as part of the "zero discharge" practice. • No muds or cuttings shall be discharged near the seafloor or at the sea surface once the blowout preventer and marine riser have been installed. No additional or excess muds or cuttings beyond those necessary to properly accomplish the riserless portion of the drilling activity shall be discharged on or near the seafloor.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			• Perform an assessment survey after the drilling of the well(s) is complete. (a) Conduct an ROV survey to assess sedimentation and its effects on the area capable of supporting high-density deepwater benthic communities (see chemosynthetic map parameter 1, which depicts the area. Transects must be run no more than 50 ft [15 m] apart.). (b) Ensure that the imagery in the ROV survey is high enough quality to adequately assess drilling effects. (This can be accomplished by employing the use of high-resolution still photography, high-resolution video, and/or lower resolution imaging through the use of close-up photography.). (c) The surveyed areas shall be recorded and documented on disc or removable drive for review, and the screen should show time, date, depth, heading, and location coordinates. This mitigation may be applied by BSEE at the post-approval stage.
6.01	Coastal Zone Management Mitigations	Texas (Coastal Zone Management)	Drilling permits cannot be issued for the proposed wells until concurrence with the coastal zone management consistency certification has been received by BOEM's Office of Environment from the Texas General Land Office or until concurrence with the certification has been conclusively presumed.
6.02	Coastal Zone Management Mitigations	Louisiana (Coastal Zone Management)	Drilling permits cannot be issued for the proposed wells until concurrence with the coastal zone management consistency certification has been received by BOEM's Office of Environment from the Louisiana Department of Natural Resources or until concurrence with the certification has been conclusively presumed.
6.03	Coastal Zone Management Mitigations	Alabama (Coastal Zone Management)	Drilling permits cannot be issued for the proposed wells until concurrence with the coastal zone management consistency certification has been received by BOEM's Office of Environment from the Alabama Department of Environmental Management or until concurrence with the certification has been conclusively presumed.
6.04	Coastal Zone Management Mitigations	Mississippi Coastal Zone Management)	Drilling permits cannot be issued for the proposed wells until concurrence with the coastal zone management consistency certification has been received by BOEM's Office of Environment from the Mississippi Department of Marine Resources or until concurrence with the certification has been conclusively presumed.
6.05	Coastal Zone Management Mitigations	Florida (Coastal Zone Management)	Drilling permits cannot be issued for the proposed wells until concurrence with the coastal zone management consistency certification has been received by BOEM's Office of Environment from the Florida Department of Environmental Protection or until concurrence with the certification has been conclusively presumed.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
7.07	Flower Garden Banks Mitigations	Environmental Monitoring Plan	Develop a plan for the early initiation of environmental monitoring of the effects of a hydrocarbon spill that may occur as a result of the proposed activities on the resources of the Flower Garden Banks National Marine Sanctuary, including water quality, pelagic fish, and benthic communities.
7.09	Flower Garden Banks Mitigations	Pressure Sensor Testing	High- and low-pressure sensors protecting the proposed pipeline will be tested at least once bi-weekly with no more than 3 weeks elapsing between each test. The applicant will maintain these records on the platform and will make them available to BSEE personnel upon request.
7.10	Flower Garden Banks Mitigations	Pressure Sensor Setting	The low-pressure sensor protecting the proposed pipeline will be set no lower than 10 percent below the lower limit of the normal operating pressure range.
8.01, 8.02, and 8.03	Hydrogen Sulfide Mitigations	H_2S Present (plans) H_2S Unknown (plans) H_2S Absent (plans)	In response to the request accompanying your plan for a hydrogen sulfide (H_2S) classification, the area in which the proposed drilling operations are to be conducted is hereby classified, in accordance with 30 CFR § 250.490(c), as “H_2S present,” “H_2S unknown,” or “H_2S absent.” Accordingly, comply with the appropriate requirements of 30 CFR § 250.490 if H_2S is present or unknown.
8.04	Hydrogen Sulfide Mitigations	H_2S Concentration Deviation	The plan indicates that the applicant anticipates H_2S at a concentration of approximately (specify the ppm). Should the applicant actually encounter H_2S at a concentration greater than 500 ppm, revise the plan in accordance with 30 CFR § 550.285 to include toxic modeling and an analysis of any potential environmental impacts. Contact BOEM’s Office of Environment to obtain the methodology for modeling an H_2S plume. The applicant must receive approval of the revised plan before additional permits filed under the plan will be approved.
8.05	Hydrogen Sulfide Mitigations	Corrosion Inspections (H_2S pipelines)	Inspect the pipeline(s) <<bi-annually, annually, or biennially>> for an indication of corrosion or other flaws. Report the results of these inspections to BSEE’s Office of Field Operations within 30 days of completion. This mitigation may be applied by BSEE at the post-approval stage.
8.07	Hydrogen Sulfide Mitigations	National Ocean Service Notification (H_2S pipelines)	When the applicant provides the National Ocean Service, Nautical Data Section with a copy of the pipeline construction report plat, the applicant must also request that the National Ocean Service, Nautical Data Section include the pipeline(s) on their navigation charts and identify it/them as (an) H_2S or toxic sour gas pipeline(s).
8.08	Hydrogen Sulfide Mitigations	USCG Notification (H_2S pipelines)	Immediately after the applicant begins operation of the pipeline(s), the applicant must notify the U.S. Coast Guard Commander, Eighth Coast Guard District that the pipeline(s) is/are in operation and request that the USCG publish information about

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			the pipeline(s), including the fact that (it) (is) or (they) (are) transporting natural gas with a high concentration of H_2S, in the Eighth District Local Notice to Mariners, Gulf of Mexico.
8.09	Hydrogen Sulfide Mitigations	H_2S Concentration Deviation (pipeline applications)	The application indicated that the applicant anticipates the H_2S concentration of the product to be transported in the proposed pipeline is approximately (specify the ppm). Should the applicant determine at some future date that the H_2S concentration is greater than 500 ppm, immediately submit an application to modify the pipeline grant in accordance with 30 CFR § 250.1007(b) to include toxic modeling and an analysis of any potential environmental impacts. Contact BOEM's Office of Environment to obtain the methodology for modeling an H_2S plume.
8.10	Hydrogen Sulfide Mitigations	Notification to Federal Aviation Administration	Prior to initiating operations approved in your plan or pipeline application, the applicant shall update its emergency notification list in their H_2S contingency plan to include the Federal Aviation Administration (FAA): Houston Air Traffic Control/Traffic Management Control Desk). In the event of an above-water or below-water sour gas release greater than 100 standard cubic feet, notify the FAA that air traffic (except evacuation and medical aircraft) should be routed safely away from the site until further notice. For purposes of avoidance recommendations to the FAA, a distance of 10 nmi (11.5 mi; 18.5 km) and an altitude of 4,000 ft (1,1219 m), as minimal, shall be used. In the case of a release of H_2S (that constitutes an emergency), notify all facilities that might be exposed to atmospheric concentrations of 20 ppm or more of H_2S (i.e., all facilities located within <<insert number miles of the H_2S release>>. The applicant must also assist in the removal of all personnel as well as any other persons observed within the affected area.
8.11	Hydrogen Sulfide Mitigations	H_2S Absent and H_2S Present or Unknown below Certain Depths (plans)	In response to the request accompanying the plan for a H_2S classification, the area in which the proposed drilling operations are to be conducted above (specify depth) is hereby classified, in accordance with 30 CFR § 250.490(c), as H_2S absent. However, the area in which the proposed drilling operations are to be conducted below <<specify depth>> is hereby classified, in accordance with 30 CFR § 250.490(c), as H_2S present or unknown. Accordingly, comply with the appropriate requirements of 30 CFR § 250.490.
9.00	Live Bottom Areas	Hard Bottoms/ Pinnacles/Potentially Sensitive Biological Features Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans and permit applications.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
9.01	Live Bottom Areas	Hard Bottoms/ Pinnacles/Potentially Sensitive Biological Features (conventional lay barge) (pipeline applications)	BOEM's analysis indicates that there are hard bottoms/pinnacles/potentially sensitive biological features (PSBFs) that likely provide habitat for biological assemblages located within the scope of the anchor array of the pipeline lay barge. The pipeline construction activities (including the use of anchors, chains, and wire ropes) must avoid these hard bottoms/pinnacles/PSBFs as depicted on the enclosed map(s) in the application by a distance of at least 100 ft (30 m). Include lay barge anchor position plats, at a scale of 1 in = 1,000 ft (305 m) with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b), which depict the "as-placed" location of all anchors, anchor chains, and wire ropes on the seafloor and which demonstrate that the features were not physically impacted by the construction activities. This mitigation may be applied by BSEE at the post-approval stage.
9.03	Live Bottom Areas	Hard Bottoms/ Pinnacles/Potentially Sensitive Biological Features (plans)	BOEM's analysis indicates that there are hard bottoms/pinnacles/PSBFs located in the vicinity of the activities proposed in the plan that likely provide habitat for biological assemblages. Any bottom-disturbing activities associated with the activities proposed in the plan must avoid these hard bottoms/pinnacles/PSBFs as depicted on the enclosed map(s) in the application by a distance of at least 100 ft (30 m). Submit to BSEE's Office of Field Operations at the same time you submit your End of Operations Report (Form BSEE-0125) to the appropriate BSEE, Gulf of Mexico OCS Region, District Office an as-built map at a scale of 1 in = 1,000 ft with DGPS accuracy, showing the location of any seafloor disturbance (e.g., jack-up rig, barge anchors, etc.) relative to these features. This mitigation may be applied by BSEE at the post-approval stage.
9.04	Live Bottom Areas	Hard Bottoms/ Pinnacles/Potentially Sensitive Biological Features (DP lay barge) (pipeline applications)	BOEM's analysis indicates that there are hard bottoms/pinnacles/PSBFs that likely provide habitat for biological assemblages located on or near the proposed pipeline route. The pipeline construction activities must avoid these hard bottoms/pinnacles/PSBFs as depicted on the enclosed map(s) in the application by a distance of at least 100 ft (30 m). This mitigation may be applied by BSEE at the post-approval stage.
9.05	Live Bottom Areas	Hard Bottoms/ Pinnacles/Potentially Sensitive Biological Features (structure removal)	BOEM's review of the application indicates that there are hard bottoms/pinnacles/PSBFs located in the vicinity of the activities proposed in the application that likely provide habitat for biological assemblages. Any bottom-disturbing activities associated with the activities proposed in the application must avoid these hard bottoms/pinnacles/PSBFs as depicted on the enclosed map(s) in the application by a distance of at least 100 ft (30 m). Include in the post-removal report the as-built plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, which depict the "as-placed" location of all anchors, anchor chains, and

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			wire ropes on the seafloor deployed during the structure removal relative to these features. This mitigation may be applied by BSEE at the post-approval stage.
10.09	Military Mitigations	Naval Coastal Systems Center	Please be reminded that the lease stipulation requires the applicant to enter into an agreement with the Coastal Test and Evaluation Division, Coastal System Station/Code E21, Panama City, Florida 32407, concerning the control of your electromagnetic emissions and use of boats and aircraft in the Naval Coastal Systems Center Area.
11.11	Military Mitigations	Military Warning Area (all)	BOEM's review indicates that the proposed pipeline route and/or the routes to be taken by boats and aircraft in support of the proposed activities are located in or could traverse Military Warning Area W-<<insert number>> or Eglin Water Test Area EWTA-<<insert number>> (see BOEM's website at http://www.boem.gov/MWA-Boundaries/ for a map of the areas). Contact the appropriate individual military command headquarters (see BOEM's website at http://www.boem.gov/Military-Contacts-for-Warning-and-Water-Test-Areas/ for a list of the contacts) concerning the control of electromagnetic emissions and the use of boats and aircraft in this area(s) before commencing such traffic.
12.01	Military Mitigations	Unexploded Ordnance	The proposed operations are located in an area that was used until 1970 by the U.S. Department of Defense as an explosives dumping area. Please be advised that precautions should therefore be taken while conducting operations that involve any disturbance of the seafloor in order to avoid possible unexploded ordnance.
12.02	Military Mitigations	Naval Mine Warfare Area (MU 732, 733, and 734)	The proposed operations are located within a stipulated area designated by the Naval Mine Warfare Command for mine operations. Therefore, surface structures for exploration activities are subject to approval by BOEM's New Orleans Office's Regional Director after consultation with the Commander, Mine Warfare Command. No permanent structures or debris of any kind will be allowed in the area during exploration operations. Plans for any above seafloor development operations within the designated area must be coordinated with the Commander, Mine Warfare Command, 325 Fifth Street, SE, Corpus Christi, Texas 78491-5032.
14.01	Shallow Drilling Hazards Mitigations (Plans)	Shallow Gas and/or Water Flow	Exercise caution while drilling due to indications of shallow gas (and/or faulting) (and/or possible water flow).
14.02	Shallow Drilling Hazards Mitigations (Plans)	Seafloor Instability	Exercise caution during drilling rig placement due to indications of seafloor instability.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
14.03	Shallow Drilling Hazards Mitigations (Plans)	Insufficient Information	Exercise caution during drilling rig placement due to insufficient information regarding seafloor foundation integrity.
15.01 and 15.02	Shallow Hazards Mitigations	Multiple Hazards (plans) Single Hazard (plans)	BOEM's review indicates that there are pipeline(s), unidentified magnetic anomaly(ies), unidentified side-scan sonar contact(s), or other specified hazard(s) in the vicinity of <<insert name of platform(s) or well(s)>> that may pose a hazard to the proposed operations. Therefore, take precautions in accordance with NTL No. 2008-G05, Section VI.B, prior to performing operations.
15.05 and 15.06	Shallow Hazards Mitigations	Multiple Hazards (plans/pipelines) (anchoring activities) Single Hazard (plans) (anchoring)	BOEM's review indicates that there is a pipeline(s), unidentified magnetic anomaly(ies), unidentified side-scan sonar contact(s), or other specified hazard(s) in the vicinity of <<insert name of platform(s) or well(s)>> that may pose a hazard due to anchoring activities associated with the proposed operations. If any of these activities will take place within 150 m (490 ft) of the potential hazard, take precautions in accordance with NTL No. 2008-G05, Section VI.B, prior to performing operations.
15.07	Shallow Hazards Mitigations	Pipeline Spanning	BOEM's review indicates areas of seafloor relief in the vicinity of the proposed pipeline route, which may cause spanning problems for the pipeline. Use an ROV in conjunction with the pipeline construction activities to ensure that these areas are avoided to the extent possible. Additionally, include a report with the pipeline construction report, which is required by 30 CFR § 250.1008(b) and which analyzes the as-laid pipeline with respect to spanning and describes the protective measures taken to ensure pipeline integrity for those portions of the pipeline where the areas of seafloor relief could not be avoided. This mitigation may be applied by BSEE at the post-approval stage.
15.08	Shallow Hazards Mitigations	Conflict with Anchors	Please be advised that exploration activities have been approved or are pending approval for <<insert lease, block, area>>, which could potentially interfere with the proposed activities. Therefore, the applicant should contact <<insert contact name, company, address, phone number>> prior to commencement of the activities in order to avoid any potential conflicts.
16.00	Topographic Features Mitigations	Topographic Features Non-Recurring Mitigation	A non-recurring mitigation is a mitigating measure that is used for a unique, special, one-time-only mitigation that is added to certain plans or permit applications.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
16.01	Topographic Features Mitigations	Shunting All Wells (plans)	The proposed activities are within the <<4-mile, 3-mile, 1-mile, or 1,000-meter zone>> of (insert name of topographic feature). Shunt all drill cuttings and drilling fluids to the seafloor through a downpipe that terminates an appropriate distance, but no more than 10 m (33 ft), from the bottom.
16.02	Topographic Features Mitigations	Shunting Some Wells (plans)	Some of the proposed activities are within the <<4-mile, 3-mile, 1-mile, or 1,000-meter zone>> of (insert name of topographic feature). For (insert name of wells to be shunted), shunt all drill cuttings and drilling fluids to the seafloor through a downpipe that terminates an appropriate distance, but no more than 10 m (33 ft), from the bottom.
16.03	Topographic Features Mitigations	No Activity Zone (right-of-way pipeline applications)	BOEM's analysis indicates that the "no activity zone(s)" of the biologically sensitive feature(s) shown on the enclosed map(s) in the application may be located within the scope of the anchor array of the pipeline lay barge. Anchors, anchor chains, and wire ropes associated with the proposed pipeline construction activities must avoid this/these "no activity zone(s)" by a distance of at least 500 ft (152 m). Include lay barge anchor positions plats, at a scale of 1 in = 1,000 ft with DGPS accuracy, with the pipeline construction report required by 30 CFR § 250.1008(b), which depict the "as-placed" location of all anchors, anchor chains, and wire ropes on the seafloor, and which demonstrate that the "no activity zone(s)" was/were not physically impacted by the construction activities. This mitigation may be applied by BSEE at the post-approval stage.
16.04	Topographic Features Mitigations	No Activity Zone (plans)	Bottom-disturbing activities associated with the activities proposed in the plan must avoid the "no activity zone" of the biologically sensitive feature shown on the enclosed map in the application by a distance of at least 500 ft (152 m). Submit to BSEE's Office of Field Operations, at the same time the End of Operations Report (Form BSEE-0125) is submitted to the appropriate BSEE, Gulf of Mexico OCS Region, District Office an as-built map at a scale of 1 in = 1,000 ft with DGPS accuracy, showing the location of any seafloor disturbance (e.g., jack-up rig placement, rig anchors, construction barge anchors, etc.) to demonstrate that the "no activity zone(s)" was not physically impacted. This mitigation may be applied by BSEE at the post-approval stage.
16.05	Topographic Features Mitigations	No Activity Zone (structure removal)	Bottom-disturbing activities associated with the activities proposed in the application must avoid the "no activity zone" of the biologically sensitive feature shown on the enclosed map in the application by a distance of at least 500 ft (152 m). Include in the post-removal report an as-built plat, at a scale of 1 in = 1,000 ft with DGPS accuracy, depicting the "as-placed" location of all anchors, anchor chains, and wire ropes on the seafloor deployed during the structure-removal activities to show that

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			the "no activity zone" was not physically impacted. This mitigation may be applied by BSEE at the post-approval stage.
17.02	Non-Plan and Pipeline Mitigations	Fish (structure removals using explosives)	Under the Magnuson-Stevens Fisheries Conservation and Management Act, 50 CFR § 600.725 prohibits the use of explosives to take reef fish in the Exclusive Economic Zone. Consequently, those involved in explosive structure removals must not take such stunned or killed fish on board their vessels. Should this happen, they could be charged by the National Marine Fisheries Service (NMFS) with violation of the Act.
17.04	Non-Plan and Pipeline Mitigations	Site-Clearance Trawling Reporting	If trawling is used to comply with the site-clearance verification requirements under 30 CFR §§ 250.1740-1743, which mandates that turtle excluder devices be removed from the trawl nets to facilitate the collection of seabed debris, the applicant must abide by maximum trawl times of 30 minutes, allowing for the removal of any captured sea turtles. If, during trawling activities, the applicant captures a sea turtle in the nets, the applicant must (1) contact BSEE's Environmental Enforcement Branch and NMFS' Southeast Regional Office immediately, (2) resuscitate and release any captured sea turtles as per NMFS' guidelines found online at http://www.sefsc.noaa.gov/turtles/TM_NMFS_SEFSC_580_2010.pdf (refer to page 3-6, Plate 3-1), and (3) photograph the turtle and complete a sea turtle stranding form for each sea turtle caught in the nets. The form can be found at http://www.sefsc.noaa.gov/species/turtles/strandings.htm and submitted to NMFS and BSEE.
18	Conservation Information Document Mitigations	Self-Burial Approval	BOEM hereby concurs with the determination that the subject pipeline will be installed in an area that is prone to self-burial. However, in the future, should it be determined that the pipeline(s) constitute(s) a hazard to navigation or commercial fishing operations or unduly interferes(s) with other uses of the OCS, the applicant will be required to bury it (them).
18.01	Conservation Information Document Mitigations	Conservation Information Document – Condition of Approval	Within 15 days after the proposed <<well is or wells are>> completed and logged, submit a revision to the plan consisting of the information required for a Conservation Information Document in accordance with NTL No. 2000-N05.
18.02	Conservation Information Document Mitigations	Conservation Information Document – Operations Approval	At the applicant's request, we are approving your development operation coordination document (DOCD) prior to the completion of our review of the accompanying Conservation Information Document. However, please be advised that, if the Conservation Information Document review indicates that any of the proposed activities do not conform to sound conservation, engineering, and economic practices as cited in 30 CFR §§ 550.202(a) and 550.1101(a), we will, in

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			accordance with 30 CFR § 250.204(q)(1), require such revisions to the DOCD as are necessary to make the activities conform to such practices.
19.01	ROV Survey Mitigations	ROV Survey Required – Exploration Plans (EP)	In accordance with NTL No. 2008-G06, the applicant must conduct the two ROV surveys proposed in the plan. The first survey will be for the first well location approved under this plan and which is actually drilled. The post-drilling survey can be conducted at the time the applicant is preparing to leave this location. The applicant must submit both survey reports within 60 days after the rig leaves the well location. This mitigation may be applied by BSEE at the post-approval stage.
19.02	ROV Survey Mitigations	ROV Survey Required – DOCD	In accordance with NTL No. 2008-G06, the applicant must conduct the ROV surveys proposed in the plan for the facility location approved under this plan. The applicant must submit the pre- and post-installation survey reports within 60 days after the facility installation is completed. This mitigation may be applied by BSEE at the post-approval stage.
19.03	ROV Survey Mitigations	ROV Survey Not Required	In accordance with NTL No. 2008-G06, BOEM has determined that the applicant will not need to conduct the two ROV surveys proposed in the plan. This mitigation may be applied by BSEE at the post-approval stage.
21.01	Surveys Mitigations	Archaeology Assessment Not Acceptable	BOEM's review has determined that the archaeological analysis included in the survey report does not meet current BOEM requirements.
21.02	Surveys Mitigations	Archaeology Assessment Acceptable	BOEM's review has determined that the archaeological analysis included in the survey report meets current BOEM requirements.
21.03	Surveys Mitigations	Geophysical Review Acceptable	BOEM's review has determined that the subject survey report complies with the provisions of NTL No. 2008-G05 and, based on available data regarding any manmade hazards that may have been present at the time the survey was conducted, contains sufficient information to prepare an acceptable shallow hazards analysis for specific drilling or platform sites that the applicant may propose in future EPs or DOCDs. However, prior to submitting any such EPs or DOCDs, the applicant should update the accompanying anomaly map, if appropriate, to indicate the location of any manmade hazards (e.g., pipelines, abandoned wells, etc.) that did not exist at the time the survey was performed. Additionally, please be reminded that, under the guidelines of NTL No. 2008-G04, the applicant should submit high-resolution survey data from the line closest to any proposed well or platform location, with one copy of each such EP or DOCD.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
21.04	Surveys Mitigations	Geophysical Survey Report Not Acceptable	BOEM's review has also determined that the subject survey report does not comply with the provisions of NTL No. 008-G05.
21.05	Surveys Mitigations	3D Survey Waiver	Use of three-dimensional (3D) seismic data in lieu of high-resolution survey data as per NTL No. 2008-G05 is acceptable for the requested locations.
22	Pipeline Section Mitigations and Conditions	Concrete Mats	The applicant's request to install protective concrete mats over the pipeline crossings in water less than 200 ft (61 m) deep is hereby approved pursuant to 30 CFR § 250.141.
25	Pipeline Section Mitigations and Conditions	Pipeline High Pressure (PSH) Higher Than 15%	The applicant's request to set the PSH higher than 15 percent above the normal operating pressure range is hereby approved pursuant to 30 CFR § 250.142. The pipeline PSH shall be set no more than 5 percent above the latest shut-in tubing pressure of the well and will not be set above the maximum allowable operating pressure of the pipeline.
26	Pipeline Section Mitigations and Conditions	Denied Self-Burial	BOEM cannot concur with the applicant's determination that the subject pipeline will be installed in an area that is prone to self-burial. BOEM will only allow self-burial in areas with a soil strength that does not exceed 200 pounds per square foot. Therefore, the portions of the pipeline in water depths less than or equal to 200 ft (61 m) shall be buried.
28	Pipeline Section Mitigations and Conditions	Hydrostatic Head to Raise Maximum Allowable Operating Pressure	The applicant's request to determine the internal design pressure of the submerged portion of the pipeline by considering the effects of the external hydrostatic pressure, in lieu of using the standard formula outlined in 30 CFR § 250.1002(a), is hereby approved pursuant to 30 CFR § 250.141(a).
28.1	National Marine Fisheries Service Mitigations	Species Protective Measures	The applicant must comply with the following species protective measures in all activities conducted pursuant to the plan: COMPLIANCE WITH BIOLOGICAL OPINION TERMS AND CONDITIONS AND REASONABLE AND PRUDENT MEASURES. This approval is conditioned upon compliance with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued by the NMFS on March 13, 2020. This includes mitigation, particularly any appendices to Terms and Conditions applicable to the plan, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp, and any additional reporting required by BOEM or BSEE developed as a result of BiOp implementation. The NMFS Biological Opinion may be found here at (https://www.fisheries.noaa.gov/resource/document/biologicalopinion-federally-regulated-oil-and-gas-program-activities-gulfmexico). The appendices and

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			protocols may be found at (https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-programgulf-mexico). SUPPORT BASES AND VESSEL TRANSIT ROUTES: Approval of your plan is conditioned upon your use of the support bases and vessel transit routes as described in your plan. BOEM/BSEE must be notified at least 15 days prior to any vessel route changes that require transit of the Bryde's whale area, and you must receive prior approval for that transit from BOEM/BSEE. MARINE TRASH AND DEBRIS AWARENESS AND ELIMINATION: The applicant will follow the guidance provided under Appendix B, Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols, found in the Biological Opinion issued by the National Marine Fisheries Service on March 13, 2020. The guidance can be accessed on NOAA Fisheries' Internet website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulfmexico. VESSEL-STRIKE AVOIDANCE/REPORTING: The applicant will follow the guidance provided under Appendix C, Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols, found in the Biological Opinion issued by the National Marine Fisheries Service on March 13, 2020. The guidance can be accessed on the NOAA Fisheries' Internet website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulfmexico. SEISMIC SURVEY OPERATION, MONITORING, AND REPORTING GUIDELINES: The applicant will follow the guidance provided under Appendix A, Seismic Survey Mitigation and Protected Species Observer Protocols, found in the Biological Opinion issued by the National Marine Fisheries Service on March 13, 2020. The guidance can be accessed on the NOAA Fisheries Internet website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulfmexico. These measures are designed to promote environmental protection, consistent environmental policy, compliance with environmental laws, and safety.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
29	National Marine Fisheries Service Mitigations	Oil-Spill Financial Responsibility (OSFR) Coverage	BOEM's review of the application indicates that, per 30 CFR §§ 553.3(1)-(3), the proposed right-of-way pipeline is classified as a covered offshore facility and requires OSFR coverage. At this time, BOEM's records do not indicate that the required OSFR coverage is in place. The applicant is advised that they may begin construction of the proposed pipeline immediately. However, in accordance with 30 CFR § 553.15(b), the applicant may not begin operation of the pipeline until they have submitted an application demonstrating evidence of OSFR coverage to BOEM and have notified BSEE.
99	National Marine Fisheries Service Mitigations	Department of Transportation Right-of-Way Pipeline	The applicant shall construct, operate, and maintain the pipeline in accordance with the appropriate U.S. Department of Transportation regulations.
110	National Marine Fisheries Service Mitigations	Spanning Potential	There are several fault scarps along with the proposed pipeline route. Include with the construction report a listing of the location and length of any pipeline "spanning," resulting from laying the pipeline over these fault scarps. Also include a description of any remedial action necessary to minimize "spanning" and prevent pipeline damage. This mitigation may be applied by BSEE at the post-approval stage.
120.1	Office of Structural Technical Support Mitigations	Reminder of NTL No. 2008-G05	If there are pipelines within the immediate proximity of the proposed platform site, precautions outlined in NTL No. 2008-G05, "Shallow Hazards Program," shall be taken while conducting operations.
120.15	Office of Structural Technical Support Mitigations	Notify National Imagery and Mapping	In order to assure publication of onsite activity as it affects marine navigation safety, the applicant must notify the National Imagery and Mapping Agency in advance of commencement of platform installation.
120.2	Office of Structural Technical Support Mitigations	Send Report to Office of Structural and Technical Support	Written notification shall be submitted to the Office of Structural and Technical Support and the Pipeline Section within 15 calendar days of completion of the platform installation operations, at which time the applicant will be provided with the "Complex Identification Number" that has been assigned to this structure. The "Complex Identification Number" should be included with other pertinent information (i.e., the right-of-way number, area code, block number, platform name, etc.) in all future correspondence related to this structure. Should significant problems occur during structure installation operations, please inform the Office of Structural and Technical Support immediately. If for any reason the applicant decides not to install this structure, it shall submit a written cancellation letter.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
120.7	Office of Structural Technical Support Mitigations	Downhole Well Plugging	In accordance with 30 CFR § 250.1710, the applicant must downhole plug and abandon all wells on <<insert area/block platform name>> (except <<insert well names>>), no later than (insert date). However, the applicant will not be required to sever the casings, remove the wellhead, or clear the site until the right-of-use expires.
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these requirements per associated MMPA, ESA, and other applicable consultations	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Vessel-Strike Avoidance/Reporting	The applicant will follow the guidance provided under BOEM NTL No. 2016-G01, “Vessel Strike Avoidance and Injured/Dead Protected Species Reporting.” BOEM NTL No. 2016-G01 provides guidance on how a seismic operator should implement monitoring programs to minimize the risk of vessel strikes to protected species and should report observations of injured or dead protected species. In lieu of a formal observer program, this NTL provides specific guidelines that should be followed to identify and avoid injury to marine mammals and sea turtles.
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these requirements	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Seismic Survey Operation, Monitoring, and Reporting Guidelines	The applicant will follow the guidance provided under Joint NTL No. 2012-G02, “Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program.” Additionally, the applicant will comply with the guidance under this NTL when operating in all water depths (not just in water depths >200 m [656 ft] or in the Eastern Planning Area), and the NTL’s “shut-down conditions” will be applied towards manatees.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
per associated MMPA, ESA, and other applicable consultations			
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these requirements per associated MMPA, ESA, and other applicable consultations	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Pre-Activity Sound-Source and Array Calibration Verification	Prior to conducting survey activities, the applicant will verify in writing that the proposed airgun arrays to be used are of the lowest sound intensity level that still achieves the survey goals. The written verification must include confirmation that the airgun array has been calibrated/tuned to maximize subsurface illumination and minimize, to the extent practicable, horizontal propagation of noise.
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Mandatory Separation Buffer between Survey Operations	The applicant will be required to maintain, to the extent it can practicably and safely do so, a minimum separation distance of 30 km (19 mi) from any other vessels concurrently conducting deep-penetration seismic surveys and 40 km (29 mi) when operating within an Area of Concern. To assist in implementation of this measure, BOEM will provide the applicant with contact information for all deep-penetration seismic applicants concurrently permitted/authorized to operate within or near the proposed survey area.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
requirements per associated MMPA, ESA, and other applicable consultations			
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these requirements per associated MMPA, ESA, and other applicable consultations	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Supplemental Reporting Requirements	In addition to the reporting requirements under Joint NTL No. 2012-G02, the applicant is required to submit bi-weekly reports containing the information listed below. The reporting periods end on the 1st and 15th of each month. These bi-weekly reports are required for the total duration of the permit. When applicable, the reports must be submitted with survey navigation data for the 2-week reporting period. BOEM has a suggested format for the written report. If BOEM's suggested written format is not used, the following information must be submitted along with the navigation data: (1) the dates, locations, and duration of any deep-penetration seismic operations conducted during the reporting period (the navigation data provides this information); (2) any circumstances that caused the total energy output of the airgun source array to exceed that set forth in the permit application; (3) confirmation that the permittee maintained, to the extent they could practicably and safely do so, the minimum separation distance (If applicable, submit a written explanation of why the minimum separation distance was not maintained.); and (4) confirmation that the permittee complied with the other terms of Section V of the Settlement Agreement.
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Military Warning Area Coordination	BOEM's review indicates that the routes to be taken by boats in support of the applicant's activities will traverse Military Warning Areas W-92, W-147AB, and W-602. The applicant shall contact the appropriate individual military command headquarters concerning the control of electromagnetic emissions and use of boats in each of the areas before commencing the operations.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
to these requirements per associated MMPA, ESA, and other applicable consultations			
[1] no assigned mitigation numbers and [2] applicants would be subject to additional requirements or modifications to these requirements per associated MMPA, ESA, and other applicable consultations	Geological and Geophysical Mitigations (deep-penetration applications involving the use of airguns)	Marine Trash and Debris Awareness and Elimination	The applicant will follow the guidance provided under BSEE NTL No. 2012-G01, "Marine Trash and Debris Awareness and Elimination." The BSEE NTL No. 2012 G01 provides information on reducing, if not eliminating, trash intentionally jettisoned into the Gulf of Mexico. The programs described in the NTL to assist in the reduction of marine trash and debris are the marine trash and debris placards, marine trash and debris awareness training, and the marine trash and debris awareness training and certification process.
No Assigned Mitigation Numbers	Geological and Geophysical Mitigation Natural Resource Defense Council Area of Concern (equal to or greater than	Seismic Survey Restriction Period	BOEM's review indicates that the proposed survey area falls within a portion of an unusual mortality event area declared/established by the National Marine Fisheries Service for cetaceans (whales and dolphins). The applicant shall adhere to a restriction period between March 1 and April 30 (primary bottlenose dolphin calving season) for deep-penetration seismic surveys on the Federal OCS in coastal waters out to the 20-m (66-ft) isobath in the northern Gulf of Mexico to avoid potential impacts to dolphins in regards to behavioral disruptions to mother/calf bonding or masking of important acoustic cues. No airgun use, including the use of mitigation guns, is permitted during the restriction period.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
	20-m [66-ft] water depth)		
No Assigned Mitigation Numbers	Geological and Geophysical Mitigation Natural Resource Defense Council Area of Concern (equal to or greater than 100-m [328-ft] water depth)	Required Passive Acoustic Monitoring (PAM)	BOEM requires that the applicant use PAM in water depths of 100 m (328 ft) or greater at times of reduced visibility (e.g., darkness, rain, fog, etc.) as part of its protected species observer program. The PAM will be monitored at all times of reduced visibility. Applicants will be required to provide BSEE with a description of the passive acoustic system, the software used, and the monitoring plan prior to its use. Additionally, after survey completion, the applicant will provide an assessment of the usefulness, effectiveness, and problems encountered with the use of PAM for marine mammal detection to BSEE for review.
No Assigned Mitigation Numbers	Mitigation for High-Resolution Surveys	Vessel-Strike Avoidance/Reporting	The applicant will follow the guidance provided under BOEM NTL No. 2016-G01, “Vessel Strike Avoidance and Injured/Dead Protected Species Reporting.” BOEM NTL No. 2016-G01 provides guidance on how a seismic operator should implement monitoring programs to minimize the risk of vessel strikes to protected species and should report observations of injured or dead protected species. In lieu of a formal observer program, this NTL provides specific guidelines that should be followed to identify and avoid injury to marine mammals and sea turtles.
No Assigned Mitigation Numbers	Mitigation for High-Resolution Surveys	Marine Trash and Debris Awareness and Elimination	The applicant will follow the guidance provided under BSEE NTL No. 2012-G01, “Marine Trash and Debris Awareness and Elimination.” The BSEE NTL No. 2012-G01 provides information on reducing, if not eliminating, trash intentionally jettisoned into the Gulf of Mexico. The programs described in the NTL to assist in the reduction of marine trash and debris are the marine trash and debris placards, marine trash and debris awareness training, and the marine trash and debris awareness training and certification process.
	Geological and Geophysical Non-Recurring Mitigations	Benthic Communities	Review of BOEM’s 3D seismic database of water-bottom anomalies identified both confirmed deepwater benthic communities and features that could potentially support communities within the area of the proposed activities. Based on BOEM’s review of exploration activities proposed in the applicant’s application, the following non-recurring mitigations are applied to the area encompassed by the plan: • BOEM’s 3D seismic database of water-bottom anomalies and confirmed communities shall be used to identify features for the purpose of applying this mitigation.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			• The following nine water-bottom anomaly categories will be considered as supporting or potentially supporting deepwater benthic communities, unless proved otherwise through high-resolution surveys: anom_conf_coral; anom_conf_mvol; anom_conf_orgs; anom_poss_oil_pos; wb_anom_lith; wb_anom_mvol; wb_anom_neg; wb_anom_pock; and wb_anom_pos. • These shape files may be downloaded from http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Map-Gallery/Seismic-Water-Bottom-Anomalies-Map-Gallery.aspx. • Features shall be either avoided or surveyed to confirm the presence or absence of deepwater benthic communities. • Per NTL No. 2009-G40, "Deepwater Benthic Communities," a minimum separation of 250 ft (76 m) must be maintained between documented communities or features that could potentially support high-density deepwater benthic communities and bottom-disturbing activities (e.g., sensors deployed on the seafloor). – Therefore, a minimum distance of separation for planned sensor deployment sites from any feature or community documented in BOEM's water-bottom anomaly database must be at least 250 ft (76 m). – If at any time it is determined that a node has landed within 250 ft (76 m) of any feature or community documented in BOEM's water-bottom anomaly database, an ROV must be used to document the seafloor surrounding the landing location. The seafloor beneath the node and arms must be surveyed visually with an ROV for damages. All images collected during this survey, showing the area within the footprint of the node, must be returned to BOEM's Gulf of Mexico OCS Region, Biological Sciences Unit for evaluation. • As required by NTL No. 2009-G40, for bottom-disturbing activities occurring within 500 ft (152 m) of a high-density deepwater benthic community, the operator must provide BOEM with an as-placed plat showing the actual location of the disturbance on the seafloor, in relation to documented anomalies and communities. This requirement will apply to sensors placed within 500 ft (152 m) of a documented anomaly or community, as shown in BOEM's 3D seismic database.

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			For sensor deployments requiring as-placed plats, prepare at a scale of 1 in = 1,000 ft and submit to BOEM's Regional Supervisor, Office of Resource Evaluation, Data Acquisition and Special Projects Unit.
	Geological and Geophysical Non-Recurring Mitigations	Tethered Ocean Bottom Node Surveys	Acoustic buoy releases, tethered acoustic pingers, and nodal tethering lines pose an entanglement risk to sea turtles and other marine life. Implementing the following measures reduces the risk of entanglement and ensures proper reporting of entanglement situations. Reasonable measures are available to applicants using this deployment technique to reduce the risk of entanglement. These measures include the following: (1) shortening the acoustic buoy line and tethered acoustic pinger line to the shortest length practical; and (2) replacing tether rope lines equal to or greater than ¼-in diameter with a thicker, more rigid tether line, modifying the line by tying knots in the line to increase the diameter and rigidness in order to minimize the risk of entanglement. Additional measures include ensuring that a Protected Species Observer (PSO) is onboard each vessel during tethered node retrieval operations. The PSOs will document any entanglement of marine species in the nodal gear, specifically noting the location where entanglement occurred (e.g., pinger tether, acoustic buoy line, etc.). If a marine protected species becomes entangled, specifically a sea turtle, the PSO will immediately begin resuscitation procedures as described in the National Oceanic and Atmospheric Administration's guidelines that can be found at http://www.st.nmfs.noaa.gov/Assets/Observer-Program/pdf/Shrimp_Reef_fish_Manual_9_22_10.pdf. The PSO must also contact the sea turtle stranding network's State coordinator to report the incident, condition of the turtle, and request additional instructions to reduce risk of injury or mortality, including rehabilitation and salvage techniques.
	Geological and Geophysical Non-Recurring Mitigations	Topographic Features	The applicant must adhere to the provisions of the topographic features lease stipulation and the policy described in NTL No. 2009-G39, "Biologically-Sensitive Underwater Features and Areas," which restricts any bottom-disturbing activities within 152 m (500 ft) of the designated "No Activity Zone" of a topographic feature, as well as all applicable requirements described in the NTL.
	Geological and Geophysical Non-Recurring Mitigations	Potential Archaeological Resource Protection	BOEM's review of the application indicates that numerous targets identified by existing remote-sensing data are located in the project area where the ocean bottom cables (OBCs) are proposed to be deployed. Therefore, in order to demonstrate compliance with 30 CFR § 551.6(a)(5), the applicant will either (1) ensure that all seafloor-disturbing actions required for the OBC deployment avoid the features by a distance greater than that listed in the tables or (2) conduct an underwater archaeological investigation prior to cable deployment to determine whether the feature represents an archaeological resource. If the applicant

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			chooses to avoid the feature, it will be required to submit a plat, at a scale of 1 in = 1000 ft with DGPS accuracy, with its final report as required by 30 CFR § 551.8(c)(2), which demonstrates the feature was not physically impacted by the OBC deployment and retrieval or by any other associated bottom disturbances. If the applicant chooses to conduct an underwater archaeological investigation, it will be required to comply with the investigation methodology and reporting guidelines found on BOEM's website at http://www.boem.gov/gom-archaeology/. This is only a partial list of potential archaeological sites within the project area, based on existing remote-sensing data. There are significant portions of the project area within the OCS that have received either limited or no previous archaeological survey, and these areas are likely to contain additional archaeological materials that may be impacted by the proposed operations. If the applicant discovers additional manmade debris that appears to indicate the presence of a shipwreck (e.g., a sonar image or visual confirmation of an iron, steel, or wooden hull; wooden timbers; anchors; concentrations of manmade objects such as bottles or ceramics; and piles of ballast rock) within or adjacent to the proposed action area during the proposed survey operations, the applicant will be required to immediately halt operations, take steps to ensure that the site is not disturbed in any way, and contact BOEM's Regional Supervisor, Office of Environment within 48 hours of its discovery. The applicant must cease all operations within 1,000 ft (305 m) of the site until BOEM's Regional Director instructs the applicant on what steps must be taken to assess the site's potential historic significance and what steps the applicant must take to protect it. If an OBC becomes snagged on any submerged object, divers are required to un-snag and retrieve the OBC, and the applicant must submit a report detailing each instance of this activity. This report should include the coordinates of the snag (to DGPS accuracy), the diver's description of the submerged object creating the snag, any damage that may have resulted from the OBC placement or retrieval operations, and any photographic or video imagery that is collected. The applicant must submit a report of any data collected as a result of these investigations.
	Geological and Geophysical Non-Recurring Mitigations	Benthic Communities (ROV Deployed OBNs)	The method <<INSERT COMPANY NAME>> proposes for deployment and retrieval of ocean bottom nodes (OBNs) is summarized as follows: <<SUMMARIZE METHODS FROM APPLICATION, INCLUDING CONTRACTOR PROPOSED MITIGATIONS>> – For example:

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			1. Each node will be deployed with a work-class ROV with a positioning beacon attached, ROV launched from the node vessel. Multiple ROVs may be operating simultaneously. 2. A subsea node transport system carrying nodes will be lowered to a suitable water depth. 3. ROV will land on the seafloor as close to the pre-plot as practical and deploy a node onto the seafloor using manipulator tool. 4. ROV will remain on the seafloor as required to get a position fix. 5. ROV will take off from the seafloor and travel to the next pre-plot node position. The process will be repeated until all nodes are deployed. Multiple ROVs may be working simultaneously each carrying sets of nodes transferred from the subsea node transport system. Upon completion of source vessel activity, the nodes will be retrieved in a fashion similar to the method described for deployment. BOEM review of geophysical activities proposed in <<INSERT APPLICATION #>> identified confirmed and potential sensitive sessile benthic resources within the proposed node area. According to NTL No. 2009-G40, the minimum separation distance for bottom-disturbing activities is 76 m (250 ft) from any sensitive sessile benthic community (e.g., deepwater coral, chemosynthetic tube worms). Based on the methods described in the application, BOEM authorizes the applicant to deploy nodes with less than 76-m (250-ft) avoidance of high-density deepwater benthic communities contingent upon the applicant adhering to the mitigations described below: 1. All seafloor disturbances, including nodes, cables, and ROV, must remain a minimum of 5 m (16 ft) from all sensitive sessile benthic communities. 2. The contractor must photograph the seabed within a 10-m (33-ft) radius of any node placed within 76 m (250 ft) of a BOEM anomaly (June 2019 dataset, see the link below). Photographs of each such location shall be taken: pre-node

Mitigation Number	Mitigation Type	Mitigating Measure Title	Description of Mitigation
			deployment, post-node deployment, and post-node retrieval. The photos shall clearly show the geographic location of each node. 3. If any sessile benthic communities are present at a proposed node location, a new site that allows compliance with the above requirements shall be selected. 4. The contractor must provide an as-place d GIS shapefile of actual OBN locations to demonstrate compliance. Submit the required photographs and shapefile to BOEM's Regional Supervisor, Office of Resource Evaluation, Data Acquisition and Special Projects Unit, within 90 calendar days after you complete the geological and geophysical activity. Refer to the following BOEM website for GIS data layers of known 3D seismic water bottom anomalies: https://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/. The following feature classes have a high probability of supporting sensitive sessile benthic organisms and shall be avoided unless visual inspection and photographic data confirm an absence of high-density deepwater benthic communities: 1. Anomaly_patchreefs (shallow water) 2. Anomaly_confirmed_patchreefs (shallow water) 3. Seep_anomaly_positives 4. Seep_anomaly_positives_possible_oil 5. Seep_anomaly_positives_confirmed_oil 6. Seep_anomaly_positives_confirmed_gas 7. Seep_anomaly_confirmed_corals 8. Seep_anomaly_confirmed_organisms 9. Seep_anomaly_confirmed_hydrate 10. Seep_anomaly_confirmed_carbonate 11. Anomaly_Cretaceous 12. Anomaly Cretaceous talus.

2020 Biological Opinion Mitigations

A series of mitigations with no assigned number have been created as a result of the Endangered Species Act (ESA) Consultation with NMFS that concluded on March 13, 2020 (2020 BiOp). Specific conditions of approval as part of the ESA Consultation process with NMFS are given below.

For Plans

- **Compliance with Biological Opinion Terms and Conditions and Reasonable and Prudent Measures:** This approval is conditioned upon compliance with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued by NMFS on March 13, 2020. This includes mitigation, particularly any appendices to Terms and Conditions applicable to the plan, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp; and any additional reporting required by BOEM or BSEE developed as a result of BiOp implementation. The NMFS Biological Opinion may be found online at https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico. The appendices and protocols may be found online at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.
- **Support Bases and Vessel Transit Routes:** Approval of your plan is conditioned upon your use of the support bases and vessel transit routes as described in your plan. BOEM/BSEE must be notified at least 15 days prior to any vessel route changes that require transit of the Bryde's whale area, and you must receive prior approval for that transit from BOEM/BSEE.
- **Seismic Survey Operation, Monitoring, and Reporting Guidelines:** The applicant will follow the guidance provided under "Appendix A: Seismic Survey Mitigation and Protected Species Observer Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be found on the NOAA Fisheries' website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.
- **Marine Trash and Debris Awareness and Elimination**: The applicant will follow the guidance provided under "Appendix B: Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be found on the NOAA Fisheries' website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Vessel-Strike Avoidance/Reporting:** The applicant will follow the guidance provided under "Appendix C: Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be found on the NOAA Fisheries' website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

For Pipelines

- **Compliance with Biological Opinion Terms and Conditions and Reasonable and Prudent Measures:** This approval is conditioned upon compliance with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued NMFS on March 13, 2020. This includes mitigation, particularly any appendices to Terms and Conditions applicable to the plan, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp and any additional reporting required by BOEM or BSEE developed as a result of BiOp implementation. The NMFS Biological Opinion may be found online at https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico. The appendices and protocols may be found online at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Support Bases and Vessel Transit Routes:** Approval of your plan is conditioned upon your use of the support bases and vessel transit routes as described in your plan. BOEM/BSEE must be notified at least 15 days prior to any vessel route changes that require transit of the Bryde's whale area, and you must receive prior approval for that transit from BOEM/BSEE.

- **Marine Trash and Debris Awareness and Elimination:** The applicant will follow the protocols provided under "Appendix B: Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Vessel-Strike Avoidance/Reporting:** The applicant will follow the protocols provided under "Appendix C: Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Sea Turtle Resuscitation Guidelines:** The applicant will follow the guidance provided under "Appendix J: Sea Turtle Handling and Resuscitation Guidelines" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Slack-Line Precautions and Reporting Requirement:**

  – If your operations require the use of flexible, small diameter (<1 in) nylon, plastic, or fiber lines to support your operations, you must make every effort to reduce the slack in the lines to prevent accidental entanglement with protected species and other marine life.

  – You are expected to utilize hands-on monitoring, lashings, tape, and other tensioning tools to reduce any unnecessary looseness in the lines and/or potential looping. The lines should be monitored regularly.

  – If an animal is detected entangled, you are required to ensure requisite personnel safety first and then contact the appropriate agency. For marine mammals and sea turtle entanglement, contact the stranding network listed at https://www.fisheries.noaa.gov/report. Other ESA-listed species should be reported to State wildlife management agency(ies) and call 985-722-7902 for additional guidance on continued monitoring requirements, recovery assistance needs (if required), and incidental report information.

  – Within 24 hours of any event, notify NMFS at nmfs.psoreview@noaa.gov and BSEE at protectedspecies@bsee.gov.

For Structure Removals

- **Compliance with Biological Opinion Terms and Conditions and Reasonable and Prudent Measures:** This approval is conditioned upon compliance with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued by NMFS on March 13, 2020. This includes mitigation, particularly any appendices to Terms and Conditions applicable to the plan, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp and any additional reporting required by BOEM or BSEE developed as a result of BiOp implementation. The NMFS Biological Opinion may be found online at https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico. The appendices and protocols may be found online at https://www.fisheries.noaa.gov/resource/

document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Support Bases and Vessel Transit Routes:** Approval of your plan is conditioned upon your use of the support bases and vessel transit routes as described in your plan. BOEM/BSEE must be notified at least 15 days prior to any vessel route changes that require transit of the Bryde's whale area, and you must receive prior approval for that transit from BOEM/BSEE.

- **Marine Trash and Debris Awareness and Elimination:** The applicant will follow the protocols provided under "Appendix B: Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Vessel-Strike Avoidance/Reporting:** The applicant will follow the protocols provided under "Appendix C: Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Sea Turtle Resuscitation Guidelines:** The applicant will follow the protocols provided under "Appendix J: Sea Turtle Handling and Resuscitation Guidelines" found in the Biological Opinion issued by NMFS on March 13, 2020. The appendix can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

For Geological and Geophysical Surveys

- **Compliance with Biological Opinion Terms and Conditions and Reasonable and Prudent Measures:** This approval is conditioned upon compliance with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued by NMFS on March 13, 2020. This includes mitigation, particularly any appendices to Terms and Conditions applicable to the plan, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp and any additional reporting required by BOEM or BSEE developed as a result of BiOp implementation. The NMFS Biological Opinion may be found online at https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico. The appendices and protocols may be found online at https://www.fisheries.noaa.gov/resource/

document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Support Bases and Vessel Transit Routes:** Approval of your application is conditioned upon your use of the support bases and vessel transit routes as described in your application. BOEM/BSEE must be notified at least 15 days prior to any vessel route changes that require transit of the Bryde's whale area, and you must receive prior approval for that transit from BOEM/BSEE.

- **Seismic Survey Operation, Monitoring, and Reporting Guidelines:** The applicant will follow the guidance provided under "Appendix A: Seismic Survey Mitigation and Protected Species Observer Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The guidance can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Marine Trash and Debris Awareness and Elimination:** The applicant will follow the protocols provided in "Appendix B: Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The appendix can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

- **Vessel-Strike Avoidance/Reporting:** The applicant will follow the guidance provided under "Appendix C: Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols" found in the Biological Opinion issued by NMFS on March 13, 2020. The appendix can be accessed on the NOAA Fisheries website at https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico.

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- **Slack-Line Precautions and Reporting Requirement:**
  - If your operations require the use of flexible, small diameter (<1 in) nylon, plastic, or fiber lines to support your operations, you must make every effort to reduce the slack in the lines to prevent accidental entanglement with protected species and other marine life.

  - You are expected to utilize hands-on monitoring, lashings, tape, and other tensioning tools to reduce any unnecessary looseness in the lines and/or potential looping. The lines should be monitored regularly.
  - If an animal is detected entangled, you are required to ensure requisite personnel safety first and then contact the appropriate agency. For marine mammals and sea turtle entanglement, contact the stranding network listed at https://www.fisheries.noaa.gov/report. Other ESA-listed species should be reported to State wildlife management agency(ies) and call 985-722-7902 for additional guidance on continued monitoring requirements, recovery assistance needs (if required), and incidental report information.
  - Within 24 hours of any event, notify NMFS at nmfs.psoreview@noaa.gov and BSEE at protectedspecies@bsee.gov.

- **Seismic Survey Restriction Period:** The applicant shall adhere to a restriction period between January 1 and April 30 (primarily bottlenose dolphin calving season) in the portion of the 20-m (66-ft) isobath outside the EPA (i.e., from the Texas/Louisiana border to the eastern border of Franklin County, Florida) that is currently identified and declared by NOAA in the recent unusual mortality event. The applicant shall adhere to a restriction period between March 1 and April 30 for deep-penetration seismic surveys on the Federal OCS in coastal waters out to the 20-m (66-ft) isobath in the EPA. The seasonal restriction is to avoid potential impacts to dolphins in regards to behavioral disruptions to mother/calf bonding or masking of important acoustic cues. No airgun use, including the use of mitigation guns, is permitted during the restriction period.

- **Required Passive Acoustic Monitoring (PAM):** BOEM requires that the applicant use PAM in water depths of 100 m (328 ft) or greater at times of reduced visibility (e.g., darkness, rain, fog, etc.) as part of its protected species observer program. The PAM will be monitored at all times of reduced visibility. Applicants will be required to provide BSEE with a description of the passive acoustic system, the software used, and the monitoring plan *prior to its use*. Additionally, after survey completion, the applicant will provide an assessment of the usefulness, effectiveness, and problems encountered with the use of PAM for marine mammal detection to BSEE for review. The pre-survey information and post-survey assessment is to be submitted via email to protectedspecies@bsee.gov or via paper copy to the Bureau of Safety and Environmental Enforcement, Gulf of Mexico Regional Office, 1201 Elmwood Park Blvd., New Orleans, Louisiana 70123-2394; Attention: Environmental Enforcement Branch (MS GE-466).

- **Pre-Activity Sound-Source and Array Calibration Verification:** Prior to conducting survey activities, the applicant will verify in writing that the proposed airgun arrays to be used are of the lowest sound intensity level that still achieves the survey goals. The written verification must include confirmation that the airgun array has been calibrated/tuned to maximize subsurface illumination, and minimize, to the extent practicable, horizontal propagation of noise. The written verification is to be submitted via email to GGPermitsGOMR@boem.gov or via paper copy to the Bureau of Ocean Energy Management, Gulf of Mexico Regional Office, 1201 Elmwood Park Blvd., New Orleans, Louisiana 70123-2394; Attention: Data Acquisition and Special Projects Unit (MS GM-881A).

- **Mandatory Separation Buffer Between Survey Operations[4]:** The applicant will be required to maintain, to the extent it can practicably and safely do so, a minimum separation distance of 30 km (19 mi) from any other vessels concurrently conducting deep-penetration seismic surveys and 40 km (25 mi) when operating within an Area of Concern. Details on the locations of these Areas of Concern can be found at http://www.boem.gov/BOEM-Lawsuit-Settlement-Agreement/. To assist in implementation of this measure, BOEM will provide the applicant with contact information for all deep-penetration seismic applicants concurrently permitted/authorized to operate within or near the proposed survey area.
- **Supplemental Reporting Requirements:** In addition to the reporting requirements under NTL No. 2016-G02, the applicant is required to submit bi-weekly reports containing the information listed below. The reporting periods end on the 1st and 15th of each month. These bi-weekly reports are required for the *total* duration of the permit. When applicable, they must be submitted with survey navigation data for the 2-week reporting period. BOEM has a suggested format for the written report. If BOEM's suggested written format is not used, the following information must be submitted along with the navigation data:
  - The dates, locations, and duration of any deep-penetration seismic operations conducted during the reporting period. (The navigation data provides this information.)
  - Any circumstances that caused the total energy output of the airgun source array to exceed that set forth in the permit application.
  - Confirmation that the permittee maintained, to the extent it could practicably and safely do so, the minimum separation distance. If applicable, submit a written explanation of why the minimum separation distance was not maintained.
  - Confirmation that the permittee complied with the other terms of Section V of the Settlement Agreement.

[4] Implementation of this requirement may no longer be required upon expiration of the settlement agreement and stay.

CHAPTER 7

POTENTIAL LEASE STIPULATIONS

What is in This Chapter?

- A discussion of potential lease stipulations that could be applied to future GOM oil and gas lease sales.
- Each potential stipulation discussion is divided into the following subsections:
  - Stipulation Overview
  - Potential Stipulation Language
  - Effectiveness of the Lease Stipulation

Key Points

- These potential lease stipulations were developed from numerous scoping efforts for the National OCS Oil and Gas Program, as well as from lease stipulations applied in previous lease sales.
- The Final Notice of Sale package for each individual lease sale will contain the lease stipulations being applied for that lease sale, and any stipulations to be included are also described in the Record of Decision for that lease sale under NEPA.
- The lease stipulations described below would be reconsidered for each proposed lease sale, as applicable.
- Mitigating measures in the form of lease stipulations are added to the lease terms and are therefore enforceable as part of the lease.

7 POTENTIAL LEASE STIPULATIONS

7.1 INTRODUCTION

Mitigations can be applied at the lease sale stage, typically through applying what are commonly referred to as lease stipulations to OCS oil and gas leases as a result of any given lease sale. Stipulations are attached to OCS oil and gas leases and are legally binding. Stipulations are applied to leases when a lessee obtains a lease, while COAs are applied to permits during the postlease review process outlined in **Chapter 6**.

This chapter discusses the potential lease stipulations that could be considered for a lease sale. These potential lease stipulations were developed from numerous scoping efforts for the National OCS Oil and Gas Program, as well as from lease stipulations applied in previous lease sales. The 10 lease stipulations described below could be considered for future proposed lease sales in the GOM, as applicable. While these potential stipulations could be further analyzed in future NEPA analyses, that would not ensure that the Assistant Secretary for Land and Minerals Management will make a decision to apply the stipulations to OCS oil and gas leases that may result from any proposed

OCS oil and gas lease sale nor does it preclude minor modifications in wording during subsequent steps in the prelease process if comments indicate changes are necessary or if conditions change.

Lease stipulations are considered for adoption by the Assistant Secretary for Land and Minerals Management, under authority delegated by the Secretary of the Interior, and any stipulations to be included in a lease sale are described in the Record of Decision for that lease sale. Mitigating measures in the form of lease stipulations are added to the lease terms and are therefore enforceable as part of the lease. In addition, each exploration and development plan, as well as any pipeline applications that result from a lease sale, will undergo a NEPA review, and additional project-specific mitigations may be applied as conditions of plan approval at the postlease stage (refer to **Chapter 5**). The BSEE has the authority to monitor and enforce these conditions, and under 30 CFR part 250 subpart N, may seek remedies and penalties from any operator that fails to comply with those conditions, stipulations, and mitigating measures.

Some lease stipulations apply to all blocks that may be offered, while other lease stipulations apply only to specified blocks. Each Final Notice of Sale package will include maps indicating which blocks will have potential lease stipulations, and the "List of Blocks Available for Leasing" contained in the Final Notice of Sale package will identify the lease stipulations applicable to each block. The Final Notice of Sale package will contain the Final Notice of Sale, information to lessees, and lease stipulations. A recent list of frequently applied lease stipulations for Gulf of Mexico OCS oil and gas lease sales includes the following:

- Stipulation No. 1 – Military Areas;
- Stipulation No. 2 – Evacuation;
- Stipulation No. 3 – Coordination;
- Stipulation No. 4 – Protected Species;
- Stipulation No. 5 –Topographic Features;
- Stipulation No. 6 – United Nations Convention on the Law of the Sea Royalty Payment
- Stipulation No. 7 – Agreement between the United States of America and the United Mexican States Concerning Transboundary Hydrocarbon Reservoirs in the Gulf of Mexico
- Stipulation No. 8 – Live Bottom
- Stipulation No. 9 – Blocks South of Baldwin County, Alabama
- Stipulation No. 10 – Restrictions due to Rights-of-Use and Easements for Floating Production Facilities

7.2 STIPULATION NO. 1 – MILITARY AREAS

7.2.1 Stipulation Overview

Stipulation No. 1 may be included in leases, issued as a result of a proposed OCS oil and gas lease sale, located within the Warning Areas and Eglin Water Test Areas as shown in **Figure 7.2.1-1**. The Military Areas Stipulation has been applied to all blocks leased in military areas since 1977 and reduces potential impacts, particularly in regards to safety, but it does not reduce or eliminate the actual physical presence of OCS oil- and gas-related operations in areas where military operations are conducted. The stipulation contains a “hold harmless” clause (holding the U.S. Government harmless in case of an accident involving military operations) and requires lessees to coordinate their activities with appropriate local military contacts.

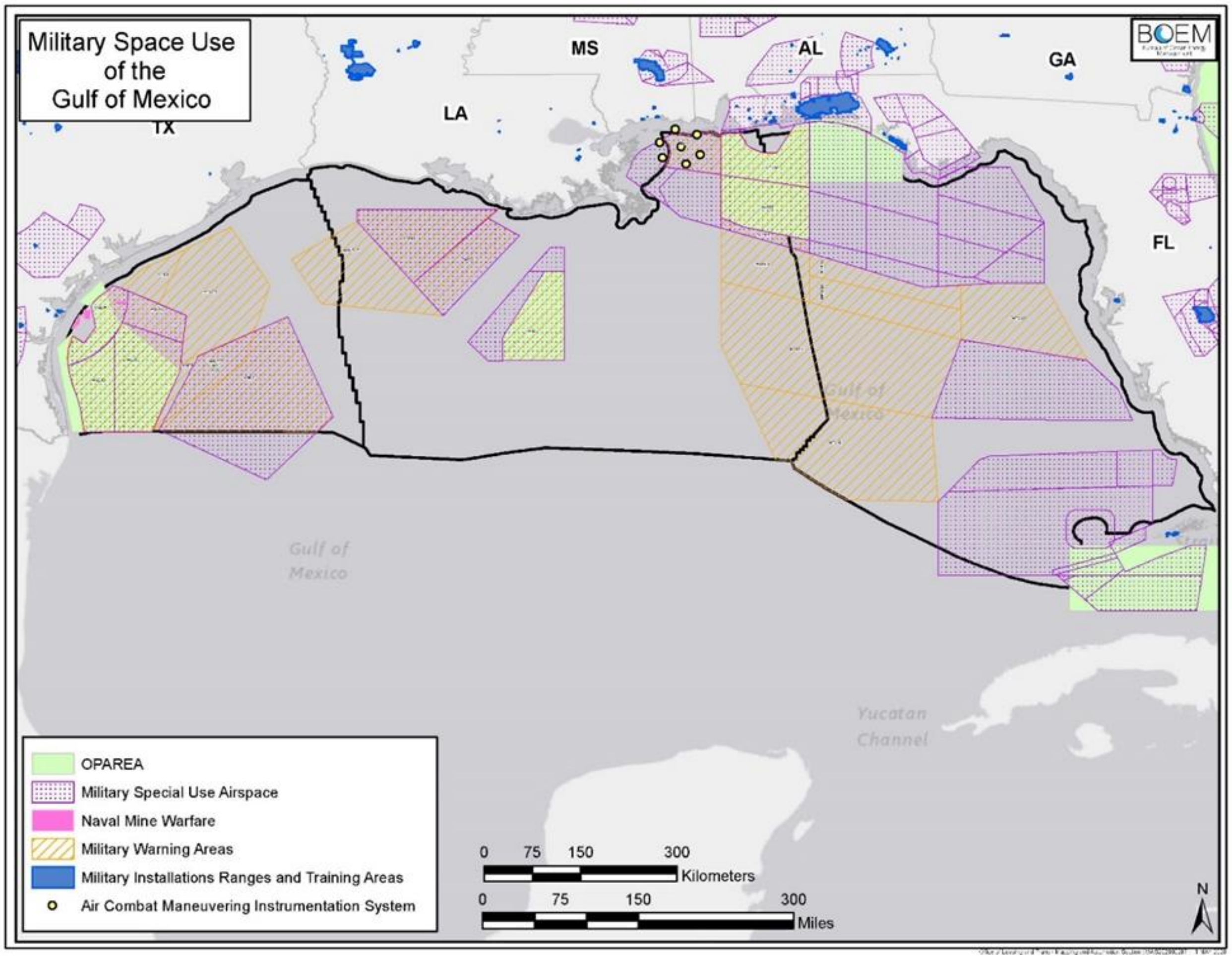

*Figure 7.2.1-1. Military Warning Areas and Eglin Water Test Areas in the Gulf of Mexico (reprint of **Figure 2.7.2-3**).*

7.2.2 Potential Stipulation Language

The potential stipulation reads as follows:

A. Hold and Save Harmless

Whether compensation for such damage or injury might be due under a theory of strict or absolute liability or otherwise, the lessee assumes all risks of damage or injury to persons or property that occur in, on, or above the Outer Continental Shelf (OCS), and to any persons or to any property of any person or persons who are agents, employees, or invitees of the lessee, its agents, independent contractors, or subcontractors doing business with the lessee in connection with any activities being performed by the lessee in, on, or above the OCS if such injury or damage to such person or property occurs by reason of the activities of any agency of the United States (U.S.) Government, its contractors or subcontractors, or any of its officers, agents, or employees, being conducted as a part of, or in connection with, the programs and activities of the command headquarters listed in the table in Section C, Operational.

Notwithstanding any limitation of the lessee's liability in Section 14 of the lease, the lessee assumes this risk whether such injury or damage is caused in whole or in part by any act or omission, regardless of negligence or fault, of the U.S. Government, its contractors or subcontractors, or any of its officers, agents, or employees. The lessee further agrees to indemnify and save harmless the U.S. Government against all claims for loss, damage, or injury sustained by the lessee, or to indemnify and save harmless the U.S. Government against all claims for loss, damage, or injury sustained by the agents, employees, or invitees of the lessee, its agents, or any independent contractors or subcontractors doing business with the lessee in connection with the programs and activities of the aforementioned military installation, whether the same be caused in whole or in part by the negligence or fault of the U.S. Government, its contractors or subcontractors, or any of its officers, agents, or employees, and whether such claims might be sustained under a theory of strict or absolute liability or otherwise.

B. Electromagnetic Emissions

The lessee agrees to control its own electromagnetic emissions and those of its agents, employees, invitees, independent contractors, or subcontractors emanating from individual designated defense warning areas in accordance with the requirements specified by the commander of the command headquarters listed in the following table to the degree necessary to prevent damage to, or unacceptable interference with, Department of Defense flight, testing, or operational activities conducted within individual designated warning areas. Necessary monitoring, control, and coordination with the lessee, its agents, employees, invitees, independent contractors, or subcontractors will be affected by the commander of the appropriate onshore military installation conducting operations in the particular warning area, provided, however, that control of such electromagnetic emissions shall in no instance prohibit all manner of electromagnetic communication during any period of time between a lessee, its agents, employees, invitees, independent contractors, or subcontractors, and onshore facilities.

C. Operational

The lessee, when operating, or causing to be operated on its behalf, a boat, ship, or aircraft traffic in an individual designated warning area, must enter into an agreement with the commander of the individual command headquarters listed in the following list, prior to commencing such traffic. Such an agreement will provide for positive control of boats, ships, and aircraft operating in the warning areas at all times.

Warning and Water Test Area	Command Address	Contact(s)	Email	Phone
W-59	Naval Air Station JRB 159 Fighter Wing 400 Russell Avenue, Box 27 Building 285 (Operations) New Orleans, Louisiana 70143-0027	TSgt. Michael Frisard TSgt. Scott Fenton	michael.j.frisard.mil@mail.mil scott.p.fenton2.mil@mail.mil	(504) 391-8637 (504) 391-8695 /8696
W-92	Fleet Area Control and Surveillance Facility Attention: Deputy Airspace Officer 118 Albemare Ave. P.O. Box 40 Jacksonville, Florida 32212	Ronald McNeal	ronald.mcNeal@navy.mil	(904) 542-2112
W-147	147 OSS/OSA 14657 Sneider Street Houston, Texas 77034-5586	Sgt. Dion Folley Sgt. Gina Turner	dion.r.folley.mil@mail.mil gina.l.turner@mail.mil	(281) 929-2142 (281) 929-2710 /2803
W-155	NASP Sector Control Attention: Facility (FACSFAC) NAS Pensacola 1860 Perimeter Road, Building 3963 NASP Florida 32508-5217	Facility (FACSFAC) NAS	NASP.SECTORCONTROL@navy.mil	(850) 452-2735 Base Operations: (850) 452-2431
W-228	Chief, Naval Air Training Code N386 (ATC and Air Space Management) Naval Air Station Corpus Christi, Texas 78419-5100	Tom Bily	thomas.bily@navy.mil	(361) 961-0145
W-453	Air National Guard – CRTC 4715 Hewes Avenue, Building 60 Gulfport, Mississippi 39507-4324		usaf.ms.ms-crtc.mbx.mscrtc-director-of-operations@mail.mil	(228) 214-6027

Warning and Water Test Area	Command Address	Contact(s)	Email	Phone
W-602	VQ-4 Operations Department 7791 Mercury Road Tinker AFB, Oklahoma 73145-8704		TNKR_VQ4_Dep_Skeds@navy.mil	(405) 739-5700
Eglin Water Test Areas 1, 2, 3, and 4	101 West D Ave, Bldg. 1, Suite 116 Eglin AFB, Florida 32562 Range and Operations Sustainment Section 96 TW/XPO Eglin AFB, Florida 32542	Steven C. Dietzius, Technical Director (96TW/CT) Mr. Charles Smith	 charles.smith.7@us.af.mil	(850) 882-0762 (850) 882-5614

7.2.3 Effectiveness of the Lease Stipulation

The hold harmless section of the military stipulation serves to protect the U.S. Government from liability in the event of an accident involving the lessee and military activities. This serves to reduce the impact of OCS oil- and gas-related activity on the communications of military missions and reduces the possible impacts of electromagnetic energy transmissions on missile testing, tracking, and detonation. The operations of the military and the lessee and its agents will not be affected by this chapter.

The operational section requires notification to the military of OCS oil- and gas-related activity to take place within a military use area. This allows the base commander to plan military missions and maneuvers that will avoid the areas where OCS oil- and gas-related activities are taking place or to schedule around these activities. Prior notification helps reduce the potential impacts associated with vessels and helicopters traveling unannounced through areas where military activities are underway.

This stipulation reduces potential impacts, particularly in regard to safety, but it does not reduce or eliminate the actual physical presence of OCS oil- and gas-related operations in areas where military operations are conducted. The reduction in potential impacts resulting from this stipulation makes multiple-use conflicts between military operations and OCS oil- and gas-related activities unlikely. Without the stipulation, some potential conflict is likely. The best indicator of the overall effectiveness of the stipulation may be that there has never been an accident involving a conflict between military operations and OCS oil- and gas-related activities.

7.3 Stipulation No. 2 – Evacuation

7.3.1 Stipulation Overview

Stipulation No. 2 may be included in leases issued as a result of a proposed OCS oil and gas lease sale located in the easternmost portion of the CPA and any blocks leased in the EPA. An evacuation stipulation has been applied to all blocks leased in these areas since 2001. The Evacuation Stipulation is designed to protect the lives and welfare of offshore oil and gas personnel.

The OCS oil- and gas-related activities have the potential to occasionally interfere with specific requirements and operating parameters for the lessee's activities in accordance with the military stipulation clauses contained herein. If it is determined that the operations will result in interference with scheduled military missions in such a manner as to possibly jeopardize the national defense or to pose unacceptable risks to life and property, then a temporary suspension of operations and the evacuation of personnel may be necessary.

7.3.2 Potential Stipulation Language

A. The lessee, recognizing that oil and gas resource exploration, exploitation, development, production, abandonment, and site cleanup operations on the leased area of submerged lands may occasionally interfere with tactical military operations, hereby recognizes and agrees that the United States reserves and has the right to temporarily suspend operations and/or require evacuation on this lease in the interest of national security. Such suspensions are considered unlikely in this area. Every effort will be made by the appropriate military agency to provide as much advance notice as possible of the need to suspend operations and/or evacuate. Advance notice of fourteen (14) days normally will be given before requiring a suspension or evacuation, but in no event will the notice be less than four (4) days.

Temporary suspension of operations may include the evacuation of personnel and appropriate sheltering of personnel not evacuated. Appropriate shelter means the protection of all lessee personnel for the entire duration of any Department of Defense activity from flying or falling objects or substances; it will be implemented by a written order from the Bureau of Safety and Environmental Enforcement (BSEE) Gulf of Mexico Regional Supervisor for District Field Operations (RSDFO), after consultation with the appropriate command headquarters or other appropriate military agency or higher authority.

The appropriate command headquarters, military agency, or higher authority will provide information to allow the lessee to assess the degree of risk, and provide sufficient protection for, the lessee's personnel and property. Such suspensions or evacuations for national security reasons normally will not exceed seventy-two (72) hours; however, any such suspension may be extended by order of the BSEE Gulf of Mexico RSDFO. During such periods, equipment may remain in place, but all production, if any, must cease for the duration of the temporary suspension if the BSEE Gulf of Mexico RSDFO so directs. Upon cessation of any temporary suspension, the BSEE Gulf of Mexico RSDFO immediately will notify the lessee that such suspension has terminated and operations on the leased area can resume.

B. The lessee must inform BSEE of the persons/offices to be notified to implement the terms of this stipulation.

C. The lessee is encouraged to establish and maintain early contact and coordination with the appropriate command headquarters to avoid or minimize the effects of conflicts with potentially hazardous military operations.

D. The lessee is not entitled to reimbursement for any costs or expenses associated with the suspension of operations or activities or the evacuation of property or personnel in fulfillment of the military mission in accordance with subsections A through C above.

E. Notwithstanding subsection D, the lessee reserves the right to seek reimbursement from appropriate parties for the suspension of operations or activities, or the evacuation of property or personnel, associated with conflicting commercial operations.

7.3.3 Effectiveness of the Lease Stipulation

This stipulation would provide for the evacuation of personnel and shut-in of operations during any events conducted by the military that could pose a danger to ongoing OCS oil- and gas-related operations. It is expected that the invocation of these evacuation requirements would be extremely rare. It is expected that these measures would eliminate dangerous conflicts between OCS oil- and gas-related activities and military operations. Continued close coordination between BSEE and the military may result in improvements in the wording and implementation of these stipulations.

7.4 STIPULATION NO. 3 – COORDINATION

7.4.1 Stipulation Overview

Stipulation No. 3 may be included in leases issued as a result of an OCS oil and gas lease sale located in the easternmost portion of the CPA or any blocks leased in the EPA. A coordination stipulation has been applied to all blocks leased in these areas since 2001. The Coordination Stipulation is designed to increase communication and cooperation between military authorities and offshore oil and gas operators. Specific requirements and operating parameters are established for the lessee's activities in accordance with the Military Areas Stipulation clauses. For instance, if it is determined that the operations will result in interference with scheduled military missions in such a manner as to possibly jeopardize the national defense or to pose unacceptable risks to life and property, then certain measures become activated and the OCS oil- and gas-related operations may be curtailed in the interest of national defense.

7.4.2 Potential Stipulation Language

A. The placement, location, and planned periods of operation of surface structures on this lease during the exploration stage are subject to approval by the Bureau of Ocean Energy Management (BOEM) Gulf of Mexico Regional Director (RD) after the review of an operator's Exploration Plan (EP). Prior to approval of the EP, the lessee must consult with the appropriate command headquarters regarding the location, density, and planned periods of operation of such structures, and to maximize exploration while minimizing conflicts with Department of Defense activities.

When determined necessary by the appropriate command headquarters, the lessee will enter into a formal Operating Agreement with such command headquarters, which delineates the specific requirements and operating parameters for the lessee's activities in accordance with the military stipulation clauses contained herein. If it is determined that the operations will result in interference with scheduled military missions in such a manner as to possibly jeopardize national defense or to pose unacceptable risks to life and property, then the BOEM Gulf of Mexico RD may approve the EP with conditions, disapprove it, or require modification in accordance with 30 CFR part 550. The BOEM Gulf of Mexico RD will notify the lessee in writing of the conditions associated with plan approval, or the reason(s) for disapproval or required modifications.

Moreover, if there is a serious threat of harm or damage to life or property, or if it is in the interest of national security or defense, pending or approved operations may be suspended or halted in accordance with 30 CFR part 250. Such a suspension will extend the term of a lease by an amount equal to the length of the suspension. The Bureau of Safety and Environmental Enforcement (BSEE) Gulf of Mexico RD will attempt to minimize such suspensions within the confines of related military requirements. It is recognized that the issuance of a lease conveys the right to the lessee, as provided in Section 8(b)(4) of the Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. § 1337(b)(4), to engage in exploration, development, and production activities conditioned upon other statutory and regulatory requirements.

B. The lessee is encouraged to establish and maintain early contact and coordination with the appropriate command headquarters to avoid or minimize the effects of conflicts with potentially hazardous military operations.

C. If national security interests are likely to be in continuing conflict with an existing Operating Agreement, EP, Development and Production Plan, or Development Operations Coordination Document, the BSEE Gulf of Mexico RD, in consultation with BOEM, will direct the lessee to modify any existing Operating Agreement or to enter into a new Operating Agreement to implement measures to avoid or minimize the identified potential conflicts, subject to the terms and conditions and obligations of the legal requirements of the lease.

7.4.3 Effectiveness of the Lease Stipulation

This stipulation would provide for review of pending oil and gas operations by military authorities and could result in delaying oil and gas operations if military activities have been scheduled in the area that may put the oil and gas operations and personnel at risk or if such operations could result in serious threat of harm or damage to life or property, or jeopardize the national security or defense.

7.5 STIPULATION NO. 4 – PROTECTED SPECIES

7.5.1 Stipulation Overview

Stipulation No. 4 may be included in all leases issued as a result of an OCS oil and gas lease sale. The Protected Species Stipulation has been applied to all blocks leased in the GOM since December 2001. This stipulation was developed in consultation with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and the U.S. Department of the Interior, Fish and Wildlife Service in accordance with consultation requirements under the Endangered Species Act and the Marine Mammal Protection Act, and is designed to minimize or avoid potential adverse impacts to federally protected species under both Acts.

7.5.2 Potential Stipulation Language

A. The Endangered Species Act (16 U.S.C. §§ 1531 *et seq*.) and the Marine Mammal Protection Act (MMPA) (16 U.S.C. §§ 1361 *et seq*.) are designed to protect threatened and endangered species and marine mammals and apply to activities authorized under OCSLA (43 U.S.C. §§ 1331 *et seq*.). The Congressional Declaration of Policy included in OCSLA provides that it is the policy of the United States that the OCS should be made available for expeditious and orderly development, subject to environmental safeguards, in a manner that is consistent with the maintenance of competition and other national needs (see 43 U.S.C. § 1332). Both the BOEM and the BSEE comply with the on the OCS.

B. The lessee and its operators must:

1. Comply with the Reasonable and Prudent Measures and implementing Terms and Conditions of the Biological Opinion issued by the National Marine Fisheries Service (NMFS) on March 13, 2020 (2020 NMFS BiOp). This includes mitigation, particularly any appendices to Terms and Conditions applicable to the activity, as well as record-keeping and reporting sufficient to allow BOEM and BSEE to comply with reporting and monitoring requirements under the BiOp; and any additional reporting required by BOEM or BSEE developed as a result of implementation of the 2020 NMFS BiOp. The 2020 NMFS BiOp may be found here: (https://www.fisheries.noaa.gov/resource/document/biological-opinion-federally-regulated-oil-and-gas-program-activities-gulf-mexico). The Appendices and protocols may be found here: (https://www.fisheries.noaa.gov/resource/document/appendices-biological-opinion-federally-regulated-oil-and-gas-program-gulf-mexico).

2. Immediately report all sightings and locations of injured or dead protected species (e.g., marine mammals and sea turtles) to the appropriate hotlines listed at https://www.fisheries.noaa.gov/report (phone numbers vary by state) as required in the 2020 NMFS BiOp Appendix C. If oil and gas industry activity is responsible for the injured or dead animal (e.g., injury or death was caused by a vessel strike, entrapment or entanglement), the responsible parties must notify BOEM and BSEE within 24 hours of the strike or entrapment/entanglement by email to protectedspecies@boem.gov and protectedspecies@bsee.gov, respectively.

3. Unless previously approved by BOEM or BSEE through a plan or permit issued under this lease, notify BOEM at least 15 days prior to any proposed vessel transit of the Bryde's whale area, and receive prior approval for that transit from BOEM. The Bryde's whale area, as described in the 2020 NMFS BiOp, includes the area from 100- to 400-meter isobaths from 87.5° W to 27.5° N as described in the status review (Rosel et al. 2016), plus an additional 10 km around that area.

The lessee and its operators, personnel, and subcontractors, while undertaking activities authorized under this lease, must implement and comply with the specific mitigating measures outlined in the following Appendices of the 2020 NMFS BiOp:

- Appendix A: "Seismic Survey Mitigation and Protected Species Observer Protocols";
- Appendix B: "Gulf of Mexico Marine Trash and Debris Awareness and Elimination Survey Protocols";
- Appendix C: "Gulf of Mexico Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols";
- Appendix I: "Explosive Removal of Structure Measures"; and
- Appendix J: "Sea Turtle Handling and Resuscitation Guidelines".

Certain postlease approvals (e.g., for activities proposing new and unusual technologies, seismic surveys, use of equipment presenting entanglement risks) will require step-down review by NMFS, as provided by the 2020 NMFS BiOp, and additional mitigations to protect ESA-listed species may be applied at that time. At the lessee's option, the lessee, its operators, personnel, and contractors may comply with the most current measures to protect species in place at the time an activity is undertaken under this lease, including but not limited to, new or updated versions of the 2020 NMFS BiOp, its Appendices, or through new or activity-specific consultations. The most current applicable terms and conditions and reasonable and prudent measures from the 2020 NMFS BiOp or other relevant consultations will be applied to postlease approvals. The lessee and its operators, personnel, and subcontractors will be required to comply with the mitigating measures identified in the above referenced 2020 NMFS BiOp (including Appendices), and additional measures in the conditions of approvals for their plans or permits.

7.5.3 Effectiveness of the Lease Stipulation

This stipulation was developed in consultation with NMFS and FWS, and is designed to minimize or avoid potential adverse impacts to federally protected species. The stipulation immediately implements existing mitigations on postlease activities and notifies lessees that subsequent approvals for OCS oil- and gas-related activities may include additional mitigations (as conditions of approval) when those actions have the potential to impact marine mammals, sea turtles, and other federally protected species. Among other protections, these requirements and conditions provide protection by ensuring that operations are conducted at least a minimum distance away from the animal.

7.6 STIPULATION NO. 5 – TOPOGRAPHIC FEATURES

7.6.1 Stipulation Overview

High-relief topographic features that provide habitat for coral-reef-community organisms are located in the WPA and CPA. BOEM protects these features from OCS oil- and gas-related activities through stipulations attached to leases. There are currently no identified topographic features protected under this stipulation in the EPA.

The OCS oil- and gas-related activities resulting from an OCS oil and gas lease sale could have potentially severe impacts on or near hardbottom communities in the GOM. The DOI has recognized this issue and has made the Topographic Features Stipulation part of leases on or near these biotic communities since 1973 to mitigate potential impacts. By applying the stipulation, potential impacts from nearby OCS oil- and gas-related activities were mitigated to the greatest extent possible. This stipulation does not prevent the recovery of oil and gas resources but would serve to protect valuable and sensitive biological resources.

If applied, this stipulation would likely be included in leases issued as a result of an OCS oil and gas lease sale on blocks within the areas indicated in **Figure 7.6.1-1**. The detailed topographic features map package is available from BOEM's New Orleans Office, Public Information Office and on BOEM's website at http://www.boem.gov/Topographic-Features-Stipulation-Map-Package/. BOEM policy, as it relates to the Topographic Features Stipulation, is described in NTL No. 2009-G39, "Biologically-Sensitive Underwater Features and Areas," and can be found on BOEM's website at https://www.boem.gov/sites/default/files/regulations/Notices-To-Lessees/2009/09-G39.pdf. Specific OCS blocks affected by the Topographic Features Stipulation are listed on BOEM's website at https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Gulf-of-Mexico-Region/topoblocks.pdf. A detailed map showing the locations of the affected blocks can be found on BOEM's website at https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Gulf-of-Mexico-Region/topomap.pdf.

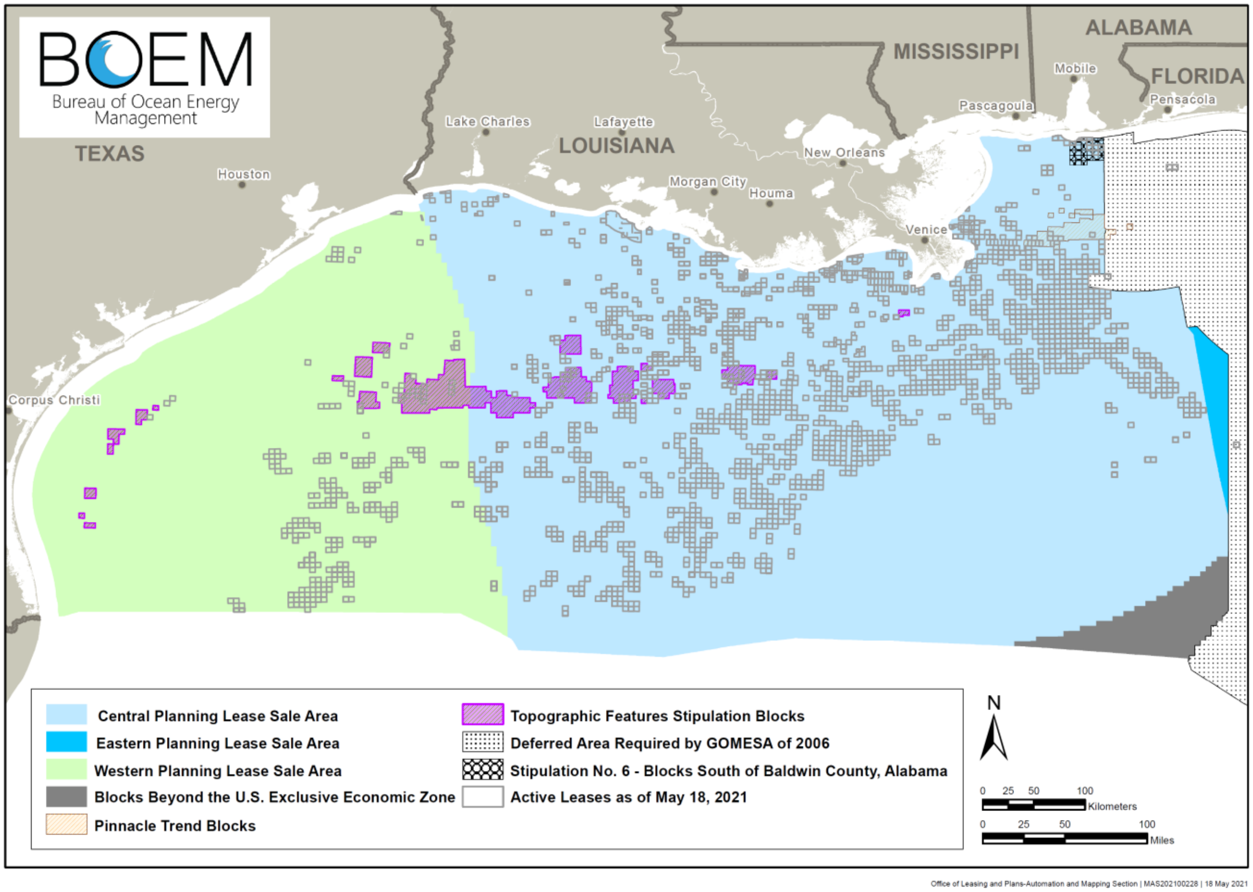

Figure 7.6.1-1. Blocks That Could Be Subject to the Topographic Features Stipulation, Live Bottom Stipulation, or the Blocks South of Baldwin County, Alabama Stipulation in the Gulf of Mexico Overlaid with the 2017-2022 GOM Multisale EIS Proposed Lease Sale Areas.

The Topographic Features Stipulation was formulated based on consultation with various Federal agencies and comments solicited from the States, industry, environmental organizations, and academic representatives. The stipulation is based on years of scientific information collected since the inception of the stipulation. This information includes various Bureau of Land Management/MMS (BOEM)-funded studies of topographic highs in the GOM; numerous stipulation-imposed, industry-funded monitoring reports; and the National Research Council's report entitled *Drilling Discharges in the Marine Environment* (National Research Council 1983). The blocks affected by the previously applied Topographic Features Stipulation are shown in **Figure 7.6.1-1**.

This stipulation would establish No Activity Zones at the topographic features where no bottom-disturbing activity, including anchoring and structure emplacement, would be allowed. The No Activity Zone would protect the most sensitive reef biota that are found at the peaks of the topographic features within the No Activity Zone. Each bank-specific No Activity Zone is described in the table in **Chapter 7.7.2** below. Outside the No Activity Zone, additional restrictive buffer zones based on an essential fish habitat programmatic consultation with the NOAA Fisheries would be established to distance OCS oil- and gas-related, bottom-disturbing activities from the No Activity

Zone. Oil and gas operations could occur within these buffer zones, but drilling discharges would be shunted to near the seafloor within the zones. Shunting of the drilling effluent to near the seafloor allows cuttings to be discharged deeper than the portions of the high-relief topographic feature where the most sensitive reef-building corals live. Low-relief banks would likely have a No Activity Zone and restrictive buffer zones surrounding the No Activity Zone but would not have a shunting requirement. Shunting near these low-relief banks would discharge drilling muds in the same water-depth range as the features' associated biota that are being protected and could potentially smother those features.

Three topographic features (i.e., the East Flower Garden Bank, West Flower Garden Bank, and Stetson Bank) comprise the Flower Garden Banks National Marine Sanctuary as of the publication of this document. Because the features of the East and West Flower Garden Banks have received National Marine Sanctuary status, under BOEM's Topographic Features Stipulation, they are now protected to a greater degree than the other topographic features, as outlined in the table in **Chapter 7.6.2** below. Under BOEM's Topographic Features Stipulation and based on an essential fish habitat programmatic consultation with the NOAA Fisheries, the added provisions at the East and West Flower Garden Banks include a larger and deeper No Activity Zone and a larger shunting zone (4 mi [6 km] surrounding the No Activity Zone) than the other BOEM-protected topographic features. Stetson Bank, which was made part of the Flower Garden Banks National Marine Sanctuary in 1996, does not have the same biological complexity as the East and West Flower Garden Banks, and therefore has similar No Activity Zone and shunting zone protections to the other BOEM-protected topographic features.

7.6.2 Potential Stipulation Language

The stipulation provides for protection of the following banks through the applicable mitigation measures in the Western Planning Area.

Bank Name	Biogeographic Region	No Activity Zone (defined by isobaths in meters)
West Flower Garden Bank	Shelf Edge Banks	100 (Defined by 1/4 x 1/4 x 1/4 system)
East Flower Garden Bank	Shelf Edge Banks	100 (Defined by 1/4 x 1/4 x 1/4 system)
MacNeil Bank	Shelf Edge Banks	82
29 Fathom Bank	Shelf Edge Banks	64
Rankin Bank	Shelf Edge Banks	85
Bright Bank[1]	Shelf Edge Banks	85
Stetson Bank	Shelf Edge Banks	52
Appelbaum Bank	Shelf Edge Banks	85
Mysterious Bank	Low-Relief Banks[2]	74, 76, 78, 80, 84
Coffee Lump	Low-Relief Banks[2]	Various
Blackfish Ridge	Low-Relief Banks[2]	70
Big Dunn Bar	Low-Relief Banks[2]	65

Bank Name	Biogeographic Region	No Activity Zone (defined by isobaths in meters)
Small Dunn Bar	Low-Relief Banks[2]	65
32 Fathom Bank	Low-Relief Banks[2]	52
Claypile Bank[3]	Low-Relief Banks[2]	50
Dream Bank	South Texas Banks[4]	78, 82
Southern Bank	South Texas Banks[4]	80
Hospital Bank	South Texas Banks[4]	70
North Hospital Bank	South Texas Banks[4]	68
Aransas Bank	South Texas Banks[4]	70
South Baker Bank	South Texas Banks[4]	70
Baker Bank	South Texas Banks[4]	70

Notes**:**

1. Central Planning Area bank in the Gulf of Mexico with a portion of its "1-Mile Zone" and/or "3-Mile Zone" in the WPA.
2. Only paragraph A applies.
3. Paragraphs A and B apply. In paragraph B, monitoring of the effluent to determine the effect on the biota of Claypile Bank is required rather than shunting.
4. Only paragraphs A and B apply.

The stipulation provides for protection of the following banks through the applicable mitigation measures in the Central Planning Area:

Bank Name	No Activity Zone (defined by isobaths in meters)
Alderdice Bank	80
Bouma Bank	85
Bright Bank[1]	85
Diaphus Bank[2]	85
Elvers Bank	85
Ewing Bank	85
Fishnet Bank[2]	76
Geyer Bank	85
Jakkula Bank	85
McGrail Bank	85
Parker Bank	85
Rezak Bank	85
Sackett Bank[2]	85
Sidner Bank	85
Sonnier Bank	55
Sweet Bank[3]	85

Notes**:**

1. Gulf of Mexico CPA bank with a portion of its "3-Mile Zone" in the Gulf of Mexico Western Planning Area.
2. Only paragraphs A and B apply.
3. Only paragraph A applies.

The lessee and its operators, personnel, and subcontractors are responsible for carrying out the specific mitigation measures outlined in the most current Notice to Lessees and Operators (NTLs) as described at http://www.boem.gov/notices-to-lessees-and-operators/, which provide guidance on how to follow the requirements of this stipulation (NTL No. 2009-G39). See the "Topographic Features Stipulation Map" and the figures in the "Western and Central Gulf of Mexico Topographic Features Stipulation Map package" on the Bureau of Ocean Energy Management website at http://www.boem.gov/Topographic-Features-Stipulation-Map-Package/. In the event that any portion of this lease becomes a part of a National Marine Sanctuary, then, in addition to any of the requirements of this stipulation, the lessee must comply with any applicable requirements of the regulations on National Marine Sanctuaries, currently codified at 43 CFR part 922, including the requirement to seek certification for activities under this lease or to seek a permit from the National Oceanic and Atmospheric Administration for approval of otherwise prohibited activities. In addition to the foregoing, the lessee, its operators, personnel, and subcontractors, as applicable, shall comply with the following:

A. No activity, including the placement of structures, drilling rigs, pipelines, or anchoring, will be allowed within the listed isobath ("No Activity Zone") of the banks listed above.

B. Operations within the area shown as the "1,000-Meter Zone" on the "Topographic Features Stipulation Map" must be restricted by shunting all drill cuttings and drilling fluids to the bottom through a structurally sound downpipe that terminates at an appropriate distance, but no more than 10 meters, from the bottom.

C. Operations within the area shown as the "1-Mile Zone" on the "Topographic Features Stipulation Map" must be restricted by shunting all drill cuttings and drilling fluids to the bottom through a structurally sound downpipe that terminates at an appropriate distance, but no more than 10 meters, from the bottom. Where a "1-Mile Zone" is designated, the "1,000-Meter Zone" in paragraph B is not designated. This restriction on operations also applies to areas surrounding the Flower Garden Banks, namely the "4-Mile Zone" surrounding the East Flower Garden Bank and the West Flower Garden Bank.

D. Operations within the area shown as "3-Mile Zone" on the "Topographic Features Stipulation Map" (http://www.boem.gov/Topographic-Features-Stipulation-Map-Package/) must be restricted by shunting all drill cuttings and drilling fluids to the bottom through a structurally sound downpipe that terminates at an appropriate distance, but no more than 10 meters, from the bottom. If more than two exploration wells are to be drilled from the same surface location within the "3-Mile Zone," all drill cuttings and drilling fluids must be restricted by shunting to the bottom through a downpipe that terminates at an appropriate distance, but no more than 10 meters, from the bottom.

7.6.3 Effectiveness of the Lease Stipulation

The purpose of the stipulation is to protect the biota of the topographic features from adverse impacts due to routine OCS oil- and gas-related activities. Such impacts include physical damage from anchoring and rig emplacement and potential toxic and smothering impacts from muds and cuttings discharges. The Topographic Features Stipulation has been used on leases since 1973 to effectively prevent damage to the biota of these banks from routine OCS oil- and gas-related activities. Anchoring related to OCS oil- and gas-related activities on the sensitive portions of the topographic features has been prevented. Monitoring studies have demonstrated that the shunting requirements of the stipulations are effective in preventing the muds and cuttings from impacting the biota of the banks. Long-term monitoring studies conducted by the NOAA and BOEM at the East and West Flower Garden Banks have shown that no significant long-term changes have been detected in coral cover or coral diversity at the East and West Flower Garden Banks from 1988 to 2017 (Johnston et al. 2013; 2015; 2018; Zimmer et al. 2010) and probably not since the first measurements were taken in the mid-1970s (Gittings 1998). The stipulation, if adopted for an OCS oil and gas lease sale, will continue to protect the biota of the banks.

7.7 STIPULATION NO. 6 – UNITED NATIONS CONVENTION ON THE LAW OF THE SEA ROYALTY PAYMENT

7.7.1 Stipulation Overview

Stipulation No. 6 could be included in leases issued as a result of a lease sale in the WPA and CPA in the area beyond the U.S. Exclusive Economic Zone, formerly known as the “Western Gap” (**Figure 7.7.1-1**).

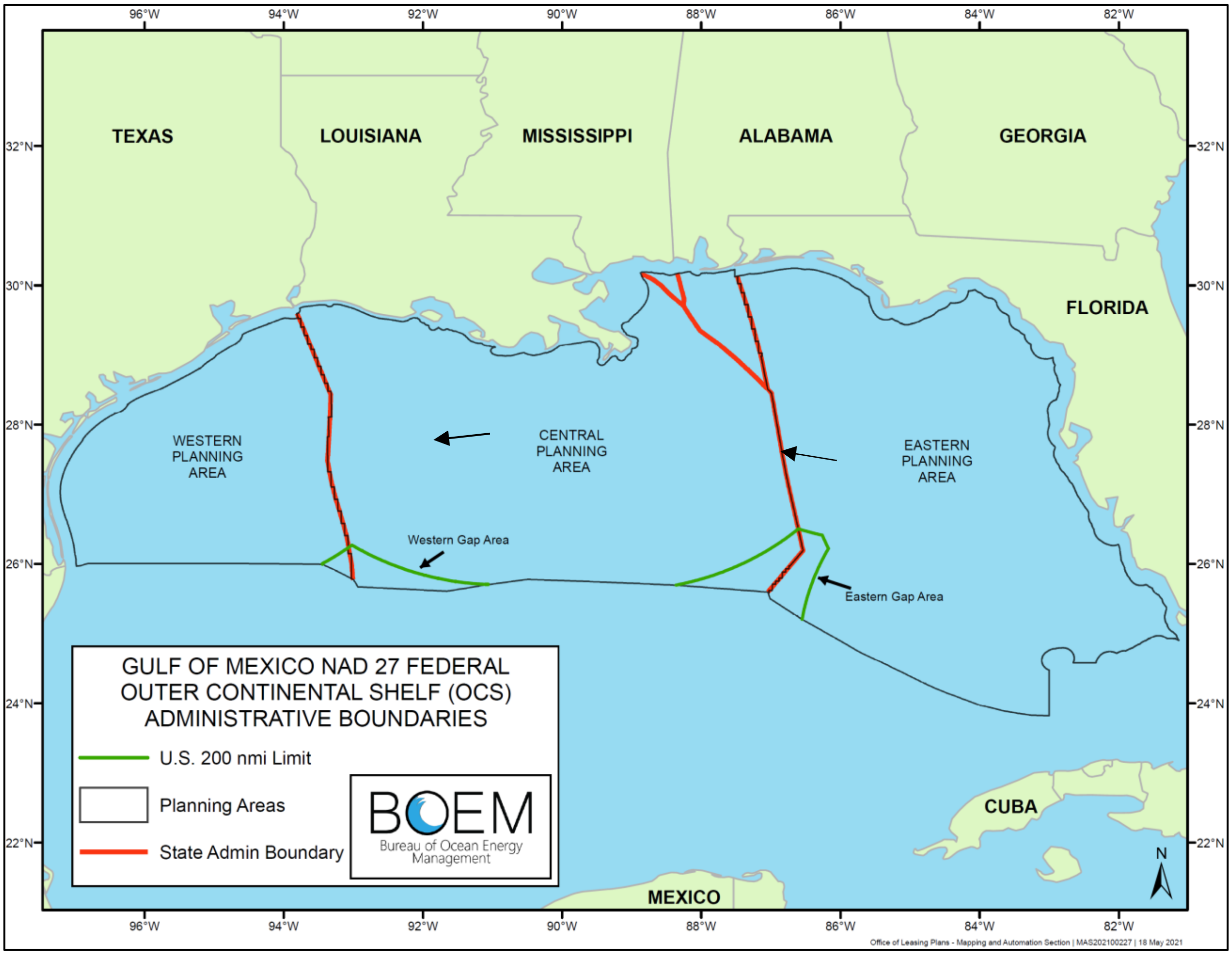

Figure 7.7.1-1. Gulf of Mexico OCS Administrative Boundaries, the "Western Gap" Area, and the "Eastern Gap" Area.

7.7.2 Potential Stipulation Language

If the United States of America becomes a party to the 1982 United Nations Convention on the Law of the Sea (UNCLOS, or Convention) prior to or during the life of a lease issued by the U.S. Government on a block or portion of a block located beyond its Exclusive Economic Zone as defined in UNCLOS, and subject to such conditions that the Senate may impose through its constitutional role of advice and consent, then the following royalty payment lease provisions will apply to the lease so issued, consistent with Article 82 of UNCLOS:

A. UNCLOS requires annual payments by coastal states party to the Convention with respect to all production at a site after the first five years of production at that site. Any such payments will be made by the U.S. Government and not the lessee.

B. For the purpose of this stipulation regarding payments by the lessee to the U.S. Government, each lease constitutes a separate site, whether or not a lease is committed to a unit.

C. For the purpose of this stipulation, the first production year begins on the first day of commercial production (excluding test production). Once a production year begins, it will run for a period of 365 days, whether or not the lease produces continuously in commercial quantities. Subsequent production years will begin on the anniversary date of first production.

D. If total lease production during the first five years following first production exceeds the total royalty suspension volume(s) provided in the lease terms, or through application and approval of relief from royalties, the provisions of this stipulation will not apply. If, after the first five years of production, but prior to termination of this lease, production exceeds the total royalty suspension volume(s) provided in the lease terms, or through application and approval of relief from royalties, the provisions of this stipulation no longer will apply effective the day after the suspension volumes have been produced.

E. If, in any production year after the first five years of lease production, due to lease royalty suspension provisions or through application and approval of relief from royalties, no lease production royalty is due or payable by the lessee to the U.S. Government, then the lessee will be required to pay, as stipulated in paragraph 1 below, UNCLOS-related royalty in the following amount so that the required Convention payments may be made by the U.S. Government as provided under the Convention:

   1. In the sixth year of production, one percent of the value of the sixth year's lease production saved, removed, or sold from the leased area;

   2. After the sixth year of production, the Convention-related royalty payment rate will increase by one percent for each subsequent year until the twelfth year and will remain at seven percent thereafter until lease termination.

F. If the United States becomes a party to UNCLOS after the fifth year of production from the lease, and a lessee is required, as provided herein, to pay UNCLOS-related royalty, the amount of the royalty due will be based on the above payment schedule as determined from first production. For example, the U.S. Government's accession to UNCLOS in the tenth year of lease production would result in an UNCLOS-related royalty payment of five percent of the value of the tenth year's lease production, saved, removed, or sold from the lease. The following year, a payment of six percent would be due and so forth, as stated above, up to a maximum of seven percent per year.

G. If, in any production year after the first five years of lease production, due to lease royalty suspension provisions or through application and approval of relief from royalties, lease production royalty is paid but is less than the payment provided for by the Convention, then the lessee will be required to pay to the U.S. Government the Convention-related royalty in the amount of the shortfall.

H. In determining the value of production from the lease if a payment of Convention-related royalty is to be made, the provisions of the lease and applicable regulations will apply.

I. The UNCLOS-related royalty payment(s) required under paragraphs E through G of this stipulation, if any, will not be paid monthly but will be due and payable to the Office of Natural Resources Revenue on or before 30 days after expiration of the relevant production lease year.

J. The lessee will receive royalty credit in the amount of the UNCLOS-related royalty payment required under paragraphs E through G of this stipulation, which will apply to royalties due under the lease for which the Convention-related royalty accrued in subsequent periods as non-Convention-related royalty payments become due.

K. Any lease production for which the lessee pays no royalty other than a Convention-related requirement, due to lease royalty suspension provisions or through application and approval of relief from royalties, will count against the lease's applicable royalty suspension or relief volume.

L. The lessee will not be allowed to apply or recoup any unused UNCLOS-related royalty credit(s) associated with a lease that has been relinquished or terminated.

7.8 Stipulation No. 7 – Agreement between the United States of America and the United Mexican States Concerning Transboundary Hydrocarbon Reservoirs in the Gulf of Mexico

7.8.1 Stipulation Overview

Stipulation No. 7 could be included in leases issued as a result of future OCS oil and gas lease sales that are wholly or partially located within 3 statute miles (2.6 nmi; 4.8 km) of the Maritime and Continental Shelf Boundary with Mexico, commonly referred to as the "Eastern Gap" (**Figure 7.7.1-1**). The Eastern Gap area is comprised of any and all blocks in the WPA and CPA that are wholly or partially located within 3 statute miles (2.6 nmi; 4.8 km) of the Maritime and Continental Shelf Boundary with Mexico, as the Maritime Boundary is delimited in the Treaty to Resolve Pending Boundary Differences and Maintain the Rio Grande and the Colorado River as the International Boundary, signed November 24, 1970; the Treaty on Maritime Boundaries between the United Mexican States and the United States of America, signed on May 4, 1978; and, as the continental shelf in the western Gulf of Mexico beyond 200 nmi (230 mi; 370 km) is delimited in the Treaty between the Government of the United Mexican States and the Government of the United States of America, signed on June 9, 2000.

7.8.2 Potential Stipulation Language

The *Agreement between the United States of America and the United Mexican States Concerning Transboundary Hydrocarbon Reservoirs in the Gulf of Mexico* (Agreement), signed on February 20, 2012, entered into force on July 18, 2014. All activities carried out under this lease must comply with the Agreement and any law, regulation, or condition of approval of a unitization agreement, plan, or permit adopted by the United States to implement the Agreement before or after issuance of this lease. The lessee is subject to, and must comply with all terms of the Agreement, including, but not limited to, the following requirements:

A. When the United States is obligated under the Agreement to provide information that may be considered confidential, commercial, or proprietary to a third-party or the Government of the United Mexican States, if the lessee holds such information, the lessee is required to provide it to the lessor as provided for in the Agreement;

B. When the United States is obligated under the Agreement to prohibit commencement of production on a lease, Bureau of Safety and Environmental Enforcement (BSEE) will direct a Suspension of Production with which the lessee must comply;

C. When the United States is obligated under the Agreement to seek development of a transboundary reservoir under a unitization agreement, the lessee is required to cooperate and explore the feasibility of such a development with a licensee of the United Mexican States;

D. When there is a proven transboundary reservoir, as defined by the Agreement, and the relevant parties, including the lessee, fail to conclude a unitization agreement, the lessee's rights to produce the hydrocarbon resources will be limited by the terms of the Agreement;

E. If the lessee seeks to jointly explore or develop a transboundary reservoir with a licensee of the United Mexican States, the lessee is required to submit to BSEE information and documents that comply with and contain terms consistent with the Agreement, including, but not limited to, a Final unitization agreement that designates the unit operator for the transboundary unit and provides for the allocation of production and any redetermination of the allocation of production; and

F. The lessee is required to comply with and abide by determinations issued as a result of the Agreement's dispute resolution process on, among other things, the existence of a transboundary reservoir, and the allocation and/or reallocation of production.

The lessee and its operators, personnel, and subcontractors are required to comply with these and any other additional measures necessary to implement the provisions of the Agreement, including, but not limited to, conditions of approval for their plans and permits for activities related to any transboundary reservoir or geologic structure subject to the Agreement.

A copy of the Agreement is attached to this lease. The lessee accepts the risk that a provision of the Agreement or any United States law, regulation, or condition of approval of a unitization agreement, plan, or permit implementing the Agreement may increase or decrease the lessee's obligations and rights under the lease. The summary of provisions of the Agreement set forth above is provided for the lessee's reference. To the extent this summary differs or conflicts with the express language of the Agreement or implementing regulations, the provisions of the Agreement and regulations are incorporated by reference in their entirety and will control and be enforceable as binding provisions of this lease.

7.8.3 Effectiveness of the Lease Stipulation

The Transboundary Agreement removes uncertainties regarding development of transboundary resources in the resource-rich Gulf of Mexico. As a result of the Agreement, nearly 1.5 million ac of the OCS would be made more accessible for exploration and production activities. BOEM's estimates indicate that this area contains as much as 172 million barrels of oil and 304 billion cubic feet of natural gas. The Agreement also opens up resources in the Western Gap that were off limits to both countries under a previous treaty that imposed a moratorium along the boundary. The Transboundary Agreement sets clear guidelines for the development of oil and natural gas reservoirs that cross the maritime boundary. Under the Agreement, U.S. companies and Petróleos Mexicanos (PEMEX) would be able to voluntarily enter into agreements to jointly develop those reservoirs. In the event that consensus cannot be reached, the Transboundary Agreement establishes the process through which U.S. companies and PEMEX can individually develop the resources on each side of the border while protecting each nation's interests and resources.

7.9 STIPULATION NO. 8 – LIVE BOTTOM

7.9.1 Stipulation Overview

BOEM protects live bottoms in the GOM through two stipulations attached to leases, as well as through postlease conditions of approvals attached to permits. BOEM defines "live bottom areas" as seagrass communities or those areas that contain biological assemblages consisting of such sessile invertebrates 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 favors the accumulation of turtles, fishes, and other fauna. Live bottom features may include pinnacle trend features, low-relief features, or potentially sensitive biological features (PSBFs). Protective measures have been developed over time based on the nature and sensitivity of these various live bottom habitats and their associated communities, as understood from decades of BOEM-funded and other environmental studies. These protections were developed into two stipulations, the Live Bottom (Pinnacle Trend) Stipulation and the Live Bottom (Low-Relief) Stipulation, as discussed below. These stipulations have historically been applied to OCS leases in areas with known concentrations of these live bottom features.

The two Live Bottom Stipulations are intended to protect hardbottom habitat and their associated live bottom communities from damage and, at the same time, provide for recovery of potential oil and gas resources nearby. The PSBFs, which are found throughout the GOM, are not protected by lease stipulations but are protected by mitigations that are attached as conditions of approval to permits at the postlease review stage. BOEM policy as it relates to these lease stipulations and postlease mtigations is described in NTL No. 2009-G39, "Biologically-Sensitive Underwater Features and Areas," and can be found on BOEM's website at https://www.boem.gov/sites/default/files/regulations/Notices-To-Lessees/2009/09-G39.pdf. Specific OCS blocks affected by the Live Bottom Stipulations are listed on BOEM's website at https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Gulf-of-Mexico-Region/topoblocks.pdf. A detailed map showing the locations of the affected blocks can be found on BOEM's website at https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Gulf-of-Mexico-Region/topomap.pdf.

The Pinnacle Trend is located offshore Mississippi and Alabama in the northeastern CPA. The pinnacles are a series of topographic irregularities with variable biotal coverage, which provide structural habitat for a variety of pelagic fish. The pinnacles would be classified as live bottom under the Live Bottom Stipulation. The Live Bottom (Pinnacle Trend) Stipulation has been routinely applied to appropriate CPA oil and gas lease sales since 1974 to protect the known Pinnacle Trend features in the CPA. The Live Bottom (Pinnacle Trend) Stipulation would be included on leases on 74 OCS lease blocks in the northeastern CPA, including the Main Pass Area, South and East Addition Blocks 190, 194, 198, 219-226, 244-266, 276-290; Viosca Knoll Area Blocks 473-476, 521, 522, 564, 565, 566, 609, 610, 654, 692-698, 734, 778; and Destin Dome Area Blocks 577, 617, 618, 661 (refer to **Figures 7.6.1-1 and 7.9.1-1**). Within the Live Bottom (Pinnacle Trend) Stipulation blocks, no bottom-disturbing activities may occur within 30 m (100 ft) of any hardbottom/pinnacles that have a vertical relief of 8 ft (2 m) or more. A bottom survey report showing pinnacle location and proposed bottom-disturbing activity will be required as part of any permit application to ensure that sensitive seafloor features are avoided.

Live bottom (low-relief) features are seagrass communities; areas that contain biological assemblages consisting of sessile invertebrates living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where a hard substrate and vertical relief may favor the accumulation of turtles, fishes, or other fauna. The Live Bottom (Low Relief) Stipulation OCS blocks are located in water depths of 100 m (328 ft) or less in the EPA and 142 OCS blocks in the northeastern CPA, including Pensacola Blocks 751-754, 793-798, 837-842, 881-886, 925-930, and 969-975; and Destin Dome Blocks 1-7, 45-51, 89-96, 133-140, 177-184, 221-228, 265-273, 309-317, 353-361, 397-405, 441-448, 485-491, 529-534, and 573-576 (refer to **Figure 7.9.1-1**). Within the Live Bottom (Low Relief) Stipulation Blocks, no bottom-disturbing activities may occur within 30 m (100 ft) of any live bottom (low-relief) feature. A bottom survey report showing live bottom location and proposed bottom-disturbing activity will be required as part of any permit application to ensure that sensitive seafloor features are avoided. While the Live Bottom (Low Relief) Stipulation blocks described here are located in areas currently under moratorium, they could be subject to this stipulation if the moratorium expired and they were leased in the future.

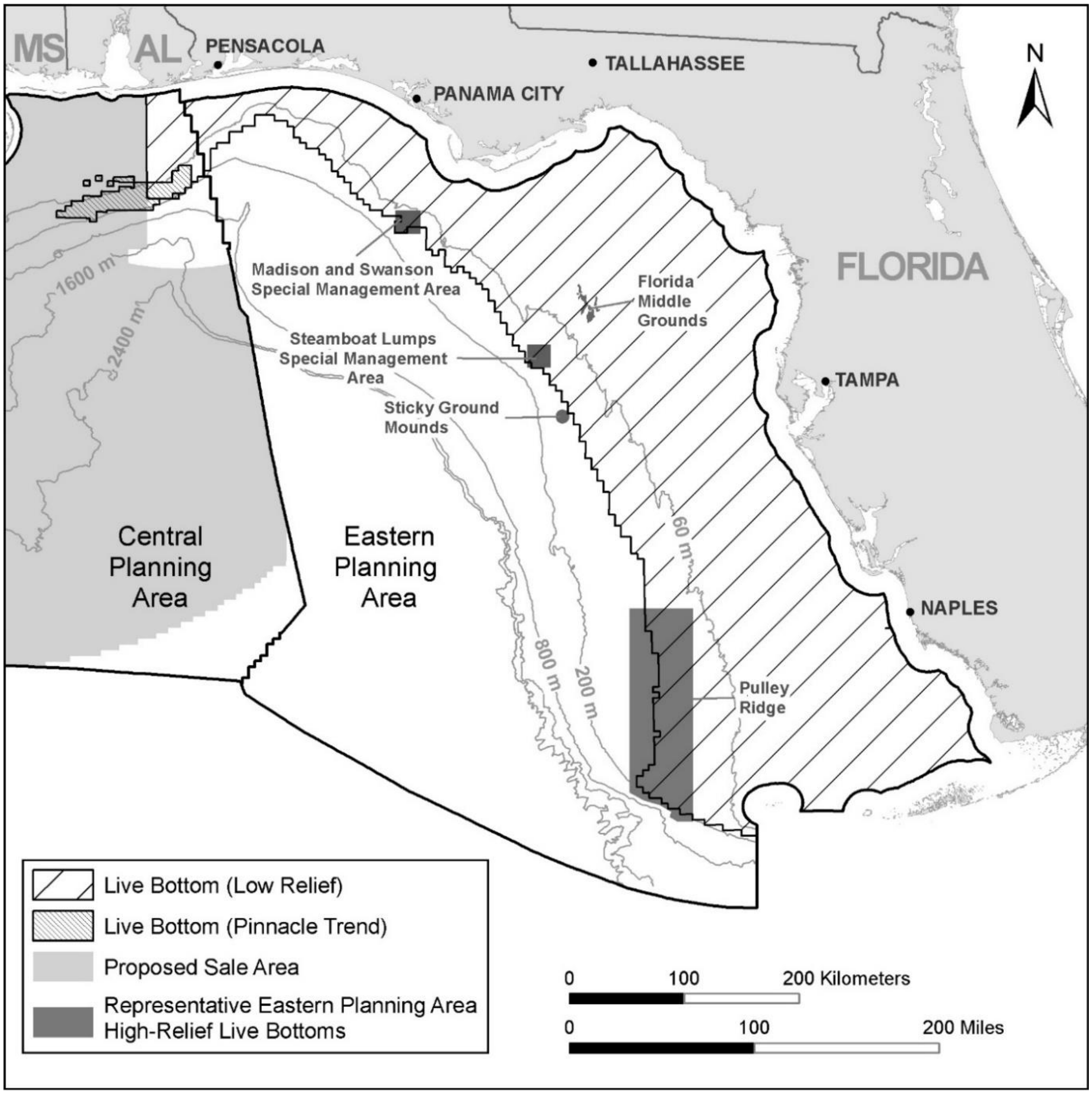

Figure 7.9.1-1. Live Bottom (Low Relief) Stipulation Blocks in the EPA and CPA.

The PSBFs are those features not protected by a biological lease stipulation that are of moderate to high relief (8 ft [2 m] or higher), provide surface area for the growth of sessile invertebrates, and attract large numbers of fish. These features are located outside any No Activity Zone of any of the named topographic features or the 74 live-bottom (pinnacle trend) stipulated blocks. Because PSBFs occur throughout the GOM, they are not protected through lease stipulations that apply to specific OCS blocks but rather are protected by conditions of approval attached to permits following a site-specific review of a permit application. No bottom-disturbing activities may occur within 30 m (100 ft) of any PSBF. A bottom survey report showing PSBF location and proposed bottom-disturbing activity will be required as part of any permit application to ensure that sensitive seafloor features are avoided.

The potential stipulation language outlined below is only for the Live Bottom (Pinnacle Trend) Stipulation. This stipulation is the only Live Bottom Stipulation that has been applied to OCS oil and gas leases recently because the live bottom, low-relief blocks in the EPA and CPA are currently under moratorium. Should the moratorium end, stipulation language will be included for the Live Bottom (Low Relief) OCS blocks. In addition, because there are no lease stipulations for PSBFs, their protection will be handled at the postlease, site-specific review stage and conditions of approval will be added to permits to prevent any potential damage to those features.

7.9.2 Potential Stipulation Language

The proposed stipulation reads as follows:

A. For the purpose of this stipulation, “live bottom areas” are defined as seagrass communities or those 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 favors the accumulation of turtles, fish, and other fauna. Live bottom features may include Pinnacle Trend features, low-relief features, or potentially sensitive biological features.

B. Prior to any drilling activities or the construction or placement of any structure for exploration or development on this lease, including but not limited to, anchoring, well drilling and pipeline and platform placement, the lessee will submit to the Bureau of Ocean Energy Management (BOEM) Gulf of Mexico Regional Director (RD) a live bottom survey report containing a bathymetry map prepared using remote-sensing techniques. The bathymetry map shall be prepared to determine the presence or absence of live bottoms that could be impacted by the proposed activity. This map must encompass the area of the seafloor where surface-disturbing activities, including anchoring, may occur.

C. If it is determined that the live bottoms might be adversely impacted by the proposed activity, the BOEM Gulf of Mexico RD will require the lessee to undertake any measure deemed economically, environmentally, and technically feasible to protect the live bottom areas. These measures may include, but are not limited to, relocation of operations and monitoring to assess the impact of the activity on the live bottom areas.

7.9.3 Effectiveness of the Lease Stipulation

The sessile and pelagic communities associated with the crest and flanks of the live bottom features could be adversely impacted by OCS oil- and gas-related activities if such activities took place on or near these communities without the Live Bottom Stipulation. Impacts from mechanical damage, including anchors, could potentially be long term if the physical integrity of the live bottoms themselves became altered. By identifying the live bottom features present at the activity site, the lessee would be directed to avoid placement of the drilling rig and anchors on the sensitive areas. Through detection and avoidance, this stipulation would minimize the likelihood of mechanical damage from OCS oil- and gas-related activities associated with rig and anchor emplacement to the sessile and pelagic communities associated with the crest and flanks of such features.

For many years, the live bottom stipulations have been made a part of leases on blocks in the CPA and EPA (prior to moratoria) to ensure that potential damage to pinnacle trend areas and low-relief features from nearby OCS oil- and gas-related activities is mitigated to the greatest extent possible. This stipulation does not prevent the recovery of oil and gas resources; however, it does serve to protect valuable and sensitive biological resources. Studies at the Pinnacle Trend have shown that the Live Bottom (Pinnacle Trend) Stipulation has successfully prevented mechanical damage to the pinnacle habitats through the survey and distancing requirements, and sediments have not shown elevated barium levels from OCS oil- and gas-related activities within 25 km (15 mi) of the area (Continental Shelf Associates Inc. and Texas A&M University Geochemical and Environmental Research Group 2001).

7.10 Stipulation No. 9 – Blocks South of Baldwin County, Alabama

7.10.1 Stiuplation Overview

This stipulation could be included on leases on blocks south of and within 15 mi (24 km) of Baldwin County, Alabama (**Figure 7.6.1-1**). The stipulation would specify requirements for consultation that lessees must follow when developing plans for fixed structures, with the goal of reducing potential visual impacts

7.10.2 Potential Stipulation Language

The proposed stipulation reads as follows:

A. To minimize visual impacts from development operations on this block, the lessee will contact lessees and operators of leases in the vicinity prior to submitting a Development Operations Coordination Document (DOCD) to determine if existing or planned surface production structures can be shared. If feasible, the lessee's DOCD should reflect the results of any resulting sharing agreement, propose the use of subsea technologies, or propose another development scenario that does not involve new surface structures.

B. If the lessee cannot formulate a feasible development scenario that does not call for new surface structure(s), the lessee's DOCD should ensure that they are the minimum distance necessary for the proper development of the block and that they will be constructed and placed using orientation, camouflage, or other design measures in such a manner as to limit their visibility from shore.

C. The Bureau of Ocean Energy Management (BOEM) will review and make decisions on the lessee's DOCD in accordance with applicable Federal regulations and BOEM assessments, and in consultation with the State of Alabama (Geological Survey/Oil and Gas Board).

7.10.3 Effectiveness of the Lease Stipulation

For several years, the then-Governor of Alabama had indicated opposition to new leasing south and within 15 mi (24 km) of Baldwin County but requested that, if the area is offered for lease, a lease stipulation to reduce the potential for visual impacts should be applied to all new leases in this area. Prior to the decision in 1999 on the Final Notice of Sale for Lease Sale 172, BOEM's New Orleans Office's Regional Director, in consultation with the Geological Survey of Alabama/State Oil and Gas Board, developed a lease stipulation to be applied to any new leases within the 15-mi (24-km) area to mitigate potential visual impacts. The stipulation specifies requirements for consultation that lessees must follow when developing plans for fixed structures. A lessee's DOCD should reflect the results of any resulting sharing agreement, should propose the use of subsea technologies, or should propose another development scenario that does not involve new surface structures. If the lessee cannot formulate a feasible development scenario that does not call for new surface structure(s), the lessee's DOCD should ensure that the structures are the minimum necessary for the proper development of the block and that they will be constructed and placed, using orientation, camouflage, or other design measures, in such a manner as to limit their visibility from shore. The stipulation has been continually adopted in annual CPA lease sales and regionwide lease sales since 1999 and has effectively mitigated visual impacts.

7.11 Stipulation No. 10 – Restrictions due to Rights-of-Use and Easements for Floating Production Facilities

7.11.1 Stipulation Overview

This proposed stipulation is intended to be lease sale-specific language and would incorporate maps for each potentially affected block containing rights-of-use and easements (refer to **Figure 7.11.3-1** for an example map). This stipulation is designed to minimize or avoid potential space-use conflicts with moored and/or floating production facilities that have already been granted rights-of-use and easements in particular OCS blocks.

7.11.2 Proposed Stipulation Language

The proposed stipulation reads as follows:

> The lessee may not conduct activities, including, but not limited to, the construction and use of structures, operation of drilling rigs, laying of pipelines, and/or anchoring on the seafloor or in the water column within the areas depicted by the attached map(s). Nevertheless, sub-seabed activities that are part of exploration, development, and production activities from outside the areas depicted on the attached maps may be allowed within the areas depicted by the attached map(s), including the use of directional drilling or other techniques.

7.11.3 Effectiveness of the Lease Stipulation

This stipulation is designed to minimize or avoid potential space-use conflicts with moored and/or floating production facilities that have already been granted rights-of use and easements in particular OCS blocks. BOEM has effectively used this stipulation for over a decade to make bidders aware of other activities with rights-of-use and easements on the blocks offered for OCS oil and gas leasing, and BOEM may require buffers or additional requirements prior to issuing leases on those specific blocks.

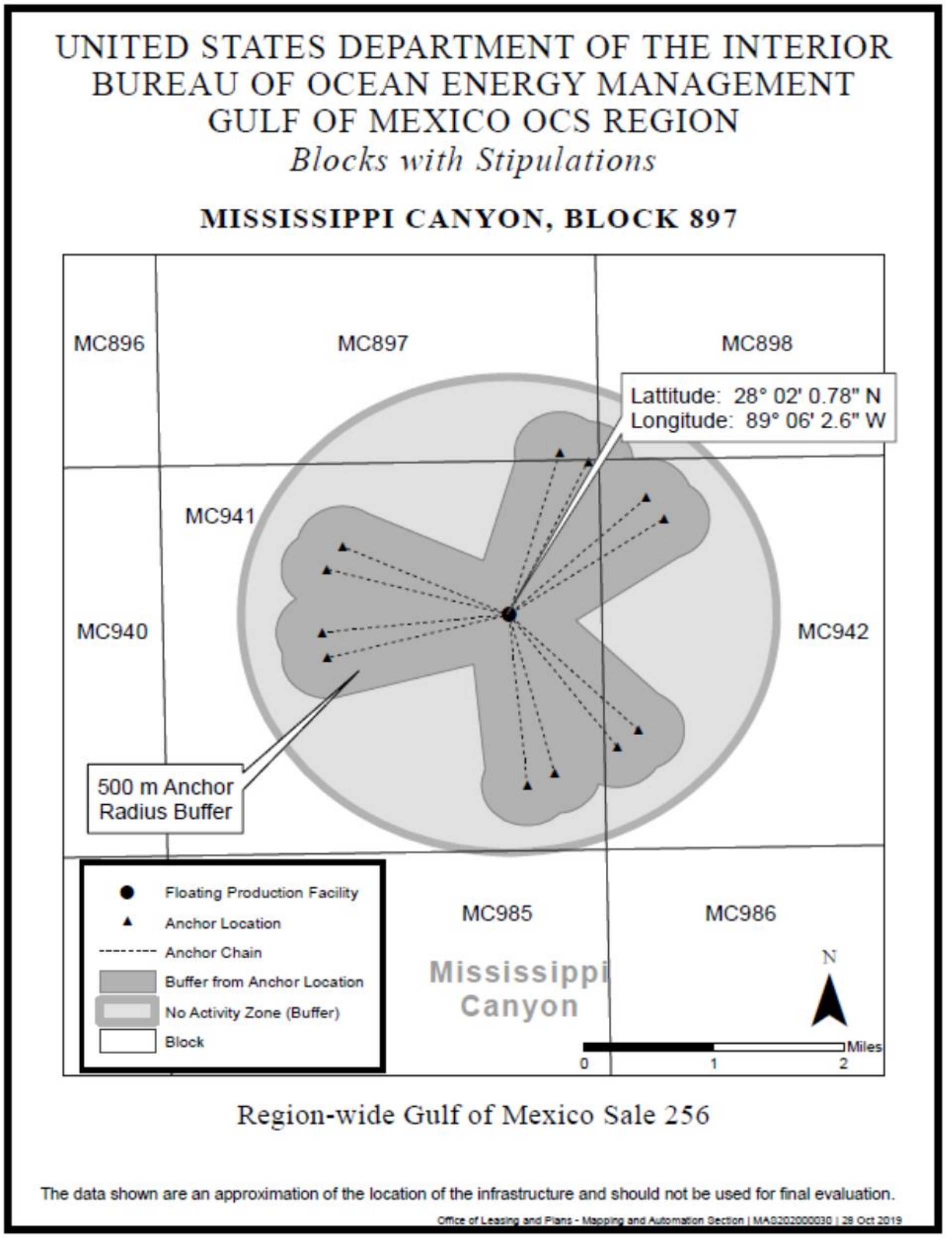

Figure 7.11.3-1. Example Map of a Block Subject to This Stipulation under Lease Sale 256 (complete Notice of Sale package can be found on BOEM's website at https://www.boem.gov/sale-256).

CHAPTER 8

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8 REFERENCES CITED

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

A ABBREVIATIONS AND ACRONYMS

°C	degrees Centigrade
°F	degrees Fahrenheit
2D	two dimensional
3D	three dimensional
4D	four dimensional
ac	acre
ACP	Area Contingency Plan
AFB	Air Force Base
AHTS	anchor handling, towing, and supply
AML	above mudline
APD	application for permit to drill
API	American Petroleum Institute
AQRV	air-quality-related value
Area ID	Area Identification
BAST	best available and safest technology
Bbbl	billion barrel
bbl	barrel
Bcf	billion cubic feet
Biological Environmental Background Report	*Biological Environmental Background Report for the Gulf of Mexico OCS Region*
BML	below mudline
BiOp	biological opinion
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	blowout preventer
B.P.	before present
BSEE	Bureau of Safety and Environmental Enforcement
CAA	Clean Air Act
Call	Call for Information
CAP	criteria air pollutant
Cd	cadmium
CE	categorical exclusion
CEI	Coastal Environments, Inc.
CERA	categorical exclusion review with analysis
CEQ	Council on Environmental Quality
CEVI	coastal economic vulnerability index
CFR	Code of Federal Regulations
CH_4	methane
CIAP	Coastal Impact Assistance Program
CID	Conservation Information Document
cm	centimeter

cm/s	centimeters/second
CMP	Coastal Management Program
CO	carbon monoxide
CO_2	carbon dioxide
COA	condition of approval
Council	Gulf Coast Ecosystem Restoration Council
Couvillion	Couvillion Group, LLC
CPA	Central Planning Area
CPAP	criteria precursor air pollutant
CPRA	Coastal Protection and Restoration Act
Cu	copper
CWA	Clean Water Act
CWPPRA	Coastal Wetlands Planning, Protection and Restoration Act
CZMA	Coastal Zone Management Act
dB	decibel
dB re 1µPa	decibel at 1 microPascal
DMR	discharge monitoring report
DNA	Determination of NEPA Adequacy
DOC	Department of Commerce
DOCD	development operations coordination document
DOD	Department of Defense
DOI	Department of the Interior
DOT	Department of Transportation (U.S.)
DPP	development production plan
DWOP	deepwater operations plan
DWRRA	Deep Water Royalty Relief Act of 1995
e.g.	for example
EA	environmental assessment
EFH	essential fish habitat
EIA	economic impact area
EIS	environmental impact statement
EP	exploration plan
EPA	Eastern Planning Area
ESA	Endangered Species Act
ESI	environmental sensitivity index
et al.	and others
et seq.	and the following
EWTA	Eglin Water Test Area
FAZ	full azimuth
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FPS	floating production structure
FPSO	floating production, storage, and offloading

FR	*Federal Register*
ft	foot
FWS	Fish and Wildlife Service (U.S.)
G&G	geological and geophysical
GAO	Government Accounting Office
GHG	greenhouse gas
GIS	geographic information system
GIWW	Gulf Intracoastal Waterway
GOM	Gulf of Mexico
GOMESA	Gulf of Mexico Energy Security Act
GPS	global positioning system
Gulf of Mexico OCS Oil- and Gas-Related Activities SID	*Programmatic Description of the Potential Effects from Gulf of Mexico OCS Oil- and Gas-Related Activities: A Supporting Information Document*
H_2S	hydrogen sulfide
ha	hectare
HABHRCA	Harmful Algal Bloom and Hypoxia Research and Control Act
HAP	hazardous air pollutant
Hg	mercury
hr	hour
HRG	high-resolution geophysical
Hz	Hertz
i.e.	that is
in	inch
in^3	cubic inch
in/s	inches/second
IPF	impact-producing factor
IPCC	Intergovernmental Panel on Climate Change
ITL	Information to Lessees and Operators
kg/ha/yr	kilogram per hectare per year
kHz	kilohertz
km	kilometer
km^2	square kilometer
kn	knot
LA 1	Louisiana Highway 1
LCA	Louisiana Coastal Area
LADOT	Louisiana Department of Transportation and Development
LCE	Loop Current eddies
LNG	liquefied natural gas
LOOP	Louisiana Offshore Oil Port
m	meter
MARAD	Maritime Administration (U.S. Dept. of Transportation)
MARPOL	International Convention for the Prevention of Pollution from Ships

MBTA	Migratory Bird Treaty Act
MC20	Mississippi Canyon Area Block 20
mg/L	milligrams/liter
mi	mile
mph	mile per hour
mm	millimeter
MMbbl	million barrel
MMIS	Marine Minerals Information System
MMP	Marine Minerals Program
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MODU	mobile offshore drilling unit
MWA	military warning area
Mya	million years ago
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NACE	National Association of Corrosion Engineers
NADP	National Atmospheric Deposition Program
NASEM	National Academies of Sciences, Engineering, and Medicine
NAZ	narrow azimuth
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NH_3	ammonia
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
nmi	nautical mile
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NORM	naturally occurring radioactive material
NOS	Notice of Sale
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRHP	National Register of Historic Places
NTL	Notice to Lessees and Operators
NUT	new or unusual technology
O_3	oxygen
OBC	ocean-bottom cable
OBF	oil-based fluid
OBN	ocean-bottom node
OCS	Outer Continental Shelf

OCSLA	Outer Continental Shelf Lands Act
ODMDS	ocean dredged-material disposal site
OPAREA	offshore operating area
OSHA	Occupational Safety and Health Administration
OSRP	oil-spill response plan
OSV	offshore supply vessel
PAH	polycyclic aromatic hydrocarbon
PAM	passive acoustic monitoring
Pb	lead
PCB	polychlorinated biphenyl
PIES	pressure-inverted echo sounder
pH	potential for hydrogen
$PM_{2.5}$	particulate matter 2.5 micrometers or less in aerodynamic diameter
PM_{10}	particulate matter 10 micrometers or less in aerodynamic diameter
PM	particulate matter
PMT	pressure monitoring transponder
ppb	parts per billion
ppm	parts per million
PSBF	potentially sensitive biological features
PSD	Prevention of Significant Deterioration
RESTORE Act	Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act
ROD	Record of Decision
ROV	remotely operated vehicle
RUE	right-of-use and easement
SAV	submerged aquatic vegetation
SBF	synthetic-based fluid
SEA	site-specific environmental assessment
Secretary	Secretary of the Interior
SEMS	Safety and Environmental Management Systems
SO_2	sulfur dioxide
SO_x	sulfur oxide
SSER	site-specific environmental review
SSRA	significant sediment resources area
TEC	Taylor Energy Company
TIMS	Technical Information Management Systems
TLP	tension-leg platform
Trust Fund	Gulf Coast Restoration Trust Fund
Trustee Council	Natural Resource Damage Assessment Trustee Council
TRW	Topographic Rossby Waves
TSS	traffic separation scheme
UME	unusual mortality event
UTRR	undiscovered technically recoverable resources

U.S.	United States
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	volatile organic compound
VSP	vertical seismic profiling
WAZ	wide azimuth
WBF	water-based fluid
WCD	worst-case discharge
WCR	Blowout Preventer Systems and Well Control Final Rule
WPA	Western Planning Area
WTCW	well treatment, completion, and workover
yd	yard
yr	year
Zn	zinc

Appendix B

Glossary

B 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 (BiOp)—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.

Casing—Steel pipe cemented in place during the construction process to stabilize the wellbore. The casing forms a major structural component of the wellbore preventing the formation wall from caving into the wellbore and providing a means of maintaining control of formation fluids and pressure as the well is drilled.

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.

Decibel—A logarithmic measure of the intensity of a sound; generally, a degree of loudness.

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.

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—A large-diameter pipe that connects the subsea BOP stack to a floating rig or platform to take mud returns to the surface.

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.

Short tons—A unit of weight equal to 2,000 pounds (907.19 kilograms).

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/data/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 Oil and Gas 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.

APPENDIX C

CONVERSION CHART

C CONVERSION CHART

To convert from	To	Multiply by
centimeter (cm)	inch (in)	0.3937
millimeter (mm)	inch (in)	0.03937
meter (m)	foot (ft)	3.281
meter^2 (m^2)	foot^2 (ft^2)	10.76
meter^2 (m^2)	yard^2 (yd^2)	1.196
meter^2 (m^2)	acre (ac)	0.0002471
meter^3 (m^3)	foot^3 (ft^3)	35.31
meter^3 (m^3)	yard^3 (yd^3)	1.308
kilometer (km)	mile (mi)	0.6214
kilometer^2 (km^2)	mile^2 (mi^2)	0.3861
hectare (ha)	acre (ac)	2.47
liter (L)	gallons (gal)	0.2642
degree Celsius (°C)	degree Fahrenheit (°F)	°F = (1.8 x °C) + 32

1 barrel (bbl) = 42 gal = 158.9 L = approximately 0.1428 metric tons
1 nautical mile (nmi) = 1.15 mi (1.85 km) or 6,076 ft (1,852 m)
tonnes = 1 long ton or 2,240 pounds (lb)

KEYWORD INDEX

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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.