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Essential Fish Habitat Assessment for Oil and Gas Activities in the Gulf of Mexico

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Contents

List of Tables

Abbreviations and Acronyms

Short Form	Long Form
°C	degrees centigrade
°F	degrees Fahrenheit
bbl	barrel (of oil)
BOEM	Bureau of Ocean Energy Management
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
CD	consistency determination
CFR	Code of Federal Regulations
CMP	Coastal Management Program
COA	Condition of Approval
CZMA	Coastal Zone Management Act
DOCD	development operations coordination document
DPP	development and production plan
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
e.g.	*exempli gratia* ("for example")
EIS	environmental impact statement
EP	exploration plan
ESA	Endangered Species Act
et al.	*et alia* ("and others")
FGBNMS	Flower Garden Banks National Marine Sanctuary
FMP	Fishery Management Plan
ft	feet
G&G	geological and geophysical
GOMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
GOMRO	Gulf of Mexico Regional Office
HAPC	habitat area of particular concern
Hz	Hertz
i.e.	*id est* ("that is")
km	kilometer
m	meter
MARAD	Maritime Administration (US Department of Transportation)
mi	mile

Short Form	Long Form
National OCS Leasing Program	National Outer Continental Shelf Oil and Gas Leasing Program
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	Notice of Sale
NPDES	National Pollution Discharge Elimination System
NTL	Notice to Lessees and Operators
OCS	Outer Continental Shelf
pH	potential of hydrogen
PSBF	potentially sensitive biologic features
PTS	permanent threshold shift
ROD	Record of Decision
ROV	remotely operated vehicle
SAV	submerged aquatic vegetation
SEA	Site-specific Environmental Assessment
TTS	temporary threshold shift
U.S.	Unites States
USACE	US Army Corps of Engineers
USCG	US Coast Guard
USDOI	US Department of the Interior
USDHS	US Department of Homeland Security
USDOC	US Department of Commerce
USDOT	US Department of Transportation
USEPA	US Environmental Protection Act
USFWS	US Fish and Wildlife Service

1.0 Proposed Actions

1.1 Purpose of and Need for the Proposed Actions

This Essential Fish Habitat (EFH) Assessment serves as the initiation of a Programmatic EFH Consultation between the Bureau of Ocean Energy and Management's (BOEM) Gulf of Mexico Regional Office (GOMRO) and the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) for oil- and gas-related activities on the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM). Pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (NMFS 2007), Federal agencies are required to consult with NMFS on any action that may result in adverse effects to EFH. NMFS published the final rule implementing the EFH provisions of the Magnuson-Stevens Fisheries Conservation and Management Act (50 Code of Federal Regulations [CFR] part 600) on January 17, 2002. Certain OCS activities authorized by BOEM may result in adverse effects to EFH and require consultation.

BOEM oversees the National Outer Continental Shelf Oil and Gas Leasing Program (National OCS Leasing Program), pursuant to Section 18 of the Outer Continental Shelf Lands Act (OCSLA)(43 U.S.C. §§ 1331 et seq.). OCSLA requires the Secretary of the Interior (Secretary) to develop a schedule of lease sales for five-year periods to best meet national energy needs. Proposed lease sales provide qualified bidders the opportunity to bid upon and lease acreage in the GOM OCS and to explore, develop, and produce oil and natural gas.

The proposed actions addressed in this EFH Assessment include reasonably foreseeable oil and gas activities on the GOM's OCS, including proposed lease sales and activities related to exploration, development, production, and decommissioning, including, but not limited to, geological and geophysical (G&G) activities, drilling, construction, support, removal, and site clearance operations. Related activities that do not occur on the OCS, such as inshore and onshore activities (e.g., vessel traffic, navigation channel maintenance, and new pipeline landfalls) are also addressed and assessed for potential impacts to EFH and federally managed fisheries species (i.e., species managed under a fisheries management plan (FMP)) in the GOM.

The previous programmatic EFH Assessment for the GOM (BOEM 2016), which was prepared in association with the Environmental Impact Statement (EIS) for the 2017–2022 National OCS Leasing Program, is set to expire in July 2022. Going forward, BOEM proposes that EFH consultation not be tied to a specific five-year National OCS Leasing Program. Rather, consultation will focus on the suite of BOEM and BSEE-authorized activities associated with any National OCS Leasing Program, independent of the specific years. Reinitiation will occur when NMFS and BOEM jointly agree to reinitiate consultation, when BOEM significantly alters the proposed action (e.g., the Eastern Planning Area becomes available for leasing), or upon meeting conditions for site-specific EFH consultation (e.g., as identified in conservation recommendations). BOEM subject-matter experts routinely review activities for proposed technologies, methods, locations, and other sources of potential effects to species and habitats. This process includes concurrent reviews for circumstances that could result in the initiation of site-specific EFH consultation as determined by the current EFH consultation and conservation recommendations.

To facilitate a simplified description of the proposed actions and BOEM's environmental review processes, this assessment groups activities into *Pre-Lease Assessment and Coordination*, *Exploration, Development, and Production Activities*, and *Decommissioning* (see below under **Related Activities**). Although some activities may occur at multiple stages in the OCS oil and gas lease, exploration, development, production and decommissioning life cycle, the simplified presentation helps reduce redundancy in the description of activities and analysis.

1.2 Related Activities

1.2.1 Pre-lease Assessment and Coordination

Scoping before lease sales is conducted in accordance with the Council on Environmental Quality's (CEQ) regulations implementing the National Environmental Policy Act (NEPA). BOEM conducts early coordination with appropriate Federal and State agencies and other concerned parties before a proposed lease sale. Key agencies and organizations include NMFS, U.S. Fish and Wildlife Service (USFWS), U.S. Department of Defense, U.S. Coast Guard (USCG), U.S. Environmental Protection Agency (USEPA), State Governors' offices, and industry groups. BOEM provides relevant NEPA documents, as appropriate, for review and comment by Federal, State, and local governments, federally recognized Indian Tribes, nongovernmental organizations, and other interested parties.

As part of this process, Section 307(c)(1) of the Coastal Zone Management Act (CZMA) requires that Federal agency activities affecting any land or water use or natural resource of the coastal zone be carried out in a manner that is consistent to the maximum extent practicable with the enforceable policies of a State's federally approved coastal management program (CMP). Before each proposed lease sale, BOEM reviews and analyzes the potential impacts to any natural resources, land uses, or water uses of the coastal zone as outlined by our environmental review(s) and considers new information and applicable BOEM studies as they pertain to the enforceable policies of each State's CMP. Based on the analyses, BOEM prepares a Consistency Determination (CD) for each State in which a proposed lease sale could have reasonably foreseeable coastal effects. The CD takes into consideration the reasonably foreseeable coastal effects of a proposed lease sale and its consistency with the enforceable policies identified by an affected State's CMP. BOEM's Director sends a CD to each affected State's CMP at least 90 days before final approval of a proposed lease sale pursuant to the CZMA.

BOEM typically prepares an EIS that provides programmatic NEPA coverage for multiple lease sales and is used for tiering purposes for NEPA related to activities on the GOM OCS. The EIS analyzes proposed alternatives and associated impacts. The final EIS is published approximately five months before the first proposed GOM lease sale in each National OCS Leasing Program. A Record of Decision (ROD) will identify the alternative chosen and include a summary of the proposed action and the alternatives evaluated in the EIS, the conclusions of the impact analyses, and other information considered in reaching the decision. The ROD is issued concurrently with the Final Notice of Sale. Before subsequent lease sales covered by the programmatic EIS, information and analyses are reviewed for NEPA adequacy and, if necessary, a supplemental EIS may be prepared.

A Proposed NOS is typically made available to the public 4–5 months before a proposed lease sale. If the decision by the Assistant Secretary of the Interior for Land and Minerals Management is to hold a proposed lease sale, a Final NOS will be published in its entirety in the Federal Register at least 30 days before the lease sale date, as required by the OCSLA.

1.2.2 Exploration, Development, and Production Activities

BOEM employs a range of mitigation measures to minimize potential impacts that could result from BOEM authorized activities on the OCS. These measures are implemented through operating regulations, lease stipulations, Notices to Lessees and Operators (NTLs), and project-specific requirements or conditions of approval. Such measures address concerns related to endangered and threatened species, geologic and humanmade hazards, military warning and ordnance disposal areas, archaeological sites, air and water quality, sensitive benthic communities, artificial reefs, operations in hydrogen sulfide prone areas, and shunting of drill effluents in the vicinity of biologically sensitive features. BOEM reviews proposed activities for compliance with regulatory requirements and applies conditions of approval as needed. Following are descriptions of several categories of proposed activities reviewed by BOEM.

Geological and Geophysical (G&G) Permits: A G&G permit must be obtained from BOEM before conducting off-lease G&G exploration or scientific research on unleased OCS lands or on lands under lease to a third party (30 CFR §§ 551.4 (a)-(b)). Geological investigations include various seafloor sampling techniques to determine the geochemical, geotechnical, or engineering properties of the sediments. On-lease G&G activities are considered ancillary and do not require a separate permit.

Plans: Exploration plans (EPs), development and production plans (DPPs), and development operations and coordination documents (DODCs) (30 CFR §§ 550.211 through 550.273) 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. 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. The EP describes exploration activities, drilling rigs or vessels, proposed drilling and well-testing operations, environmental monitoring plans, and other relevant information, and it includes a proposed schedule of the exploration activities. A DPP or DOCD 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.

New or Unusual Technology (NUT): Technologies continue to evolve to meet the technical, environmental, and economic challenges. NUTs may be identified by the operator in its EP, and DPP or DOCD or BSEE pipeline or structure permit application and assessed during BOEM’s NEPA review processes. The operating procedures developed during the engineering, design, and manufacturing phases of the project, coupled with the results (recommended actions) from hazard analyses performed, will be used to develop the emergency action and curtailment plans. NUTs are also reviewed by the NMFS for potential impacts to ESA-listed species.

BSEE Permit Applications: Before an operator can conduct operations proposed under an EP, DPP, or DOCD, they must also obtain the requisite BSEE permits for well, structure, and pipeline activities, and ensure that the activities proposed in the subsequent permit applications conform with those proposed in the associated plan (30 CFR § 550.281). The regulatory linkage between the EP, DPP, DOCD, and BSEE permit allows for BOEM's NEPA review of the plan to be adopted by BSEE for NEPA compliance coverage for the associated permit approval and ensures that the requisite mitigation measures are carried over to the offshore operations.

Well Permits–Application for Permit to Drill (APD): Before conducting drilling operations, an operator is required to submit an APD and obtain approval from Bureau of Safety and Environmental Enforcement (BSEE) (30 CFR § 250.410(d)(1)). The APD must include information such as location plats (30 CFR § 250.412), design criteria used for the proposed well (30 CFR § 250.413), blow out prevention system descriptions (30 CFR § 250.731), and requirements for using a mobile offshore drilling unit (30 CFR § 250.713).

Structure Permits: BSEE requires that operators submit permit applications for review and approval before conducting structure installation, modification, and repair activities (30 CFR § 250.905). The applications must include location plats, drawings and design data, and environmental information associated with soils, currents, and other site conditions to support the facility installation and maintenance, which is assessed by BSEE to allow for the safe installation, maintenance, and repair of the structure. Other items associated with vessels, moorings, and the associated emissions and discharges are addressed in the associated DPP or DOCD and assessed for impacts under the plan's NEPA review.

Pipeline Permits: Regulatory processes and jurisdictional authority concerning pipelines on the OCS and in coastal areas are shared by several Federal agencies, including the Department of the Interior (USDOI), the Department of Transportation (USDOT), the U.S. Army Corps of Engineers (COE), the Federal Energy Regulatory Commission, and the USCG. Pipeline applications for OCS pipelines are submitted to BSEE and then forwarded to BOEM. Pipeline information is required in an associated DPP or DOCD (30 CFR § 550.256); however, since the information provided in most plans is minimal and subject to change. BOEM reviews subsequent pipeline applications separately. Pipeline applications may be for lease-term (LT) pipelines or right-of-way (ROW) pipelines with the latter on or crossing other lessees' leases or unleased areas of the OCS. Pipeline permit applications include a pipeline location plat, vessel information, profile drawing, safety schematic diagram, pipe design data, a shallow hazard survey report, and an archaeological report, if applicable. BSEE evaluates the design, fabrication, installation, and maintenance of all OCS pipelines.

BSEE District Offices provide for both annual scheduled inspection and periodic unscheduled (unannounced) inspections of oil and gas operations on the OCS. The District inspections are to assure compliance with all regulatory constraints that allow commencement of the drilling, development, and production operations and focus on safety issues and technical oversight. BSEE's Office of Environmental Compliance conducts compliance-verification reviews and facility and site inspections to assess compliance with environmental mitigation measures conditioned as plan and permit approval. Post-activity compliance review and field inspection findings are shared with BOEM resource specialists to help improve subsequent reviewing and mitigation development. The lessee is required to use the best available and safest drilling technology to enhance the evaluation of conditions of abnormal pressure and to minimize the potential for the well to flow or kick (i.e., a well control problem that occurs when formation fluids or gas are forced into the wellbore). Because blowout preventers (BOPs) are important for the safety of the drilling crew, and for the rig and the wellbore itself, BOPs are regularly inspected, tested, and refurbished. BSEE's responsibilities under the Oil Pollution Act of 1990 include spill prevention, review, and approval of oil-spill-response plans; inspection of oil-spill containment and cleanup equipment; and ensuring oil-spill financial responsibility for facilities in offshore waters located seaward of the coastline or in any portion of a bay that is connected to the sea either directly or through one or more other bays. The responsible party for covered offshore facilities must demonstrate oil-spill financial responsibility, as required by BOEM's regulation at 30 CFR part 553. Under 30 CFR part 250.1500 subpart O, BSEE has outlined well control and production safety training program requirements for lessees operating on the OCS.

Decommissioning

Decommissioning operations generally occur after lease expiration, when well-related (e.g., wells and conductors) or platform-related (e.g., jacketed platforms and well protectors) infrastructure, as well as subsea pipelines, are deemed economically unviable or when the physical condition of the equipment and/or structures becomes unsafe or a navigation hindrance. Operators must submit applications for the permanent abandonment of well-related infrastructure by completing an Application for Permit to Modify (30 CFR § 250.1704(g)) or in the case of platform-related infrastructure, a final structure removal application (30 CFR § 250.1704(b)) must be submitted to BSEE. In some cases, the Regional Supervisor may grant the operator a departure from platform-related infrastructure removal requirements if the structure becomes part of a state artificial reef program (30 CFR § 250.1730(a)) and satisfies the USCG's navigation requirements (30 CFR § 250.1730(b)). For pipeline decommissioning, an operator must submit an application to BSEE if they intend to decommission a pipeline in-place (30 CFR § 250.1751(a)) or submit a pipeline removal application (30 CFR § 250.1752(a)). An operator may decommission a pipeline in-place if the Regional Supervisor determines that the pipeline does not constitute a hazard (i.e., obstruction) to navigation and commercial fishing operations, unduly interfere with other uses of the OCS, or have adverse environmental effects (30 CFR § 250.1750). Unlike applications for decommissioning pipelines in-place (30 CFR § 250.1751), an operator proposing to remove a pipeline is required to include plans to protect sensitive biological features as part of their proposed removal procedures (30 CFR § 250.1752(6)).

Well-related decommissioning operations, such as the permanent abandonment of wells, 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 mechanically cutting and retrieving the casing at least 15 feet (ft) (5 meters [m]) below the mudline. Jetting of the sediments is typically conducted in order to obtain access to cutting points.

Platform-related decommissioning operations, such as the removal of jacketed platforms and well protectors, involves the use of explosive and/or mechanical severance techniques. The application to decommission a platform must describe the proposed techniques, the types of explosives (e.g., number and sizes of charges), the depth of detonation below the mudline, as well as plans for protecting, assessing, and mitigating impacts to sensitive marine life, including marine mammals, sea turtles, fish, and benthic communities (30 CFR § 250.1726 (d)). Like well-related infrastructure, platform-related infrastructure must be removed to at least 15 ft (5 m) below the mud line and jetting is often conducted to access cutting points. Operators are also required to flush all production risers with seawater before removal.

Pipeline decommissioning operations (removal or decommissioning in-place) typically involves pigging the pipelines (unless the Regional Supervisor determines that pigging is not practical), which is a method used to perform various maintenance operations such as cleaning and inspecting the pipeline. Both removed and decommissioned in-place pipelines must be cleaned and/or flushed. Pipelines that are decommissioned in-place must be filled with seawater, and each end must be cut, plugged, and buried at least 3 ft (1 m) below the seafloor or covered with protective concrete mats (30 CFR § 250.1751). All valves and fittings that could interfere with other uses of the OCS are removed. If a pipeline is to be removed, typically a pipeline lay barge (either anchored or dynamically positioned) will use a reverse reel lay technique whereby the pipeline is lifted from the seabed, reeled back onto the vessel, and eventually brought back to shore for salvaging.

Once the removal and salvage of well-related and platform-related infrastructure is completed, the seabed must be cleared of any potential obstructions. Operators are required to perform site-clearance verification (SCV) work to ensure that the seafloor of their lease(s) has been restored to pre-lease conditions and that all debris and obstructions are removed as to avoid impacting other OCS users (30 CFR § 250.1703(e)). Based on requirements found in Subpart Q of the OCSLA regulations (30 CFR §§ 250.1740–250.1743), operators have the option of trawling (with commercial nets) or conducting diver, high-resolution sonar, or ROV (remotely operated vehicle) surveys over structure-centered grid areas. Guidelines also direct trawlers to conduct their operations in a manner that would avoid causing undue or serious harm to the marine environment (30 CFR § 250.1703[g]). A common practice with several decommissioning subcontractors is the use of high-frequency sonar to detect objects on the seafloor and then dispatch divers or ROVs to aid in the recovery or investigation of the objects. Unlike trawling, survey-led recovery activities only disturb the seafloor in a limited area around the obstruction, reducing the potential for impacts to sensitive benthic habitats.

2.0 Lease Stipulations and Guidance

BOEM developed lease stipulations to protect the most sensitive live bottom areas, including topographic features, live bottom Pinnacle Trend habitats, low-relief live bottom habitats, and potentially sensitive biologic features (PSBF). Guidance documents (e.g., NTLs) were developed in consultation with various Federal agencies and informed by comments solicited from State, industry, environmental organizations, and academic representatives and provide clarification of siting and mitigative measures expected to satisfy regulatory and lease stipulation requirements.

NTL 2009-G39 ("Biologically-Sensitive Underwater Features and Areas") (MMS 2009a) and NTL 2009-G40 ("Deepwater Benthic Communities") (MMS 2009b) offer guidance about the codified regulations at 30 CFR § 550.216(a), 30 CFR § 550.221(a), 30 CFR § 550.247(a), 30 CFR § 250.552(a), and 30 CFR § 550.282. These are regulations for BOEM's oil- and gas-related activities (e.g., drilling wells, shunting of drill cuttings and fluids, and pipeline emplacements) and their required monitoring programs and reports. NTL 2009-G40 offers guidance by providing a consistent and comprehensive approach for avoiding impacts to all deepwater benthic communities (MMS 2009b). NTL 2009-G40 defines deepwater benthic communities as either features or areas that could support chemosynthetic communities or deepwater corals and other associated hard bottom communities (MMS 2009b). Recent lease stipulation examples may be found on the BOEM website (https://www.boem.gov/oil-gas-energy/lease-sales) under individual lease sale Final Notices of Sale. The Topographic Features Stipulation Map Package includes drawings of each bank with associated protection zones. In addition, BOEM reviews proposed oil- and gas-related activities for any activities requiring site-specific EFH consultation. Such activities are those not included in the Proposed Action and bottom disturbing activities occurring closer to sensitive habitat than is recommended in BOEM guidance, which is based on prior programmatic EFH consultations between BOEM and NOAA.

Links to BOEM's NTLs addressing biologically sensitive features, the Western and Central GOM Topographic Features Stipulation Map Package, and a map depicting the live bottom (pinnacle trend and low relief features) lease blocks in the GOM are provided below.

NTL No. 2009-G39
https://www.boem.gov/sites/default/files/regulations/Notices-To-Lessees/2009/09-G39.pdf

NTL No. 2009-G40
https://www.boem.gov/sites/default/files/regulations/Notices-To-Lessees/2009/09-G40.pdf

Western and Central GOM Topographic Features Stipulation Map Package
https://www.boem.gov/sites/default/files/oil-and-gas-energy-program/Leasing/Regional-Leasing/Gulf-of-Mexico-Region/Topographic-Features-Stipulation-Map-Package.pdf

Live bottom (Pinnacle Trend and Low Relief Features) Lease Blocks Map
https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Gulf-of-Mexico-Region/topomap.pdf

3.0 Habitats

3.1 Gulf of Mexico Essential Fish Habitat

BOEM will continue to evaluate and assess risks to federally managed species and identified EFH in upcoming environmental compliance documentation under NEPA and other statutes based on the most recent and best available information. The EFHs that are covered in related BOEM environmental documents are water column, wetlands, submerged aquatic vegetation (e.g., seagrasses, macro-algae), live bottoms (including potentially sensitive biological features), topographic features, *Sargassum*, chemosynthetic communities, and deepwater benthic communities. Descriptions of the aforementioned habitats in the GOM are provided below and more in-depth analyses of these and other important habitats in the GOM can be found in BOEM's *Biological Environmental Background Report for the Gulf of Mexico OCS Region* (BOEM 2021a).

3.1.1 Water Column

To help focus this analysis, we distinguish between coastal and offshore waters. Coastal waters include all bays and estuaries from the Rio Grande River to Florida Bay. Offshore waters include both State offshore waters and Federal OCS waters extending from outside the barrier islands to the Exclusive Economic Zone (EEZ). The inland extent is defined by the CZMA. Offshore waters can be further divided into three regions: the continental shelf west of the Mississippi River; the continental shelf east of the Mississippi River; and deep water (> 984 ft; 300 m).

The coastal waters of the GOM region are found along the coastline of five states, from the southern tip of Texas moving eastward through Louisiana, Mississippi, Alabama, and ending in the Florida Keys. Including the shore of all barrier islands, wetlands, inland bays, and inland bodies of water, the combined coastlines of these states total over 47,000 miles (mi) (75,639 kilometers [km]) (National Ocean Service 2011). The GOM coastal areas comprise over 750 bays, estuaries, and sub-estuary systems that are associated with larger estuaries (USEPA 2012). More than 60 percent of U.S. drainage, including outlets from 33 major river systems and 207 estuaries, flows into the GOM (USEPA 2012). The largest contributing flows from the U.S. coast are from the Mississippi and Atchafalaya Rivers in Louisiana.

The GOM's shallow, offshore waters (water depth < 984 ft [300 m]) east and west of the Mississippi River are highly productive and largely influenced by freshwater inputs from rivers and estuaries, particularly in the northcentral and western GOM. The physical oceanography of the GOM's deep, offshore waters can be approximated as a two-layer system with an upper layer about 2,625- to 3,281 ft (800 to 1,000 m) deep that is highly influenced by the Loop Current; and the lower layer below roughly 3,281 ft (1,000 m) that has near uniform currents (Inoue et al. 2008; Welsh et al. 2009). The Loop Current and its associated eddies are dominant circulation features in the GOM's deep offshore waters, creating dynamic zones with strong divergences and convergences that concentrate and transport organisms (this includes larvae from both oceanic and continental shelf fisheries species).

3.1.1. Water Quality in the Gulf of Mexico

The term "water quality" describes the condition or environmental health of a waterbody or resource. It reflects particular biological, chemical, and physical characteristics and the ability of the waterbody to maintain the ecosystems it supports and influences. The primary factors influencing water quality in coastal and offshore waters are temperature, salinity, dissolved oxygen, chlorophyll content, nutrients, potential of hydrogen (pH), oxidation reduction potential, pathogens, transparency (i.e., water clarity, turbidity, or suspended matter), and contaminant concentrations (e.g., heavy metals, hydrocarbons, and other organic compounds). In the GOM, water quality is greatly affected by both natural and anthropogenic factors.

Lower salinities are naturally characteristic in shallow, GOM waters where fresh water from rivers and estuaries enter and mix with coastal waters. There is a widespread surface turbidity layer in the northcentral GOM associated with the freshwater plumes from the Mississippi and Atchafalaya rivers. This is due to suspended sediment in river discharge, especially during seasonal periods of heavy precipitation and snowmelt in the upper Mississippi River. Outside of these areas, water clarity in the GOM is good to excellent, with low levels of suspended sediment. During summer months, shelf stratification results in a large hypoxic zone on the Louisiana-Texas shelf in bottom waters (Turner et al. 2005). The hypoxic zone in the GOM occurs seasonally and is influenced by the timing of the Mississippi and Atchafalaya River discharge (largely spring-summer), and the formation of the zone is attributed to nutrient influxes and shelf stratification. The hypoxic zone persists until wind-driven circulation mixes the water column and the large, seasonal influxes of river discharge subside.

Offshore waters, especially deep waters along the continental margin, are directly affected by natural hydrocarbon and brine seeps. Natural seeps are extensive throughout the continental slope of the GOM and are chronic contributors of petroleum hydrocarbons to the offshore environment. BOEM's Seismic Water Bottom Anomalies database identifies over 23,000 sites of likely or confirmed hydrocarbon seepage (a link for these ArcGIS™ data layers can be found in http://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/). Pelagic tar, which can have both natural and anthropogenic origins (Green et al. 2018; Warnock et al. 2015), is a common form of hydrocarbon contamination present within the water column in offshore waters. Aggregates of pelagic tar (e.g., tar balls and tar mats) can eventually reach coastal waters of the GOM.

Anthropogenic factors that affect coastal water quality in the GOM include urban runoff containing oil and trace metals; agricultural runoff containing fertilizer (e.g., nutrients including nitrogen and phosphorus); pesticides, and herbicides; upstream withdrawals of water for agricultural, industrial, and domestic purposes; upriver flood control measures that introduce large volumes of freshwater; and contamination by industrial and sewage discharges, dumping, air emissions, and spills of oil and hazardous materials. Urban and agricultural runoff can cause excess nutrients to enter coastal waters and contributes to the formation of algal blooms in the GOM. Some may result in harmful algal blooms, which result in mass mortalities of aquatic animals and pose health risks to humans. Mixing or circulation of coastal water can either improve these water quality issues through flushing or be the source of factors contributing to its decline.

The USEPA, in their National Coastal Condition Report, rated the conditions of multiple U.S. Gulf coastal water indices listed in Table 1 (USEPA 2012). Of the evaluation indices listed, sediment quality (ranked as poor) poses an impact risk to coastal water quality as contaminants in sediments may be re-suspended into the water by anthropogenic activities, storms, and other natural events. Sediments in the GOM coastal region have been found to contain contaminates such as pesticides, metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons (USEPA 2012).

Table 1: USEPA's National Coastal Condition Report ratings for the GOM
(USEPA 2012)

Gulf Coast Index Evaluated	USEPA Rating of Condition
Sediment quality	Poor
Coastal habitat	Poor
Benthic	Fair to Poor
Coastal water quality	Fair
Fish tissue contaminants	Good
Overall coastal water condition	*Fair*

3.1.2 Wetlands

Wetlands occur throughout GOM coastal areas , with the highest density occurring in Louisiana and southern Florida (Dahl and Stedman 2013). Coastal wetlands are complex systems that provide many essential functions and serve as a front line of defense against storm surge and a buffer against sea-level rise. High organic productivity and efficient nutrient recycling are characteristic of coastal wetlands. Wetland corridors provide habitat for a large and diverse group of resident plants, invertebrates, fish, 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.

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 (*Rhizophora mangle*), black (*Avicennia germinans*), and white mangroves (*Languncularia racemose*). Mangroves provide essential habitat for a diversity of animals, including fish, oysters, shrimp, and other invertebrates, which subsequently support wading birds, pelicans, and the Endangered Species Act (ESA)-listed American crocodile (*Crocodylus acutus*). 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.

3.1.3. Submerged Aquatic Vegetation (Seagrasses and Macro-Algae)

Submerged aquatic vegetation (SAV) is a vital component of coastal aquatic ecosystems, with at least 26 species of SAV growing in the northern GOM (Carter et al. 2011; Yarbro and Carlson Jr 2013). They are defined as the collection of benthic plants (e.g., seagrasses) that settle and grow in marine and/or estuarine waters, but do not emerge above the water's surface. The SAV provides several vital ecological functions, including foraging material for grazers, habitat for marine life, and essential nursery grounds for numerous commercially important fish and invertebrate species. The SAV also provides shelter and protection for many species from predation. Further, SAV provides food resources for associated infauna species, nekton, megaherbivores, and overwintering waterfowl (Castellanos and Rozas 2001; Heck et al. 2003; Maiaro 2007; Orth et al. 2006; Rooker et al. 1998; Rozas and Odum 1988).

According to the most recent and comprehensive data available, an estimated 1.25 million acres (ac) (500,000 hectares [ha]) of SAV beds exist in exposed, shallow coastal and/or nearshore waters and embayments of the GOM; over 80 percent of these beds are in Florida Bay and Florida coastal waters (calculated from Handley et al. 2007). In the northern GOM from south Texas to Mobile Bay, Alabama, marine SAV occur in relatively small beds behind barrier islands in bays, lagoons, and coastal waters; freshwater SAV occurs in the upper regions of estuaries and rivers (Castellanos and Rozas 2001; Handley et al. 2007; Onuf 1996). 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). In the northern GOM, SAV coverage has decreased from the bays of Texas to the GOM shores of Florida (Handley et al. 2007). Though declines have been documented for different species in different areas, it is difficult to estimate rates of decline because of the fluctuation of biomass among the different species seasonally and annually.

3.1.4 Oyster Reefs

The Eastern oyster (*Crassostrea virginica*) is the dominant reef-building species in the northern GOM and is primarily found in shallow-water, coastal estuarine areas. Maturation (>75 mm [2.95 in] shell height) typically occurs within 1 year of settlement. Oysters can form extensive reefs, isolated clusters, or, in southwest Florida, attach to the prop roots of mangroves. Ecosystem services provided by oyster reefs include

- providing a nursery, food, and habitat for recreationally and commercially important fish, crustaceans, and other invertebrates;
- providing a natural filter for phytoplankton, detritus, bacteria, and contaminants;
- preventing coastal erosion and boat wake mitigation; and
- acting as sentinels for environmental monitoring (Volety et al. 2014).

Reef characteristics such as adjacent habitat, connectivity, redundancy, complexity, and water quality affect associated oyster reef assemblages. A synthesis of occupancy studies identified overall 115 fish and 41 decapod crustacean species inhabiting oyster reefs in northern GOM estuaries (La Peyre et al. 2019). The cycle of oyster recruitment, growth, death, and degradation create a succession of available benthic habitat. Relict oyster reefs can create habitat that provide refuge from predation and substrate for egg-laying by mobile organisms (Tolley and Volety 2005).

Oyster reefs are sensitive to damage and impairment. In the Big Bend region of Florida, evidence suggests that the primary mechanisms for reef loss is reduced survival and recruitment due to decreased freshwater inputs, which increase vulnerability to wave action and sea-level rise (Seavey et al. 2011). Aggregate analysis and in situ sampling of restoration sites in the north-central GOM indicate that 73 percent of restoration efforts produced at least one living oyster (La Peyre et al. 2014).

Oyster reefs typically occur in inshore waters and would not be affected by routine BOEM-authorized OCS activities and, therefore, will not be further analyzed in this assessment as a habitat. However, oysters are also a commercially and recreationally valuable species and are discussed further as a managed species (see **Chapter 4–Managed Species** and **Section 6.9–Impacts of Accidental Events**).

3.1.5 Live Bottoms (Pinnacle Trend and Low-Relief Features)

Live bottom habitats (pinnacle trend and low-relief features) can be found in the coastal and offshore waters of the GOM. In NTL 2009-G39 (MMS 2009a), BOEM defines pinnacle trend features as 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 the growth of sessile invertebrates and attract large numbers of fish. Low-relief live bottom features are defined as seagrass communities (see **Section 3–Submerged Aquatic Vegetation**), 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 hard substrate and vertical relief may favor the accumulation of sea turtles, fish, and other fauna.

The northeastern central portion of the GOM includes a region with a large concentration of small, isolated, low to moderate relief carbonate reefal features or outcrops collectively known as the "Pinnacle Trend." These outcrops of unknown origin or hard substrates exposed by erosion provide surface area for the growth of sessile invertebrates and attracts large numbers of fish. This area is located at the outer edge of the Mississippi-Alabama shelf between the Mississippi River and De Soto Canyon. The Pinnacle Trend spreads over a 64 x 16 mi area (103 x 26 km) in water depths of 200–650 ft (60–200 m).

The inner and middle Mississippi-Alabama shelf has a high concentration of low-relief live bottom habitats, including fields of small seafloor mounds that rise only about 3–6 ft (1–2 m) from the seafloor but provide hard surfaces for encrusting and attached epifauna. Low-relief live bottom habitats also include isolated low-relief, reef-like structures; rubble fields; low-relief flat rocks (e.g., 20 ft long and 2 ft thick [6 m long and 0.6 m thick]); limestone ledges (e.g., 13 ft [4 m] high); rocky outcrops off Mobile Bay (59- to 131-ft [18- to 40-m] depth range; 16 ft wide and 7 ft high [5 m wide and 2 m high]); and clustered reefs (e.g., tens of meters across and 10 ft [3 m] high) (Schroeder et al. 1988; Schroeder et al. 2000). Hard bottom features on the Mississippi-Alabama-Florida Shelf typically provide reef habitat for tropical organisms, including sessile epifauna (e.g., soft corals, nonreef-building hard corals, sponges, bryozoans, and crinoids) and fish; these areas are typically of low relief (<3 ft; 1 m) (Thompson et al. 1999). Other low-relief, hard bottom areas include De Soto Canyon, Florida Middle Grounds, Pulley Ridge, Steamboat Lumps, Madison Swanson, and the Sticky Grounds. Low-relief live bottoms also include SAV communities, although, in areas of the eastern GOM (e.g., Big Bend region of Florida, the Florida Everglades, and the Florida Keys), some seagrass communities exist outside of estuarine habitats and extend into shallow, offshore waters. Biological lease stipulations have been routinely applied since 1973 (Pinnacle Trend features) and 1982 (low relief features) and have required lessees to comply with measures created to reduce potential impacts to live bottom habitats resulting from bottom-disturbing activities. A link to the map of leases blocks included in the Live Bottom Stipulation can be found in **Section 2–Lease Stipulations and Guidance**).

3.1.6 Potentially Sensitive Biological Features

The term "PSBFs" is used by BOEM to describe hard bottom features not protected by a biological lease stipulation that are of moderate to high relief (about 8 ft or higher [2.4 m]), provide surface area for the growth of sessile invertebrates, and attract large numbers of fish. These features are located outside of any "No Activity Zones" of any of the named topographic features (banks) listed in BOEM's Western and Central Gulf of Mexico Topographic Features Stipulation Map Package or the identified live bottom (pinnacle trend and low-relief) stipulated lease blocks (see links in **Section 2–Lease Stipulations and Guidance**). Although they are not protected by a biological lease stipulation, NTL 2009-G39 (see link in **Section 2–Lease Stipulations and Guidance**) provides guidance for avoiding impacts to these features when proposed activities occur in the vicinity of identified PSBFs (MMS 2009a).

3.1.7 Topographic Features

In NTL 2009-G39 , BOEM defines topographic features as 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 (MMS 2009a). Topographic features support, either as shelter or food, large numbers of commercially and recreationally important fish. They are typically up thrusts of rock due to uplift (salt diapirs) by underlying layers of salt deep under the seafloor. Some others, like the South Texas banks, are relic coral reefs left over from the last sea-level low stand (about 10,000 years ago) or fossilized shorelines (Berryhill Jr. 1987; Bright and Rezak 1976; Rezak and Bright 1981). Other identified topographic features in the GOM include the mid-shelf and shelf-edge banks (including the East and West Flower Garden Banks). These topographic highs, or subsea banks are identified in BOEM's Western and Central Gulf of Mexico Topographic Features Stipulation Map Package and they are protected through biological lease stipulations that have been implemented since 1973 (see links in **Section 2–Lease Stipulations and Guidance**).

3.1.8 Sargassum Habitats

Pelagic *Sargassum* algae are one of the most ecologically important brown algal genera found in the pelagic environment of tropical and subtropical regions of the world. Throughout the GOM, *Sargassum* is ubiquitous in surface waters, generally forming large mats or "floating islands" that can be up to dozens of meters long and in diameter. The pelagic complex in the GOM is mainly made up of *S. natans* and *S. fluitans* (Lee and Moser 1998; Littler and Littler 2000; Stoner 1983). Both species of macrophytes (aquatic plants) are hyponeustonic (living immediately below the surface) and fully adapted to a pelagic existence (Lee and Moser 1998). *Sargassum* serves as nurseries, sanctuaries, and forage grounds for both commercially and recreationally exploited fish, such as billfish, jacks, tunas, and dolphinfish (Dooley 1972; Lafolley et al. 2011).

3.1.9 Deepwater Benthic Communities

Deepwater coral communities survive on hardbottom substrate across the GOM continental slope, which is composed of either exposed bedrock or relict authigenic carbonate coral reef (Brooks et al. 2016). Both hard- and soft-bodied corals colonize deepwater substrate, including some scleractinian corals (e.g., *Lophelia pertusa*), and they are often found in association with high-density chemosynthetic communities. Associated sessile and mobile benthic megafauna include sponges, anemones, echinoderms, crustaceans, and demersal fish. Field data suggest that the extent of deepwater hardbottom habitat in the GOM is large and that diversity of corals and sponges is high (Boland et al. 2017).

3.1.9.1 Cold Seeps and Chemosynthetic Communities

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 GOM at water depths greater than 984 ft (300 m), 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. GOM seep communities tend to be large, up to several hundred meters across (MacDonald 1992). Typical chemosynthetic fauna in the GOM include chemoautotrophic bacteria, vestimentiferan tubeworms, mussels, epibenthic clams, and burrowing clams (MacDonald et al. 1990). Over 330 chemosynthetic communities are confirmed in the GOM 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). BOEM has compiled a geodatabase (i.e., ArcGIS™ layers) containing known seep communities, as well as a map depicting the locations of these features (seep_anomaly_confirmed_organisms in map legend) in the GOM. Both the seismic water bottom anomalies geodatabase and the seismic water bottom anomaly map are available for download at the following URLs.

Seismic Water Bottom Anomalies Geodatabase
http://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/)

Seismic Water Bottom Anomalies Map
https://www.boem.gov/sites/default/files/oil-and-gas-energy-program/Mapping-and-Data/Map-Gallery/Fig1-GOM-anomalies-2016.pdf

3.1.10 Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPCs) are subsets of EFH (designated by regional fishery management councils) exhibiting one or more of the following traits:

- ecologically important for federally managed species (e.g., spawning and/or nursery grounds);
- especially sensitive or vulnerable to anthropogenic impacts (e.g., overfishing);

- stressed by development (e.g., nutrient and sediment pollution); and/or
- rare area as compared with the rest of a species' EFH geological range.

Among documented reefs and topographic features, the following are currently designated GOM HAPCs (unnamed features are referred to by the OCS lease block in which they occur): the Alabama Alps; Alderdice Bank; AT 047 and 357; Bouma Bank; East Flower Garden Banks; Fathom 29; Florida Middle Grounds; Garden Banks 299 and 535; Geyer Bank; Green Canyon 140, 272, 234, 354, and 852; Harte Bank; Jakkula Bank; L&W Pinnacles; McGrail Bank; MacNeil Bank; Madison-Swanson Marine Reserve; Mississippi Canyon 118, 751, and 885; Pulley Ridge; Rankin Bright Bank; Rezak Sidner Bank; Roughtongue Reef; Scamp Reef; Sonnier Bank; South Reed; Southern Bank; Stetson Bank; Tortugas Ecological Reserve; Viosca Knoll 826, 862, and 906; West Florida Wall; and West Flower Garden Banks. Many of the banks are ecologically important habitat for protected corals and federally managed fish species (e.g., red grouper). The HAPCs for the spawning, eggs, and larval life stage of Atlantic bluefin tuna (*Thunnus thynnus*) in the GOM encompass the water column from the 100 m (328 ft) isobath to the seaward limit of the EEZ (Texas to the Florida Straights). See **Figure 1** for a map of the aforementioned HAPCs in the GOM. New HAPCs or revisions to existing HAPC boundaries can be made by the Gulf of Mexico Fisheries Management Council (GOMFMC) and NOAA Fisheries as new information becomes available.

Although the HAPC designation does not provide added protection for or restriction to an area, it can be used to prioritize conservation efforts or as a focus for additional fishery management efforts. Several benthic HAPCs (e.g., McGrail Bank, MacNeil Bank, Jakkula Bank, and Alabama Alps) are currently protected through the Topographic Features and Live Bottom (e.g., Pinnacle Trend) biological lease stipulations that have been routinely applied for decades. Recent lease stipulation examples may be found on the BOEM website (https://www.boem.gov/oil-gas-energy/lease-sales) under recent individual lease sale Final Notices of Sale. The Topographic Features Stipulation Map Package includes drawings of each bank with associated protection zones (see **Section 2–Lease Stipulations and Guidance**). Additionally, other benthic HAPCs are protected as a result of the Condition of Approvals (COAs) applied to proposed activities to ensure minimum distance guidance determined in past EFH consultations is followed. For the purposes of this EFH Assessment, impacts (including routine, accidental and cumulative) to benthic HAPCs within the proposed project area (i.e., Central and Western Planning Areas) are discussed in the relevant Live Bottoms (Pinnacle Trends and Low Relief), PSBFs, and Topographic Features sections as these habitat types encompass designated benthic HAPCs in the region that would be most vulnerable to BOEM-regulated activities (see **Chapters 5—Impacts of Routine Activities**, **Chapter 6—Impacts of Accidental Events**.

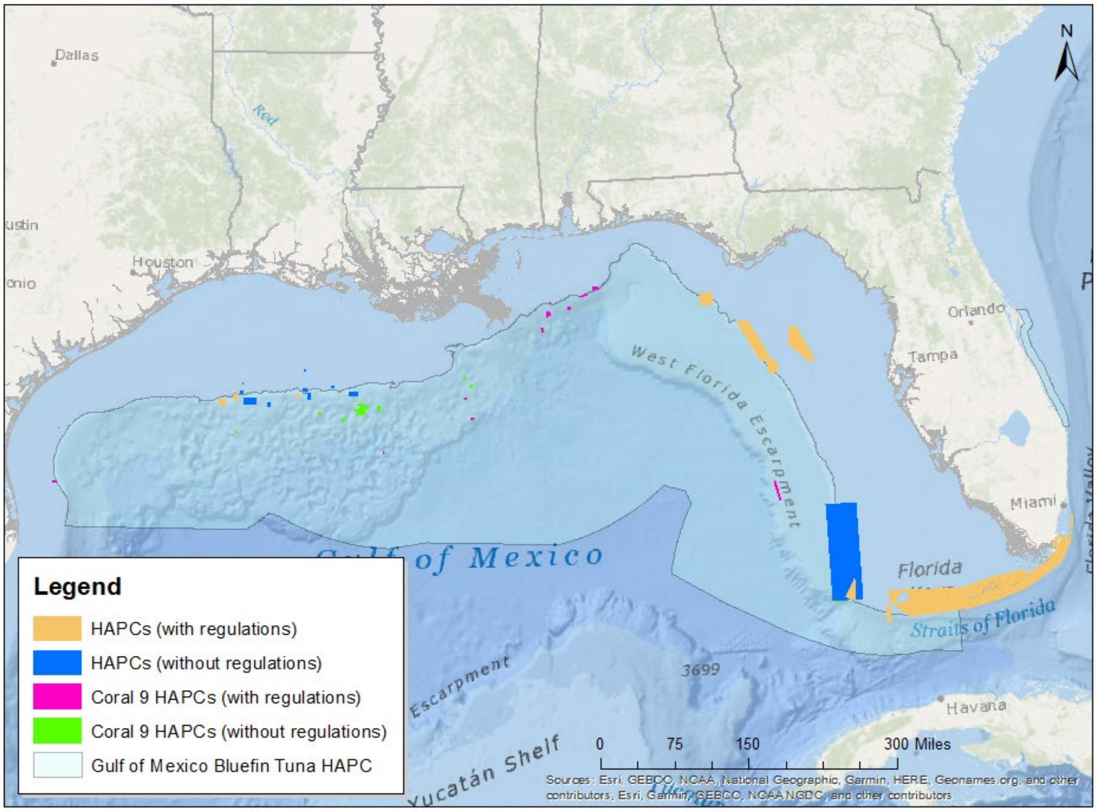

Figure 1. Gulf of Mexico Habitats of Particular Concern.

The publicly available HAPC data used in this image were either downloaded (1/15/2022) from the NOAA website (Reef & Banks Essential Fish Habitat (EFH) Habitat Area of Particular Concern (HAPC) Map & GIS Data | NOAA Fisheries) or provided to BOEM by NOAA HMS Division staff (i.e., bluefin tuna HAPC).

3.1.11 Humanmade Structures and Artificial Reefs (non-EFH designated habitat)

Though not identified or described by NOAA Fisheries as EFH, humanmade structures (e.g., standing and/or active energy production platforms) and artificial reefs (e.g., reefed platforms, reef balls, and ships) in the GOM serve as important habitat for many species. However, their creation has likely facilitated the expansion of non-native species (e.g., orange cup coral and lionfish), which can threaten native populations of fish and invertebrates. When humanmade structures and artificial reefs are constructed, they provide new hard substrate similar in function to newly exposed hard bottom, with the additional benefit of substrate extending from the seabed towards the surface. In the northern GOM, humanmade structures of high profile, such as standing energy production platforms and large artificial reefs (e.g., energy production platforms converted into artificial reefs via toppling or partial removal), have been found to support higher densities of both unmanaged and managed pelagic and demersal species compared to more widespread, lower profile natural hard bottom or reef (Streich et al. 2017a; Streich et al. 2017b;

Wilson et al. 2003). However, fish communities at natural reefs, such as those found in the northern GOM's Flower Garden Banks National Marine Sanctuary (FGBNMS), may be more diverse. For example, comparisons of community composition between standing platforms and natural reefs in the FGBNMS has indicated that species richness (total number of species) is higher on natural reefs (Rooker et al. 1997).

To date, more than 500 oil and gas platforms have been converted and accepted into state artificial reef programs after being decommissioned from offshore GOM waters. State artificial reef programs ranked from most to least conversions are Louisiana, Texas, Mississippi, Alabama, and Florida. Other active and decommissioned OCS oil- and gas-related infrastructure (e.g., pipelines and subsea systems) also provide artificial habitat for offshore species such as reef fish (e.g., red snapper). In addition to energy related infrastructure, Gulf state artificial reef programs from Texas to Florida emplace artificial reefs in coastal and offshore waters using materials such as concrete and limestone rubble, concrete pyramids and reef balls, ships, and surplus military equipment (e.g., armored personnel carriers). Jetties and breakwaters also provide hard substrate for intertidal species.

4.0 Managed Species

The GOM is identified as EFH for species managed by the GOMFMC and is covered in the Shrimp FMP, Red Drum FMP, Reef Fish FMP, Spiny Lobster FMP, Coral and Coral Reef FMP, and Coastal Migratory Pelagic FMP. The highly migratory species managed by the NMFS (these species continue to have EFH designations extending in some cases to the EEZ) also have EFH identified in the GOM. Many of these species are of commercial and recreational importance, and all of them spend a portion of their life cycle within the waters of the GOM (e.g., bluefin and yellowfin tuna). The NMFS lists the species, EFH categories and designations, and HAPCs in their *Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies; Gulf of Mexico Region* (NMFS 2010). The following is summarized from the GOMFMC's *Final Environmental Impact Statement; Generic Essential Fish Habitat Amendment to the Following Fishery Management Plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral and Coral Reefs of the Gulf of Mexico, Spiny Lobster in the Gulf of Mexico and South Atlantic, Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic* (GOMFMC 2004), the *Final Amendment 1 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan, Essential Fish Habitat* (NMFS 2009), and the primary literature. For the full list of species and their scientific names, refer to **Table 2.**

4.1 Red Drum

Red drum (*Sciaenops ocellatus*) are an estuarine-dependent species of fish that occur throughout the GOM from the estuaries to 131 ft (40 m) offshore, using a variety of demersal habitats throughout their lives (e.g., artificial reefs, seagrass beds, mud flats, coastal beaches, and nearshore shelf waters) (Chen 2017). Males and females, which can tolerate wide salinity ranges, typically form large spawning aggregations in estuarine passes where they release eggs and sperm into the water column. Female red drum can release up to 2 million eggs in a season (generally between August and October). The eggs hatch within 24 to 36 hours and are eventually carried by wind and tides into estuarine nursery grounds. Juveniles spend their early lives in estuaries feeding on a variety of small prey such as copepods, mysid shrimp, polychaetes, bivalves, and amphipods (Bass and Avault Jr. 1975; Peters and McMichael 1987). Adult red drum are generalists and forage on a variety of both fish and invertebrate prey (e.g., mollusks, crabs, shrimp, menhaden, anchovies, pinfish, spot, and Atlantic croaker) (Boothby and Avault Jr. 1971; Scharf and Schlight 2000).

4.2 Reef Fish

Federally managed reef fish in the GOM include members of the snapper, grouper, jack, tilefish, and triggerfish families. All managed species, excluding tilefish, can typically be found in association with hard-bottom or "reef-like" habitat (including humanmade structures and artificial reefs), particularly as adults. Young-of-the-year and age 1–2 juvenile snappers (i.e., red, gray, and lane), greater amberjack (*Seriola dumerili*), and gag grouper (*Mycteroperca microlepis*) have been found occupying humanmade structures (i.e., standing platforms) in the nearshore federal waters (≤ 59 ft [18 m] depth) of Louisiana (Munnelly et al. 2021). In contrast, tilefish species (i.e., blueline and golden tilefish) dwell within soft sediments in deep, offshore waters where they maintain burrows (Able et al. 1982). The larvae of many reef fish can be found in offshore surface waters and eventually recruit to estuarine nursery habitats (i.e., sheltered bays, wetlands, and seagrass beds) as post-larvae and juveniles. However, juvenile jack and triggerfish species are often found occupying floating *Sargassum* (Dooley 1972). Age-0 and age-1 red snapper (*Lutjanus campechanus*) juveniles can typically be found over low-relief sand, shell rubble, and mud bottom substrates in shallow offshore waters in the northern GOM (Patterson et al. 2005; Rooker et al. 2004; Wells et al. 2008). Late juveniles and adult reef fish opportunistically occupy pelagic and benthic habitats of the GOM, frequently exhibiting preference for shelf habitat with moderate to high relief, such as topographic features, as well as humanmade structures and artificial reefs. Reef fish species demonstrate a general tendency for older, larger individuals to move into deeper waters toward the shelf edge. However, generalizations may not accurately reflect habitat usage by individual species and different life history stages. For a list of reef fish species and their associated EFH in the GOM, refer to **Table 3**.

4.3 Coastal Migratory Pelagic Species

Coastal migratory pelagic species such as mackerels (i.e., king and Spanish), bluefish (*Pomatomus saltatrix*), and cobia (*Rachycentron canadum*) generally inhabit sunlit waters in coastal or estuarine habitats extending to the continental shelf. Their eggs and larvae rely on pelagic waters, and juveniles are commonly reliant on estuaries and shallow, offshore waters. Spawning occurs over the mid- or inner-continental shelf. The habitat locations for these species can be found in **Table 4**.

4.4 Shrimp

Shallow water penaeid shrimps in the GOM (e.g., brown, white, pink) complete their life-cycle within a year, typically reaching sexual maturity after 2–3 months (Tunnell 2017) and producing hundreds of thousands of eggs that can be released several times throughout a spawning season (i.e., spring, summer, fall). They generally spawn offshore and have demersal eggs and pelagic larvae, which feed on algae and zooplankton (**Table 5**). Larvae and post-larvae can be found in nearshore shelf waters and eventually enter estuaries where they settle into benthic habitats. As juveniles, they live in estuaries, are omnivores, and will emigrate offshore where they reach sexual maturity and spawn. Royal red shrimp (*Pleoticus robustus*) are a species of penaeid shrimp in the GOM of moderate commercial value. Unlike shallow water species of penaeid shrimps, royal red shrimp can live for several years and are found in deepwater over a variety of sediments (e.g., sand, silt, mud). They can also be found amongst deep sea corals in association with complex reef habitats.

4.5 Caribbean Spiny Lobster

Caribbean spiny lobsters (*Panulirus argus*) in the GOM are largely found in south Florida (i.e., the Florida Straits). Larvae can be found offshore in surface waters, eventually settling as postlarvae into the shallow coastal waters of bays, lagoons, and reef flats, and are supported by the production of seagrasses, benthic algae, phytoplankton, and detritus from mangroves (GOMFMC 2021). Within these sheltered habitats, postlarvae and juveniles can often be found occupying rocks, artificial reefs, natural holes and crevices, sponges, octocorals, and among mangrove roots covered in fouling organisms (e.g., oysters, sponges, and algae) (Acosta and Butler IV 1997; Bertelsen et al. 2009; GOMFMC 2021). Adults can be found offshore in association with hard bottom (e.g., natural reefs and artificial reefs), and they spawn offshore in reef fringes. Adults can also be found in seagrass beds within bays, typically feeding on a variety of invertebrates, carrion, and vegetation (i.e., seagrasses and algae).

4.6 Corals

Corals reproduce both asexually (through localized cloning of existing colonies) or sexually (through broadcast spawning of larvae or male gametes in the case of brooding), enabling long-distance dispersion that creates genetic links among regions (NOAA 2016; Veron 2013). The primary locations of the roughly 100 species of shallow-water zooxanthellate corals in the GOM are the East and West Flower Garden Banks, Florida Middle Grounds, and the Dry Tortugas. Seven of these species (i.e., elkhorn coral, staghorn coral, Caribbean boulder star coral, lobed star coral, mountainous star coral, pillar coral, and rough cactus coral) are currently listed as threatened under the ESA (NOAA 2014). Deepwater heterotrophic (non-photosynthetic) corals occur on isolated hard substrates throughout the GOM in over 164 ft (50 m) water depth and include over 250 species that generally grow very slowly. Deep-sea species include stony branching corals, octocorals, cup corals and black corals, and they provide shelter and foraging opportunities for a variety of species (e.g., shrimps, crabs, fish, brittle stars, and demersal fish).

4.7 Highly Migratory Species

Highly Migratory Species (HMS) include tunas, oceanic sharks, swordfish (*Xiphias gladius*), and billfish. These represent a diverse group of species with a wide range of EFH that extend from the GOM into the Caribbean and up the U.S. Atlantic Coast. Adult distribution varies seasonally in the GOM and HMS are commonly associated with hydrographic features. Boundaries between water masses (e.g., the Mississippi River plume and frontal boundaries of the Loop Current and its associated eddies) are habitats that may host higher densities (Rooker et al. 2012; Teo et al. 2007). Some species are also associated with waters overlying topographic features, such as the Pinnacles offshore Mississippi and Alabama and the abundance of fisheries in De Soto Canyon. **Tables 6 and 7** provide descriptions of where these species could be found in the GOM. In many of the descriptions, the Gulf Coast States are used to provide a reference point for approximately where in the GOM the species could occur.

The following information can be found in detail in *Final Amendment 1 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan, Essential Fish Habitat* (NMFS 2009). NMFS has designated a vast area of the western and eastern GOM for the spawning, eggs, and larval life stages of Atlantic bluefin tuna as a HAPC; this species is found in both the GOM and the Atlantic Ocean (NOAA 2017; NMFS 2009). Oceanic sharks occupy a range of habitats and have been known to use estuaries, coastal, neritic, and offshore pelagic environments. Although information is still scarce for the smalltail shark (*Carcharhinus porosus*), bigeye sixgill shark (*Hexanchus nakamurai*), broadnose sevengill shark (*Notorynchus cepedianus*), bluntnose sixgill shark (*Hexanchus griseus*), and whale shark (*Rhincodon typus*), studies have provided sufficient information to update life history descriptions for most of these species and EFH boundaries based on distribution data collected since 2009 (NMFS 2015).

4.8 Other Species of Importance

4.8.1 Fish

Mullets are an estuarine-dependent species of fish that can be found in coastal waters, estuaries, and rivers throughout the GOM. They have wide salinity and depth (3–393 ft [1–120 m]) ranges. Their eggs are planktonic and found offshore. Larvae are pelagic and migrate inshore through estuaries, and feed on zooplankton. Juveniles use estuaries, are found in the mud and sand, and feed on detritus and algae. Adults are found in estuaries and rivers occupying SAV, sand, and mud bottoms, and spawn offshore in large schools during the fall and winter.

Gulf menhaden (*Brevoortia patronus*) are estuarine-dependent, pelagic, and schooling planktivores that occur at depths from 3 to 459 ft (1 to 140 m). They are highly prevalent in the northern GOM, particularly off the coasts of Louisiana and Mississippi (Lassuy 1983; SEDAR 2011). Eggs are pelagic and found both inshore and offshore. Larvae are passively transported into estuaries and are associated with lower salinities. Juveniles are found in non-vegetated areas and move to more saline bays as they grow. Adults are found in nearshore waters and bays (<59 ft [18 m]), and they spawn over the shelf between September and April (VanderKooy and Smith 2002).

Two protected fish species (smalltooth sawfish [*Pristis pectinata*] and Gulf sturgeon [*Acipenser oxyrhynchus desotoi*]) are found in the GOM. Smalltooth sawfish are rare in the northern GOM and their designated critical habitat is outside of the proposed action area. Juvenile smalltooth sawfish are generally restricted to estuarine waters of peninsular Florida, whereas adults have a broader distribution and could be found in the southeastern GOM. Gulf sturgeon inhabit and have critical habitat in onshore waters but can also be found in nearshore waters (up to 100 ft [30 meters]) within the proposed action area. Currently, the present range of Gulf sturgeon extends from Lake Ponchartrain and the Pearl River system in Louisiana and Mississippi, respectively, east to the Suwannee River in Florida.

4.8.2 Invertebrates

Blue crabs (*Callinectes sapidus*) are found all over the GOM depending on the life history stage. Females, which brood their eggs, occur in high-salinity waters by barrier islands or bay mouths. Larvae (i.e., zoeae) are pelagic and are carried offshore to develop over the shelf. Post-larvae (i.e., megalope) migrate to estuaries and settle in SAV and shoreline habitat. Juveniles use vegetated habitats with mud and sand bottoms in estuaries, and they tolerate a wide salinity range. Adults are found using the same areas as juveniles, but females are generally found in higher salinity habitats (e.g., lower bays) Blue crabs are omnivores. Spawning season occurs between December and October, with peaks in the spring and summer.

Oysters are found in inshore waters. Eggs are demersal, but oyster larvae are free swimming until their foot forms. During spatfall, oyster larvae sink to the bottom and settle on hard substrate. The oyster life cycle is dependent on salinity cues (e.g., spawning). Adults grow attached to the substrate and are filter feeders. Oysters are planktivorous and broadcast spawners. They release eggs and sperm during the spring to the fall in warm, high-salinity waters.

5.0 Impacts of Routine Activities

Routine operations continue during the life of a lease, and different activities can have different effects on EFH. Generally, the activities begin with seismic surveys. The impact-producing factors associated with routine G&G activities include noise from various seismic surveys and bottom disturbances related to coring or node placement. Exploration and delineation wells are drilled to find and help define the amount of resource or the extent of the reservoir. Development wells are then drilled from movable structures, fixed bottom-supported structures, floating vertically moored structures, floating production facilities, and drillships. Any drilling will cause some sort of bottom area disturbance and sediment displacement. Some exploration drilling, platform, and pipeline emplacement and decommissioning operations on the OCS require anchors to hold the rig, topside structures, derrick barge or support vessels in place. Anchors disturb the seafloor and sediments in the area where dropped or emplaced. Drilling muds and cuttings and produced waters occurring with production and development are discharged, but they are subject to regulation by USEPA.

Once a lease has expired, bottom-founded structures (i.e., platforms) and their related components must be severed at least 15 ft (5 m) below the mudline and brought to shore (30 CFR §§ 250.1725 and 250.1728). This is to ensure that no obstructions remain that could interfere with future lessees and other activities in the area. In certain cases, BSEE can grant a departure from complete removal of an oil and gas platform for conversion into an artificial reef provided the reefed structure is incorporated into a state artificial reef program (30 CFR § 250.1730). Converted structures are either reefed in place or moved to an established artificial reef site. In some cases, operators are granted a waiver by BSEE to decommission oil and gas infrastructure (e.g., pipelines, drilling templates, pipeline end terminations or manifolds) in place. Decommissioning involves the use of nonexplosive and/or explosive severance techniques. Nonexplosive severance methods include abrasive cutters, mechanical cutters, and diamond wire cutters. Explosive methods may be used to sever piles, but these methods may result in possible impacts to fisheries species and EFH.

Not all BOEM-regulated activities occur offshore–there are also routine operations that can affect EFH in coastal waters. Coastal land disturbance can impact EFH through the construction and operation of coastal infrastructure (i.e., construction facilities, support facilities, oil and gas transportation via onshore pipelines, and processing facilities), vessel traffic, and navigation canals.

5.1 Water Column

The primary impact-producing factors to water quality in coastal waters from BOEM authorized oil- and gas-related activities are point-source and storm-water discharges from support facilities and vessel discharges; although, these activities are highly regulated, localized, and temporary in nature. Vessel traffic and the creation and maintenance of navigation channels can also increase turbidity in the water column and lead to saltwater intrusion in coastal, freshwater habitats, which can be problematic for some aquatic organisms and SAV communities. However, the impacts to the water column and associated organisms are expected to be highly localized because much of the service-vessel traffic associated with BOEM-regulated activities in the

GOM uses the established channels and canals along the Louisiana coast (i.e., Port Fourchon and Bayou Lafourche).

During exploration activities, the primary impact-producing factors to offshore water quality are discharges of drilling fluids and cuttings. During subsea infrastructure installation and removal activities, the primary impact-producing factors to water quality are sediment disturbance and temporarily increased turbidity. Operational discharges and wastes created during oil- and gas-related production and development activities, such as produced water and service-vessel discharges, can also impact water quality. This may include water with an oil concentration of approximately 15 parts per million as established by regulatory standards. However, USEPA's and USCG's regulations are in place to limit the toxicity of the components and the levels of incidental contaminants in these discharges, and in some cases the discharge rates and discharge locations. Any disturbance of the seafloor would increase turbidity in the surrounding water, but the increased turbidity levels are expected to be temporary and restricted to the area near the disturbance. There would be no additional direct biological impacts from potential discharges in decommissioning activities. Although, jetting activity conducted during decommissioning operations could cause temporary and localized sediment disturbance and turbidity in the water column.

5.2 Wetlands

Overall, the impacts to wetlands from routine activities associated with the proposed action are not expected to adversely alter the protective barrier beach configurations much beyond existing, ongoing impacts in localized areas. This is due to the strict regulations for discharges and wastes, the small amount of dredging, low probability of new pipeline landfalls, and no new onshore facilities expected as part of the proposed action. If any such activities should occur, multiple Federal and State regulations would ensure decreased impacts to coastal habitats including wetlands.

Most operational discharges, such as 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. In most cases, produced-water discharges from OCS wells are too distant to pose a threat to wetland 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. However, 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 wetland habitats.

Maintenance dredging of navigation channels and canals is routinely conducted to support, in part, BOEM authorized oil- and gas-related activities on the OCS. Occasionally a channel could be dredged ahead of its normal maintenance schedule to accommodate the transport of large OCS platforms or other structures or vessels. Dredging can be detrimental to coastal and estuarine habitats (e.g., wetlands) and the aquatic fish and invertebrates that use them as nursery grounds and for protection. Impacts to wetlands 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). However, many of these effects are reduced using modern dredging and disposal practices. In addition, dredged material can be beneficially used to enhance and create coastal wetlands after material has been tested for the presence of contaminants. Because of the USACE's policy of beneficial use of dredged material, an increased emphasis has been placed on the use of dredged material for marsh creation (USACE 2013).

Typically, the installation of new pipeline landfalls 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 wetlands are minimized. The addition of new pipelines to distribution points could further stress wetlands along the GOM, leading to erosion and loss, which could indirectly impact the aquatic organisms that use them for foraging, shelter, and as nursery grounds. Installation of pipelines in or near wetland habitats could lead to the hydrologic alteration, disturbance, fragmentation, and loss of wetlands (Ko and Day 2004).

Various kinds of onshore facilities service OCS development. The addition of new infrastructure (e.g., roads and onshore support bases) to support offshore oil- and gas-related activities could cause additional stress (e.g., sedimentation) to wetland habitats. Onshore support activity may also 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).

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. 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 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.

5.3 Submerged Aquatic Vegetation (Seagrasses and Macro-Algae)

Routine OCS oil- and gas-related activities in the GOM that may impact SAV communities include maintenance dredging, vessel traffic, and pipeline landfalls. Maintenance dredging of navigation channels and canals could cause increased turbidity, physical removal, and burial, which can disturb and/or destroy SAV (Erftemeijer and Lewis III 2006; Kenworthy and Fonseca 1996). The creation of new navigation channels may lead to saltwater intrusion, which can negatively impact SAV communities in coastal, freshwater habitats. Increased vessel traffic and subsequent wave action can stress SAV communities by causing an increase in turbidity and sedimentation. The construction of additional pipeline landfalls may also cause stress to SAV communities by indirectly causing nutrient loading in the water column due to wetland loss (Johnston et al. 2009; Verhoeven et al. 2006). However, these activities are not expected to significantly increase in occurrence and range in the foreseeable future. If they do occur, these activities should have minor effects on SAV due to Federal and State requirements and implemented programs, as well as the beneficial effects of natural flushing (e.g., from winds and currents). Any potential effects on SAV from routine activities are expected to be localized.

5.4 Live Bottoms (Pinnacle Trend and Low Relief)

BOEM-regulated activities have the potential to impact live bottom habitats (Pinnacle Trend and low relief) through drilling discharges, the explosive removal of platform-related infrastructure, and during the emplacement of structures (e.g., platforms) or pipelines, equipment (e.g., acoustic and/or electromagnetic equipment and anchors), or subsea infrastructure (e.g., subsurface tie-ins). However, adherence to the requirements of the live bottoms lease stipulation, COAs, as well as minimum distancing guidance developed during past EFH consultations, (See **Section 2– Lease Stipulations and Guidance**), greatly reduces the risk of impacts. BOEM routinely applies COAs to ensure approved bottom-disturbing activities are appropriately distanced from live bottom habitats (e.g., 2,000 ft [610 m] drilling buffer for drilling activity). In accordance with past conservation recommendations, if BOEM proposed approval of bottom-disturbing activities that would not meet recommended minimum distance requirements (e.g., refer to BOEM NTL 2009-G39 (MMS 2009a)), a site-specific EFH consultation will be triggered. Pipeline displacement is also a phenomenon known to occur (Nodine et al. 2006; Stress Engineering Services Inc. 2005) that could potentially cause physical damage to sensitive live bottom habitats in the GOM.

Drilling muds and cuttings discharged during routine oil- and gas-related activities generate turbidity and can result in relatively high sedimentation loading on the seabed when shunted to the seafloor, but only in close proximity to the drill site (Neff 2005). This could result in adverse impacts to Pinnacle Trend features via smothering of benthic organisms, particularly sessile benthic invertebrates (e.g., corals and sponges) near the drill site. However, turbidity generated by the deposition of drilling muds and cuttings in the Pinnacle Trend area would not greatly impact the biota of the live bottoms because the biota surrounding the pinnacle features are adapted to the turbid (i.e., nepheloid) conditions and high sedimentation rates associated with the outflow of the Mississippi River (Gittings et al. 1993). The pinnacles themselves are often coated with a veneer of sediment. However, the chemical content of drilling muds and cuttings, and, to a lesser extent, produced waters, may contain hydrocarbons, trace metals (including heavy metals), elemental sulfur, 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 (CSA 2004b). Sediment infauna have shown effects from toxins at less than 330 ft (100 m) from discharge locations, including reduced reproductive fitness, altered populations, and acute toxicity (Carr et al. 1996; Chapman et al. 1991; CSA 2004b; Hart et al. 1989; Kennicutt II et al. 1996; Montagna and Harper Jr. 1996). The toxicity of both drilling muds and cuttings and produced waters has the potential to adversely impact the live-bottom organisms of the Pinnacle Trend, but only in very close proximity to the source (Gittings et al. 1993; Neff 2005). Based on the localized impacts of routine OCS oil- and gas-related activities, the expected dilution of operational discharges, the provisions of the live bottoms lease stipulation (see link to recent lease stipulation example in **Chapter 2—Lease Stipulations and Guidance**), and applied COAs, significant adverse impacts from routine events are not anticipated to occur to the Pinnacle Trend as a result of the proposed activity.

The potential impacts from drilling discharges to low-relief live bottom features would be like the potential impacts to Pinnacle Trend features. The toxicity of drilling muds and cuttings and produced waters, as well as increased turbidity and sedimentation resulting from such bottom disturbances has the potential to adversely impact live-bottom low relief features. However, the greatest impacts of routine OCS oil- and gas-related activity are reported close to the well and the discharge of drilling muds, cuttings, and produced waters is strictly regulated by the USEPA's National Pollutant Discharge and Elimination System (NPDES) permits. In addition, many of the lease blocks to which the Live Bottom Stipulation would otherwise apply (e.g., those with live-bottom low relief features) are located in the Eastern Planning Area, are not available for lease (due to Presidential withdrawal of the area from leasing), and are typically well distanced from proposed lease sale areas. Low-relief live bottom features occurring within Live Bottom Stipulation lease blocks available for lease (i.e., in the Central Planning Area) would be protected because lease stipulations require lessees to undertake measures to avoid adverse impacts (see link to example live bottom lease stipulations in **Chapter 2—Lease Stipulations and Guidance**). Collectively, the distance of many live-bottom low relief features (e.g., those located in the Eastern Planning Area), and the requirements of the live bottom lease stipulations and applied COAs meant to protect features within blocks available for lease, greatly reduces or eliminates the effects of routine impacts associated with drilling and other bottom-disturbing activities (e.g., anchoring, infrastructure emplacement, and infrastructure removal). However, unlike Pinnacle Trend features, low-relief live bottom features do not have minimum distancing guidance from past EFH consultations. For Pinnacle Trend features, if the minimum distance guidance developed during past EFH consultations are exceeded (e.g., anchoring is proposed < 100 ft [30 m] of a Pinnacle Trend feature), BOEM would have to initiate a project-specific EFH consultation with NOAA Fisheries.

With regard to decommissioning, the shock waves produced by explosive severance activities could harm the biota of pinnacle trend and low-relief live bottoms if they occurred within close distance. The resulting rapid oscillation in the pressure waveform associated with underwater detonations can cause fish and invertebrate mortality, particularly when the rapid contraction and overextension of the swim bladder occurs in some fish species (e.g., snappers and groupers). Corals and other sessile invertebrates typically have a high resistance to explosion-related shock waves (Keevin and Hempen 1997; Schroeder and Love 2004). BSEE typically conducts a site-specific assessment of each well or platform decommissioning application and applies mitigations based on those analyses to comply with existing laws, regulatory requirements, and conservation recommendations based on consultations with other Federal Agencies. When explosive severance techniques are proposed, BSEE can enforce the use of methods designed to reduce shock impacts and minimize negative effects to biota. If a decommissioning application were submitted proposing the use of explosives near the Pinnacle Trend area or low-relief live bottom features, it is likely BSEE would require the use of nonexplosive and/or mechanical removal techniques based upon the SEA. There has also been an increasing trend in the use of mechanical removal techniques of oil and gas infrastructure in the GOM overtime. As such, impacts to biota on pinnacles and low-relief live bottoms from explosive removals are not expected to occur.

Live bottom features (both Pinnacle Trend and low relief) have the potential to be impacted by activities associated with the installation, removal, or decommission in-place of pipelines. All three operations would be performed using either an anchored or dynamically positioned vessel and would involve some level of jetting or trenching of the seabed. During installation, a reel-lay technique is used whereby the pipeline is lain along the seabed. A reverse reel-lay technique is used during removal: the pipeline segment is lifted from the seabed and reeled back onto a lay barge. These operations could cause direct physical harm to live bottom habitats, as well as seafloor disturbances resulting in localized turbidity in the water column. However, such activities would trigger an environmental review of the proposed activity by BOEM environmental personnel, who would evaluate the application to ensure that the proposed bottom-disturbing activities are conducted in accordance with lease stipulations and distance guidance (see **Section 2–Lease Stipulations and Guidance**) meant to mitigate such impacts.

Though lease stipulations and COAs mitigate impacts to live bottom habitats associated with pipeline installation, removal, and decommission in-place, they do not directly address the potential for pipeline displacement. Pipeline displacements are known to occur in the GOM, particularly in association with hurricanes (Det Norske Veritas 2006; 2007; Gagliano 2007; Gearhart et al. 2011; Hooper and Suhayda 2005; Nodine et al. 2006; Stress Engineering Services Inc. 2005). Buried pipelines can become unburied or “floated” by storm pressure (i.e., via induced bottom currents and sediment transport) on the seafloor. Such impacts to pipelines have been documented at depths greater than 200 ft (60 m) (Gearhart et al. 2011), and Hooper and Suhayda (2005) have demonstrated that intense hurricanes can generate such seafloor effects at a depth of 400 ft (121 m). Lateral movements greater than 5,000 ft (152 m) have also been reported for pipeline segments several miles in length (Gagliano 2007; Tian et al. 2015). In addition, maps of pipeline damage and storm paths for past hurricanes suggest some areas, including the Pinnacle Trend blocks, may be subject to repeated incidents (Det Norske Veritas 2007; Tian et al. 2015). Not only do large storms trigger mudslides (which pose risks to pipeline stability), but annual winter storms can too (Bentley Sr. et al. 2022), and wave period is a determining factor (Nodine et al. 2006). In addition to these studies, BOEM currently has an environmental study underway in the northern GOM investigating pipeline displacement for both active and abandoned pipeline segments. Considering this information and a trend of increasingly intense hurricanes entering the GOM, it is reasonable to assume that physical damage to live bottom habitats could potentially occur due to storm-induced displacements of nearby pipelines. Distancing infrastructure from nearby live bottom habitats, as described in BOEM and BSEE guidance, offers some protection in the event of displacement.

5.5 Potentially Sensitive Biological Features

The potential impacts to PSBFs from BOEM's oil- and gas-related activities would be similar to those previously described for live bottoms (Pinnacle Trend and low-relief features). Adherence to the requirements of the Live Bottom lease stipulation and the application of COAs based on site-specific environmental reviews greatly reduces the risk of impacts. BOEM routinely applies COAs to ensure approved bottom-disturbing activities are appropriately distanced from PSBF's (e.g., 2,000 ft [610 m] buffer for drilling activity). However, there is currently no minimum distancing guidance developed during past EFH consultations for bottom-disturbing activities (e.g., those caused by anchors, chains, or cables) that could impact PSBFs, such as the 100 ft [30m] minimum distance developed for Pinnacle Trend features. Mitigations–such as requiring the collection of remote sensing survey data and/or the submission of post-activity reports that demonstrate PSBFs were not physically impacted–are applied if the proposed bottom-disturbing activities occur within 100 ft [30 m]. This mitigation measure reduces the risk of direct physical impacts (i.e., crushing), but simple avoidance allows for variation in distancing, and it may be possible for PSBFs to experience some level of sedimentation or burial resulting from bottom-disturbing activities occurring nearby (i.e., < 100 ft [30 m]). Sedimentation and burial could potentially result in adverse impacts to sessile biota, particularly slow growing, deep water corals. As with live bottom habitats (Pinnacle Trend and low relief), PSBF's could also be vulnerable to physical impacts from pipeline displacements.

5.6 Topographic Features

Like live bottom habitats, BOEM-regulated activities have the potential to impact topographic features. Impacts to sensitive biota inhabiting topographic features can occur via interactions with drilling discharges, the explosive removal of platform-related infrastructure, and the emplacement of structures (e.g., platforms) or pipelines, equipment (e.g., acoustic and/or electromagnetic equipment), or subsea infrastructure (e.g., subsurface tie-ins). Displacement of active or abandoned pipelines may also result in the physical disturbance of topographic features.

As with the Pinnacle Trend features, the discharge of drilling muds and cuttings may result in adverse impacts to biota inhabiting topographic features due to increased turbidity, subsequent sedimentation, and exposure to toxicants in the vicinity of the well site. However, adherence to BOEM's Topographic Features Stipulation (see **Section 2–Lease Stipulations and Guidance**) and COAs, as well as mitigations developed during past EFH consultations, avoid impacts to topographic features associated with authorized drilling activities. Discharge of drilling muds, cuttings, and produced waters is strictly regulated by the NPDES permits, and a mitigation developed during past EFH consultations requires shunting of drilling muds and cuttings to within 33 ft [10 m] of the seafloor when activities are proposed within the 3-mile buffer zone of an identified topographic feature. Shunting helps to avoid exposing biota inhabiting these features to drilling mud and cuttings discharges and reduces the potential for operational discharges and wastes to reach topographic features.

Potential impacts to topographic features resulting from decommissioning activities are similar to those described previously for live bottom habitats. Refer to **Section 5–Impacts of Routine Activities–Live Bottoms (Pinnacle Trend and Low-Relief)** for information about the impacts of underwater detonations to marine biota (i.e., fish and invertebrates) and the mitigations BSEE uses to minimize those effects near sensitive benthic habitats such as topographic features. Such mitigations can include the use of methods designed to reduce shock impacts and minimize negative effects to biota. In the case of a proposed decommissioning operation near a topographic feature, it is likely the BSEE would require a mechanical rather than explosive removal.

The larger minimum distance guidance (i.e., 500-ft buffer) developed during past EFH consultations (see **Chapter 2—Lease Stipulations and Guidance**) protects topographic features from routine BOEM-authorized bottom-disturbing activities and offers increased protection from potential pipeline displacements. However, researchers investigating pipeline displacements in the GOM have shown movements in excess of 500 ft in water depths less than 400 ft after the passing of hurricanes (Gagliano 2007; Hooper and Suhayda 2005; Tian et al. 2015), which suggests that topographic features with newly emplaced pipelines or abandoned pipeline in close proximity could be vulnerable to this potential impact.

5.7 Sargassum Habitats

Operational discharges and wastes associated with BOEM authorized oil- and gas-related activities in the OCS, including drilling muds and cuttings, produced water, and operational discharges (e.g., deck runoff, bilge water, and sanitary effluent) could contact floating *Sargassum* in surface waters of the GOM. In such an instance, the quantity of *Sargassum* contacted and the duration of exposure would vary depending on a variety of factors, including season (highest abundances of *Sargassum* present in spring and summer) (Gower and King 2011), winds, prevailing surface currents, wave action, discharge type and concentration, and dispersion rates. However, the toxicity, quantity, and volume of discharges would be minor and expected to dilute to background levels quickly and within a short distance of the discharge point as such discharges are expected to comply with USEPA regulations. Therefore, although discharges could contact *Sargassum*, interaction would be limited to a very small portion of the *Sargassum* population and the organisms that inhabit it.

Drilling operations create an area of high turbidity in the cuttings discharge vicinity, which may negatively impact *Sargassum*. However, cuttings discharged at the sea surface, where contact with floating *Sargassum* could occur, tend to disperse in the water column and be distributed at low concentrations (CSA 2004a). If exposed, potential impacts from turbidity and subsequent sedimentation to fish and invertebrates (eggs, larvae, juveniles, and adult life stages) occupying *Sargassum* habitat may include changes in respiration rate, abrasion and puncturing of structures (e.g., gills and/or epidermis), reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus (Anchor Environmental CA L.P. 2003).

Runoff water from the decks of ships and platforms may contain small quantities of oil, metals, and other contaminants. Larger vessels and offshore platforms discharge effluents from sanitary facilities (gray water). They also circulate seawater to cool ship's engines, electric generators, and other machines. The cooling water discharge may be up to 20 °F (11 °C) warmer than the surrounding seawater (USCG and MARAD 2003). This temperature difference can accumulate in the vicinity of the discharge. For oil and gas platforms and drillships, localized warming of the water could occur (Emery et al. 1997; USCG and MARAD 2003). However, the effects from gray water, deck runoff, and cooling water are notable only for stationary locations. Produced waters from stationary locations are rapidly diluted and impacts are only observed within 328 ft (100 m) of the discharge point (Gittings et al. 1993; Neff and Sauer Jr. 1990; Trefry et al. 1995). Those effects are localized, with only brief contact to passing *Sargassum* before dilution to background levels.

Overall, the impacts to *Sargassum* associated with the proposed action are expected to have only minor effects on a small portion of the *Sargassum* population as a whole. The presence of *Sargassum* in the GOM is part of a large cycle that circulates from the Sargasso Sea, south to the Caribbean, and back through the GOM. *Sargassum* experiences significant growth (up to 25 grams per square meter of seawater) while in the northwestern GOM (Gower et al. 2006), which is likely influenced by nutrient input from the Mississippi and Atchafalaya rivers. Recurrent blooms have also been observed in the Caribbean and equatorial regions of the North Atlantic since 2011, often stretching from West Africa to the coast of Belize and into the GOM. Consequently, it is expected that *Sargassum* and their associated biota would be resilient to any localized impacts due to operational discharges from oil- and gas-related activities, because it is constantly replaced in any given area (Frazier et al. 2015) and vast, recurrent blooms appear to be the new normal (Wang et al. 2019).

5.8 Deepwater Benthic Communities

As with live bottom habitats and topographic features, chemosynthetic and deepwater coral communities are susceptible to physical impacts through interactions with drilling discharges, the explosive removal of platform-related infrastructure, and the emplacement of structures (e.g., platforms) or pipelines, equipment (e.g., acoustic and/or electromagnetic equipment), or subsea infrastructure (e.g., subsurface tie-ins). However, adherence to distance guidance described in NTL 2009-G40 (MMS 2009b) (link to NTL in **Section 2–Lease Stipulations and Guidance**) reduces the risk of physical impacts and exposure to drilling discharges by requiring that bottom-disturbing activities are distanced from deepwater benthic communities (≥ 2,000 ft [610 m]). As such, routine operations of a proposed action in deep water are not expected to significantly impact the ecological function or biological productivity of widely scattered, high-density deepwater benthic communities. For decommissioning using explosive severance techniques, the impacts to deepwater benthic communities would be similar to those described previously for live bottoms habitats. Refer to **Section 5–Impacts of Routine Activities–Live Bottoms (Pinnacle Trend and Low-Relief** for more detailed information regarding the impacts of underwater detonations to marine biota (i.e., fish and invertebrates) and the regulations and mitigations BSEE uses to minimize those effects to sensitive habitat, such as deepwater benthic communities. Last, current research suggests that pipelines in waters less than 400 ft are susceptible to displacement (Gearhart et al. 2011; Hooper and Suhayda 2005). Consequently, deepwater benthic communities are not currently considered to be vulnerable to impacts from pipeline displacements.

5.9 Managed Species

Routine BOEM-regulated activities such as the release of operational discharges and wastes (e.g., produced waters and drilling muds and cuttings), the emplacement of subsea structures (e.g., platforms, pipelines, anchors, and subsea tie-ins) on the OCS, maintenance dredging of inshore canals, and the creation of new pipeline landfalls may affect managed species. USEPA and USCG administer regulations and permits that are designed to keep contaminants in operational discharges and wastes below harmful levels. Once the contaminants are discharged into the water column, they are not expected to persist for long, particularly when considering the depths at which BOEM's oil- and gas-related activities occur along the OCS and beyond, where they are exposed to strong currents, wind, and wave action. However, the discharge of drilling fluids and cuttings offshore may contribute to localized, temporary marine environmental degradation, particularly when shunted to the seafloor but in close proximity to the drill site (Neff 2005). For example, drilling muds and cuttings shunted to the seafloor can cause temporary turbidity in the water column and high sedimentation loads on the seabed compared to surface discharges (Neff 2005), which could be problematic for fisheries species with limited to no mobility. 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 temporarily displaced from impacted habitats. Adherence to distance guidance in NTLs (see **Section 2–Stipulations and Guidance**) that apply to bottom-disturbing activities occurring near productive live bottom habitats and topographic features would largely avoid these impacts.

Offshore habitat modifications, such as the emplacement of subsea infrastructure throughout the OCS creates additional hard substrate in a region dominated by soft sediments. These structures can act as de facto artificial reefs and provide additional habitat for managed species throughout the northern GOM (see **Section 3–Humanmade Structures and Artificial Reefs** for more information). Inshore habitat modifications, such as maintenance dredging of canals and the creation of new pipeline landfalls have the potential to adversely impact managed species, many of which use these habitats for foraging, shelter, and as nursery grounds. See **Section 5–Impacts of Routine Activities–Wetlands**. for more detailed information regarding how these activities impact wetland habitats relied upon by many managed species in the northern GOM. However, many of the potential effects to wetlands are minimized due to the use of modern dredging/disposal practices and pipeline installation techniques.

5.9.1 Noise

The potential impacts of anthropogenic sounds to fisheries resources continues to be of increasing concern to stakeholders. Consequently, much research has been conducted on this subject. The potential impacts of noise to fisheries resources are described here as they relate to sound generated by BOEM authorized oil- and gas-related activities. Routine impact-producing factors that would have possible impacts to fisheries species include ensonification of the water column. All routine BOEM authorized oil- and gas-related activities (e.g., seismic surveys, high-resolution geophysical surveys, vessel traffic, and rotating machinery) have an element of sound generation, which can result in effects ranging from behavioral changes, masking of biologically important signals, temporary hearing loss (Popper et al. 2005), or, more rarely, physiological injury or mortality (de Soto 2016; Popper and Hastings 2009; Popper et al. 2014). The actual effects observed will depend upon a number of factors, including the source type (e.g., impulsive or non-impulsive), signal characteristics (e.g., frequency, source level, duration), the distance between the animal and the source, the cumulative sound exposure of the entire noise event, and the species' hearing sensitivity (Popper et al. 2014; Popper et al. 2019).

A growing body of research demonstrates that fish and invertebrates are sensitive to acoustic cues and are able to efficiently extract biologically-important sounds from background noise (Hastings and Popper 2005; Popper et al. 2003; Popper and Fay 1993; Wysocki and Ladich 2005). It is generally assumed that fish and invertebrates are capable of sensing the particle motion component of the sound wave, which is the tiny back-and-forth motion of water particles that accompanies a passing pressure wave (Popper and Hawkins 2018). Particle motion associated with sound waves that move through the sediment is generally referred to as "substrate vibration", and animals that live on or in the seafloor may also detect acoustic energy in this way (Hawkins et al. 2021). Some fish with special adaptions of the swimbladder are also capable of detecting acoustic pressure, which enables them to detect a broader range of acoustic frequencies over larger distances (Popper and Fay 2011; Popper et al. 2021; Wiernicki et al. 2020). Generally speaking, particle motion is most relevant within several wavelengths of a sound source, while acoustic pressure can propagate a great distance and is influenced by environmental factors like water depth, temperature, and salinity (Kalmijn 1988). Close to the seafloor and sea surface, complex patterns of particle motion can occur, as sound waves area reflected and refracted by these boundaries. Despite this complexity, one can generally assume that within a few wavelengths of a sound source, fish and invertebrates would be able to detect sound, but a greater distances, only pressure-sensitive fishes could hear it. The research thus far shows that the primary hearing range of most particle-motion sensitive organisms in below 1 kHz (Popper and Hawkins 2018).

Impulsive sounds generated by OCS oil- and gas-related activities (e.g., impact pile-driving and airguns) can potentially cause a behavioral response, reduce hearing sensitivity, or result in physiological injury to fish and invertebrates. Hair cells in fish ears regenerate (Corwin 1981), thus making Permanent Threshold Shift (PTS) highly unlikely, but very close to impulsive sound sources they could experience barotrauma, which is a physiological effect that results from a rapid change in pressure. Generally, the greater the difference between the static pressure at the site of the fish and the positive and/or negative pressures associated with the sound source, the greater the risk of barotrauma. This is because the air-filled cavity inside the body of the fish (the swimbladder) will rapidly expand and contract with the passing sound wave, which can lead to a suite of injuries ranging from recoverable hematomas to organ damage (which could lead to death) (Popper et al. 2014; Stephenson et al. 2010). The range at which physiological injury may occur is short (<33 ft; <10 m) 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 0–16 ft (0–5 m) of an airgun blast, with detrimental effects occurring closer to the source (Booman et al. 1996; Cox et al. 2012; Kostyuchenko 1973; Payne et al. 2009). At distances of more than 33 ft (10 m), detrimental effects to fish eggs were detected only at very low levels (Booman et al. 1996; Cox et al. 2012; Kostyuchenko 1973; Payne et al. 2009; Turnpenny and Nedwell 1994); however, effects may be species-specific. For example, Dungeness crab larvae exposed to airgun blasts did not show differences in survival rates compared to control groups (Pearson et al. 1994).

Temporary threshold shift (TTS) can occur when damage to hearing structures causes decreased hearing sensitivity, which means that in order for a signal to be detectable, a higher sound level is necessary. Several experiments have examined TTS in fishes after exposure to seismic airguns. McCauley et al. (2003) found damage to hearing structures for fish held in cages 16–2,625 ft (5–800 m) from an airgun, but they did not measure hearing thresholds. In Popper et al. (2005), two species with hearing specializations experienced TTS when held 43–59 ft (13–18 m) from an airgun, but they recovered within 18 hours. Several additional studies in subsequent years (e.g., Hastings et al. 2008; McCauley and Kent 2012; McCauley et al. 2008) found mixed results depending on species, proximity to the airgun, and received levels. Taken together, however, this body of work has shown that TTS and damage to hearing structures is possible from high-intensity sources, but species without hearing specializations are less likely to sustain effects, and even those with some specializations are likely to recover within several days of exposure. Similar to injurious effects, TTS is expected to occur very close to the source, and effects will be short-term. However, there is the potential for secondary effects; for example, a fish with decreased fitness (due to decreased hearing sensitivity) for a few days may be more vulnerable to predation, less likely to find a mate, or unable to find food while their hearing is recovering. This type of secondary effect has not been measured experimentally.

The research on behavioral responses of fishes to seismic airguns has covered a range of species, each with different hearing capabilities, and has employed a variety of methods. For example, some studies have used echosounders to observe potential changes in schooling behaviors in the vicinity of impulsive sound sources (e.g., Chapman and Hawkins 1969; Hawkins et al. 2014; Jorgenson and Gyselman 2009; Peña et al. 2013). In some cases, fish swim lower in the water column and schooling behaviors are disrupted, but only temporarily. Other work has used video cameras to observe potential startle responses (Boeger et al. 2006; Hassel et al. 2004; McCauley et al. 2003; Thomsen 2008; Wardle et al. 2001), which also tend to be short-lived. Tagging studies have occurred more recently (e.g., Davidsen et al. 2019; Hubert et al. 2020; Meekan et al. 2021; van der Knaap et al. 2021) and also tend to show subtle, short-term behavioral changes with no evidence that fish are fleeing an area, ceasing feeding, or permanently abandoning habitat. Despite the range species and methods covered in this research, a common trend that emerges is that fish often show an initial response (either a startle response or a change in schooling behavior), but this response is reduced with repeated exposure or ramp-up of the sound source. Though short-term changes in schooling behavior could temporarily increase vulnerability to predation, there is little chance this would have population-level effects.

5.9.1.1 Noise–Other Routine Activities

Routine vessel traffic associated with OCS oil- and gas-related activities to and from offshore facilities introduces sound into the aquatic environment. The cavitation of boat propellors produces low-frequency, nearly continuous sound that is audible by most fishes and invertebrates and could cause acoustic masking. Masking of important biologically relevant sounds has the potential to increase predation, reduce foraging success, and may preclude individuals from finding a mate, thus affecting reproductive success. However, because OCS oil- and gas-related vessel traffic generally occurs in deep, offshore waters and is widely dispersed, it is unlikely that fish and invertebrates will be significantly affected by this type of noise. Negative impacts associated with noise from vessel traffic have been primarily observed in shallow, coastal habitats with fish and invertebrate species that have limited to no mobility and are continuously subjected to the sound. 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 (e.g., Port Fourchon, Louisiana). Overall, potential negative impacts of OCS oil- and gas-related vessel noise to fish and invertebrates (e.g., masking) are expected to be short-term and not have population-level effects.

Explosive severance (e.g., platform decommissioning) creates both a shock wave and a rapid oscillation in the pressure waveform associated with detonation. As described above, barotrauma can occur when there is a rapid contraction and overextension of the swim bladder, which can be problematic (i.e., result in injury or mortality) for most managed species in the GOM that occupy oil and gas platforms (e.g., snappers, groupers, tilefish, jacks, triggerfish, wrasses, cobia). Fish mortalities that occur as a result of platform decommissioning can impact the number and age structure of fish in localized communities. However, studies of the associated mortality for several recreationally and commercially important fish (e.g., red snapper, greater amberjack, vermillion snapper, grey triggerfish, and cobia) have indicated that the current 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 that have a less developed swim bladder or that lack one altogther 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. 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. There has been relatively little research on the effect of the shock wave on fishes, but Govoni et al. (2008) examined the effect of shock waves on larval spot and pinfish, and found that mortality increased at peak pressures higher than that associated with pile-driving (Bolle et al. 2012).

6.0 Impacts of Accidental Events

This is a summary of the effects of small (i.e., <1,000 bbl), reasonably foreseeable offshore and coastal spills on EFH and fish resources. Although a catastrophic event is a low-probability event and not reasonably foreseeable nor reasonably certain to occur, there is a summary of the potential effects of a catastrophic spill on EFH and fisheries resources in BOEM's 2021 Gulf of Mexico Catastrophic Spill Event Technical Paper (BOEM 2021b). The potential impacts of spill cleanup and/or response activities, and other accidental events, such as ship strikes and collisions from oil- and gas-related vessel activity, are discussed when applicable.

6.1 Water Column

6.1.1 Unintended Releases into the Environment

Accidental events associated with a proposed action that could impact coastal and offshore water quality include spills of oil and refined hydrocarbons, releases of natural gas and condensate, and spills of chemicals or drilling fluids. The loss of well control, pipeline failures, collisions, or other malfunctions could also result in such spills. Spills from collisions are not expected to be significant because collisions occur infrequently. Overall, loss of well control events are rare events and of short duration, so potential impacts to offshore water quality are not expected to be significant except in the rare case of a catastrophic event.

Natural degradation processes (e.g., oil-degrading bacteria) would also decrease the amount of spilled oil over time. For coastal spills, two additional factors that must be considered are the shallowness of the area and the proximity of the spill to shore. Over time, natural processes can physically, chemically, and biologically degrade oil. Chemicals used in the oil and gas industry are not a significant risk in the event of a spill because they are nontoxic, used in minor quantities, or are only used on a noncontinuous basis. Although there is the potential for accidental events, a proposed action would not significantly change the water quality of the GOM over a large spatial or temporal scale outside of a catastrophic event.

6.1.2 Response Activities

Though unlikely to be used on smaller spills (i.e., <1,000 bbl), 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; NRC 2005), 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; NRC 2005). 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 (NRC 2005), 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 within the water column (BOEM 2011; National Academies of Sciences Engineering and Medicine 2020).

6.2 Wetlands

6.2.1 Unintended Releases into the Environment

Coastal and offshore oil spills can be caused by large tropical storm events, faulty equipment, and 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 nautical miles (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 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 regard 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 BOEM’s 2021 Gulf of Mexico Catastrophic Spill Event Technical Paper for an analysis of impacts from a low-probability, catastrophic spill event (BOEM 2021b).

Coastal communities and habitats, such as wetlands, can be indirectly and directly impacted by accidental 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. 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 2020). 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 2010) 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. Releases into the environment (e.g., spilled oil) could result in loss of ecosystem function, physical ecosystem structure, and functional and structural value loss. 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.

Mangroves, which occur on the coasts of Florida, Louisiana, and parts of Texas, are also highly vulnerable to oil spills (Duke and Burns 2003; Duke et al. 1997; Hensel et al. 2014; Hinwood et al. 1994). Oil can coat the breathing surfaces of the mangroves; this kills shorter plants 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; Hensel et al. 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.

Though oil can completely foul wetland plants, it is the amount and type of oil, and 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-barrel (bbl) spill of Louisiana crude oil impacted 49 ac (20 ha) of wetlands, resulting in considerable short-term effects on the brackish marsh community. Though considerable die off 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 SAV: 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).

6.2.2 Response Activities

Response activities in coastal habitats, such as wetlands, 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 SAV because they are only tolerant of 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 SAV can be extremely sensitive to the disturbances associated with cleanup activities. Though 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 and deeper 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 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).

6.3 Submerged Aquatic Vegetation (Seagrasses and Macro-Algae)

6.3.1 Unintended Releases into the Environment

An inland spill resulting from a vessel accident or pipeline rupture poses the greatest threat to inland SAV communities. However, the size of these types of spills is generally small and short in duration. Direct impacts to SAV could include toxicity and shading, which may cause injury to vegetation and plant mortality (Erftemeijer and Lewis III 2006; Martin and Swenson 2018). SAV may be indirectly impacted by oil that has settled into benthic sediments. For example, lab experiments using Ruppia maritima, one of the northern GOM’s most common species of SAV, revealed that plants exposed to contaminated sediments experienced significant changes in reproductive output, root morphology, and uprooting force; although no significant changes to growth were observed (Martin et al. 2015). The floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amounts of microorganisms that consume oil could alleviate prolonged effects to SAV communities. SAV are also less susceptible to oil spills because they largely avoid direct contact with the oil pollutant (U.S. Department of the Navy 2018), and safety and spill-prevention technologies continue to improve, decreasing the potential for direct impacts to SAV from a proposed action.

6.3.2 Response Activities

The impacts of response activities to SAV communities are incorporated into the discussion of impacts to wetlands and their associated vegetation (see **Section 6–Impacts of Accidental Events–Estuarine–Wetlands–Response Activities**).

6.3.2.1 Ship Strikes and Collisions

Although SAV communities occur at depths that make them vulnerable to interactions with ship hulls and propulsion systems, damages to these habitats from BOEM-regulated vessel activities are not anticipated to occur. Much of the service-vessel traffic associated with OCS oil- and gas-related activities uses well established channels and canals along the Louisiana and Texas coasts and would avoid the shallow waters behind barrier islands in bays, lagoons, and coastal waters where SAV in the northern GOM generally occurs.

6.4 Live Bottoms (Pinnacle Trend and Low Relief)

6.4.1 Unintended Releases into the Environment

Disturbances resulting from the proposed action, including oil spills and loss of well control, have the potential to disrupt and alter the ecological value of live bottom habitats. However, live bottom (e.g., the Pinnacle Trend) features represent only a small fraction of the continental shelf area. As such, the small portion of the seafloor covered by these features, combined with the random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the Pinnacle Trend features. The depth below the sea surface to which the Pinnacle Trend features rise (130 ft [40 m] or more below the sea surface) also helps to protect them from surface oil spills. Disturbance of the sea surface by storms can mix surface oil (including dispersed oil) into the water column, but the effects are generally limited to the upper 33 ft (10 m) of the water column, with 60 percent of the oil found in the top 7 ft (2 m) of water (Lewis and Aurand 1997; McAuliffe et al. 1981). Only large spills have the potential to the reach live bottom (low relief) features because of the estimated distance of the proposed action from those features, which are primarily located in the eastern GOM along the continental shelf of west Florida. Although oil from a large spill could potentially reach live bottom (low relief) features present in the Central Planning Area.

A subsurface spill or plume may impact sessile biota of live bottom (Pinnacle Trend and low-relief) features, and oil or dispersed oil may cause lethal or sublethal impacts to benthic organisms if a plume reaches these features. It is also expected that a certain quantity of oil may eventually settle on the seafloor through a binding process with suspended sediment particles (i.e., adsorption) or after being consumed and excreted by phytoplankton (Passow et al. 2012;

Valentine et al. 2014). The product of these processes is sometimes referred to as "marine oil snow." 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 live bottom habitat, some of the organisms may become smothered by marine snow particles and/or other sediments, and experience long-term exposure to hydrocarbons and/or oil-dispersant mixtures that could persist within the sediments (Fisher et al. 2014a; 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). However, sedimented oil should be well dispersed because of the distance from live bottoms. This would result in a light layer of deposition that would be easily removed by sessile, benthic organisms and have low toxicity.

6.4.2 Response Activities

Benthic organisms in live bottom habitats (e.g., corals) are also vulnerable to spill cleanup and/or 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 live bottom habitats and associated organisms.

6.5 Potentially Sensitive Biological Features

6.5.1 Unintended Releases into the Environment

The vulnerability of PSBFs and their associated biota (i.e., sessile invertebrates) to oil and dispersed oil from an accidental event (i.e., oil spills and loss of well control) are like those described previously for live Bottom habitats (Pinnacle Trend and low-relief features). The level of impact from 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.

6.5.2 Response Activities

Similar to live bottom habitats, response activities such as anchoring and accidental loss of equipment could occur, causing unanticipated harm to PSBFs. Response-related equipment such as seafloor-anchored booms may be used and could inadvertently contact PSBFs and impact associated organisms.

6.6 Topographic Features

6.6.1 Unintended Releases into the Environment

The Topographic Features Stipulation (see **Section 2–Lease Stipulations and Guidance**) is implemented by BOEM on lease blocks with topographic features to assist in preventing most of the potential impacts to associated communities from loss of well control, surface and subsurface oil spills, and the related effects by increasing the distance of such events. Only large spills have the potential to reach the topographic features because of the features' water depths, the currents surrounding features, and the probable distance from a proposed action. The effects would be primarily sublethal and impacts would be at the community level in the unlikely event that oil from a subsurface spill would reach the biota of a topographic feature. In the unlikely event dispersants are used, dispersed oil adsorbed to sediments (as marine oil snow), turbidity, and sedimentation from a spill reaching sessile benthic organisms (e.g., corals) in topographic features would likely result in sublethal impacts comparable to those described previously for live bottom habitats.

6.6.2 Response Activities

Organisms inhabiting topographic features may be at risk from spill clean-up and response activities. Potential impacts to topographic features would be similar to those described previously for live bottom habitats (pinnacles and low relief) and PSBFs.

6.7 *Sargassum* Habitats

6.7.1 Unintended Releases into the Environment

Pelagic *Sargassum* occur seasonally as a patchy resource in almost every part of the northern GOM, resulting in a wide distribution over a very large area. Considering the ubiquitous distribution and occurrence of pelagic *Sargassum* in the upper water column near the sea surface, potential accidental spills from oil and gas operations would be expected to contact and degrade localized portions of the *Sargassum* community. All spill types (including surface oil and fuel spills), underwater loss of well control, and chemical spills would contact *Sargassum* algae. The quantity and volume of most of these spills would be relatively small compared with the pelagic waters of the GOM and the total biomass of *Sargassum* impacted would vary by season (highest concentrations present during spring and summer). Therefore, most spills would only contact a very small portion of the *Sargassum* population. The impacts to *Sargassum* that are associated with a proposed action are expected to have only minor effects to a small portion of the overall *Sargassum* habitat in the GOM. In the case of a very large spill, *Sargassum* and its associated communities of fish and invertebrates could suffer severe impacts to a sizable portion of the population in the northern GOM. However, *Sargassum* have a yearly growth cycle that promotes quick recovery from impacts and it would be expected to restore to typical population levels in one to two growing seasons. Accidental impacts associated with a proposed action are expected to have only minor effects to a small portion of the overall *Sargassum* habitat available in the GOM due to the patchy and ephemeral nature of *Sargassum*.

Surface oil from an accidental spill can also interact with the biota that occupy *Sargassum* habitat. Although detrimental effects to fish and invertebrates could occur, the severity of impacts would largely depend on the level of contamination, the use of dispersants, duration of exposure, and life stage of the organism. Interactions with surface oil would be problematic for the early life stages of fish (particularly larvae) as they are generally more sensitive to acute oil exposure than adults. Eggs and larvae in *Sargassum* 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, any potential impacts from a reasonably foreseeable spill would likely be minor as the probability of surface oil causing mortality to a proportion of a species' larval cohort large enough to impact stock levels would be low.

6.7.2 Response Activities

Burning, skimming, and chemical dispersants or coagulants can negatively impact floating *Sargassum* and *Sargassum* communities. Burning surface oil would cause direct mortality of *Sargassum*, and associated biota could be killed or suffer from habitat loss and subsequent predation from a lack of shelter. Skimming activities could result in the removal of *Sargassum* associated animals within and surrounding the mats, and trap them in oiled surface waters (BOEM 2011). 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. If dispersants are used, dispersants and dispersed oil can accumulate in *Sargassum*, creating pathways for oil-related injuries such as the exposure of *Sargassum* communities to high concentrations of contaminants, the vertical transport (i.e., sinking) of oiled *Sargassum* and subsequent loss of habitat, and the creation of low-oxygenated waters surrounding mats, which can stress associated biota and minimize the ecosystem services provided by this important pelagic habitat (Powers et al. 2013).

6.7.3 Ship Strikes and Collisions

Vessel strikes and collisions with Sargassum mats and associated communities could occur during routine oil- and gas-related transits of personnel and equipment. *Sargassum* can come into contact with vessel hulls and/or propulsion systems resulting in the separation of large mats, death of the *Sargassum* algae, and/or the dislodgement or death of associated organisms. 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.

6.8 Deepwater Benthic Communities

6.8.1 Unintended Releases into the Environment

Deepwater benthic communities may be vulnerable to the accidental release of oil or other contaminants from a surface vessel, well, or pipeline. The possibility of oil from a surface spill reaching a depth of 984 ft (300 m) or greater in any meaningful concentration is very small. However, subsea oil plumes resulting from high-pressure subsea oil releases and/or the application of chemical dispersants (typically during a catastrophic spill) may result in the entrainment of oil droplets in the water column (Boehm and Fiest 1982). This could create a subsurface plume (Adcroft et al. 2010) that may reach deepwater benthic communities. If such an oil plume were to contact deepwater benthic habitats and organisms, the impacts could range from minor to severe. Minor, sublethal effects that may occur to benthic organisms exposed to oil or dispersants include reduced feeding, reduced reproduction and growth, physical tissue damage, and altered behavior. Severe impacts 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 and Rezak 1978; Le Hénaff et al. 2012; McGrail 1982; Rezak et al. 1983). Overall, it is expected that oil from small, reasonably foreseeable accidental events associated with a proposed action would likely result in either negligible or minimal and localized impacts to deepwater benthic communities. This is due to adherence to COAs and the minimum distancing guidelines developed during past EFH consultations (see in **Section 2–Lease Stipulations and Guidance**).

6.8.2 Response Activities

Deepwater benthic communities may also be vulnerable to spill cleanup and/or 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. In addition, drilling muds may be pumped into a well to stop a loss of well control. It is possible that, during this process, some of this mud may be forced out of the well and deposited on the seafloor near the well site. If this occurs, the severity of impacts would vary depending on the level of sedimentation experienced by benthic organisms and any impacts beyond the immediate area would be limited. However, these effects should be similar to routine well-spudding activities, because the well sites are buffered by a distance of ≥ 2000 ft [610 m] (per NTL 2009-G40 (MMS 2009b)) from sensitive benthic communities.

6.9 Managed Species

6.9.1 Unintended Releases into the Environment

Accidental events that could impact fisheries species include loss of well control and oil or chemical spills. Although a highly unlikely occurrence, loss of well control could suspend large amounts of sediment and has the potential to affect fisheries species in the immediate area. Fish and invertebrates exposed to turbidity increases 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). If oil spills due to a proposed action were to occur in open waters of the OCS proximate to mobile adult fish, the effects would likely be sublethal. The extent of damage would be reduced because adult fish have the ability to move away from unfavorable conditions, metabolize hydrocarbons, and excrete metabolites and parent compounds (Lee et al. 1972; Snyder et al. 2019).

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 through a variety of routes, including respiration, ingestion of food (particularly benthic prey), and absorption through the skin (Logan 2007). Oil concentrated in surface waters could also directly contact and coat fish and invertebrate eggs and larvae found at or near the surface. Eggs and larvae floating in surface waters 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, the intensity of 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 habitats. Fish and invertebrates inhabiting shallow-water habitats (e.g., estuaries, wetlands, oysters, and SAV) are at increased risk because they can receive higher oil loading per unit volume of seawater than those in deeper offshore water (Pfetzing and Cuddeback 1993). However, much of the OCS oil- and gas-related activity occurs far offshore and 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). Fish and invertebrate populations of the GOM have repeatedly proven to be resilient to large, annually occurring areas of hypoxia, major hurricanes, and oil spills. As such, the proposed action is not expected to significantly affect populations or stocks of managed species in the GOM.

6.9.2 Response Activities

Though they are unlikely to be used in the event of a small, reasonably foreseeable 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 were 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 dispersed oil were found to have higher concentrations of PAHs compared to fish exposed to crude oil not treated with 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 determine the impacts to individuals, and the long-term effects are not well understood.

7.0 Cumulative Impacts

This section summarizes of the cumulative contributions of other natural and anthropogenic stressors to EFH in the GOM such as natural disturbances (e.g., hurricanes) and fishing (both commercial and recreational), as well as BOEM's routine activities and accidental events associated with the proposed action.

7.1 Water Column

Water quality in the coastal and offshore waters of the GOM are impacted by a variety of stressors not related to BOEM-regulated activities, including sediment disturbance and suspension (i.e., turbidity) from both natural and anthropogenic sources (e.g., tropical storms and dredging and/or channelization); commercial and recreational vessel activity (e.g., bottom trawling) and discharges (e.g., sanitary wastes, bilge water, deck drainage); erosion; surface runoff from both point- and nonpoint-sources of pollution; air emissions and pollution; and accidental events (e.g., oil and chemical spills, sewage spills) from State oil- and gas-related activities and crude oil imports by tanker. Natural hydrocarbon and brine seeps are potential impacting factors to offshore waters that introduce contaminants such as hydrocarbons (i.e., PAHs) into the water column. These sources collectively impair the water quality of coastal and offshore waters in the GOM over time, particularly in the northcentral region, where the majority of oil- and gas-related activity, commercial bottom trawling, natural seeps, and large river inflows (e.g., Mississippi and Atchafalaya rivers) occur. Consequently, the condition of coastal waters within the U.S. Gulf Coast are rated as fair by the USEPA (USEPA 2012), largely due to excessive inputs of nutrients and other contaminants from inland sources.

Due to the multitude of factors that significantly contribute to the degradation of water quality (coastal waters in particular) in the GOM, the effects resulting from the proposed action represent a small addition to other cumulative impacts (i.e., other Federal and State agency actions, private vessels, point and nonpoint sources of pollution, and natural events or processes) Increased turbidity and operational discharges resulting from the proposed action (i.e., canal and channel maintenance dredging and operational discharges and wastes) would be localized and temporary in nature and minimized with adherence to Federal and State permit regulations, BOEM-implemented mitigation measures (i.e., distance guidance in NTLs for bottom-disturbing activities), and by dilution and dispersion of discharges and wastes through mixing with currents. Because a catastrophic accident is considered rare and not expected to occur in coastal waters, the impact of small, accidental spills that are reasonably foreseeable to overall water quality in the GOM is expected to be negligible. In offshore waters, degradation processes in both surface and subsurface waters would decrease the amount of spilled oil over time through natural processes that can physically, chemically, and biologically degrade oil (NRC 2003). The effect on coastal water quality from smaller, accidental spills is expected to be minimal relative to the cumulative inputs of hydrocarbons and other contaminants (e.g., heavy metals) from other sources (e.g., atmospheric deposition, river outflow, surface runoff in urban waterways, industrial discharges). Thus, the incremental contributions of the routine activities and reasonably foreseeable accidental events associated with the proposed action are not expected to contribute appreciably to overall impacts on water quality in the GOM.

7.2 Wetlands

Natural and anthropogenic stressors have cumulatively 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. 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. In concert, these factors result in the rapid wetland loss. 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. 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 Jr et al. 2001; Day et al. 2000), including State oil and gas activities. Erosion of shorelines, storm intensification, and coastal flooding due to climate change may also continue to incrementally impact coastal wetlands in the GOM.

Past and current BOEM-regulated activities resulting from the proposed action can cumulatively affect wetlands and their associated vegetation. These activities include maintenance dredging of navigation canals, the creation of new canals, vessel traffic, existing and new pipeline landfalls, and operational discharges and wastes (see **Section 5–Impacts of Routine Activities–Wetlands**. Small, reasonably foreseeable spills of contaminants could also occur as a result of the proposed action, which can adversely impact wetlands (see **Section 6–Impacts of Accidental Events–Wetlands**). Considering that the majority of these activities occur in a few localized areas (e.g., Port Fourchon, Louisiana) that have existing, well armored canals, the rarity of new pipeline landfalls, the existence of mitigating measures from present regulatory programs of Federal or State agencies, adherence to MARPOL regulations for operational discharges and wastes, as well as the low probability of a catastrophic spill, the incremental contributions of the proposed action to the degradation of wetlands in the GOM are expected to be minor. Reasonably foreseeable spills of contaminants and associated response activities as a result of the proposed activities could result in minor to moderate cumulative impacts to localized areas of estuarine habitats. The level of impact would depend on a variety of factors, including oil type, volume, and season.

7.3 Submerged Aquatic Vegetation (Seagrasses and Macro-Algae)

Activities not regulated by BOEM–including nutrient loading in coastal waters, dredging activities, shoreline development, and increased commercial and recreational boating and fishing practices–pose the greatest overall risk to SAV in the northern GOM (Handley et al. 2007) and cumulatively degrade these habitats overtime. Naturally occurring weather events, such as hurricanes, can also cumulatively impact SAV habitats both directly and indirectly, resulting in density decreases that may be due to storm-induced erosion, as well as prolonged lower than normal salinity and dissolved oxygen levels following stormwater drainage (Wilson et al. 2019).

Collectively, these activities and natural events have resulted in and will likely continue to cause measurable impacts to SAV throughout the GOM.

Past and current BOEM-regulated activities associated with the proposed action can cumulatively impact SAV communities in coastal waters. These activities include vessel traffic, coastal habitat modification (e.g., construction of new pipeline landfalls and or facilities), channel creation and/or dredging, and accidental releases of oil or chemicals into the environment (see **Section 5–Impacts of Routine Activities—Submerged Aquatic Vegetation** and **Section 6–Impacts of Accidental Events—Submerged Aquatic Vegetation**). Overall, the incremental contributions of the activities resulting from the proposed action are expected to be minor, considering many of the impacting activities are not expected to significantly increase in occurrence and range in the foreseeable future, and they are minimized due to Federal and State requirements and implemented programs, natural flushing of coastal waters (e.g., from winds and currents), and the primary use of well-established channels and canals by vessels. Further, accidental releases from inland sources (e.g., vessel accident or pipeline rupture) are generally small and short in duration and the floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amounts of microorganisms that consume oil could alleviate prolonged effects to SAV. SAV are also less susceptible to oil spills because they largely avoid direct contact with the oil pollutants (U.S. Department of the Navy 2018), and safety and spill-prevention technologies continue to improve, decreasing the potential for direct impacts to SAV from the proposed action.

7.4 Live Bottoms (Pinnacle Trend and Low Relief)

Activities not regulated by BOEM that may occur in the vicinity of the Pinnacle Trend and low-relief live bottom features include discharges and wastes (i.e., land-based sources leading to hypoxic conditions), accidental spills from State oil- and gas-related activities, recreational boating and fishing, import tankering, and commercial fishing activities (e.g., bottom trawling and longlines), and the introduction of invasive species. Natural events, such as tropical storms and hurricanes, can also lead to physical damages of live bottom habitats. These factors can cumulatively contribute to the degradation of live bottom features in the GOM over time.

The GOM annually develops an extensive seasonal hypoxic zone on the OCS west of the Mississippi Delta during the late spring and summer. 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 GOM, 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. 2002).

Recreational boating and fishing activity may incrementally impact live bottom (Pinnacle Trend and Low Relief) habitats in the proposed action area. Recreational fishing activity can result in adverse impacts to sensitive sessile invertebrates, such as corals associated with Pinnacle Trend features, from physical damage caused by lead weights and anchors, as well as entangled and abandoned fishing gear. Low relief live bottom habitats, such as SAV communities, can be impacted by recreational boating activity via interactions with boat propellers and anchors.

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 BOEM-regulated OCS oil- and gas-related oil spills.

Large ships occasionally anchor in the general area of live bottoms; anchoring recreational and commercial fishing vessels may actively target live bottom areas because of their association with desirable fishing opportunities. These bottom-disturbing activities could potentially lead to severe physical damage to individual benthic features if gear comes into direct contact with live bottoms. Commercial fishing activities can be particularly damaging, especially when bottom-tending fishing gear of any type (e.g., trawls and bottom-set longlines) are used. Bottom-tending fishing gear 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).

The introduction of the Indo-Pacific lionfish in the region could potentially alter fish and invertebrate populations on topographic features. The predatory nature of this fish, combined with the lack of natural predators, suggests that increases in lionfish could result in top-down impacts to reef-associated organisms, ultimately leading to a decrease in biodiversity and abundance of small, reef fish and benthic invertebrates (Lesser and Slattery 2011). However, significant declines of lionfish populations on natural reefs (>75%) in the northern GOM have been reported recently due to the emergence of an ulcerative skin disease (Harris et al. 2020).

During severe storm events, bottom sediments can be suspended into the water column (Brooks and Giammona 1991; CSA 1992), potentially affecting organisms inhabiting live bottom habitats (e.g., corals and seagrasses) due to resulting sedimentation and turbidity. Because of the depth of the Pinnacle Trend area, these forces are not expected to be strong enough to cause direct physical damage to most organisms living on those reefs. However, storm-induced movements of humanmade objects present on the seafloor (e.g., lost fishing gear and/or marine trash and debris) may cause direct damage if they come into contact with live bottoms. Low-relief live bottom features, such as seagrass beds, would have the same or similar impacts to those described previously for SAV habitats.

Possible impacts from BOEM-regulated activities include anchoring, structure emplacement and removal, pipeline emplacement, drilling discharges, and discharges of produced waters (see **Section 5—Impacts of Routine Activities—Live Bottoms**). In addition, accidental subsea oil spills or loss of well control associated with ongoing OCS oil- and gas-related activities could cause damage to live bottom communities (see **Section 6—Impacts of Accidental Events—Live Bottoms**), but these impact-producing factors would be restrained by implementation of lease stipulations and site-specific mitigations. Potential, localized impacts to live bottom features are expected to be negligible when such resources are considered on a regionwide scale. Potential impacts from discharges would be further reduced by adherence to the USEPA's discharge regulations and permit restrictions. Therefore, the incremental contributions associated with the proposed action to the cumulative impacts affecting live bottom habitats in the GOM are expected to be negligible.

7.5 Potentially Sensitive Biological Features

PSBFs would be subject to some of the same cumulative stressors and associated impacts as live bottom (Pinnacle Trend and low relief) habitats (see **Section 7.2.3**) and topographic features (see **Section 7.2.5**). Cumulative stressors that may impact PSBF's that are not regulated by BOEM include discharges and wastes (i.e., land-based sources leading to hypoxic conditions), accidental spills from State oil- and gas-related activities, import tankering, commercial and recreational fishing activities, and the introduction of invasive species. Natural events, such as tropical storms and hurricanes, as well as climate change-related effects may also impact PSBFs. In addition, BOEM-regulated activities such as pipelaying, anchoring, structure emplacement, drilling, and accidental releases into the environment (i.e., loss of well control) all have the potential to cumulatively impact PSBFs. However, SEAs of proposed activities and COAs largely avoid or minimize impacts to PSBFs. Past emplacements of subsea infrastructure, anchoring, and drilling effluents associated with drilling for oil and gas may have caused harm to PSBFs before distance requirements were implemented (see **Section 2–Lease Stipulations and Guidance**). Refer to the aforementioned Sections in **Chapter 7—Cumulative Impacts** for information on how these cumulative stressors could impact PSBFs.

7.6 Topographic Features

Activities not regulated by BOEM that may occur in the vicinity and cumulatively impact topographic features include land-based discharges and wastes, recreational and commercial boating and fishing, crude oil imports by tanker, and the introduction of invasive species. Natural events, such as tropical storms and hurricanes, can also cause physical damages to topographic features, as well as climate change-related effects (e.g., ocean acidification). In addition, BOEM-regulated bottom disturbing activities and accidental releases in the environment have the potential to contribute appreciably to the overall impacts to topographic features. Collectively, these factors can incrementally contribute to the degradation of topographic features in the GOM over time.

Riverine inputs and terrestrial floodwater containing freshwater, toxic chemicals, nutrients, and other anthropogenic debris from large storms 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.

Recreational and commercial boating and fishing activities may cause incremental harm to topographic features in the GOM. However, several large banks have been included as part of the FGBNMS and are protected from ship anchoring, the destructive impacts of bottom-tending fishing gear (e.g., commercial bottom trawls and longlines), oil and gas exploration, and salvage activities. A Final Rule issued by NOAA in January 2021 recently increased the area of the East and West Flower Garden Banks and Stetson Bank, as well as extended protections to 14 additional bank features (e.g., Geyer Bank, Bouma Bank, and Bright Bank) in the region (NOAA

2021). Though these topographic features are protected from vessel anchoring, any unenforced anchoring could result in bottom disturbance, including crushing of hard substrates and structure-forming organisms such as corals and sponges, burial of organisms, and scarring of the seafloor. The degree of damage depends on the size of the anchor and chain (Lissner et al. 1991). Anchor damages incurred by benthic organisms may take more than 10 years to recover, depending on the extent of the damage (Fucik et al. 1984; Rogers and Garrison 2001). In addition to anchoring, scuba diving activity may affect topographic features through crushing or fracturing by divers or removal of organisms; however, most shallow-water topographic features on the OCS are deep enough that recreational scuba diving activities are limited. Where scuba diving over topographic features 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.

Fishing pressure at topographic features may alter fish community structure and have a top-down regulatory impact on fish populations (Boaden and Kingsford 2015), which could ultimately impact benthic communities. This could occur through unsustainable harvest practices; however, most managed fish populations in the GOM are stable or recovering. Harvest activities are managed and monitored by other Federal agencies (i.e., GOMFMC and NMFS), and populations are not expected to be depleted to a point where benthic populations are impacted.

The introduction of the Indo-Pacific lionfish in the region could potentially alter fish and invertebrate populations on topographic features. See **Section 7.2.3—Live Bottoms (Pinnacle Trends and Low Relief**) for more information on how the Indo-Pacific lionfish can impact productive, hard bottom habitats like Pinnacle Trend features and topographic features and associated biological communities.

Climate change-related effects have the potential to alter 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.

BOEM-regulated activities that may contribute appreciably to the overall impacts to topographic features are bottom-disturbing activities and accidental releases into the environment (**Section 5–Impacts of Routine Activities–Topographic Features** and **Section 6–Impacts of Accidental Events–Topographic Features**). Because the proposed Topographic Features Stipulation has been in effect for decades, and is expected to remain in effect, it is assumed to be in effect for this analysis. The proposed Topographic Features Stipulation prohibits bottom-disturbing oil and gas activities within the No Activity Zone and restricts them in defined buffer zones, thus preventing adverse impacts to the benthic communities inhabiting topographic features (see **Section 2 – Lease Stipulations and Guidance**) Impacts to topographic features could occur as a result of oil- and gas-related spills or other types of releases from past and future OCS leasing. To date, past reasonably foreseeable spills have not had any identifiable impact on any topographic features. Any dispersed surface oil that may reach the benthic communities of topographic features in the GOM would be expected to be at a concentration low enough to have no discernable long-term impacts (<1 parts per million) (Cook and Knap 1983; Dodge et al. 1984; Elgershuizen and De Kruijf 1976; Lewis and Aurand 1997; Lewis 1971; McAuliffe et al. 1980; McAuliffe et al. 1981; Wyers et al. 1986). Because all BOEM-regulated anchoring activities have been and remain prohibited or regulated on and around topographic features and that siting restrictions minimize the potential for oil to contact these habitats in the case of an accidental spill, the incremental contributions of the proposed action to the cumulative impacts affecting topographic features are expected to be negligible.

7.7 Sargassum Habitats

Activities not regulated by BOEM that have cumulatively impacted and continue to impact *Sargassum* habitats in the GOM include recreational and commercial vessel activity and land-based runoff, which introduces excess nutrients into coastal waters and leads to eutrophication. Though vessel activity may be detrimental to *Sargassum* habitat, nutrient loading in coastal waters may lead to an increase in biomass.

Vessel activity (e.g., recreation, commercial or recreational fishing, military use, shipping, or in support of State oil- and gas-related infrastructure) operating in offshore 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 if motorists propel through the mats, and 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 because 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.

Eutrophication, often caused by non-point discharge and waste sources, has led to declining coastal water conditions in the GOM, but may positively impact *Sargassum* and its associated communities. It is possible that *Sargassum* encountering nutrient rich waters from riverine inputs will undergo an increase in growth due to the presence of excess nutrients in the water column (Oviatt et al. 2019). For example, *Sargassum* have been found to experience significant growth while in the northern GOM (Gower et al. 2006), which may be largely influenced by nutrient inputs from the Mississippi and Atchafalaya River outflows. Any increase in *Sargassum* growth would increase available habitat for *Sargassum* associated communities; the exact impact of excess nutrient inputs in coastal waters is currently unknown because *Sargassum* passively floats in and out of these waters, depending on oceanographic drivers.

BOEM-regulated activities that may cumulatively impact *Sargassum* and its associated communities include vessel activity, operational discharges and wastes, and accidental releases into the environment (see **Section 5–Impacts of Routine Activities–Sargassum Habitats** and **Section 6–Impacts of Accidental Events–Sargassum Habitat**). Overall, the incremental impacts resulting from past BOEM-regulated activities and future activities resulting from the proposed action to *Sargassum* in the GOM are expected to be short-term, localized, and primarily sublethal, affecting only small portions of the overall Sargassum habitat present in the GOM.

7.8 Deepwater Benthic Communities

Cumulative stressors not regulated by BOEM–such as recreational and commercial fishing activities and climate change–may impact deepwater benthic communities (i.e., chemosynthetic and deep-sea coral communities) in the GOM. The gear used during recreational and commercial fishing activities (e.g., lead weights, bottom trawls, and bottom longlines) can cause physical damage to slow-growing, deepwater organisms. For example, it is possible that the deep water trawls used to target commercially valuable penaeid shrimps in the GOM have caused damage to deepwater coral communities in the past and may continue to do so. Deepwater coral communities exhibit a patchy distribution throughout the Gulf and not all have been surveyed and mapped. As such, interactions between these habitats and bottom tending gear are possible. Protections enacted by the NMFS and GOMFMC (i.e., coral HAPC's with restrictions for bottom-tending gear) serve to protect some identified locations of deepwater benthic communities.

Regional and global environmental changes attributed to greenhouse gas-driven climate change, such as changes in ocean acidity levels and water temperature, have the potential to alter deepwater benthic communities in the GOM, corals in particular. For example, Kurman et al. (2017) found that *Lophelia pertusa*, a deep-sea coral commonly found in the GOM, experienced negative net calcification rates in the long-term when exposed to waters with low pH levels. However, the same study also found evidence suggesting that populations of *L. pertusa* in the GOM may have the genetic variation necessary to produce an adaptive response to future changes in pH levels. Other research has shown negative effects to *L. pertusa* survivorship when exposed to increasing water temperatures, although the potential for adaptation due to genetic variability in GOM populations should be taken into consideration (Lunden et al. 2014).

BOEM-regulated activities such as pipelaying, anchoring, structure emplacement, drilling, and accidental releases into the environment (i.e., loss of well control) all have the potential to cumulatively impact deepwater benthic communities. Past emplacements of subsea infrastructure, anchoring, and drilling effluents associated with drilling for oil and gas may have caused harm to deepwater benthic communities before distance guidance in the form of BOEM's NTLs were implemented (see **Section 2–Lease Stipulations and Guidance**). The aforementioned activities are also expected as part of the proposed action and may impact deepwater benthic communities, although adherence to distance guidance in BOEM's NTLs should largely avoid any potential effects. Past oil spills, such as the *Deepwater Horizon* spill, have impacted deepwater coral communities in the vicinity of the wellhead (6–22 km), which likely came into contact with oil plumes entrained in layers of deepwater (Fisher et al. 2014a; Fisher et al. 2014b; White et al. 2012). If a catastrophic oil spill occurred in the future it would have the potential to adversely impact deepwater benthic communities in localized areas. However, these events are statistically rare, not reasonably foreseeable, and may affect only a small portion of such communities present throughout the GOM.

7.9 Managed Species

Managed species in the GOM are cumulatively impacted by a multitude of stressors not related to BOEM-regulated activities including recreational and commercial fishing activities, coastal eutrophication, and harmful algal blooms. Recreational and commercial fishing of fisheries species can result in adverse population-level impacts. For example, past fishing activity in the GOM resulted in significant declines in red snapper populations, although the fisheries current status has since been reclassified from "overfished" to "rebuilding" due to federal fishery management efforts (NMFS 2021a). Other targeted species, such as greater amberjack, are currently overfished and others are experiencing overfishing (e.g., cobia and lane snapper) (NMFS 2021b). The introduction of excess nutrients from both natural and anthropogenic sources into coastal waters can result in eutrophication and likely contributes to the formation of harmful algal blooms (Gilbert et al. 2005) throughout the Gulf coast. Both occurrences are capable of causing mass mortalities of coastal aquatic organisms, including managed fisheries species.

Additional stressors that have caused and continue to incrementally harm managed species in the GOM include invasive species, oil and/or chemical spills from State oil- and gas-related activities, and coastal habitat modifications. The introduction of invasive species such as tiger shrimp (*Panaeus monodon*), orange cup coral (*Tubastraea tagusensis*), and Indo-Pacific lionfish (*Pterois spp.*) to the Gulf may have long-term consequences for native fish and invertebrate communities. As with all invasive species, they have the potential to transmit disease, compete with and displace native species, and alter community structure and food webs (Molnar et al. 2008). Managed species in the GOM can also be impacted by accidental oil and/or chemical spills from State oil- and gas-related activities in coastal waters, the effects of which would range from sub-lethal to lethal depending on a variety of factors (e.g., contaminant volume, water depth, wave action, and life stage). Past and ongoing coastal habitat modifications–such levee construction, channelization (i.e., dredging), and shoreline development–can lead to wetland vegetation loss and increased turbidity in the water column, which can adversely impact SAV communities (See **Section 7–Cumulative Impacts–Wetlands** and **Section 7–Cumulative Impacts–Submerged Aquatic Vegetation**). These essential habitats are important to many managed fisheries species throughout the GOM (e.g., penaeid shrimps and red drum), offering shelter from predators, foraging opportunities, and nursery habitat.

BOEM-regulated activities associated with the proposed action–such as coastal habitat modification, offshore habitat modification (i.e., infrastructure emplacement), operational discharges and wastes, underwater sound produced from an array of activities (e.g., seismic surveys, pile-driving, and explosive removals), and accidental releases into the environment–may cumulatively impact managed species in the GOM. Details describing the potential impacts of each activity can be found in **Section 5–Impacts of Routine Activities** and **Section 6–Impacts of Accidental Events**. The incremental contributions are expected to add minimally to the overall cumulative effects from other activities or stressors present in the GOM. The majority of managed species in the region are widely distributed throughout the GOM and into the Caribbean and/or western Atlantic waters and most are broadcast spawners exhibiting high fecundity (i.e., individuals release massive quantities of eggs into the water column). As such, the cumulative effects associated with the proposed activity are not expected to result in population-level impacts because these activities are spatially and temporally limited and would affect only a small portion of any population, resulting at times in minimal decreases in fish resources and/or standing stocks. In addition, site-specific environmental analyses and mitigation measures (e.g., distance guidance) offer further protections for managed species inhabiting sensitive benthic habitats (e.g., topographic features and live bottoms), reducing the potential of adverse cumulative impacts.

8. Overall Conclusions

8.1 Water Column

Operational discharges and wastes resulting from BOEM-regulated activities associated with the proposed action, and reasonably foreseeable accidental releases of contaminants into the environment, can result in water quality degradation. However, any changes to water quality resulting from these impact-producing factors are expected to be temporary and localized. Operational discharges and wastes associated with BOEM-regulated activities are subject to multiple federal regulations and permit requirements administered by the USEPA and USCG designed to keep contaminants in operational discharges and wastes below harmful levels. Though accidental releases into the environment (i.e., oil or chemical spills) could occur in offshore or coastal waters, these events occur infrequently, are typically short in duration, and, in the case of oil, can be broken down by natural degradation processes. Chemicals used in the oil and gas industry are not a significant risk in the event of a spill because they are nontoxic, used in minor quantities, or are used on a noncontinuous basis. As such, reasonably foreseeable spills are not expected to significantly impact water quality except in the rare case of a catastrophic event. Finally, effects to water quality resulting from the proposed action would represent relatively minor additions to other anthropogenic and natural cumulative impacts in the region and are not expected to result in the inability of this EFH to support managed fisheries species.

8.2 Wetlands

BOEM-regulated activities in association with the proposed action such as maintenance dredging of navigation canals, routine vessel traffic, and the creation of new canals, pipeline landfalls, and new onshore facilities can result adverse impacts to wetland habitats. However, any impacts to wetlands as a result of the proposed action are expected to be minor and highly localized due to the small amount of anticipated dredging, low probability of new pipeline landfalls and onshore facilities, and the use of existing navigation channels in a few limited areas, many of which are heavily armored and use maintenance techniques that work to decrease erosion. The existence of mitigating measures from present regulatory programs of Federal and State agencies also help to lessen any potential impacts to wetlands from new onshore construction activities. If new canals or pipeline landfalls were created, intermediate to long-term effects to wetlands could occur and adversely impact EFH quality in those areas.

If oil from a small spill in coastal or inland waters reached estuarine habitats and associated vegetation and sediments, more wide-spread and long-term impacts may occur. The expected level and duration of impact would depend on many factors, including the source oil type, volume, and condition of the oil as it reaches shore, along with the season of the spill, the composition of the wetland plant community affected, and the response activities used. If oil contaminants become trapped in estuarine sediments, long-term exposure and impacts to wetland vegetation and associated biota could be expected. In terms of cumulative impacts, considering the multitude of anthropogenic and natural stressors that significantly contribute to the long-term decline of wetland habitats throughout the GOM, the activities associated with the proposed action represent relatively small, incremental additions to wetland degradation in localized areas.

8.3 Submerged Aquatic Vegetation (Seagrasses and Macro-Algae)

BOEM-regulated activities associated with the proposed action–such as maintenance dredging, vessel traffic, and the creation of new pipeline landfalls–all have the potential to adversely impact SAV communities. However, these activities are not expected to significantly increase in occurrence and range in the foreseeable future. If they do occur, these activities should have minor effects on SAV due to Federal and State requirements and implemented programs, as well as the beneficial effects of natural flushing (e.g., from winds and currents). Any potential effects on SAV from routine activities are expected to be localized.

An inland spill resulting from a vessel accident or pipeline rupture poses the greatest threat to inland SAV communities. However, the size of these types of spills is generally small and short in duration. Further, the floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amounts of microorganisms that consume oil could alleviate prolonged effects to SAV communities. SAV are also less susceptible to oil spills as they largely avoid direct contact with the oil pollutant (U.S. Department of the Navy 2018), and safety and spill-prevention technologies continue to improve, decreasing the potential for direct impacts to SAV from a proposed action.

Last, the cumulative impacts to SAV communities associated with the proposed action represent minor, adverse incremental contributions to the quality of these habitats and their ability to serve as EFH for managed species. Overall, the incremental contributions of the activities resulting from the proposed action are expected to be minor considering many of the impacting activities are not expected to significantly increase in occurrence and range in the foreseeable future, they are minimized due to Federal and State requirements and implemented programs, natural flushing of coastal waters (e.g., from winds and currents), and the primary use of well-established channels and canals by vessels.

8.4 Live Bottoms (Pinnacle Trend and Low Relief)

BOEM-regulated activities associated with the proposed action such as anchoring, structure emplacement, pipeline installation, discharge of drilling muds and cuttings, and structure removal and/or decommissioning all have the potential to adversely impact live bottom habitats. However, significant adverse impacts to both the Pinnacle Trend and low relief live bottom features are not expected to occur. Adherence to the live bottom lease stipulation, COAs, and minimum distance guidelines developed during past EFH consultations (see **Section 2–Lease Stipulations and Guidance**), greatly reduces the risk of physical impacts (i.e., crushing), sedimentation or burial resulting from drilling-induced turbidity, and toxicity-related impacts from drill cuttings and fluids. Any future decommissioning activities using explosives are not expected to result in adverse impacts due BSEE's development of SEAs for each structure removal application and the expectation that nonexplosive/mechanical removal techniques would be required at locations in close proximity to live bottom habitats.

If a reasonably foreseeable, accidental release of contaminants, such as a small oil spill and loss of well control, were to occur, any impacts to live bottom habitats and their ability to support managed fisheries species are expected to be minor, short-term, and localized. The depths of Pinnacle Trend features (130 ft [40 m] or more below the sea surface) work to minimize any contact with surface oil and the sparseness of these habitats on the OCS, combined with the random nature of oil spill locations and distance guidance described in NTLs, serves to limit the extent and intensity of damage from any given oil spill to these features. Impacts to low relief live bottom habitats, which are primarily located in the eastern GOM along the continental shelf and well distanced from BOEM-regulated activities on the OCS, are not expected to come into contact with oil from a small, reasonably foreseeable spill. If emergency response activities took place over live bottom habitats, physical damage from direct contact with vessel anchors and booms could occur and would result in adverse impacts to sessile benthic organisms. Last, the cumulative impacts to live bottom habitats associated with the proposed action represent minor, adverse incremental contributions to the quality of these habitats and their ability to serve as EFH for managed species largely due adherence to live bottom lease stipulation, COAs, and the minimum distance guidance developed during past EFH consultations (i.e., for Pinnacle Trend features, specifically).

8.5 Potentially Sensitive Biological Features

As with other live bottom habitats, BOEM-regulated activities associated with the proposed action–such as bottom-disturbing activities (e.g., pipeline emplacement, drilling, and anchoring), the release of operational discharges**,** and structure removal and/or decommissioning–have the ability to adversely impact PSBFs. Adherence to the requirements of the live bottom lease stipulation and applied COAs greatly reduces the risks of these impacts. BOEM routinely applies COAs to ensure approved bottom-disturbing activities are appropriately distanced from sensitive benthic habitats (e.g., 2,000 ft [610 m] buffer for drilling activity). However, there is currently no minimum distancing guidance developed for PSBFs and bottom-disturbing activities (e.g., those caused by anchors, chains, or cables) that could impact PSBFs, such as the 100 ft [30m] minimum distance recommended for Pinnacle Trend features. For activities proposed within 100 ft (30 m) of identified PSBFs, operators are required to supply post-activity reports to BSEE documenting that no physical contact with any identified features occurred. This mitigation measure greatly reduces the risk of physical impacts (e.g., crushing). However, it may be possible for PSBFs to experience some level of sedimentation or burial resulting from nearby bottom-disturbing activities, which may result in short-term, localized, and minor impacts to PSBFs. Any future decommissioning activities using explosives are not expected to result in adverse impacts due BSEE's development of SEAs and application of COAs for each structure removal application and the expectation that mechanical removal techniques would be required at locations in close proximity to PSBFs.

Accidental releases of contaminants into OCS waters can also result in negative impacts to PSBFs. Impacts resulting from a small oil spill in offshore waters would be comparable to those described previously for live bottoms (e.g., Pinnacle Trend features) and are not expected to result in significant adverse impacts to PSBFs. Response activities (e.g., emergency anchoring) could result in direct, adverse impacts to PSBFs by crushing sessile benthic organisms such as corals. Due to a lack of protective lease stipulations for PSBFs, the proposed action may contribute minor, adverse incremental impacts to the overall cumulative impacts affecting these habitats and their ability to serve as EFH.

8.6 Topographic Features

BOEM-regulated activities associated with the proposed action–such as pipeline emplacement, drilling, and anchoring, the release of operational discharges, and structure removal and/or decommissioning–have the ability to adversely impact topographic features. However, significant adverse impacts to topographic features and their associated biota are not expected. Adherence to topographic lease stipulations and the COAs applied during site-specific reviews (e.g., shunting of drill cuttings and fluids) would largely prevent physical impacts from the emplacement of subsea infrastructure, sedimentation or burial resulting from bottom disturbances, and any potential toxicity-related impacts from exposure to drill cuttings and fluids. As with live bottom habitats, any future decommissioning activities using explosives are not expected to result in adverse impacts to the biota inhabiting topographic features due BSEE's development of SEAs and the application of COAs for each structure removal application and the expectation that mechanical removal techniques would be required at locations in close proximity to these sensitive habitats.

Contaminants from a small oil spill and loss of well control are not expected to reach topographic features due to BOEM's implementation of the Topographic Features Stipulation, which works to distance such events from these features. This stipulation would prevent most of the potential impacts to associated communities from a loss of well control, surface and subsurface oil spills, and related effects. Only large spills, particularly those which require the use of chemical dispersants, would be expected to potentially reach topographic features. Because of the increased distance requirements for these features, any impacts to biota surrounding topographic features are expected to be short-term, sub-lethal, and at the community level. Organisms inhabiting topographic features may be at risk from spill clean-up and response activities. Potential impacts to topographic features would be similar to those described previously for live Bottom habitats (pinnacles and low relief) and PSBFs, resulting from bottom-disturbing activities (i.e., emergency anchoring). Last, the cumulative impacts to features associated with the proposed action represent minor, adverse incremental contributions to the quality of these habitats and their ability to serve as EFH for managed species largely due to the more stringent protective measures currently in place (e.g., topographic lease stipulations).

8.7 Sargassum Communities

Pelagic *Sargassum* and their associated communities may be adversely impacted by activities associated with the proposed action that could result in contact with drilling muds and cuttings, operational discharges, and unanticipated releases into the environment. Larval fish and eggs found in association with *Sargassum* habitat would be the most sensitive to discharge-induced turbidity, toxicity, and/or sedimentation. However, the expected level of impact would be highly variable and dependent on a variety of factors including season, winds, prevailing surface currents, wave action, discharge type and concentrations, and dispersion rates. In general, it is expected that any discharges and associated changes in water temperature would be rapidly diluted to background levels and potential impacts to *Sargassum* and its associated biota would be highly localized, primarily sub-lethal, and not result in population-level impacts.

Reasonably foreseeable accidental events (e.g., small surface oil or fuel spills) that may occur as a result of the proposed action, could negatively impact *Sargassum* and their associated communities, particularly eggs and larvae, if they are exposed to toxicants. However, considering its ubiquitous distribution throughout the GOM, quick growth cycle, and *Sargassum's* patchy and ephemeral nature, negligible impacts to very localized portions of *Sargassum* habitat and communities in the GOM would be expected.

Overall, it is expected that the incremental contributions from the proposed action would result in negligible, adverse cumulative impacts to *Sargassum* and not result in a wide-spread inability of this habitat to serve as EFH. Past and present BOEM-regulated activities, as well as other anthropogenic stressors (i.e., commercial and recreational vessel traffic) do not appear to cause significant degradation and declines in available *Sargassum* habitat and associated communities in the GOM. Some stressors, such nutrient enrichment from land-based outflows, may actually increase the total availability of *Sargassum* habitat in the GOM.

8.8 Deepwater Benthic Habitats

BOEM-regulated activities such as physical impacts from anchoring, structure emplacement, and pipeline installation, the discharge of drilling muds and cuttings, and structure removals/decommissioning could adversely impact deepwater benthic habitats (i.e., chemosynthetic and deepwater coral communities) in the GOM. However, the overall level of impact to these habitats in the GOM is expected to be negligible due to adherence to applied COAs reflecting minimum distance requirements developed during past EFH consultations (see **Section 2–Lease Stipulations and Guidance**). Adherence to COAs and minimum distancing requirements greatly reduces the risk of physical impacts (e.g., crushing) due to structure or pipeline emplacement and impacts related to the exposure of organisms to drilling discharges (i.e., turbidity, sedimentation, and contaminants) by requiring bottom-disturbing activities are distanced from deepwater benthic habitats (i.e., ≥ 2,000 ft [610 m]). Any potential impacts to these habitats from decommissioning is expected to be negligible due to the regulations and mitigations BSEE uses to minimize negative effects to sensitive benthic habitats (i.e., the use of mechanical versus explosive severance techniques near productive benthic habitats). Reasonably foreseeable accidental events, such as small oil or chemical spills in surface waters are expected to have negligible impacts to deepwater benthic communities as contaminants have a very small chance of reaching these deepwater habitats in significant concentrations. The cumulative impacts to deepwater benthic communities associated with the proposed action represent negligible, adverse incremental contributions to the quality of these habitats and their ability to serve as EFH for managed species. This is largely due to the distance guidance described in NTL-2009-G40 (MMS 2009b) and applied through COAs intended to mitigate potential impacts to deepwater benthic habitats as a result of drilling discharges.

8.9 Managed Species

BOEM-regulated activities that could occur in association with the proposed action–such as the release of operational discharges and wastes, the emplacement of subsea infrastructure, coastal habitat modifications (i.e., maintenance dredging of inshore canals and the creation of new pipeline landfalls), and noise produced from a variety of sources (e.g., vessel traffic, seismic airguns, and explosive structure removals)–have the potential to impact managed species in the northern GOM. However, it is expected that any coastal and marine habitat modifications resulting from these activities would cause a nondetectable decrease in managed species, most of which are widely distributed throughout the GOM and into the Caribbean and/or western Atlantic waters.

Potential impacts from routine discharges and wastes are expected to be negligible, short-term, and localized due to adherence to distance and contaminant level requirements in BOEM's NTLs and NPDES permits, respectively. The emplacement of subsea infrastructure on the OCS is expected to have more long-term and wide-spread impacts to managed species in the region because these structures provide additional habitat that has been shown to support relatively high densities of managed fisheries species. Conversely, they may also assist in the proliferation of invasive species. Due to the use of modern dredging and disposal practices and techniques used during canal maintenance and pipeline installation, and the low probability of new pipeline landfall construction, the expected impacts from coastal habitat modifications are expected to be minor, localized, and not result in population-level impacts to managed species (i.e., via indirect impacts to estuarine EFH). Noise-related impacts to managed species are expected to vary (i.e., physically, temporally, and spatially) widely depending on the sound source, the distance between the sound and the receiving organism, the type of species (e.g., with or without a swim bladder), life-stage, and prior experience (i.e., potential for habituation), and they are not expected to result in population-level impacts. Though it is expected that some level of mortality to managed fisheries species (e.g., red snapper) will occur during the use of explosive structure removal techniques, studies have indicated that the documented mortalities do not result in stock-level impacts to fisheries species in the region under the current rate of explosive structure removals in the GOM (Gallaway et al. 2020; Gitschlag et al. 2001).

Small, reasonably foreseeable oil spills or loss of well control would likely result in short-term effects on the environment that could temporarily affect habitat suitability for managed species. Much of the OCS oil- and gas-related activity occurs far offshore where released oil interacts with currents, waves, and other physiological processes, which would allow for the toxicity of spilled oil to be greatly reduced or eliminated by weathering and biodegradation before reaching managed species in any meaningful concentration. If managed species were to interact with spill-related contaminants, the nature of effects would vary depending on life stage, level of exposure, duration, and associated response activities. Response activities, such as the burning of surface oil or the use of dispersants, could potentially exacerbate impacts to the eggs and larvae of managed species. However, it is expected that controlled surface burning would impact only a very small portion of a managed species larval cohort and the use of dispersants for a small oil spill in considered unlikely. The depths of benthic habitats, the application of COAs, and minimum distance requirements developed during past EFH consultations (see **Chapter 2—Lease Stipulations and Guidance**) are expected to largely avoid interactions between sessile managed species (e.g., corals), demersal fish species, and spill-related contaminants. Overall, the impacts to managed species in the GOM from reasonably foreseeable accidental events are expected to be minor, short-term, and not result in population or stock-level impacts. In terms of cumulative impacts, the incremental contributions resulting from a small spill are considered to be negligible to minor when considering other natural and/or anthropogenic impacts such as coastal eutrophication and fishing-related impacts.

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Table 2. Gulf of Mexico Managed Species

Coastal Migratory Pelagic Fish
cobia (Rachycentron canadum)
king mackerel (Scomberomorus cavalla)
Spanish mackerel (Scomberomorus maculatus)
Corals
Class Hydrozoa (stinging and hydrocorals)
Class Anthozoa (sea fans, whips, precious coral, sea pen, stony corals)
*Listed corals also covered under ESA consultation
Red Drum Fishery
red drum (Sciaenops ocellatus)
Shrimp Fishery
brown shrimp (Farfantepenaeus aztecus)
pink shrimp (Farfantepenaeus duorarum)
royal red shrimp (Pleoticus robustus)
white shrimp (Litopenaeus setiferus)
Spiny Lobster Fishery
spiny lobsters (Panulirus argus)

Highly Migratory Species	Highly Migratory Species (cont.)	Reef Fish Fishery
albacore (Thunnus alalunga)	almaco jack (Seriola rivoliana)	almaco jack (Seriola rivoliana)
Atlantic angel shark (Squatina dumerili)	banded rudderfish (Seriola zonata)	banded rudderfish (Seriola zonata)
Atlantic bigeye tuna (Thunnus obesus)	black grouper (Mycteroperca bonaci)	black grouper (Mycteroperca bonaci)
Atlantic bluefin tuna (Thunnus thynnus)	blackfin snapper (Lutjanus buccanella)	blackfin snapper (Lutjanus buccanella)
Atlantic sharpnose (Rhinocodon terraenovae)	blueline tilefish (Caulolatilus microps)	blueline tilefish (Caulolatilus microps)
Atlantic yellowfin tuna (Thunnus albacares)	cubera snapper (Lutjanus cyanopterus)	cubera snapper (Lutjanus cyanopterus)
basking shark (Cetorhinus maximus)	gag (Mycteroperca microlepis)	gag (Mycteroperca microlepis)
bigeye sand shark (Odontaspis noronhai)	goldface tilefish (Caulolatilus chrysops)	goldface tilefish (Caulolatilus chrysops)
bigeye sixgill shark (Hexanchus vitulus)	goliath grouper (Epinephelus itajara)	goliath grouper (Epinephelus itajara)
bigeye thresher shark (Alopias superciliosus)	gray snapper (Lutjanus griseus)	gray snapper (Lutjanus griseus)
bignose shark (Carcharhinus altimus)	gray triggerfish (Balistes capriscus)	gray triggerfish (Balistes capriscus)
blacknose shark (Carcharhinus acronotus)	greater amberjack (Seriola dumerili)	greater amberjack (Seriola dumerili)
blacktip shark (Carcharhinus limbatus)	hogfish (Lachnolaimus maximus)	hogfish (Lachnolaimus maximus)

Highly Migratory Species	Highly Migratory Species (cont.)	Reef Fish Fishery
blue marlin (Makaira nigricans)	lane snapper (Lutjanus synagris)	lane snapper (Lutjanus synagris)
blue shark (Prionace glauca)	lesser amberjack (Seriola fasciata)	lesser amberjack (Seriola fasciata)
bonnethead shark (Sphyrna tiburo)	mutton snapper (Lutjanus analis)	mutton snapper (Lutjanus analis)
bull shark (Carcharhinus leucas)	Nassau grouper (Epinephelus striatus)	Nassau grouper (Epinephelus striatus)
Caribbean reef shark (Carcharhinus perezi)	queen snapper (Etelis oculatus)	queen snapper (Etelis oculatus)
Caribbean sharpnose shark (Rhinocodon porosus)	red grouper (Epinephelus morio)	red grouper (Epinephelus morio)
common thresher shark (Alopias vulpinus)	red snapper (Lutjanus campechanus)	red snapper (Lutjanus campechanus)
dusky shark (Carcharhinus obscurus)	scamp (Mycteroperca phenax)	scamp (Mycteroperca phenax)
finetooth shark (Carcharhinus isodon)	silk snapper (Lutjanus vivanus)	silk snapper (Lutjanus vivanus)
Galapagos shark (Carcharhinus galapagensis)	snowy grouper (Epinephelus niveatus)	snowy grouper (Epinephelus niveatus)
great hammerhead (Sphyrna mokarran)	speckled hind (Epinephelus drummondhayi)	speckled hind (Epinephelus drummondhayi)
	tilefish (Lopholatilus chamaeleonticeps)	tilefish (Lopholatilus chamaeleonticeps)
	vermilion snapper (Rhomboplites aurorubens)	vermilion snapper (Rhomboplites aurorubens)
	warsaw grouper (Epinephelus nigritus)	warsaw grouper (Epinephelus nigritus)
	wenchman (Pristipomoides aquilonaris)	wenchman (Pristipomoides aquilonaris)
	yellowedge grouper (Epinephelus flavolimbatus)	yellowedge grouper (Epinephelus flavolimbatus)
	yellowfin grouper (Mycteroperca venenosa)	yellowfin grouper (Mycteroperca venenosa)
	yellowmouth grouper (Mycteroperca interstitialis)	yellowmouth grouper (Mycteroperca interstitialis)
	yellowtail snapper (Ocyurus chrysurus)	yellowtail snapper (Ocyurus chrysurus)

Sources: GOMFMC, 2004; USDOC, NMFS, 2010.

Table 3. Described Essential Fish Habitat Locations for Reef Fish in the Gulf of Mexico

Species Name	Eggs	Larvae	Post Larvae	Juveniles	Adults
Almaco jack	Gulfwide	Gulfwide	-	Gulfwide, associated with floating structures (Sargassum) and barrier islands in the late summer and fall, and feed on invertebrates	Southern GOM, offshore associated with platforms, prey on fish, and spawning is hypothesized to be spring and fall
Banded rudderfish		Gulf Stream every other month (starting with January)	-	Offshore, associated with floating structures (Sargassum), year-round	Coastal waters over the continental shelf, both pelagic and epibenthic; feed on fish and shrimp, and spawn year-round offshore
Black grouper	Pelagic and occur offshore	Pelagic and occur offshore	-	Inshore to estuaries with seagrass, rocky bottoms, or coral reefs, eat crustaceans, and move to deeper water with size	Deeper (>20 m; 65 ft) waters than the other life history stages over rocky bottoms and coral reefs (mid to high relief), feed on fish, and spawn in May near the Florida Keys
Blackfin snapper	Continental shelf year-round	-	-	Shallow waters with hard substrate (12-40 m; 39-131 ft) by the Virgin Islands in spring	Continental shelf edge, eat nekton, and spawn year-round
Blackfin snapper	Continental shelf year-round	-	-	Shallow waters with hard substrate (12-40 m; 39-131 ft) by the Virgin Islands in spring	Continental shelf edge, eat nekton, and spawn year-round
Blueline and goldface tilefish	Pelagic and occur offshore	Pelagic and occur offshore	-	Pelagic and occur offshore	Continental shelf edge and upper slope (91–150 m; 298–492 ft) associated with irregular bottoms, feed on benthic invertebrates and some fish, and spawn in burrows and crevices in summer and fall
Cubera snapper	Near coral reefs and wrecks of medium depth (80 m; 262 ft) in the summer	-	-	Shallow vegetated waters in estuaries near streams and rivers wide salinity ranges	Southern GOM near reefs and mangroves, in wide salinity ranges, eat nekton, and spawn in the Florida Keys at approximately 80 m (262 ft)
Gag	Pelagic and occur in the winter to spring	Pelagic and occur in the winter to spring, shallow (<5 m; 16 ft) estuaries associated with grass beds or oysters, eat crustaceans then nekton, and then recruit to offshore hard bottoms in the fall	-	--	In water depths of 20–100 m (65–326 ft) associated with hard bottoms that have some relief, feed on nekton, and spawn offshore shelf edge break in the winter but peaking in the spring

Species Name	Eggs	Larvae	Post Larvae	Juveniles	Adults
Goliath grouper	Pelagic and occur offshore in the late summer and early fall	Pelagic and occur offshore in the late summer and early fall	-	High salinity (>25 psu) estuaries and bays, and feed on crustaceans and vegetation	Near jetties, coral reefs, and crevices at 2–55 m (6-180 ft); feed on crustaceans; and spawn from summer to winter with peaks in the late summer offshore in structures or patchy reefs
Gray snapper	High salinity continental shelf waters near coral reefs in the summer	High salinity continental shelf waters near coral reefs in the summer and eat zooplankton	Move to estuaries with vegetation (seagrass), wide salinity and temperature ranges, and eat copepods and amphipods	Feed on crustaceans	Onshore and offshore, eat nekton, and spawn offshore near reefs in summer
Greater amberjack	Gulfwide	Gulfwide	Offshore in the summer	Gulfwide with floating structures (Sargassum) in the late summer and fall and feed on invertebrates	Gulfwide, near the structured habitat, eat invertebrates and fish, and spawn in the spring and summer offshore
Grey trigger	Sand bottoms near reef habitats in the spring and summer seasons	-	Upper water column in spring and summer seasons	Upper water column associated with Sargassum and eat from Sargassum	Continental shelf waters (>10 m; 33 ft), reefs in the late spring and summer, and eat invertebrates
Hogfish		-	-	Seagrass beds of Florida Bay and eat invertebrates	Coral reefs and rocky flats, and eat mollusks
Lane snapper	Continental shelf and offshore in the summer	-	-	Low salinity inshore grasses, coral reefs, and soft bottoms (0-20 m; 0-65 ft), and eat small invertebrates	High salinity offshore waters in sand bottoms with structure; wide depth range of 4–130 m (13-426 ft); eat nekton, annelids, and algae; spawning peak offshore in midsummer
Lesser amberjack	Gulfwide	Gulfwide	-	Gulfwide, associated with floating structures (Sargassum) in the late summer and fall and feed on invertebrates	Gulfwide, near the bottom, associated with structures, feed on squid, and spawn in spring and fall
Marbled grouper (insufficient information to identify EFH)	-	-	-	-	-

Species Name	Eggs	Larvae	Post Larvae	Juveniles	Adults
Mutton snapper	Shallow continental shelf waters	Shallow continental shelf waters	-	Seagrasses during the summer	Seagrass or reefs, year-round, eat nekton, and spawn in south Florida at drop offs near coral reefs in late spring
Nassau grouper (protected)	Not offshore but are in highly saline waters in the winter	Not offshore but are in highly saline waters in the winter, and start feeding on other larvae	-	Saline, shallow, vegetated waters or associated with reefs in similar waters, move offshore with size, and start feeding on fish	Associated with reeds and crevices, feed on nekton, and spawn in the winter at full moon over soft corals, sponges, and sand
Queen snapper	Offshore	Offshore	-	-	Deep water in southern GOM (>100 m; 328 ft) in rocky bottoms; eat fish, crustaceans, and squid; and spawn in March and August in St. Lucia
Red grouper	Pelagic and occur offshore over the continental shelf, and feed on zooplankton over the continental shelf, and feed on zooplankton	Pelagic and occur offshore over the continental shelf, and feed on zooplankton	-	Inshore by seagrass and rock formation, have wide salinity range, feed on crustaceans, and move into deeper waters with size	Continental shelf near live bottoms and crevices (3–190 m; 9–623 ft), feed on nekton, and spawn offshore as protogynous hermaphrodites in late the winter and spring
Red snapper	Offshore in the summer and fall	Continental shelf waters in summer and fall, and eat rotifers and algae	-	Continental shelf associated with structures and feed on zooplankton and shrimp	Hard and irregular bottoms, eat nekton, and spawn offshore away from coral reefs in sand bottoms with low relief in summer and fall
Scamp	Pelagic and occur offshore in the spring	Pelagic and occur offshore in the spring	-	Inshore associated with hard bottoms	Continental shelf associated with high-relief hard bottoms that have complex structure, feed on nekton, and spawn at the continental shelf edge (60–100 m; 196-328 ft) in complex habitat from early spring to summer
Silk snapper	Shallow water year-round and eat nekton	Shallow water year-round and eat nekton	-	Shallow water year-round and eat nekton	Edge of the continental shelf (90–140 m; 295–459 ft), ascend at night, feed on nekton, and spawn year-round (more so in the late summer)
Snowy grouper	Pelagic and occur offshore	Pelagic and occur offshore	-	Benthic and found inshore associated with shallow reefs, feed on nekton, and move offshore with size	Deep water (100–200 m; 328–656 ft) with high-relief rocky bottoms, feed on nekton, and spawn in spring and summer

Species Name	Eggs	Larvae	Post Larvae	Juveniles	Adults
Speckled hind	Pelagic and occur offshore	Pelagic and occur offshore	-	Shallow waters	Hard bottoms/ rocky reefs commonly at 60–120 m (196–393 ft); they are the apex predator of the mid-shelf coral reef and spawn at continental shelf edge in spring and late summer
Tilefish	Pelagic and occur on the near shelf edge in the spring and summer	Pelagic and occur on the near shelf edge in the spring and summer	-	-	Outer continental shelf (>250 m; 820 ft), feed on crustaceans, burrow in clay/mud, and spawn spring to fall
Vermilion snapper	-	-	-	Coral reefs and rocky bottoms (20-200 m; 65-656 ft), spawn offshore in spring-summer	Coral reefs and rocky bottoms (20–200 m; 65–656 ft), and spawn offshore in spring-summer
Wenchman	Continental shelf waters, warmer months	Continental shelf waters, warmer months	-	-	Hard bottoms of the mid- to outer shelf (80–200 m; 262–656 ft), feed on small fish, and spawn in burrows and crevices in summer and fall
Yellowedge grouper	Pelagic and occur offshore	Pelagic and occur offshore	-	Shallow waters with rocky bottom habitats	Outer continental shelf (>180 m; 590 ft) with high relief, hard-bottom habitats; feed on nekton; and spawn in the spring and summer
Yellowfin grouper	-	-	-	Seagrass beds then move to rocky bottoms	Adults are not common but can be found near the shoreline to mid-shelf with rocky bottoms and coral reefs, feed on nekton, and spawn in spring and summer
Yellowmouth grouper	Pelagic and occur offshore	Pelagic and occur offshore	-	Shallow waters with mangroves (e.g., lagoons) and feed on fish	Inshore in water depths <100 m (328 ft) over rocky bottom and corals, feed on nekton, and spawn in spring and summer
Yellowtail snapper	Found in February and October	Shallow water with vegetation and structure and feed on zooplankton	-	Nearshore with vegetation and move to shallow coral reefs with age	Semipelagic and use deeper coral reefs (50 m; 164 ft), feed on nekton, and spawn away from shore with peaks in February–April and September–October

Table 4. Described Essential Fish Habitat Locations for Coastal Migratory Species Using the Gulf of Mexico

Species	Eggs	Larvae	Juveniles	Adults
Cobia	Top meter of the water column	Offshore waters	Coastal waters and offshore on the shelf in the upper water column, found in the summer, and feed on nekton	Shallow coastal waters and offshore shelf waters (1-70 m; 3-229 ft) from March to October and spawn in the shelf waters in the spring and summer
King mackerel	Pelagic and occur offshore in spring and summer	Mid to outer continental shelf (25-180 m; 82-590 ft) in October and feed on other larval fish	Inshore waters on the inner shelf and feed on estuarine dependent fish	Pelagic and occur in coastal to offshore waters, feed on nekton, and spawn from May to October on the outer continental shelf
Spanish mackerel	Pelagic and found on the continental inner shelf (<50 m; 164 ft) in spring and summer	Continental inner shelf from spring to fall and feed on larval fish	Estuarine and coastal waters with a wide salinity range and feed on fish	Inshore and coastal waters, feed on estuarine dependent fish, and spawn on the inner shelf from May to September

Table 5. Described Essential Fish Habitat and Spawning Locations for Shrimp in the Gulf of Mexico

Species	Eggs	Larvae	Post Larvae	Juveniles	Adult
Brown shrimp	-	-	Migrate to estuaries in early spring	Associated with vegetation and mud bottoms, and sub-adults use bays and shelf as they move from estuaries to offshore waters	Spawn in deep waters (>18 m; 59 ft) over the continental shelf generally in the spring
Pink shrimp	Spring and summer	-	-	Use the seagrass beds (*Halodule* and *Thalassia*, depending on size)	Offshore over the continental shelf on sand/shell bottoms
Royal red shrimp	Winter and spring on the upper slope (250-550 m; 820-1,804 ft)	-	-	-	Upper slope associated with muddy bottoms and spawn there from winter to spring, feed on benthic organisms, and are not estuarine dependent
White shrimp	Spring and fall	-	-	Associated with soft bottoms with detritus and vegetation	Nearshore soft bottoms and spawn at <27 m (88 ft) from spring to fall, and migrate through the water column between night and day

Table 6. Described Essential Fish Habitat Locations for Highly Migratory Species in the Gulf of Mexico

EEZ = Exclusive Economic Zone

* The states are used to help visualize approximately where in the GOM the species could occur.

** Central Gulf—This is the central portion of the entire GOM, not the GOM's Central Planning Area (CPA).

Species	Eggs	Larvae	Juvenile	Adult
Albacore tuna	-	-	-	Central Gulf
Atlantic bigeye tuna	-	-	Found in waters adjacent to Louisiana/Mississippi and Florida*	Central Gulf**
Atlantic bluefin tuna	100 m (328 ft) to the EEZ	100 m (328 ft) to the EEZ	-	Spawn in the spring over the continental shelf in the Gulf
Atlantic yellowfin tuna	Offshore	Offshore	Central Gulf from Texas to the Florida panhandle	Offshore
Blue marlin	Mid-Florida Keys	Mid-Florida Keys	Central Gulf waters from Texas to Florida	Central Gulf waters from Texas to Florida
Longbill spearfish	-	-	Central Gulf from Louisiana to the Florida panhandle and the Keys	Central Gulf from Louisiana to the Florida panhandle and the Keys
Sailfish	-	-	Central Gulf waters from Texas, Louisiana, and the Florida panhandle	Central Gulf waters from Texas, Louisiana, and the Florida panhandle
Skipjack tuna	Offshore out to the EEZ	Offshore out to the EEZ	Central Gulf waters from Louisiana to Florida	Central Gulf waters from Texas to Florida and spawn offshore
Swordfish	100 fathoms (200 m; 656 ft) to the EEZ	100 fathoms (200 m; 656 ft) to the EEZ	Gulf waters from Texas to Florida	Spawn offshore associated with the Loop Current
White marlin	-	-	Central Gulf from Texas to the Florida panhandle and Keys	Central Gulf from Texas to the Florida panhandle and Keys

Table 7. Described Essential Fish Habitat Locations for Shark Species Using the Gulf of Mexico

* The states are used to help visualize approximately where in the GOM the species could occur.

** Central Gulf—This is the central portion of the entire GOM, not the GOM's Central Planning Area (CPA).

Shark Species	Neonates	Young of Year	Juveniles	Adult
Atlantic angel shark	-	-	Localized in coastal waters from eastern Louisiana to the Florida panhandle	Localized in coastal waters from eastern Louisiana to the Florida panhandle
Atlantic sharpnose shark	-	-	-	Found in coastal waters from Texas to the Florida Keys
Basking shark (no EFH described for the GOM)	-	-	-	-
Bigeye thresher shark	-	-	-	Found in the Central Gulf and Key West, Florida
Bignose shark	-	-	Localized areas from Louisiana to the Florida Keys	Localized areas from Louisiana to the Florida Keys
Blacknose shark	Found in the coastal waters of Florida	Found in the coastal waters of Florida	Localized in the coastal waters of Texas, western Louisiana, and Mississippi to Florida	Localized areas in waters from Texas to the Florida Keys
Blacktip sharks	-	-	-	Coastal waters from Texas to the Florida Keys
Blue shark (no EFH described for the GOM)	-	-	-	-
Bonnethead shark	-	-	-	Found in coastal shallow waters with sandy and muddy bottoms around Texas, eastern Mississippi, and to the Florida Keys
Bull shark	Coastal waters of Texas but are also found in localized areas in Florida	Coastal waters of Texas, but are also found in localized areas in Florida	Coastal waters from Texas through eastern Louisiana to the panhandle and western Florida	Southern and mid-coast of Texas to Louisiana and the Florida Keys
Caribbean reef sharks	-	-	-	Coastal waters of the Florida Keys

Caribbean sharpnose shark (no EFH identified due to insufficient data)	-	-	-	-
Common thresher shark	-	-	-	Found in the Central Gulf and the Florida Keys
Dusky shark	-	-	Central Gulf** adjacent to south Texas and Florida	Central Gulf adjacent to south Texas and Florida
Finetooth shark	Inshore waters from Texas, eastern Louisiana, Mississippi, Alabama, and the Florida panhandle	Inshore waters from Texas, eastern Louisiana, Mississippi, Alabama, and the Florida panhandle	Found in inshore waters from south Texas and the Florida Keys, and from eastern Louisiana to the Florida panhandle	Found in inshore waters from south Texas and the Florida Keys, and from eastern Louisiana to the Florida panhandle
Great hammerheads	-	-	-	Coastal areas from Texas to Florida*
Lemon shark	Found in waters adjacent to mid-Texas and the Florida Keys with a localized area adjacent to the middle of Florida	Found in waters adjacent to mid-Texas and the Florida Keys with a localized area adjacent to the middle of Florida	Found in coastal waters of Texas, eastern Louisiana, and Florida	Coastal waters adjacent to Florida
Longfin makos and shortfin makos	-	-	-	Deepwater offshore in the Central Gulf and the Florida Keys
Narrowtooth shark (no EFH identified due to insufficient data)	-	-	-	
Night sharks	-	-	-	Found in localized areas of offshore waters adjacent to Texas, Louisiana, and Florida
Nurse sharks	-	-	-	Coastal waters of Florida
Oceanic whitetip shark	-	-	-	Found in the Central Gulf and the Florida Keys
Sandbar shark	-	-	-	Coastal waters near Florida and some localized areas near Alabama
Scalloped hammerhead	Coastal waters from Texas to Florida	Coastal waters from Texas to Florida	Coastal and offshore waters from mid-Texas to Louisiana	Coastal GOM waters from Texas to Florida and offshore waters from Texas to eastern Louisiana

Silky sharks	-	-	-	Offshore waters in the Central Gulf adjacent to Texas, Louisiana, and the Florida Keys
Spinner shark	Coastal waters near Texas, Louisiana, and Florida	Coastal waters near Texas, Louisiana, and Florida	Localized in waters reaching from south Texas to Florida	Localized in waters reaching from south Texas to Florida
Tiger sharks	Localized areas near the Texas/Louisiana border and Florida panhandle	Localized areas near the Texas/Louisiana border and Florida panhandle	Found in Florida waters	Found in both shallow and deep waters
Whale sharks	-	-	-	Found in the waters of the Central Gulf ranging from Texas to the Florida panhandle
White sharks	-	-	-	Southwest coastal waters of Florida and Florida Keys