Deepwater Port License Application for the

Texas Gulf Terminals Project

Volume II – Environmental Evaluation (Public)

Section 5:

Inshore and Offshore Aquatic Environment

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

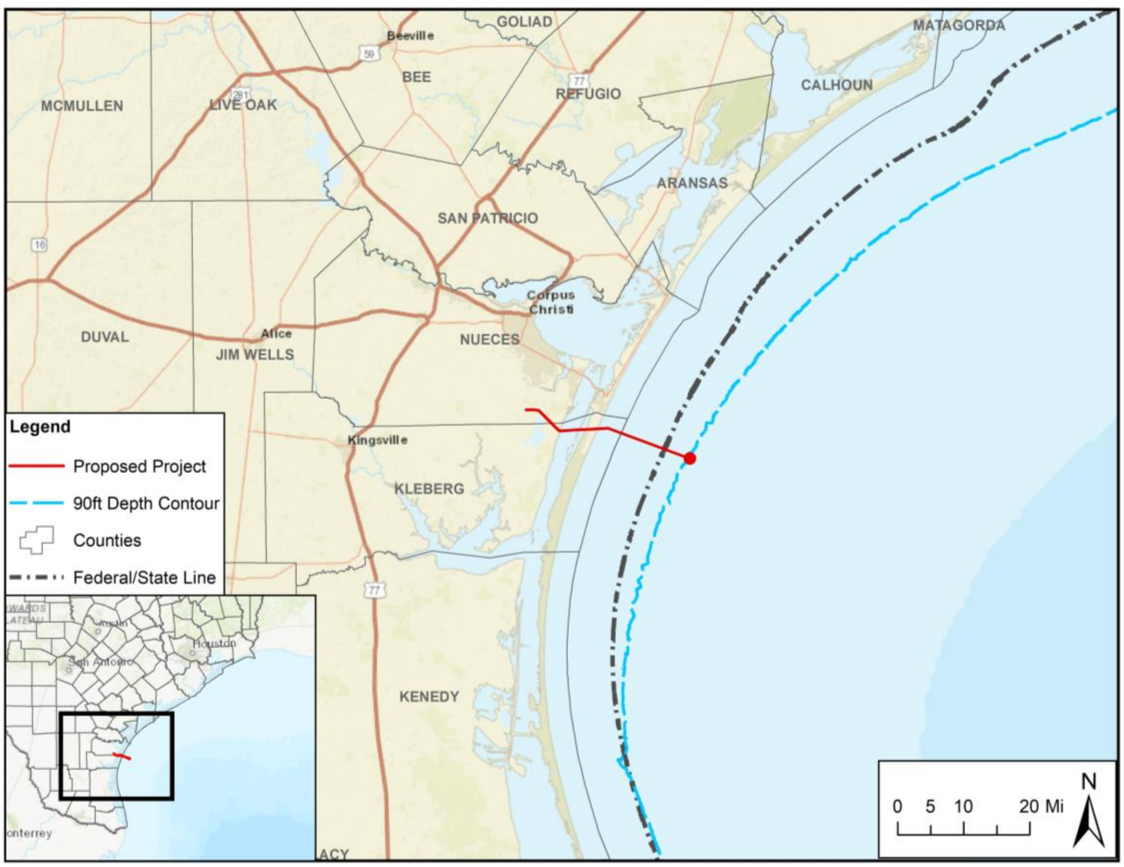
>	greater than
ac	acre
Applicant	Texas Gulf Terminals Inc.
bbl.	barrel(s)
BMP	Best Management Practice
BOEM	Bureau of Ocean Energy Management
bph	barrels per hour
CALM	Catenary Anchor Leg Mooring
CCSC	Corpus Christi Ship Channel
CFR	Code of Federal Regulations
cm	centimeters
CWA	Clean Water Act, as amended in 1977
CZMA	Coastal Zone Management Act
DOI	Department of the Interior
DWH	Deepwater Horizon
DWP	deepwater port
DWPA	Deepwater Port Act of 1974, as amended
DWPL	Deepwater Port License
e.g.	exempli gratia [Latin for '*for example*']
Executive Order	Executive Order
et seq.	et sequentes [Latin for *'and the following'*]
ft.	feet
GIWW	Gulf Intracoastal Waterway
GMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
gpm	gallons per minute
ha	hectare
HDD	Horizontal Directional Drilling
i.e.	id est [Latin for *'in other words'*]
km	kilometer
m	meter
MARAD	Maritime Administration
MARPOL	The International Convention for the Prevention of Pollution from Ships
MHT	mean high tide
mi	Miles
MPA	Marine Protected Area
mph	miles per hour
m/s	meters per second
NASA	National Aeronautics and Space Administration
NERR	National Estuarine Research Reserves
NHC	National Hurricane Center
NMS	National Marine Sanctuaries
NMSA	National Marine Sanctuaries Act

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NTL	Notices to Lessee
NWR	National Wildlife Refuge
OCS	Outer Continental Shelf
OSTF	onshore storage terminal facility
PLEM	pipeline end manifold
PINS	Padre Island National Seashore
POCC	Port of Corpus Christi
Project	Texas Gulf Terminals Project
SPM	single point mooring
sq.	Square
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
U.S.	United States [of America]
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VLCC	very large crude carrier
WOUS	Waters of the United States

PROJECT OVERVIEW

Texas Gulf Terminals Inc. (TGTI; also referred to as Applicant) is proposing to construct and operate a deepwater port (DWP), associated pipeline infrastructure, booster station, and an onshore storage terminal facility (OSTF), collectively known as the Texas Gulf Terminals Project (Project), for the safe, efficient and cost-effective export of crude oil to support economic growth in the United States of America (U.S.). The Applicant is filing this Deepwater Port License (DWPL) application to obtain a license to construct, own, and operate the Project pursuant to the Deepwater Port Act of 1974, as amended (DWPA), and in accordance with the U.S. Coast Guard (USCG) and the Maritime Administration's (MARAD) implementing regulations.

The Applicant is proposing to construct and operate the Project to allow direct and full loading of very large crude carriers (VLCC) at the DWP, via a single point mooring (SPM) buoy system. The proposed Project consists of the construction of a DWP, onshore and inshore pipeline infrastructure, offshore pipelines, and an OSTF. The proposed DWP would be positioned outside territorial seas of the Outer Continental Shelf (OCS) Mustang Island Area TX3 (Gulf of Mexico [GOM]), within the Bureau of Ocean Energy Management (BOEM) block number 823. The proposed DWP is positioned at Latitude N27° 28' 42.60" and Longitude W97° 00' 48.43", approximately 12.7 nautical miles (nm) (14.62 statute miles [mi]) off the coast of North Padre Island in Kleberg County, Texas. Refer to the Vicinity Map depicting the location of the proposed Project.



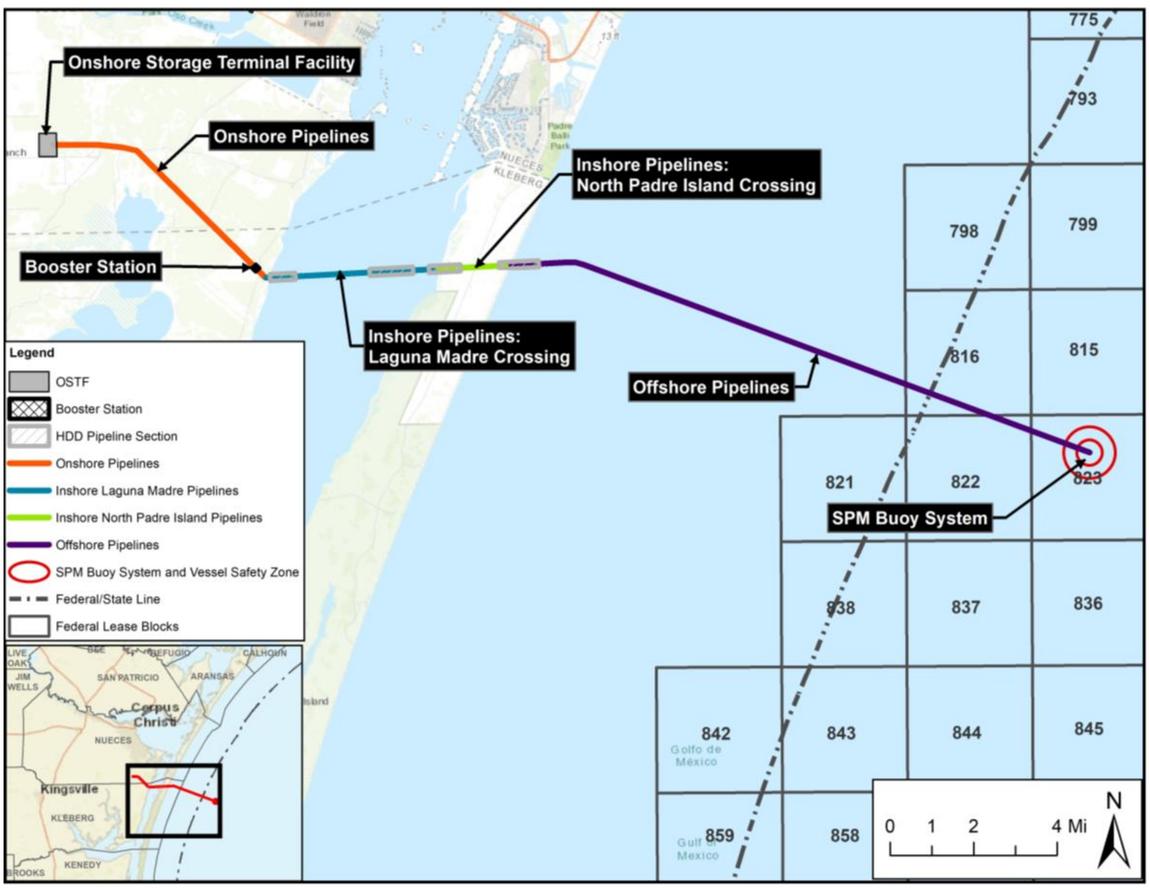
Vicinity Map

The proposed Project involves the design, engineering, and construction of a DWP, 26.81 miles of pipeline infrastructure, booster station, and an OSTF. For the purposes of this DWPL application, the proposed Project is described in three distinguishable segments by locality including "offshore", "inshore", and "onshore".

Onshore Project components includes an approximate 150-acre (ac) (60.7 hectares [ha]) OSTF, an 8.25 ac (3.3 ha) booster station, and approximately 6.36 mi of two (2) new 30-inch-diameter crude oil pipelines extending from the OSTF located in Nueces County, to the booster station located in Kleberg County, and continue to the landward side of the mean high tide (MHT) line of the Laguna Madre. The proposed OSTF will serve as the primary collection and storage terminal of crude oil to be directly pumped through the proposed pipeline infrastructure to the DWP. Outbound flow rates from the OSTF to the DWP are anticipated to be approximately 60,000 barrels per hour (bph).

Inshore components associated with the proposed Project are defined as those components located between the western Laguna Madre MHT line and the MHT line located at the interface of North Padre Island and the GOM; this includes approximately 5.74 mi of two (2) new 30-inch-diameter crude oil pipelines and an onshore block valve station located on North Padre Island. The onshore valve station will serve as the primary conjunction between the proposed onshore and offshore pipeline infrastructure.

Offshore components associated with the proposed Project include the DWP and offshore pipelines. Principle structures associated with the proposed DWP includes one SPM buoy system consisting of the SPM buoy, pipeline end manifold (PLEM), sub-marine hoses, mooring hawsers, and floating hoses to allow for the loading of crude oil to vessels moored at the proposed DWP. The proposed SPM buoy system will be of the Catenary Anchor Leg Mooring (CALM) type permanently moored with a symmetrically arranged six-leg anchor chain system extending to pile anchors fixed on the seafloor. Offshore pipeline infrastructure associated with the proposed Project consist of approximately 14.71 mi of two (2) new 30-inch-diameter pipelines extending from MHT line on North Padre Island to the SPM buoy system located at the proposed DWP. Refer to the Project Components Map below for a depiction of the location of the Project components discussed above.



Project Component Map

5.0 INSHORE AND OFFSHORE AQUATIC ENVIRONMENT

The aquatic environment includes a diverse set of habitats that occur within and adjacent to the Project area. Due to the location of the various Project components, the aquatic environment is discussed in terms of inshore and offshore habitat. Inshore habitat refers to aquatic environments located landward from the mean high tide (MHT) line of North Padre Island. Offshore habitat refers to the aquatic environment located seaward into the Gulf of Mexico (GOM) from the MHT line of North Padre Island. This section describes the various aquatic habitats and the potential Project impacts on these resources, and is structured as follows:

Section 5.1 Applicable Laws and Regulations: Background on relevant regulatory laws for consideration;
Section 5.2 Existing Conditions: Information on the existing inshore and offshore aquatic environment in the Project vicinity;
Section 5.3 Environmental Consequences: An analysis of environmental consequences;
Section 5.4 Cumulative Impacts: An analysis of cumulative impacts;
Section 5.5 Mitigation Measures: Proposed mitigation measures;
Section 5.6 Summary of Potential Impacts: A summary of potential impacts; and
Section 5.7 References.

5.1 Applicable Laws and Regulations

The Applicant has reviewed the following laws and statues that relate to the aquatic environment required to comply with the Deepwater Port (DWP) Act during construction and operation of the proposed Project; Marine Protected Areas, E.O. 13158, 65 FR 24909, Marine Protection, Research, and Sanctuaries Act of 1972, Pub. L. 92–532, 16 U.S.C. 1431, et. seq. and 33 U.S.C. U.S.C. 1401, et. seq., National Wildlife Refuge (NWR) System Administration Act, Coral Reef Protection, E.O. 13089, 63 FR 32701, Antiquities Act of 1906 (Nation Park System), National Estuarine Research Reserves (NERR) under the Coastal Zone Management Act of 1972 (CZMA), Outer Continental Shelf Lands Act administered by the BOEM, Notices to Lessees (NTLs), and National Environmental Policy Act of 1969 (NEPA), Pub. L. 91–190, 42 U.S.C. 4321, *et.* seq.,

5.1.1 Marine Protected Areas

Under Executive Order (EO) 13158, a Marine Protected Area (MPA) is any "area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." There are more than 1,200 MPAs in the U.S., protecting about 26 percent of U.S. marine waters (National Marine Protected Areas Center 2016). These areas have various levels of protection, depending on the managing agency and resources protected. Examples of areas covered by the broader definition of MPA include, but are not limited to, National Marine Sanctuaries (NMS), National Estuarine Research Reserves (NERR), fishery management areas, state parks, and Wildlife Management Areas.

5.1.2 National Marine Sanctuaries Act

The National Marine Sanctuary Program was created by Title III of the Marine Protection, Research and Sanctuaries Act of 1972, which was renamed the National Marine Sanctuaries Act (NMSA) in 1992 (16 U.S. Code [U.S.C.] 1431 et seq.). The Secretary of Commerce, under the NMSA, designates and protects areas of the marine environment deemed nationally significant because of various qualities (including importance due to conservation, recreation, ecology, history, science, culture, archeology, education, or esthetics). There are 13 designated NMS and two that are currently in the process of being designated (National Oceanic and Atmospheric Administration [NOAA] 2018a). Two designated NMS are in the GOM (the Flower Garden Banks NMS and the Florida Keys NMS); the closest (Flower Garden Banks NMS) is about 174 miles (mi) (280 kilometer [km]) east of the SPM buoy system.

5.1.3 National Wildlife Refuge System

The National Wildlife Refuge (NWR) System Administration Act, as amended by the Refuge Improvement Act of 1997, consolidated lands administered by the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS), into a single NWR System. The Act specifies that the mission of the system is to "administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the U.S. for the benefit of present and future generations of Americans." The management and extend of public use within each NWR is dictated by various legislation and the administrative action that created the unit (USFWS 2018a).

The closest NWR to the Project is the Aransas NWR, which is more than 40 mi (64 km) from any Project component. The Aransas NWR, which encompasses Matagorda Island and portions of the adjacent mainland, was established in 1937 to serve as "a refuge and breeding ground for migratory birds and other wildlife…" (USFWS 2018b). The Matagorda Island unit, a barrier island, is about 38 mi (61 km) long and includes salt marsh, tidal flats, and beaches. There are no public means for accessing the island, resulting in a relatively undisturbed barrier island ecosystem (USFWS 2018c).

5.1.4 Coral Reefs

Under EO 13089, federal agencies determine whether or not actions may affect coral reefs, thereby ensuring that any authorized activity will not reduce ecosystem conditions, and will work to protect, and if possible, enhance the ecosystems. The Project will not impact any coral reefs and the closest one (Stetson Bank, which is part of the Flower Garden Banks NMS) is about 174 mi (280 km) east of the SPM buoy system.

5.1.5 Antiquities Act of 1906 - National Park System

The National Park System, authorized by the Antiquities Act of 1906, provided protection to lands owned by the U.S. designated as "national monuments." The National Park System is regulated by the Department of the Interior (DOI) and administered by the DOI's National Park Service (NPS) and consists of 400 protected areas spanning over 84 million acres (ac) (34 million hectares [ha]) across the U.S. (NPS 2018a). The mission of the NPS, as outlined in the Organic Act of 1916, is to promote and regulate the use of national parks which purpose is to conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same manner and by such means as will leave them unimpaired for the enjoyment of future generations (NPS 2018a)."

The closest national park to the Project is the Padre Island National Seashore (PINS), which is located approximately 0.6 mi (1.0 km) from the Project area. The PINS separate the GOM from the Laguna Madre and provides protection of approximately 70 mi (113 km) of coastline, dunes, prairies, and wind tidal flats that provide necessary habitat for a variety of wildlife species, including nesting grounds for the Kemp's ridley sea turtle and sanctuary for 380 bird species (NPS 2018b).

5.1.6 Coastal Zone Management Act - National Estuarine Research Reserves

The National Estuarine Research Reserves (NERR), authorized by the Coastal Zone Management Act of 1972 (CZMA) is administered by the NOAA and managed by a lead state agency or university. This program provides protection to select coastal areas and includes a network of 29 coastal estuaries striving for long-term research, education, and coastal stewardship.

The closest NERR to the Project area is the Mission-Aransas NERR, located approximately 22 mi (35 km) northeast in Port Aransas, Texas. This NERR is managed by the University of Texas Marine Science Institute and serves as a "living laboratory" for ongoing research of estuarine resources (NOAA 2018b).

5.1.7 Outer Continental Shelf Lands Act administered by the BOEM - Notice to Lessees and Operators

The BOEM's Notices to Lessees (NTLs) are formal documents that provide clarification, description, or interpretation of a regulation or OCS standard; provide guidelines on the implementation of a special lease stipulation or regional requirement; or provide a better understanding of the scope and meaning of a regulation by explaining BOEM's interpretation of a requirement. The applicability and adherence to NTLs have been considered during siting, and will continue to be considered during construction and operation of the proposed Project.

NTL No. 2009-G39 provides and consolidates guidance for the avoidance and protection of biologically sensitive features and areas (i.e., topographic features, pinnacles, live bottoms [low-relief features]), and other potentially sensitive biological features, when conducting OCS operations in water depths less than 984 feet [ft.] (300 meters [m]) in the GOM. In the context of this NTL, topographic features are isolated areas of moderate to high relief that provide habitat for hard-bottom communities of high biomass and diversity and large numbers of plant and animal species, and support, either as shelter or food, large numbers of commercially and recreationally important fishes. Live bottoms (pinnacle trend features) are small, isolated, low to moderate relief carbonate reef 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. Live bottoms (low relief features) are seagrass communities, areas that contain biological assemblages consisting of sessile invertebrates living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where a hard substrate and vertical relief may favor the accumulation of turtles, fishes, or other fauna. Potentially sensitive biological features are those features not protected by a biological lease stipulation that are of moderate to high relief (about 8 ft. [2.4 m] or higher), provide surface area for the growth of sessile invertebrates, and attract large numbers of fish. The Project would affect OCS Lease Block 823 (SPM buoy system), as well as Lease Blocks 816 and 822 (pipelines); none of these blocks are identified as restrictions per NTL No. 2009-G09. The closest blocks with an applicable stipulation are about 30 mi (48 km) to the east of the SPM buoy system. Further, side-scan sonar surveys of the Project area did not identify any biological features of moderate to high relief, which would require avoidance of bottom-disturbing activities. Although a series of three offshore bars with relief greater than (>) 5 ft. (1.5 m) were identified close to shore during side-scan sonar surveys, they are likely transient sediment features that are hallmarks of winter beach profiles, where the sand and sediments are migrating away from the beaches.

5.1.8 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires all federal agencies to consider the potential environmental consequences of their proposals, document the environmental analysis, and make this information available to the public for comment prior to making a permit decision on any major federal action. Issuing permits for construction of the Project would qualify as a major federal action and trigger the requirement for NEPA analysis. Under the DWPA, the USCG would initiate the NEPA process and have federal jurisdiction over the entire Project under NEPA. The USCG and Maritime Administration (MARAD) have determined that an environmental impact statement (EIS) will be prepared to support the NEPA process.

5.2 Existing Conditions

The GOM is a semi-enclosed oceanic basin with a surface area of more than 395 million ac (160 million ha) and an average depth of 1.2 mi (1.9 km) (Minerals Management Service 2000). The GOM is connected to the Atlantic Ocean via the Straits of Florida, and to the Caribbean Sea by the Yucatan Channel. In addition to the inputs of marine water, more than 60 percent of the U.S. drainage, including outlets from 33 river systems and 207 estuaries flow into the GOM. Within the U.S., the Mississippi and Atchafalaya Rivers are the largest contributors of freshwater input into the GOM (BOEM 2017).

For purposes of this assessment, the aquatic environment is discussed in terms of inshore and offshore habitat. Inshore waters are generally considered to be any waters that occur within bays and on the landward sides of barrier islands; these waters generally make up the estuaries. Offshore waters are those that occur off the coast of the mainland or off the seaward coast of barrier islands. The inshore components of the proposed Project include the pipelines crossing over Padre Island, through Laguna Madre, to the shore of the mainland. The offshore components include the offshore pipelines (from the seaward boundary of Padre Island) to the SPM buoy system.

5.2.1 Inshore

There is a nearly continuous estuarine ecosystem along the northern GOM coast, comprising 31 major estuarine systems (BOEM 2016). Within the 367 mi (591 km) of Texas coastline, there are 12 major and minor estuaries that differ in size and ecological/hydrological characteristics (Texas Water Development Board [TWDB] 2018a). The inshore areas (landward of Padre Island) between Corpus Christi and Baffin Bays are part of the Coastal Bend Bays and Estuaries complex, which includes three individual estuaries. The complex includes barrier islands, wetlands (tidal and freshwater marshes), open bays, seagrass meadows, oyster reefs, serpulid worm reefs, and wind tidal flats. As discussed in Volume II, Section 6: Commercial and Recreational Fisheries, many fishes and invertebrates are dependent on, or make use of, estuaries at some point in their life cycle (BOEM 2017).

5.2.1.1 Coastal Barrier Beaches

The GOM shoreline is approximately 1,631 mi (2,625 km) long and includes coastlines of Florida, Alabama, Mississippi, Louisiana, and Texas (NOAA 2008). Barrier islands make up more than two-thirds of the northern GOM's coastline. They are dynamic landforms, with winds and waves constantly modifying and moving the sand, such that the island is continually accreting and eroding. Barrier islands within the GOM can be divided into five geologic subareas; the subarea affected by the Project is the Texas Barrier Island Complex. This complex extends from the Mexican border to Galveston Bay. The barrier islands within this complex are mostly accreted sediments that were reworked from river deposits, previously accreted Gulf shores, bay and lagoon sediments, and exposed seafloors (BOEM 2017).

Padre Island is the world's longest barrier island at 113 mi long. Padre Island extends from an area off of Corpus Christi Bay to the Brownsville Ship Channel. The inshore pipelines would cross the northern side of Padre Island, about 0.6 mi (1 km) from the PINS. The National Seashore protects the longest stretch of undeveloped barrier island in the world, about 70 mi (113 km) of uninterrupted coastline (NPS 2018b). The seashore supports habitats associated with fish populations, marine mammals, threatened and endangered species, and numerous migratory bird species.

5.2.1.2 Wetlands

Wetlands are a subset of the Waters of the U.S. (WOUS) that are regulated under Section 404 of the Clean Water Act (CWA). Wetlands associated with the Project are located in the outer coastal plain region which consists of low lying, flat-to-rolling terrain containing numerous streams, abundant rainfall, and a complex coastline which supports the establishment of wetlands. Generally, coastal marshes, beach/dune systems, and wet flats are seen within the outer coastal plain region. Wetlands within the Project area consist of coastal lowlands, tidal marshes, flats, estuaries, islands, and river deltas. In addition, coastal fringe wetlands may be found within estuaries, bays, and along the shoreline of the region (U.S. Army Corps of Engineers [USACE] 2010). Wetland habitats, which are common along the coast, provide necessary needs for various shorebirds, waterfowl, and avian colonial nesting species by providing food resources as well as forage fishery species. Wetlands are discussed in detail in Volume II Section 4: Wetlands and Waters of the U.S.

5.2.1.3 Laguna Madre

Between the mainland shore and the shoreward boundary of Padre Island, the inshore pipelines cross the upper Laguna Madre. Laguna Madre is a long, narrow, and shallow bay that stretches about 130 mi (209 km) between Corpus Christi and the Rio Grande (Spiller and Blankinship 2018); its average depth is 4.5 ft. (1.4 m) (TWDB 2018b). Although it is part of an estuary, Laguna Madre is hypersaline due to the regional characteristics (low rainfall/freshwater inflow and high evaporation) but is extremely productive in terms of fisheries. Seagrass is prevalent within Laguna Madre and it includes about 80 percent of the remaining seagrass in Texas, which makes it an important nursery area for larval and juvenile shrimp, fish, and crab. Because of the high salinity, oysters are only found at the southern end of Laguna Madre, where salinities are more moderate. Serpulid reefs, rock reefs formed by the calcareous tubes of serpulid worms, are also present in Laguna Madre (Spiller and Blankinship 2018).

5.2.1.4 Seagrass Beds

The GOM houses over 7 million ac (2.8 million ha) of seagrass bed habitat, about 235,000 ac (95,101 ha) of which are located along the Texas coast (Texas Parks and Wildlife Department [TPWD] 2018a). Seagrasses are submerged flowering plants anchored to the seafloor that grow within bays, lagoons, and shallow coastal waters. These grasses require light for photosynthesis and are therefore highly dependent upon water quality and clarity for survival (USGS 2007). Seagrasses support a large number of invertebrates and fish, many of which are commercially and recreationally important.

The Laguna Madre accounts for about 80 percent of seagrass along the Texas coast which provide critical habitat for fish and waterfowl (Onuf 1994). The generally shallow depths of the hypersaline Laguna Madre, as well as the isolated nature of the area from silt-laden tributaries, allows for conditions to support the growth of seagrass beds. The upper Laguna Madre supports four of Texas' five species of seagrass, including shoal grass (*Halodule beaudettei*), star grass (*Halophilla engelmannii*), manatee grass (*Cymodocea filiformis*), and widgeon grass (*Ruppia maritima*) (TPWD 2018a, TPWD 1996); however, shoal grass is the predominant species, accounting for 64.1 percent of the ground cover (Dunton 2015). Although the fifth species, turtle grass (*Thalassia testudinum*) is found in the lower Laguna Madre, it is absent from the upper Laguna Madre (TPWD 2018a, TPWD 1996). The Benthic Survey Report containing details of existing seagrass in the Laguna Madre near the Project area can be referenced in Appendix E.

5.2.1.5 Oyster Reefs

Generally, oyster reefs in the northern GOM are located in less than 9 ft. (3 m) of water; however, they have been known to exist at depths as great as 15 ft. (4.5 m) (Kilgen and Dugas 1989). Oyster reefs serve a large ecological role to fisheries, providing nursery habitat, food, and protection for adult and juvenile species. Oyster reefs are inhabited by a variety of aquatic species including bristle worms (polychaete), crabs (Brachyura), and amphipods which fill a multi-faceted roll for a variety of finfish, providing nutrient recycling; organic matter; and a food source. In the northern GOM, fish species including red drum (*Sciaenops ocellatus*), striped bass (*Morone saxatilis*), and sheepshead (*Archosargus proba-tocephalus*) are known to favor oyster reefs for foraging areas (Southwest Fisheries Science Center 2014 and National Wildlife Federation [NWF] 2013).

Oyster reef habitat is generally found near the mouths of estuaries in areas with low to moderate wave action but have also been recorded in small estuarine streams and bayous of intertidal or subtidal areas. Due to their location, which is generally subtidal, habitat associated with oyster reefs can significantly affect sedimentation rates. Historically, the majority of oyster reefs in Texas were located in Galveston Bay with some additional areas in the Corpus Christi-Aransas Bay area (Kilgen and Dugas 1989). Oyster reefs are absent throughout most of the Laguna Madre and reappear near Port Isabel and in South Bay; however, NOAA's GOM Data Atlas identifies oyster reefs on the bay side of Padre Island between the Project and Corpus Christi Bay (Figure 5-1). The closest known reef area is about 3.5 mi (5.6 km) from the landfall location of the inshore pipelines.

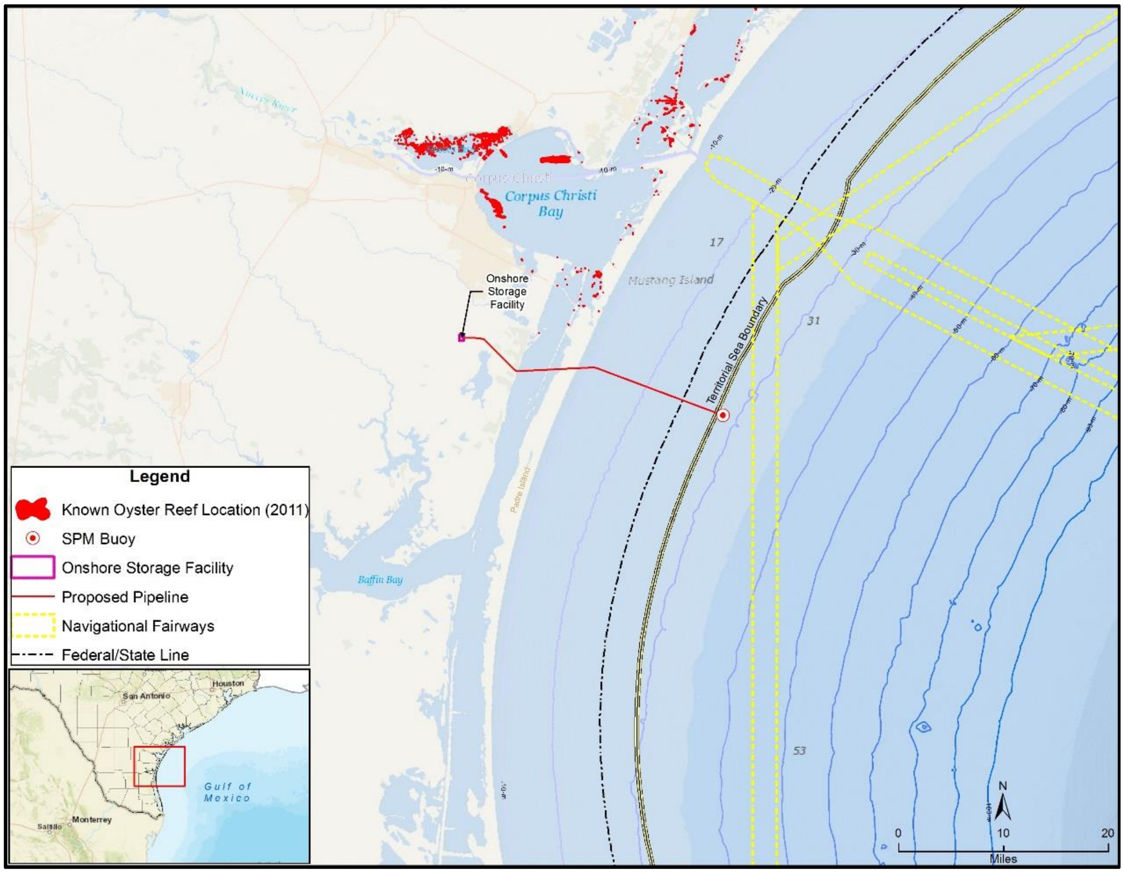


Figure 5-1: Oyster Reefs in the Project Vicinity

5.2.1.6 Serpulid Reefs

Serpulid reefs are calcareous reefs providing inland hard-bottom habitats within hypersaline bays. These reefs provide a unique hard bottom habitat amongst areas that are generally dominated by soft bottom sediments. Serpulid reefs formed from the calcareous tubes of polychaeta worms approximately 3,000 years ago and ceased formation 300 years ago. Like oyster reefs, these reefs provide essential needs to aquatic ecosystems such as shelter, food, and protection, which can increase species populations and diversity. These ancient reefs are located just south of Baffin Bay within the Laguna Madre (Spiller and Blankinship 2018).

5.2.2 Offshore

The continental shelf portion of the GOM extends over a gradual slope from the coastline to the shelf/slope transition, which is generally considered to be in water depths of about 660 ft. (200 m). Offshore habitats within the GOM include soft bottom communities, hard/live bottom habitats, artificial reefs, the water column, submerged aquatic vegetation, and *Sargassum* mats, each of which support varied species assemblages. Those areas with structure (e.g., hard/live bottoms, reefs, and *Sargassum*) typically have higher species density and diversity and are often managed or considered separately than those that are more prevalent throughout the GOM (e.g., soft bottoms and the water column). The SPM buoy system will be located on the continental shelf, at a water depth of about 93 ft. (28 m); the offshore pipelines would transit from the SPM buoy system, moving through progressively shallower waters until reaching the shore of Padre Island.

5.2.2.1 Soft-bottom Habitats

Soft-bottom habitats are the primary benthic habitat associated with the northern GOM. These habitats consist primarily of unvegetated, soft, muddy bottoms comprised of less stable sediments including sand, clay, silt, and gravel (NOAA 1978, Flint 1981). The soft-bottom habitat within the GOM supports flora and fauna living atop (epifauna) or within (infauna) the substrate (NOAA 1978). Infaunal communities generally include polychaete worms (bristle worms), crustaceans, and mollusks whereas epifaunal communities include crustaceans, echinoderms, mollusks, hydroids, sponges, and soft and hard corals (BOEM 2017, Darnell 2015). Additionally, shrimp and demersal fish are closely associated with benthic communities. In general, infaunal density decreases with a combination of increasing fine sediments and depth (Darnell 2015). According to available data from the Florida Fish and Wildlife Conservation Commission – Fish and Wildlife Research Institute, the Project will be within soft-bottom silty sands at the seaward extent of the Project, but the sediments transition to coarse and fine-grained sand as they approach the shore (Florida Fish and Wildlife Conservation Commission 2018; see Figure 5-2). The benthos inhabiting soft bottom habitats within the Project Area are discussed in Volume II, Section 7: Wildlife and Protected Resources.

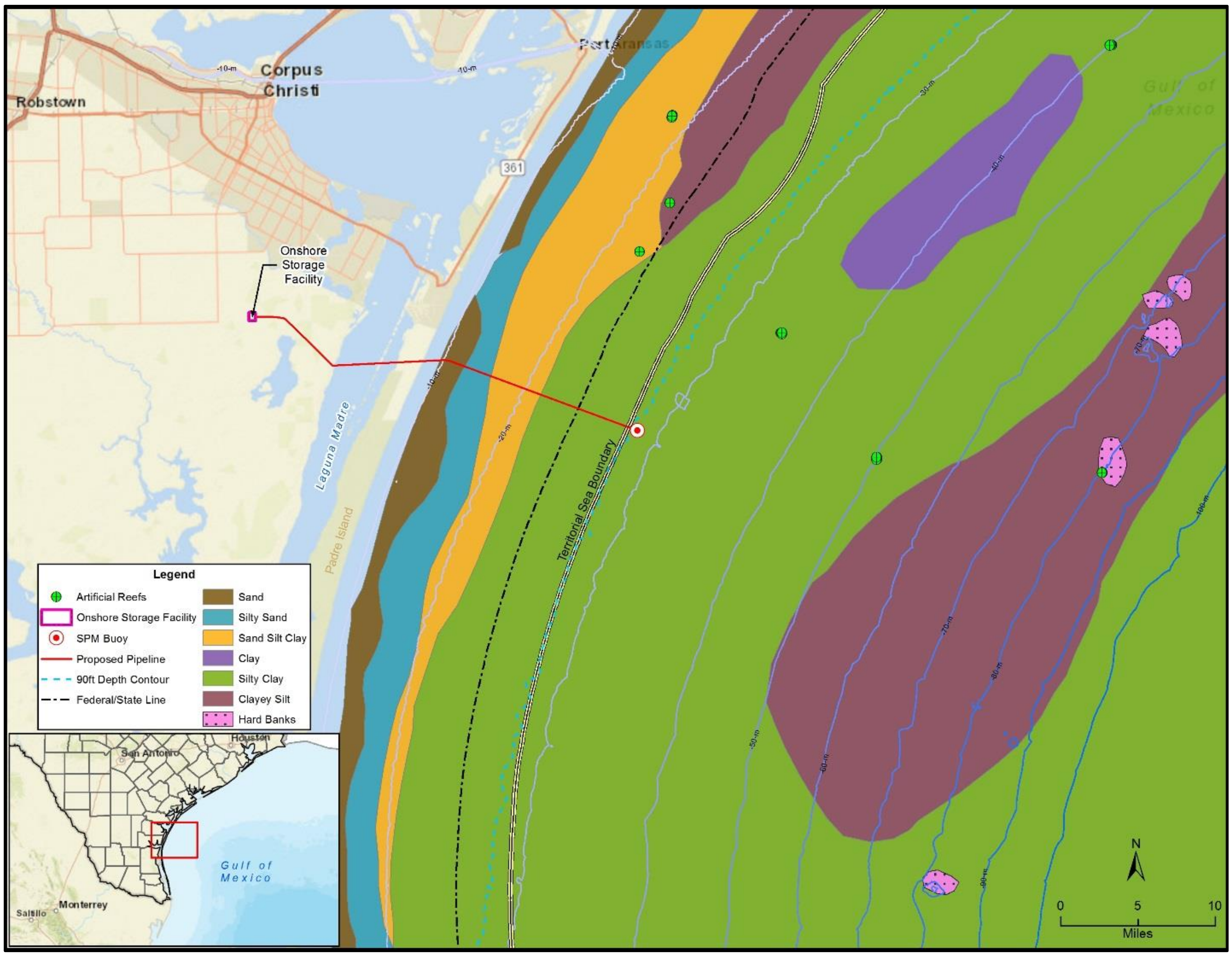


Figure 5-2: Sediment Substrate in the Project Vicinity

5.2.2.2 Hard-bottom Habitats

Hard-bottom habitats are described as naturally occurring, rocky consolidated substrates consisting of exposed sedimentary bedrock or other biogenic sources such as carbonate coral reefs. Hard bottoms are generally in areas of low relief consisting of eroded limestone, sandstone, shell and shell fragments, and coral. Sessile invertebrates including hydroids, anemones, sea whips, sponges, and encrusting algae attach to and cover the hard substrate, creating what is termed as “live bottoms” (Cummins et al. 1962). The attached flora and fauna of live bottoms can enhance the structural complexity of the benthic environment. The complex structure offers shelter that is utilized by small invertebrates and fishes, which, in turn may provide food for a variety of larger fish species (Gallaway et al. 2009). Hard bottom features may include pinnacle trends (carbonate reef materials of various size and relief) and topographic features (banks). Hard bottom habitats play an important ecological role in the marine environment and are considered biologically sensitive.

Generally, the northern GOM is not considered suitable for the development of reef-building communities due to physical and geochemical factors including temperature, sedimentation, and water clarity. However, certain areas within the northwestern GOM are an exception to this as they are higher relief areas located away from the Mississippi River, where waters are clearer and warmer (USGS 2004). However, no hard bottom habitat is present within 30 mi (48 km) of the Project (see Figure 5-2).

5.2.2.3 Artificial Reefs

The natural formation of reefs began around 3,000 years ago and ended 300 years ago. In order to prevent the degradation of reefs and to supplement the natural reef habitat, artificial reefs were established beginning in the early 19th century along the coastline (NWF 2013). Artificial reefs provide valuable habitat for a variety of marine species in areas that do not have the necessary materials for hard bottom habitat to occur. These reefs, which generally comprise of various materials such as shell, limestone, concrete rubble, and metal debris, have been known not only to attract fish, but also to increase the production of fish in an area (Stone et. al. 1979, MDMR 1999, NWF 2013). Artificial reefs are constructed for a variety of reasons, but are generally focused on increased fish population and density as well as recreational diving (South Atlantic Fishery Management Council 2018).

In the northern GOM, manmade structures such as bridge spans, decommissioned rigs, pilings, and sunken ships, are used to create artificial reef habitat which is used by invertebrates and associated species (South Atlantic Fishery Management Council 2018 and NWF 2013). Within Texas, the Artificial Reef Program was created in 1990 to promote, develop, maintain, monitor, and enhance the artificial reef potential of Texas offshore waters. The program partners with various organizations to create and maintain more than 4,000 ac of artificial reefs in Texas waters. Focused efforts include turning decommissioned ships and oil platforms, as well as concrete and heavy-gauge steel, into artificial reefs (TPWD 2018c). These anthropogenic structures have been historically successful as artificial reefs and provide habitat for a variety of fish species. Platforms often support tropically-dependent species including: blennies (Blennidae), sheepshead (*Archosargus probatocephalus*), and butterflyfishes (Chaetodonitidae) (GOM Fishery Management Council [GMFMC] 2004). Tropically independent species on platforms generally consist of: Atlantic spadefish (*Chaetodipterus faber*), lookdowns (*Selene vomer*), Atlantic moonfish (*Selene setapinnis*), red snapper (*Lutjantus campechanus*), large tomtate (*Haemulon aurolineatum*), groupers, and creole fish (*Paranthias furcifer*) (GMFMC 2004). A wide variety of large, transient species are also known to frequent artificial reefs.

In addition to artificial reefs, large inlets or ship channels are protected by jetties and concrete or rubble breakwaters along bay and barrier island shorelines. The flora and fauna of these jetties is a combination of epibenthic organisms from nearby offshore areas and oyster reefs, and tropical species that prefer artificial substrates (TPWD 2018c). The nearest artificial reef (Mustang Island Reef) is located approximately 8 mi (13 km) northeast of the Project (TPWD 2018d).

5.2.2.4 Water Column

The water column includes habitat within the mass of water between the surface and the substrate, excluding benthic or structural features. Waters occur above the continental shelf within the in the neritic zone 656 ft. (200 m) of the ocean known as the photic zone, where sunlight can penetrate, and photosynthesis can occur (BOEM 2012).

The base of the open-ocean food web is plankton, which includes small plants and algae (phytoplankton) and animals (zooplankton) that are generally at the mercy of currents. Phytoplankton are photosynthetic organisms that produce the bulk of organic matter in aquatic ecosystems. Zooplankton include organisms that remain in the planktonic community throughout their lives (holoplankton), as well as planktonic life stages of larger organisms that will eventually leave the planktonic community (meroplankton) (Byrnes et al. 2017). A relatively small component of the zooplankton community in the upper 656 ft. (200 m) of the water column are ichthyoplankton, which include eggs, larvae, and juveniles (Southwest Fisheries Science Center 2014). The distribution of ichthyoplankton is a function of the location of spawning adults, currents, and sea-surface temperatures (Byrnes et al. 2017). The planktonic community is described in greater detail in Volume II, Section 7: Wildlife and Protected Resources.

Circulation

Within the GOM, a semi-enclosed system, water temperature and salinity vary seasonally in association with changes in river inflow, down- and upwelling, surface solar heating, and winds (BOEM 2012). The dominant circulation feature in the GOM is the Loop Current, which flows into the GOM from the straits of Yucatan through the GOM and through the Straits of Florida. At times, the current is confined to the southeastern GOM; at other times, it forms a large loop that extends onto the continental shelf of the northeastern GOM. At intervals of 5 to 19 months, warm-core eddies between 124 and 249 mi (200 and 400 km) in diameter separate from the Loop Current and travel into the western GOM and last up to one year (BOEM 2012). These warm-core eddies transport warm, salty water and serve to connect the eastern and western GOM (BOEM 2017). Other, cold-water eddies also form at the edge of the Loop Current associated with nutrient-rich, highly productive waters from upwelling (BOEM 2017). The Loop Current plays an important role in the nutrient balance of shelf waters, as well as the transport of larvae and floating *Sargassum* habitat (GMFMC 2004).

On the Texas continental shelf, where the Project facilities are planned, meteorological effects can significantly affect circulation, including interruptions by tropical cyclones during the summer months. Typically, inner-shelf currents flow in the north or east direction in the summer months, and reverse flow during the remainder of the year (BOEM 2012).

Waves and Tides

Waves are one of the primary factors controlling sediment transport, deposition, and erosion in coastal habitats. Wind direction and intensities vary seasonally, with winter cold fronts causing strong onshore winds and increased wave heights. Average wave-height in the GOM ranges from 1.6 ft. (0.5 m) in the summer and 4.9 ft. (1.5 m) in the winter (Hayes et al. 2017). However, most coastal environments experience wave heights less than 2.0 ft. (0.6 m) in fair weather (Byrnes et al. 2017).

The tidal range throughout the GOM is generally less than 3.3 ft. (1 m); however, GOM tides are widely variable, including areas with tides described as semidiurnal (two high and two low tides per day), diurnal (one high and one low per day). The South Texas area is generally identified as having diurnal tides, although semi-diurnal tides have been recorded at Corpus Christi (NOAA 2018c).

There is a marked diurnal inequality for tides within much of the GOM. This inequality is emphasized during the two periods each month when the moon's declination is high (north or south). At these times, one high water and one low water are frequently seen each day. Tides in the open ocean are typically of smaller amplitude than tides along the coastline, mainly due to shoaling.

Meteorological Conditions

The state of Texas has a humid, subtropical climate, where summers are long and hot, and winters are short and mild. Climate within this region is typical of a tropical savanna. Within inland portions of the state where it is drier, ranches are prevalent across the landscape and grasslands and thick scrub-shrub flourish. The winters in the inland region are usually mild but are subject to Arctic air outbreaks from Canada. Snow is a rare occurrence due to the lack of humidity in winter, and the summers are for the most part hot and dry, but at times can be humid when winds come off the GOM. Along the southeastern Texas coast and offshore, climate is influenced by the GOM. The GOM moderates the influence of continental air masses to keep southeastern Texas from heating up and cooling off as quickly as the state's interior (NOAA 2018d; TWDB 2012; TCEQ 2018). Meteorological conditions are discussed in more detail in Volume II, Section 12: "Meteorology, Air Quality, and Noise."

Hurricanes and Cyclones

Tropical conditions, which are known to cause hurricanes (tropical cyclones), generally occur in the GOM from June 1 to November 30 of each year (National Hurricane Center [NHC] 2018). Hurricanes are known to greatly impact the continental shelf and are known navigational hazards for marine vessels (Keen & Glenn 1999, Holweg 2000). During these storm events, severe wind conditions increase the speed of surface currents, causing the cooling of surface waters and subsequent mixing of the stratified water column. Waves and currents can increase to velocities of 100 to 150 centimeters (cm) (1 to 1.5 m) per second on the continental shelf during these events (Havens et. al 2011). Additionally, cold fronts (along with wave conditions), and tropical cyclones may affect near-surface water temperatures, even though water temperature deeper than 328 ft. (100 m) remains unaffected.

The GOM is contained within the Atlantic tropical cyclone basin (NHC 2018). In the North Atlantic Basin, one of the two most prominent areas which pose a danger of hurricanes is the GOM (Holweg 2000). Hurricanes utilize warm, tropical air during their formation, rising upward from the ocean surface. When warm air rises off of the surface, an area of low air pressure occurs and is filled by surrounding high pressure air which is heated and begins to rise. As this process continues, circular movement within the atmosphere (including clouds) begins to spin and grow. The whole system is fed by ocean warmth as well as ocean water evaporating from the surface (National Aeronautics and Space Administration [NASA] 2018a). The abundant depth of warm water in the GOM is capable of fueling sudden and sustained intensification of tropical cyclones (Holweg 2000). The GOM has the ability to develop hurricanes during cooler periods as well due to the warm GOM air contrasting with cooler air along the continental boundary of North America (NASA 2018b).

In general, Atlantic cyclones will enter into the GOM from the Yucatan Channel. Hurricane intensity is measured on the Saffir-Simpson Scale and ranges from a Category 1 storm with sustained winds from 74 to 95 miles per hour (mph) that produce some damage, to a Category 5 storm with sustained winds > 157 mph that produce catastrophic damage. Nueces and Kleberg Counties were impacted by 7 and 6 major hurricanes (Category 3 or above), respectively between 1900 and 2010, and the estimated return period for a major hurricane passing within 58 m of the coast of these counties is about 33 years (NOAA 2018e). Hurricanes that have directly impacted the Texas coastline in recent years include Category 1 and 2 hurricanes such as Rita (2005), Humberto (2007), Ike (2008), and Harvey (2017). These hurricanes reported sustained winds of over 90 mph (40 meters per second [m/s]). The most recent Class III hurricane to strike the Texas coast was Hurricane Bret in 1999, which made landfall on South Padre Island with sustained winds of 115 mph (51 m/s).

5.2.2.5 Sargassum

Sargassum is a genus of brown algae that forms dense floating mats in tropical Atlantic waters and is transported into the GOM on circum-tropical currents. The floating mats provide habitat to a wide range of species in the water column and are an essential component of the water column habitat in the GOM. The floating mats include a diverse community of epibiota (algae, fungi, and invertebrates), more than 100 species of fish, and 4 species of sea turtle. About 10 percent of the invertebrate species and two fish species found using *Sargassum* mats are endemic (native or restricted to *Sargassum*) (GMFMC 2004).

Shrimp and crab come into contact with *Sargassum* as it drifts with the current through the GOM, comprising the bulk of the invertebrates that utilize *Sargassum* mats. *Sargassum* also acts as a vehicle for dispersal of some of its inhabitants and might be important in the life histories of many species of fish, providing them with a substrate, protection against predation, and concentration of food in the open GOM. Large predators associated with the *Sargassum* complex include amberjacks (*Seriola dumerili*), dolphin (*Coryphaena hippurus*), and almaco jacks (*Seriola rivoliana*) (GMFMC 2004).

5.3 Environmental Consequences

Significant impacts on the aquatic habitats identified above are those that measurably impact the ecological viability and sustainability of the resource. As proposed, the Project would include installation of approximately 26.8 mi (43.1 km) of dual, 30-inch-diameter pipeline and an offshore SPM buoy system located in 93 ft. (28 m) of water, within the Exclusive Economic Zone. Impacts on aquatic habitats would be limited to those components of the Project that are located in inshore (Laguna Madre) or offshore (seaward of North Padre Island) locations; those impacts are discussed below. Refer to Appendix A: Construction, Operation and Decommissioning Procedures, for a detailed description of techniques, procedures, and phases of the Project that were used to evaluated environmental consequences in the following sections.

5.3.1 Construction

5.3.1.1 Inshore Pipeline Installation

As described in Appendix A, inshore pipelines will be constructed across the Laguna Madre using a combination of the horizontal direction drill (HDD) method and jetting where trenching is needed. HDD construction methods result in impacts at the entry and exit points of the drill, but typically avoid impacts between the two points, whereas trenching results in an open ditch along the seafloor where the pipelines would be placed. The Project would entail crossing both the mainland shoreline (by the onshore storage facility) and the landward shoreline of Padre Island, as well as a series of small islands/dredge placement areas adjacent to the Gulf Intracoastal Waterway (GIWW) via HDD, thereby avoiding impacts on the shorelines and islands. As the floor of the Laguna Madre is generally covered in seagrass, seagrasses would be temporarily impacted within the footprint of the workspaces. No areas of hard bottom (i.e., oyster reefs or serpulid reefs) have been identified within 3.5 mi (5.6 km) from the landfall location of the inshore pipelines.

Although HDD construction generally minimizes impacts on sensitive resources, there is the potential for an inadvertent return of drilling fluids, during which HDD drilling mud forces through fractures in the overlying material and discharges to the surface. As the drilling fluid would follow the path of least resistance, fluids may come to the surface over the pipelines, or in a nearby area. Although an inadvertent return is possible, HDD drilling mud is a benign, non-toxic substance composed primarily of bentonite clay. The substance is denser than seawater and would settle on the seafloor after discharge, resulting in the smothering of benthic organisms that are within the affected area. In the case of any inadvertent return, Texas Gulf Terminals would implement its Project-specific HDD Inadvertent Return Contingency Plan, which includes measures to prevent, detect, and mitigate for inadvertent releases of drilling fluid.

About 2.05 mi (3.3 km) of pipeline will be installed via trenching within Laguna Madre. It is anticipated that approximately 9.79 ac (3.96 ha) of seagrass habitat will be temporarily impacted during construction (see Appendix E for the Benthic Survey Report and Appendix F for the Submerged Aquatic Vegetation Impact Analysis). In addition, the subsequent turbidity and sedimentation may result in temporary and minor impacts on seagrasses adjacent to the pipeline trench. Turbidity refers to the insoluble, suspended particulates that impede the passage of light through water by scattering and absorbing light energy. The reduction of penetrating light reduces the depth of the photic zone which reduces the depth at which primary productivity occurs. Historic maintenance dredging in the GIWW has been identified as a driver for seagrass loss in the Laguna Madre through turbidity and sedimentation. Turbidity, although temporary, reduces the light available to the seagrasses. The resultant sedimentation, however, can result in mounds of deposited sediment that are then prone to resuspension (Handley, Altsman, and DeMay 2007). Studies have shown that seagrasses take 3 to 5 years to recover, if buried by no more than 3 inches of sediment; however, shoal grass (which is predominant in Laguna Madre) could quickly invade buried sites and could outcompete other native species prior to their recovery (USACE and Interagency Coordination Team 2002). To minimize impacts on seagrasses from turbidity during pipeline construction, best management practices (BMPs), such as weighted turbidity curtains on the edges of the construction right-of-way to minimize the turbidity and sedimentation adjacent to construction workspaces or matting areas where vessels will be resting will be employed when appropriate and feasible. Sediment side cast from trenching will also be stored on barges rather than on the sea floor adjacent to the trench to prevent resuspension of the sediment in the water column and further mitigate increased turbidity during construction. Required mitigation and BMPs will be determined prior to construction based on the conditions of the USACE permit.

Overall, impacts of the planned inshore pipeline construction are anticipated to be minor and temporary.

5.3.1.2 Offshore Pipeline Installation

The most sensitive portion of the offshore pipeline route is near shore, where it passes through shallow water and makes landfall on Padre Island. To avoid impact on the coast of the barrier island, which includes marine/estuarine wetlands and sensitive coastal dune habitat, the offshore pipelines will be installed by HDD at this location, as described in Appendix A.

At the seaward edge of the HDD (about 3,800 ft. [1,150 m] from shore), the offshore pipelines will cross soft-bottom habitats between the HDD Box to its interconnection with the SPM buoy system about 14.7 mi (23.5 km) offshore. Offshore, trenching and backfilling for installation of the pipelines will be completed using a submersible pipeline jetting sled operated from an anchored pipe-laying barge. The pipelines will be buried a minimum of 5 ft. below the sediment surface. Operation of the sled will redeposit some material over the pipeline, but full backfilling will occur naturally due to currents and wave movement. Based on a construction workspace width of 36 ft. (7 m) and 14.0 miles (73,925 ft; 22,532 m) of pipeline length, and the 150 ft by 150 ft HDD Box located off the shore of Padre Island, about 61.61 ac (24.9 ha) of soft-bottom habitat will be directly disturbed during construction. Increased turbidity and sedimentation from trenching activities will also result in indirect impacts on the soft bottom and water column habitat that occurs immediately adjacent to construction workspaces, and the fauna that use them. Coarse sediments will fall out and resettle quickly while fine sediments remain suspended for a longer period of time; however, once installation is complete, local water turbidity should return to pre-construction levels without mitigation. Volume II Section 3: Water Quality, provides a full description of the anticipated turbidity levels during pipeline installation.

Sedimentation may smother smaller benthic organisms that are unable to avoid the area. It is expected that mobile nekton species will be displaced temporarily from the habitat but will return to the area almost immediately following construction. Similarly, the benthic community is expected to recolonize disturbed areas shortly after construction, such that no long-term effects on the community are expected.

Underwater noise may be generated by installation of the offshore pipelines in nearshore and offshore areas; however, underwater pipeline installation will progress along the route such that construction at any one location is of short duration. Therefore, impacts from pipeline installation noise will be short-term and negligible. Similarly, noise associated with increased vessel traffic will be transient as the vessel moves between Project areas, and will be mitigated through use of low speeds, which will be required for all construction and support vessels. Increases in ambient noise could decrease the quality of habitat provided by the water column and *Sargassum* mats. Noise impacts are further discussed in Section 12: Meteorology, Air Quality, and Noise.

Overall, impacts of the planned offshore pipeline construction are anticipated to be negligible and temporary.

5.3.1.3 Hydrostatic Testing of the Pipelines

The proposed inshore and offshore pipelines will be hydrostatically tested following construction. Each test of the inshore and offshore pipelines will include flooding of the pipeline with seawater and subsequent discharge of the water. During hydrostatic testing, water would be pumped into the pipe and filtered through a 100-size mesh screen (mesh opening = 0.0059 inches [0.15 millimeters]) to prevent debris from entering the new pipeline. The Applicant would pump hydrostatic test water from the pipeline into a diffuser to re-oxygenate the water before discharging it back into the marine environment. Biocides would not be used during hydrostatic testing of the pipelines. The discharges would be made in accordance with the terms of the general discharge permit governing hydrostatic testing operations of this type in the GOM and Laguna Madre. Water quality would not be impacted as a result of the hydrostatic testing of the proposed marine pipelines. Hydrostatic testing procedures are further discussed in Appendix A.

5.3.1.4 Deepwater Port Pile-driving and Installation

The seafloor in the offshore Project area is a soft-bottom environment, comprised of sand in areas closer to shore and under-consolidated mud in areas further offshore. No hard bottom habitat is present within the immediate Project area; the closest identified hard bottom areas to the SPM buoy system are about 30 mi (48 km) east, in water depths of about 230 ft. (70 m). To minimize impacts associated with offshore construction, the SPM buoy system and associated components will be fabricated onshore and delivered to the site by barge. Similarly, six anchor piles will be prefabricated on land prior to installation by industry acceptable practices at the offshore location. Noise associated with installation of the anchor piles, and the resulting impacts on fauna, are discussed in Volume II Section 7: Wildlife and Protected Species. Although increases in noise will make the aquatic environment less habitable to those species, the effect would be temporary, and no lasting habitat impact would occur. Once installed, the anchor chains will be attached to the piles, and subsequently to the SPM buoy. These construction activities will be of limited duration and are not anticipated to cause long-term adverse effects to the biological community.

Approximately 130 sq. ft. (0.003 ac or 12.07 sq. m) of soft-bottom habitat will be permanently removed within the footprint of the SPM buoy system components which include 4, 24-inch piles supporting the PLEM and 6, 60-inch piles supporting the SPM buoy anchor chains. Any non-motile biological resources in the footprint of the SPM buoy system will be lost during installation and the habitat removed for the life of the Project. Mobile organisms that are displaced during construction are expected to quickly return following construction. With the exception of the benthic community underlying the Project's footprint, the benthos is expected to rapidly recover following construction (Brooks et al. 2006). Impacts beyond the permanent footprint of the Project are anticipated to be short-term. One potential benefit associated with installation of the SPM buoy system is its potential to function as artificial hard-bottom, providing a surface area for epifaunal colonization. As previously discussed, artificial reefs and manmade structures like jetties, pilings, groins and breakwaters provide a unique habitat for hard-bottom taxa and associated nekton, particularly in areas previously void of hard substrate.

Construction and installation of the SPM buoy system components will result in an increase in turbidity in the water column within and adjacent to the Project footprint; however, this effect is expected to be localized and limited to the time of facility placement. Deposition of suspended sediments in soft bottom habitats is expected to migrate only a short distance and cover a small area relative to the total habitat available. Overall, the increased turbidity and sedimentation is considered a short-term and negligible impact given the extent of locally available soft-bottom and pelagic habitat.

Some installation activities will continue 24 hours a day and require continuous lighting. Lights in the form of navigational beacons will also be required. Lighting of vessels and workspaces will be limited to what is necessary to maintain safe working conditions. Although lighting may attract fishes, and their predators, to the construction area, resulting impacts are expected to be temporary and negligible.

5.3.1.5 Construction Vessel Operations

Construction and installation activities for all Project components will require increased vessel traffic in the Project vicinity, which could also lead to additional pollution within the water column in the form of routine discharges, and inadvertent spills. Although impacts on water quality from routine discharges will affect the marine water column, any *Sargassum* mats in the immediate vicinity of a discharge, and benthic habitats in shallow water habitats, the discharges will be in accordance with applicable regulations, will be localized, and will dissipate quickly given the dilution capacity of the GOM.

Potential spills of construction-related fuels and chemicals can result in adverse impacts to local water quality of the marine aquatic environment. Each of the vessels involved in Project construction will operate in accordance with USCG and International Maritime Organization International Convention for the

Prevention of Pollution from Ships (MARPOL) requirements to minimize the potential for a release of oils and/or chemicals to the GOM. A Project-specific spill response plan will be developed prior to construction, which will identify measures to prevent, contain, and clean up any inadvertent spills. Each vessel operator will monitor its own operations and will have sorbent materials available to contain and clean up a release, should one occur. Therefore, significant impacts related to spills and releases are not anticipated. In the highly unlikely event of a diesel spill, the diesel fuel immediately would begin dissipating. Because diesel fuel is a mixture of relatively light hydrocarbons, spreading, evaporation, dispersion, and dissolution will occur rapidly, and virtually the entire volume of fuel will have dissipated within 12 to 24 hours (International Tanker Owners Pollution Federation Limited [ITOPF] 2002). Furthermore, no oil or mixtures containing more than 15 parts of oil per million may be discharged within 50 mi (80 km) offshore (MARPOL 73/78) and no solid debris may be discharged from OCS structures and vessels (30 Code of Federal Regulations (CFR) 250.40 and MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Therefore, although additional debris may enter the water column incidentally, the anticipated amount is expected to be extremely small.

In addition to impacts incurred by discharges or spills in the water column, any *Sargassum* directly in the path of oncoming support and transport vessels may be submerged to depths under the vessel, and portions of the mat may be destroyed by passage under the propeller. However, it is likely that *Sargassum* mats in the path of vessels will be gently pushed away from the oncoming vessel due to the pressure of the bow waves and the buoyant nature of the mats. With the exception of anchoring activities, as discussed above, construction vessels are not anticipated to affect benthic habitats, particularly in deeper waters where the discharges would not reach the seafloor. Overall, potential impacts to the aquatic environmental resulting from construction vessel operations are anticipated to temporary and minor.

5.3.2 Operation

Impacts on the aquatic environment during operation of the Project would generally be limited to presence of the SPM buoy system, port calls by the VLCCs (estimated at eight per month), the sporadic transit of support vessels to and from the offshore port, and the presence of the restricted zones (Refer to Appendix A for a depiction of restricted zones). Once installed, the pipelines would be buried a minimum of 5 ft. below the seafloor; although the habitats disturbed during construction would take various amounts of time to recover to pre-construction levels, no additional impacts would be incurred during operations. Although not anticipated to occur, a release of petroleum products from the SPM buoy system or pipelines would also impact the aquatic environment.

5.3.1.4 Deepwater Port Presence

Once constructed, the SPM buoy system components will act as an artificial hard structure, allowing sessile invertebrates with a substrate on which to attach. Oil and gas platforms in the GOM have been found to be colonized by a diverse array of microorganisms, algae, and sessile invertebrates including barnacles, oysters, mussels, soft corals (bryozoans, hydroids, and octocorals), sponges, and hard-corals (Gallaway and Lewbel 1982). In addition, the SPM buoy system and components attaching it to the seafloor will likely cause fishes to congregate, creating a locally diverse fish assemblage. The SPM buoy system will require operational lighting for 24-hour operations, as well as navigational beacons. Project lighting may cause behavioral changes in nearby organisms, including attraction of predator and prey species, but would have no measurable effect on the quality of the aquatic environment. Because of the hard structure provided for marine species in an area of otherwise ubiquitous soft-bottom habitat, the presence of the Project structures is considered a long-term, beneficial impact.

The SPM buoy would be attached to the seafloor via anchor chains attached to piles (six of each). As the buoy is floating and would move with the waves, currents, and VLCC activity, the anchor chains would also move, resulting in scour in areas where the anchor chains may drag on the seafloor. Although this chain sweep will occur throughout the life of the Port, resulting in continual disturbance of the soft-bottom habitat and localized turbidity, the buoy would be limited to a swing circle with a radius of 125 ft. (38 m). Given the small footprint of the swing circle, the impact to the affected soft-bottom habitat is considered negligible.

5.3.2.1 VLCC Water Use

During facility operations, VLCCs will require the uptake of seawater in support of ballasting operations, for cooling of engines, pumps and other equipment, and in support of normal transit operations. The water column will be disturbed via the intake and discharge of water, as could any *Sargassum* present in the immediate area of these activities. Soft bottom habitats in the Project vicinity are not expected to be affected by operation of the Project due to the depth of the water in which it will be located. As VLCCs would remain offshore, no impacts on inshore habitats would occur.

The quantity of seawater withdrawals and discharges from the VLCCs will vary depending on the characteristics and size of each tanker. Continuous seawater intake will be required for the reverse osmosis desalination system (450 gallons per minute [gpm]). Intermittent seawater intake will occur weekly for the fire deluge system, bilge, and slop tanks (totally 264,300 gallons), and bi-weekly for the cooling water (totally 18,000 gallons). Annual intake of seawater for the IGS Scrubber would total 216,000 gallons. Assuming one vessel is always present at the SPM buoy system, the amount of water withdrawn is estimated to be about 250 million gallons per year, representing only a small fraction of the amount of water available within the Project area. Seawater will be pulled in through near-surface sea chests covered with a wide mesh. Typically, seawater will be drawn in through the lower sea chest, which is located towards the bottom of the vessel, approximately 66 ft. (20 m) below the water surface for a VLCC based on fully loaded draft. A lesser portion of water withdrawal might occur through the upper sea chests, which are typically located approximately 6 ft. (2 m) higher than the lower sea chests. The mesh openings, although relatively large, will preclude entrainment of most adult pelagic species. Intake velocities typically remain below 0.5 ft/sec, which will be low enough to allow adult and juvenile fish to avoid being caught in the inflow of the screens, thus minimizing entrainment effects.

Discharges from the VLCC's cooling water systems are heated discharges, with the temperature of the discharge typically in the range of 5 to 10 °F (3 to 6 °C) higher than the temperature of seawater initially withdrawn. This discharge will result in a heated plume that will return to ambient temperatures as it moves away from the tanker. Dilution and dispersion will limit the impacts from discharge to be minor and localized impacts. Further, the VLCCs and support vessels will be equipped with water and wastewater treatment systems that will ensure that discharges comply with applicable USCG and MARPOL requirements for marine vessel discharges, such that they will not result in any significant impacts on the quality of the water column habitat.

Operational intakes/discharges associated with ballasting and engine-cooling will temporarily degrade the water column and any *Sargassum* mats in the vicinity of a discharge. Soft bottom habitats in the Project vicinity are not expected to be affected by operation of the SPM buoy system due to the depth of the water in which it will be located. As discharges will quickly dilute, their overall effect is expected to be long term but localized and minor.

5.3.2.2 Support Vessel Mooring and Ancillary Operations

Support vessels will regularly transit from shore to the SPM buoy system and between the SPM buoy system and incoming VLCCs. In addition, a minimum of two supply tugs will be onsite at the SPM buoy system during operations. Although regularly occurring, these vessel transits and tug operations are not anticipated to have any lasting effect on the aquatic environment as they are consistent with ongoing vessel activity in the GOM, and as such, negligible.

5.3.2.3 Restricted Operations Zone

The safety zone established for the SPM buoy system and VLCCs would restrict non-Project related activities within approximately 760 ac (307 ha) of the marine environment which would otherwise be available for fishing opportunities. In addition, the hard structures associated with the SPM buoy system would provide new structure for epifaunal colonization and fisheries recruitment over time; therefore, as the safety zone would prohibit fishing activities, this new habitat and faunal community would be protected from fishing pressures.

5.3.2.4 Inadvertent Product Release

The probability of a major crude oil spill is extremely low (see Section 14: Safety). The major elements of the Project that could leak crude oil in the marine environment include the SPM buoy system and the pipelines.

Inshore and offshore habitats that could be affected in the event of a spill, as described in Section 5.2, include coastal barrier beaches, wetlands, seagrass beds, inshore oyster and *serpulid* reefs, soft-bottom habitats, offshore hard-bottom habitats and artificial reefs, *Sargassum*, and the water column in in the Laguna Madre and offshore. Depending on the location of a spill, these habitats may become oiled. The degree of impact on each habitat depends on the volume of oil that reaches the affected habitat and the state of the oil (fresh or lightly or highly weathered). Potential impacts on coastal wetland and water quality in the event of a spill are further described in Sections 3 and 14.

If a spill were to happen near shore, or occur offshore but reach the coast, oil would likely impact coastal barrier beaches. When oil reaches shore on a sandy beach, it may penetrate into the sand, depending on the viscosity of the oil and the grain size of the sand. Generally, more highly weathered oil (such as tarballs) penetrates the sand less readily than fresh oil, and fine-grained sand beaches are more compact and prevent deep oil penetration (NOAA – Hazardous Materials Response and Assessment Division 1992). Mechanical equipment can be used to remove oil from sandy beaches, and wave energy may aid clean-up. In addition, storms and wave energy remove oil from sandy beaches. While removal of contaminated sand from the shore following a spill may alter the shore profile, natural accretion of sand or beach nourishment may be used to restore the shoreline to pre-spill conditions. Therefore, impacts on coastal barrier beaches in the event that oil from a spill reaches shore, while adverse, are not likely to be significant.

Most seagrass beds in the Project area are protected from offshore spills by Padre Island and other barrier islands; however, in the event of a nearshore or inland spill they could be damaged. Because seagrass beds remain submerged, they would not likely be fouled by a surface oil slick but could be damaged by the reduced light penetration and oxygen depletion if weather conditions resulted in oil remaining over seagrass beds for an extended period. Oil may also mix in the water column or with nearshore sediments, which are then transported to seagrass beds, resulting in contamination of seagrass tissues (Deepwater Horizon [DWH] Natural Resource Damage Assessment [NRDA] Trustees 2016). Contamination, as well as light and oxygen depletion may reduce productivity, reduce tolerance to other stress factors, reduce reproductive success, and result in potential population-level impacts on seagrasses (Runcie *et al.* 2015, Martin *et al.* 2015). Exposure of oyster reefs to oiling can result in injury of oysters and reduced reproductive output (DWH NRDA Trustees 2016). Oil exposure also affects the growth, settlement, and survival of larval oysters, which may be exposed in the water column (Vignier *et al.* 2016). Similar to seagrass beds, oyster reefs in the Project area are protected from offshore spills by barrier islands but could be damaged in the event of a nearshore or inland spill. However, because the worst-case-scenario spill would occur offshore and oil reaching nearshore environments would be highly weathered, significant adverse impacts on seagrasses and oyster reefs are unlikely. Because the nearest serpulid reefs in the Project area are in Baffin Bay, about 20 mi (31.3 km) from the inshore pipelines in the Laguna Madre, it is unlikely that they would be impacted in the event of a spill.

Sediment may become contaminated by oil in the event of a spill when oil mixes with nearshore sediments, and is then transported away from coastlines (as described above); via direct contact with oil droplets; or via transport of oil particles from the surface slick to the seafloor via marine snow (DWH NRDA Trustees 2016, Hastings et al. 2016). During the DWH oil spill, it is estimated than > 770 square mi (2,000 square km) of deep-sea benthic hard- and soft-bottom habitats were injured (DWH NRDA Trustees 2016); however, the worst-case scenario spill would be much less by comparison. Adverse impacts on soft-bottom habitat in the event of the worst-case scenario spill would be localized, and over time toxic particles would be weathered and removed from affected habitats. Because offshore hard-bottom habitats and artificial reefs are located at depths > 5 m, oil concentrations in the water column would be diluted below acute toxicity levels and any impacts would be recovered quickly (NOAA – Hazardous Materials Response and Assessment Division 1992). Therefore, the risk of impacts on these habitats in the event of a spill is low.

Sargassum floating in areas of surface oiling may become fouled. Floating oil tends to collect and drift in drift lines along the same convergent currents that transport *Sargassum*; therefore, oil may become concentrated in the same areas as *Sargassum,* resulting in greater exposure (DWH NRDA Trustees 2016). Following the DWH oil spill, the surface area of *Sargassum* habitat was shown to be reduced, resulting in a loss of *Sargassum* habitat (DWH NRDA Trustees 2016). Oiling of *Sargassum* also exposes the organisms using that habitat to higher concentrations of contaminants and (Powers *et al.* 2013).

During the DWH oil spill, 3.2 million barrels (bbl.) of oil were released into the GOM over a period of 87 days; however, the worst-case scenario spill associated with the Project would release a total of 63,480 bbl. over 10 days. Upon release, the oil would immediately begin to weather and evaporate, and the level, timeframe, and large geographic area of oil exposure that affected *Sargassum* and other inshore and offshore aquatic habitats during that release would not occur. Impacts from smaller spills associated with chemicals stored on support vessels or the SPM buoy would be minor, and would be mitigated as discussed above, for construction.

5.3.3 Decommissioning

At the end of its useful life, the pipelines from the valve station on Padre Island to the onshore storage facility will be abandoned in place, offshore pipelines would be removed, and SPM buoy system will be removed. The abandonment of the pipeline facilities inshore and onshore will avoid habitat impacts that would be associated with their removal. Removal of the marine pipelines and the SPM buoy system are expected to disturb both open water and soft bottom habitats, as well as transient areas of *Sargassum*. The removal of pipelines SPM buoy system structures will cause a temporary increase in turbidity to both the lower water column and the seafloor. As part of the decommissioning sequence, the SPM buoy system will be shut down and removed in accordance with applicable regulatory requirements. The planned decommissioning sequence is provided in Appendix A; however, a decommissioning plan would be prepared prior to any decommissioning activities taking place. It is estimated that decommissioning would take approximately 10 weeks to complete.

Regulated intakes/discharges from vessels and vessel traffic may affect the upper water column and nearby *Sargassum* mats and assemblages. Noise will be localized where Project components are removed; no explosives would be used. Adverse impacts on the aquatic environment from removal of the offshore Project components will be similar to those discussed for construction and are considered minor and short-term.

5.4 Cumulative Impacts

Cumulative effects generally refer to impacts that are additive or synergistic in nature and result from the construction of multiple actions in the same vicinity and time frame. Cumulative impacts can result from individually minor, but collectively significant actions, taking place over a period of time. In general, small-scale projects with minimal impacts of short duration do not significantly contribute to cumulative impacts.

Activities that could impact the aquatic environment in the Project area include offshore oil and gas exploration and production; waterway improvement projects, and marine traffic associated with the oil and gas industry, as well as recreation (see Volume II Introduction, Evaluation Framework, and Summary of Impacts). Although activities associated with land-based projects can impact aquatic environments from discharges and runoff from coastal facilities, it is anticipated that these activities would be conducted in accordance with applicable permits, such that impacts are adequately minimized. Offshore oil and gas exploration activities can include installation/removal of mooring platforms and laying of pipelines and associated anchoring activities, service vessel operations, supporting infrastructure discharges, and oil spills. Many platforms have discharges of drilling wastes, produced water, and other industrial wastewater streams that have adverse impacts on water quality. The U.S. Environmental Protection Agency (USEPA) regulates the discharge of these wastes through National Pollutant Discharge Elimination System (NPDES) permits. Except in shallow waters, the effects of these discharges are generally localized near individual points of discharge (Neff 2005).

The primary cumulative effect from exploration and production activities would be the installation of platforms and other permanent structures, which would simultaneously remove soft-bottom habitat and provide hard structure for faunal communities. Further, in addition to widening the Corpus Christi Ship Channel (CCSC), the Port of Corpus Christi (POCC) Authority is also proposing to conduct ecosystem restoration to protected endangered species, wetlands, and seagrasses, which would result in beneficial impacts through creation of additional nursery habitat. These impacts are considered to have long-term beneficial impacts by creating additional habitat for aquatic species, but given the size of the Western Planning Area, the overall benefit of habitat creation from these projects is anticipated to be minor.

Waterway improvement projects are generally short-term and their effects (turbidity and sedimentation, with the potential for limited habitat loss for new construction) would typically be limited to the area where these activities take place. These projects are all over 19 mi (30.5 km) from the proposed Project, as a result, any cumulative effects of construction of the Project, when considered with these projects would be negligible.

Ongoing marine traffic associated with recreational activities and offshore oil and gas exploration have the potential for inadvertent releases of petroleum products, which could result in impacts on the aquatic environment similar to those described above for the Project. In the event of a spill, operators would be required to implement oil spill response procedures in accordance with applicable federal regulations to remove oil from the environment and mitigate impacts. Given the low probability of a spill associated with the proposed Project, and the implementation of federal regulations, the potential for cumulative impacts due to inadvertent releases of petroleum is unlikely and would be minor.

5.5 Mitigation Measures

The offshore design and location of the Project inherently minimizes impacts on aquatic habitats through a number of factors, including avoiding nearshore transit of the VLCCs and sensitive habitats that provide high-quality habitat for aquatic species. Other mitigation that will be implemented during Project construction and operation includes:

- Using BMP (e.g., weighted turbidity curtains, dredge material storage on hopper barges in place of side-casting material) on the edge of the inshore construction workspaces to minimize the migration of turbidity and sedimentation according to permit requirements and recommendations;
- Utilizing existing channels to navigate to workspaces where appropriate;
- Land-based fabrication of the offshore SPM buoy system, to minimize the timing and disturbance associated with offshore installation; and,
- HDD construction under the mainland and Padre Island shorelines to avoid sensitive coastal habitats.

5.6 Summary of Potential Impacts

Based on the analysis presented in the sections above, potential impacts on the inshore and offshore aquatic environments are summarized in the table below.

Table 5-1: Summary of Potential Impacts to Inshore and Offshore Aquatic Environments

Project Phase	Impact	Duration	Significance	Mitigation
Construction	Increased potential for inadvertent releases; impacts on the water column and offshore soft bottom habitats; disturbance of inshore seagrass habitat	Localized, Temporary	Minor	As required by USACE Permit, Using construction BMP for seagrass habitats. Land-based fabrication of the SPM buoy and installation of pipeline via HDD to minimize impacts at sensitive locations.
Operation	Increased potential for inadvertent releases; impacts on the water column and offshore soft bottom habitats from anchor chain sweep;	Long-term	Minor	N/A
Decommissioning	Increased turbidity due to operation of construction equipment and vessels	Short-term	Minor	N/A
Cumulative	Cumulative increase in discharges and runoff; and increased potential for inadvertent releases; beneficial impacts from creation additional habitat	Long-term	Minor	N/A

5.7 References

Brooks, R.A., C.N. Purdy, S.S. Bell, K.J. Sulak. 2006. The benthic community of the eastern US continental shelf: A literature synopsis of benthic faunal resources. Continental Shelf Research 26:804-818. Available at: https://www.sciencedirect.com/science/article/pii/S0278434306000409. Accessed April 2018.

Bureau of Ocean Energy Management (BOEM) 2012. Gulf of Mexico OCS Oil and Gas Lease Sales 2012-2017. Final Programmatic Environmental Impact Statement. U.S. Department of the Interior. Available at: https://www.boem.gov/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/Leasing/Five_Year_Program/2012-2017_Five_Year_Program/2012-2017_Final_PEIS.pdf. Accessed January 2018.

_____. 2016. Gulf of Mexico OCS Region. Volume 1. Oil and Gas Leasing Program: 2017-2022. Final Programmatic Environmental Impact Statement. U.S. Department of the Interior. Available at: https://www.boem.gov/BOEM-EIS-2017-009-v1/. Accessed January 2018.

_____. 2017. Gulf of Mexico OCS Region. Volume 1. Oil and Gas Leasing Program: 2017-2022. Final Programmatic Environmental Impact Statement. Available at: https://www.boem.gov/BOEM-EIS-2017-009-v1/. Accessed January 2018.

Byrnes, M., R. Davis, M. Kennicutt II, R. Kneib, I. Mendelssohn, G. Rowe, J. Tunnell, Jr., B. Vittor, and H. Ward. 2017. Habitats and Biota of the Gulf of Mexico: Before the Deepwater Horizon Oil Spill. Volume 1. Water Quality, Sediments, Sediment Contaminants, Oil and Gas Seeps, Coastal Habitats, Offshore Plankton and Benthos, and Shellfish. Edited by C. Herb Ward.

MPA Cummins, Robert, J. Rivers, and P. Struhsaker. 1962. Snapper Trawling Explorations Along the Southeastern Coast of the United States. Commercial Fisheries Review. Volume 24. No. 12. Pages 1-7. Available at: https://spo.nmfs.noaa.gov/sites/default/files/pdf-content/mfr24121.pdf. Accessed January 2018.

Darnell, R. 2015. The American Sea. A Natural History of the Gulf of Mexico. Harte Research Institute for Gulf of Mexico Studies Series. Sponsored by the Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi. 584 pages.

Deepwater Horizon Natural Resource Damage Assessment Trustees (DWH NRDA Trustees). 2016. Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement. Available at: http://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Front-Matter-and-Chapter-1_Introduction-and-Executive-Summary_508.pdf. Accessed April 2018.

Dunton, K. 2015. A Long-term Seagrass Monitoring Program for Upper Laguna Madre and Corpus Christi Bay. Publication CBBEP-99. Available at: http://www.cbbep.org/manager/wp-content/uploads/1429-Seagrass-Monitoring-Final-Report.pdf. Accessed March 2018.

Flint, R. Warren. 1981. Gulf of Mexico Outer Continental Shelf Benthos: Macroinfaunal-Environmental Relationships. Biological Oceanography, 1:2, Pages 135-155. Available at: https://www.tandfonline.com/doi/pdf/10.1080/01965581.1981.10749436?needAccess=true. Accessed January 2018.

Florida Fish and Wildlife Conservation Commission. 2018. Marine Ecosystems GIS and Mapping Data. Available at: http://myfwc.com/research/gis/. Accessed March 2018.

Gallaway, B. and G. Lewbel. 1982. The Ecology of Petroleum Platforms in the Northwestern Gulf of Mexico: A Community Profile. Bureau of Land Management Gulf of Mexico OCS Regional Office

– Open File Report 82-03. Available at: https://www.nwrc.usgs.gov/techrpt/82-27text.pdf. Accessed March 2018.

Gallaway, Benny J.; Szedlmayer, Stephen T.; and Gazey, William J. 2009. A Life History Review for Red Snapper in the Gulf of Mexico with an Evaluation of the Importance of Offshore Petroleum Platforms and Other Artificial Reefs. Reviews in Fisheries Science, 17(1): Pages 48-67. Available at: http://www.mbara.org/pdf/2009%20Red%20Snapper%20Pertoleum%20Platforms%20and%20Artficial%20Reefs.pdf. Accessed April 2018.

Gulf of Mexico Fishery Management Council (GMFMC). 2004. Final Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to the following fishery management plans of the Gulf of Mexico (GOM): 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 Reef Fishery of the Gulf of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic. March 2004. Available at: https://gulfcouncil.org/wp-content/uploads/March-2004-Final-EFH-EIS.pdf. Accessed February 2018.

Handley, L., Altsman, D., and DeMay, R., eds., 2007, Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002: U.S. Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003, 267 p. Available at: https://pubs.usgs.gov/sir/2006/5287/. Accessed March 2018.

Hastings, D., P. Schwing, G. Brooks, R. Larson, J. Moford, T. Roeder, K. Quinn, T. Bartlett, I. Romero, D. Hollander. 2016. Changes in sediment redox conditions following the BP DWH blowout event. Deep Sea Research Part II: Topical Studies in Oceanography. 129 (167-178). Available at: https://ac.els-cdn.com/S0967064514003713/1-s2.0-S0967064514003713-main.pdf?_tid=18d83180-1582-427d-a963-d00b82058746&acdnat=1523972863_550bdce2b96d7fbe3db37bfbd068bc35. Accessed April 2018.

Havens, Karl E.; Beaver, John R.; Casamatta, Dale A.; Easte, Therese L.; James, R. Thomas; McCormick, Paul; Phlips, Edward J.; Rodusky, Andrew J. 2011. Hurricane effects on the planktonic food web of a large subtropical lake. Journal of Plankton Research. Volume 3, Number 7. Pages 1081-1094. Available at: https://academic.oup.com/plankt/article/33/7/1081/1555984. Accessed March 2018.

Hayes, S. A., E. Josephson, K Maze-Foley, and P.E. Rosel. 2017b. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2017. Draft. Available online at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/draft-marine-mammal-stock-assessment-reports. Accessed May 2018.

Holweg, Eric J. 2000. Mariner's Guide for Hurricane Awareness in The North Atlantic Basin. National Oceanic and Atmospheric Administration. National Hurricane Center (NHC). Available online at: https://www.nhc.noaa.gov/marinersguide.pdf. Accessed April 2018.

International Tanker Owners Pollution Federation Limited (ITOPF). 2002. "Fate of Marine Oil Spills." Technical Information Paper. No. 2. Available at: http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP2FateofMarineOilSpills.pdf. Accessed April 2018.

Keen, Timothy R. and Glenn, Scott M. 1999. Shallow water currents during Hurricane Andrew. Journal of Geohphysical Research. Volume 104, No. C10. Pages 443-458. Available at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/1999JC900180. Accessed March 2018.

Kilgen, Ronald H. and Dugas, Ronald J. 1989. The Ecology of Oyster Reefs on the Northern Gulf of Mexico: An Open File Report. U.S. Department of the Interior. Fish and Wildlife Service. Minerals Management Service. NWRC Open File Report 89-03. Available at: https://www.boem.gov/ESPIS/3/3757.pdf. Accessed January 2018.

Martin, C. W., Hollis, L. O., and Turner, R. E. 2015. Effects of Oil-Contaminated Sediments on Submerged Vegetation: An Experimental Assessment of Ruppia maritima. PLoS ONE, 10(10). Available at: http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0138797&type=printable. Accessed April 2018.

Minerals Management Service. 2000. Physical/Biological Oceanographic Integration Workshop for the DeSoto Canyon and Adjacent Shelf. October 19-21, 1999. Department of the Interior. Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS200-074. Available online at: https://www.boem.gov/ESPIS/3/3180.pdf. Accessed April 2018.

Mississippi Department of Marine Resources (MDMR). 1999. An Evaluation of the Effectiveness of the Department of Marine Resources' Marine Resources Management and the Department of Wildlife Fisheries, and Parks; Marine Law Enforcement. Joint Committee on Performance Evaluation and Expenditure Review. Available at: http://www.peer.ms.gov/Reports/reports/rpt389.pdf. Accessed January 2018.

National Aeronautics and Space Administration (NASA). 2018a. How do Hurricanes Form? Available at: https://spaceplace.nasa.gov/hurricanes/en/. Accessed March 2018.

_____. 2018b. Hurricanes: The Greatest Storms on Earth. Available at: https://earthobservatory.nasa.gov/Features/Hurricanes/. Accessed March 2018.

National Hurricane Center (NHC). 2018. Tropical Cyclone Climatology. Available at: https://www.nhc.noaa.gov/climo/. Accessed March 2018.

National Marine Protected Areas Center. 2016. Status of U.S. Marine Protected Areas – 2016 Statistics. Available at: https://marineprotectedareas.noaa.gov/aboutmpas/status-of-usa-mpas-2016.html. Accessed March 2018.

National Oceanic and Atmospheric Administration (NOAA). 1978. MAFLA Final Report. The Mississippi, Alabama, Florida, Outer Continental Shelf Baseline Environmental Survey 1977/1978. MAFLA Report No: 1979-17. Available at: https://invertebrates.si.edu/boem/reports/MAFLA_7778_Final1b.pdf. Accessed January 2018.

_____. 2008. Gulf of Mexico Summary. Available at: https://www.st.nmfs.noaa.gov/st5/publication/communities/Gulf_Summary_Communities.pdf. Accessed March 2018.

National Oceanic and Atmospheric Administration (NOAA) – Hazardous Materials Response and Assessment Division. 1992. An Introduction to Coastal Habitats and Biological Resources for Oil Spill Response. Report No. HMRAD 92-4. Available online at: https://response.restoration.noaa.gov/sites/default/files/Monterey.pdf. Accessed April 2018.

_____. 2018a. National Marine Sanctuaries. Available online at: https://sanctuaries.noaa.gov/. Accessed March 2018.

_____. 2018b. National Estuarine Research Reserves. Living Laboratories for Science, Education, and Protection. Available Online at: https://oceanservice.noaa.gov/ecosystems/nerrs/. Accessed March 2018.

_____. 2018c. Tides and Currents: Station 8775870. Available online at: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8775870. Accessed March 2018.

_____. 2018. Data Tools: 1981-2010 Normals. Available at: https://www.ncdc.noaa.gov/cdo-web/datatools/normals. Accessed April 2018.

_____. 2018e. National Hurricane Center, Tropical Cyclone Climatology. Available at: https://www.nhc.noaa.gov/climo/. Accessed March 2018.

National Park Service (NPS) 2018a. History. About Us. Available at: https://www.nps.gov/aboutus/history.htm. Accessed March 2018.

_____. 2018b. Padre Island National Seashore Texas. Available at: https://www.nps.gov/PINS/index.htm. Accessed March 2018.

National Wildlife Federation (NWF). 2013. Artificial Reefs of the Gulf of Mexico: A Review of Gulf State Programs and Key Considerations. 22 pages. Available at: https://www.nwf.org/~/media/PDFs/Water/Review-of-GoM-Artificial-Reefs-Report.pdf. Accessed April 2018.

Neff, Jerry M 2005. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment. A Synthesis and Annotated Biography. Report prepared for the Petroleum Environmental Research Forum (PERF) and American Petroleum Institute. Available at: http://platformresearch.msi.ucsb.edu/bibliography/composition-environmental-fates-and-biological-effects-water-based-drilling-muds-and. Accessed March 2018.

Onuf, Christopher P. 1994. Laguna Madre. U.S. Geological Survey, National Wetlands Research Center. Available at: https://pubs.usgs.gov/sir/2006/5287/pdf/LagunaMadre.pdf. Accessed March 2018.

Powers, S., F. Hernandez, R. Condon, J. Drymon, and C. Free. 2013. Novel Pathways for Injury from Offshore Oil Spills: Direct, Sublethal and Indirect Effects of the Deepwater Horizon Oil Spill on Pelagic Sargassum Communities. PLoS One. 8(9). Available online at: http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0074802&type=printable. Accessed March 2018.

Runcie, John; Macinnis-NG, Cate; and Ralph, Peter. 2015. The toxic effects of petrochemicals on seagrasses. Literature review. Institute for Water and Environmental Resource Management and Department of Environmental Sciences. University of Technology, Sydney. Australian Maritime Safety Authority. Available at: https://www.researchgate.net/publication/252133825_The_toxic_effects_of_petrochemicals_on_seagrasses_Literature_review. Accessed March 2018.

South Atlantic Fisheries Management Council (SAFMC). 2018. Artificial Reef Habitats. Available at: http://safmc.net/uncategorized/artificial-reef-habitats/. Accessed April 2018.

Spiller, K., and R. Blankinship. 2016. Laguna Madre. Available online at: https://tpwd.texas.gov/fishboat/fish/didyouknow/coastal/lagunamadre.phtml. Accessed March 2018.

Southwest Fisheries Science Center. 2014. What are ichthyoplankton? National Oceanic and Atmospheric Administration NMFS Southwest Fisheries Science Center. Available at: https://swfsc.noaa.gov/textblock.aspx?division=frd&id=6210. Accessed March 2018.

Stone, Richard B.; Pratt, H.L; Parker, R.O; Davis G.E. 1979. A comparison of Fish Populations on an Artificial and Natural Reef in the Florida Keys. Marine Fisheries Review. 11 pages. Available online at: https://spo.nmfs.noaa.gov/mfr419/mfr4191.pdf. Accessed March 2018.

Texas Commission on Environmental Quality (TCEQ). 2018. Meteorological and Climatological Data. Available at: https://www.tceq.texas.gov/airquality/monops/meteorological. Accessed April 2018.

Texas Parks and Wildlife Department (TPWD). 1996. Seagrass Conservation Plan for Texas. Available at: https://tpwd.texas.gov/publications/pwdpubs/media/pwd_bk_r0400_0041.pdf. Accessed March 2018.

_____. 2018a. Seagrass Types. Available at: https://tpwd.texas.gov/landwater/water/habitats/seagrass/seagrass-types. Accessed April 2018.

_____. 2018b. Laguna Madre. Available at: https://tpwd.texas.gov/fishboat/fish/didyouknow/coastal/lagunamadre.phtml. Accessed March 2018.

_____. 2018c. Artificial Reef Program Overview. Available at: https://tpwd.texas.gov/landwater/water/habitats/artificial_reef/overview.phtml.

_____. 2018d. Texas Artificial Reefs Interactive Mapping Application. Available online: http://tpwd.texas.gov/gis/ris/artificialreefs/. Accessed March 2018.

_____. 2012. Water for Texas 2012 State Water Plan. Available at: http://www.twdb.texas.gov/publications/state_water_plan/2012/2012_SWP.pdf. Accessed April 2018.

Texas Water Development Board. 2018a. Bays and Estuaries. Available at: http://www.twdb.texas.gov/surfacewater/bays/index.asp. Accessed April 2018.

_____. 2018b. Laguna Madre Estuary. Available online at: http://www.twdb.texas.gov/surfacewater/bays/major_estuaries/laguna_madre/index.asp. Accessed March 2018.

U.S. Army Corps of Engineers and Interagency Coordination Team. 2002. Laguna Madre GIWW Dredge Material Management Plan. Available online at: http://www.swg.usace.army.mil/Portals/26/docs/Navigation/GIWW-N-ICT/LagunaMadreDMMP.pdf. Accessed March 2018.

U.S. Army Corps of Engineers (USACE). 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coast Plain Region (Version 2.0). Available at: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/AGCP_regsupV2.pdf. Accessed March 2018.

U.S. Fish and Wildlife Service (USFWS). 2018a. National Wildlife Refuge System – Legislative Mandates and Authorities. Available online at: https://www.fws.gov/refuges/policiesandbudget/mandates.html. Accessed March 2018.

_____. 2018b. Aransas National Wildlife Refuge – About the Refuge. Available online at: https://www.fws.gov/refuge/Aransas/about.html. Accessed March 2018.

_____. 2013c. Aransas National Wildlife Refuge – Matagorda Island Unit. Available at: https://www.fws.gov/refuge/Aransas/about/matagorda.html. Accessed March 2018

U.S. Geological Survey (USGS). 2004. Ecology of Live Bottom Habitats of the Northeastern Gulf of Mexico: A Community Profile. U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region. Contractor Report USGS/BRD/CR—1999-001; OCS Study MMS 99-0004. Available online at: https://www.boem.gov/ESPIS/3/3196.pdf. Accessed April 2018.

_____. 2007. Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002. Available online at: https://pubs.usgs.gov/sir/2006/5287/pdf/Abstract.pdf. Accessed March 2018.

Vignier J., P. Soudant, F. Chu, J. Morris, M. Carney, C. Lay, M. Krasnec, R. Rene, and A. Volety. 2016. Lethal and sub-lethal effects of Deepwater Horizon slick oil and dispersant on oyster (Crassostrea virginica) larvae. Marine Environmental Research. 120(20-31). Available at: http://archimer.ifremer.fr/doc/00345/45572/45181.pdf. Accessed April 2018.