Chapter 3

Description of the Affected Environment

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1. PHYSICAL ENVIRONMENT

3.1.1. Air Quality

The Clean Air Act established NAAQS; the primary standards are to protect public health and the secondary standards are to protect public welfare. New NAAQS for ozone and particulate matter took effect on September 16, 1997. The current NAAQS (40 CFR 50.12 and 62 FR 138, July 18, 1997) are shown in **Table 3-1**. The Clean Air Act Amendments of 1990 established classification designations based on regional monitored levels of ambient air quality. These designations impose mandated timetables and other requirements necessary for attaining and maintaining healthful air quality in the U.S. based on the seriousness of the regional air quality problem.

When measured concentrations of regulated pollutants exceed standards established by the NAAQS, an area may be designated as a nonattainment area for a regulated pollutant. The number of exceedances and the concentrations determine the nonattainment classification of an area. There are five classifications of nonattainment status: marginal, moderate, serious, severe, and extreme (Clean Air Act Amendments, 1990).

The Federal OCS waters attainment status is unclassified. The OCS areas are not classified because there is no provision for any classification in the Clean Air Act for waters outside the boundaries of State waters. Only areas within State boundaries are to be classified either attainment, nonattainment, or unclassifiable. Operations west of 87.5^{o} W. longitude fall under MMS jurisdiction for enforcement of the Clean Air Act. The OCS waters east of 87.5^{o} W. longitude are under the jurisdiction of USEPA. **Figure 3-1** presents the air quality status in the Gulf Coast as of August 2001. All air-quality nonattainment areas reported in **Figure 3-1** are for ozone nonattainment. No graphics depicting the boundaries (projected from historical data) of ozone areas of influence, areas at risk, or areas of violation along the Gulf Coast were available at the time of publishing this EIS. It is expected that the number of areas of violation will increase under the new 8-hour (hr) ozone NAAQS (157 micrograms (µg) per m^3) as compared to the number of areas under the old 1-hr standard (235 µg/m^3). The Gulf Coast Ozone Study group is currently using an air quality model to simulate the ozone concentrations in the Eastern Gulf Coast area; they will provide technical information on 1-hr as well as 8-hr ozone levels in this area. The Offshore Operator Committee also has monitored air quality in the Breton area, including the zone concentrations. To date, the new 8-hr ozone standard had not yet been fully implemented because of pending court action. However, on February 27, 2001, the U.S. Supreme Court unanimously upheld the constitutionality of the Clean Air Act as USEPA had interpreted it in setting these health-protective, air quality standards. Recently, the U.S. Court of Appeals for the District of Columbia Circuit Court also upheld the 1997 Clean Air Act.

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

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

Air quality data for 1993 were obtained from the Alabama Department of Environmental Management for PM_{10}, NO_2, and ozone (O_3). The data show that Mobile County is in attainment of the NAAQS for all criteria pollutants. There have been no exceedances of the NAAQS for SO_2, NO_x CO, and PM_{10} in the State of Alabama (USEPA, 2001).

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

The 8-hr ozone standard is based on the average fourth-highest value over a 3-year period. For the 1999-2001 averaging period, two monitoring sites in Escambia County exceeded the 8-hr ozone standard of 85 parts per billion (ppb). The 1-hr ozone standard is based on the number of exceedances over 3-year period. The concentration can vary significantly from one year to the next. While there was one exceedance in Florida in 1997, there were 17 exceedances at various stations in 1998, and three in 1999. In 1997, there was one exceedance of the 1-hr ozone standard, in Duval County on Florida's Atlantic Coast; it did not result in a violation. While Florida's ambient air quality standards are at least as stringent as the national standards, the State standards for sulfur dioxide are stricter than the national standards. Florida has an annual standard of 60 $\mu g/m^3$, a 24-hr standard of 260 $\mu g/m^3$, and a 3-hr standard of 1,300 $\mu g/m^3$. According to the Florida Air Quality Report for 1996 (Florida Dept. of Environmental Protection et al., 1997), sulfur dioxide concentrations are generally well within both State and National ambient air quality standards throughout the State.

The PSD Class I air quality areas, designated under the Clean Air Act, are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for Class I areas are as follows: 2.5 $\mu g/m^3$ annual increment for NO_2; 25 $\mu g/m^3$ 3-hr increment, 5 $\mu g/m^3$ 24-hr increment, and 2 $\mu g/m^3$ annual increment for SO_2; and 8 $\mu g/m^3$ 24-hr increment and 5 $\mu g/m^3$ annual increment for PM_{10}.

The proposed lease sale area includes several wilderness areas designated by the Clean Air Act as PSD Class I air quality areas: the Breton National Wildlife Refuge and National Wilderness Area off Mississippi, and the Saint Marks, Bradwell Bay, and Chassahowitzka Class I air quality areas in Florida (**Figure 3-2**). The FWS has responsibility for protecting wildlife, vegetation, visibility, and other sensitive resources called air quality related values in these areas. Class I areas are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for Class I areas are as follows: 2.5 $\mu g/m^3$ annual increment for NO_2; 25 $\mu g/m^3$ 3-hr increment, 5 $\mu g/m^3$ 24-hr increment, and 2 $\mu g/m^3$ annual increment for SO_2; and 8 $\mu g/m^3$ 24-hr increment and 5 $\mu g/m^3$ annual increment for PM_{10}. The FWS has expressed concern that the NO_2 and SO_2 increments for the Breton National Wilderness Area have been consumed.

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

3.1.2. Water Quality

For the purposes of this EIS, water quality is the ability of a waterbody to maintain the ecosystems it supports or influences. In the case of coastal and marine environments, the quality of the water is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Besides the natural inputs, human activity can contribute to water quality through discharges, run-off, burning, dumping, air emissions, and spills. Also, mixing or circulation of the water can either improve the water through flushing or be the source of factors contributing to the decline of water quality.

Evaluation of water quality is done by direct measurement of factors that are considered important to the health of an ecosystem. The primary factors influencing coastal and marine environments are temperature, salinity, oxygen, nutrients, potential of hydrogen (pH), oxidation reduction potential (Eh), pathogens, and turbidity or suspended load. Trace constituents such as metals and organic compounds can affect water quality. The water quality and sediment quality may be closely linked. Contaminants, which are associated with the suspended load, may ultimately reside in the sediments rather than the water column.

The region under consideration is divided into coastal and marine waters for the following discussion. Coastal waters, as defined by MMS, include all the bays and estuaries from the Rio Grande River to the Florida Bay (**Figure 3-3**). Marine water as defined in this document includes both State offshore water and Federal OCS waters, which includes everything outside any barrier islands to the Exclusive Economic Zone. The inland extent is defined by the Coastal Zone Management Act.

3.1.2.1. Coastal Waters

Along the Gulf Coast lies one of the most extensive estuary systems in the world, which extends from the Rio Grande River to Florida Bay (**Figure 3-3**). Estuaries represent a transition zone between the freshwater of rivers and the higher salinity waters offshore. These bodies of water are influenced by freshwater and sediment influx from rivers and the tidal actions of the oceans. The primary variables that influence coastal water quality are water temperature, total dissolved solids (salinity), suspended solids (turbidity), and nutrients. An estuary's salinity and temperature structure is determined by hydrodynamic mechanisms governed by the interaction of marine and terrestrial influences, including tides, nearshore circulation, freshwater discharges from rivers, and local precipitation. Gulf Coast estuaries exhibit a general east to west trend in selected attributes of water quality associated with changes in regional geology, sediment loading, and freshwater inflow.

Estuaries provide habitat for plants, animals, and humans. Marshes, mangroves, and seagrasses surround the Gulf Coast estuaries, providing food and shelter for shorebirds, migratory waterfowl, fish, invertebrates (e.g., shrimp, crabs, and oysters), reptiles, and mammals. Estuarine-dependent species constitute more than 95 percent of the commercial fishery harvests from the GOM. Several major cities are located along the coast, including Houston, New Orleans, Mobile, and Tampa. Tourism supplies an estimated $20 billion to the economy each year (USEPA, 1999). Shipping and marine transport is an important industry, with 7 of the top 10 busiest ports in the U.S., in terms of total tonnage, located in GOM estuaries.

Estuarine ecosystems are impacted by humans, primarily via upstream withdrawals of water for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges and agricultural runoff carrying pesticides and herbicides; and habitat alterations (e.g., construction and dredge and fill operations). Drainage from more than 55 percent of the conterminous U.S. enters the GOM, primarily from the Mississippi River. Louisiana, and Alabama ranked second, and fourth, respectively, in the nation in 1995 in terms of discharging the greatest amount of toxic chemicals (USEPA, 1999). The GOM region ranks highest of all coastal regions in the U.S. in the number of wastewater treatment plants (1,300), number of industrial point sources (2,000), percent of land use devoted to agriculture (31%), and application of fertilizer to agricultural lands (62,000 tons of phosphorus and 758,000 tons of nitrogen) (USDOC, NOAA, 1990).

A recent assessment of the ecological condition of GOM estuaries was published by the USEPA (1999). The assessment describes the general ecology and summarizes the "health" of all the GOM estuarine systems. Sources of the data include the USEPA's Environmental Monitoring and Assessment Program for Estuaries (EMAP-E), the NOAA Estuarine Eutrophication Survey (USDOC, NOAA, 1997a), and 305(b) reports from each state. A classification scheme based on 10 indicators was developed. The indicators were water quality, harmful algal blooms, sediment contaminants, habitat change, biological integrity, and public health (pathogens in shellfish and contaminants, mainly mercury, in fish).

Many Gulf Coast States now sample the edible tissue of estuarine and marine fish for total mercury. The USEPA merged both State and Federal mercury data into the Gulfwide Mercury in Tissue Database to characterize the occurrence of mercury in GOM fishery resources (Ache, 2000). The reports found that all Gulf Coast States have published fish consumption advisories for large king mackerel. The report recommends testing of additional species through a Gulfwide coordinated approach.

3.1.2.2. Marine Waters

The marine water, within the area of interest, can be divided into three regions: the continental shelf west of the Mississippi River, the continental shelf east of the Mississippi River, and deepwater (>400 m). For this discussion, the continental shelf includes the upper slope to a water depth of 400 m. While the various parameters measured to evaluate water quality do vary in marine waters, one parameter, pH, does not. The buffering capacity of the marine system is controlled by carbonate and bicarbonate, which maintain the pH at 8.2.

Continental Shelf West of the Mississippi River

The Mississippi and Atchafalaya Rivers are the primary sources of freshwater, sediment, and pollutants to the continental shelf west of the Mississippi (Murray, 1997). The drainage basin that feeds the rivers covers 55 percent of the contiguous U.S. While the average river discharge from the Mississippi River exceeds the input of all other rivers along the Texas-Louisiana coast by a factor of 10, during low-flow periods, the Mississippi River can have a flow less than all the other rivers combined (Nowlin et al., 1998). This area is highly influenced by input of sediment and nutrients from the Mississippi and Atchafalaya Rivers. A turbid surface layer of suspended particles is associated with the freshwater plume from these rivers. A nepheloid layer composed of suspended clay material from the underlying sediment is always present on the shelf. The river system supplies nitrate, phosphate, and silicate to the shelf. During summer months, the low-salinity water from the Mississippi River spreads out over the shelf, resulting in a stratified water column. While surface oxygen concentrations are at or near saturation, hypoxia, defined as oxygen (O_2) concentrations less than 2 milligrams (mg) per liter (l) O_2, is observed in bottom waters during the summer months.

The zone of hypoxia on the Louisiana-Texas shelf is one of the largest areas of low oxygen in the world's coastal waters (Murray, 1997). The oxygen-depleted bottom waters occur seasonally and are affected by the timing of the Mississippi and Atchafalaya Rivers' discharges carrying nutrients to the surface waters. This, in turn, increases the carbon flux to the bottom, which, under stratified conditions, results in oxygen depletion to the point of hypoxia (<2 mg/l O_2). The hypoxic conditions last until local wind-driven circulation mixes the water again. The area of hypoxia stretched over 17,000 km^2 at its peak and was observed as far away as Freeport, Texas. Increased nutrient loading since the turn of the 19th century correlates with the increased extent of hypoxic events (Eadie et al., 1992), supporting the theory that hypoxia is related to the nutrient input from the Mississippi and Atchafalaya River systems.

Shelf waters or sediments off the coast of Louisiana are contaminated with trace organic pollutants including polynuclear aromatic hydrocarbons (PAH), herbicides such as Atrazine, chlorinated pesticides, and polychlorinated biphenyls (PCB), and trace inorganic (metals) pollutants, for example, mercury. The concentrations of chlorinated pesticides and PCB's, which are associated with suspended particulates and sediment, continue to decline since their use has been discontinued. The source of these contaminants is the river water that feeds into the area.

Continental Shelf East of the Mississippi River

Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge, run-off from the coast, and eddies from the Loop Current. The Mississippi River accounts for 72 percent of the total discharge onto the shelf (SUSIO, 1975). The outflow of the Mississippi River generally extends only 75 kilometers (km) (45 mi) to the east of the river mouth (Vittor and Associates, Inc., 1985) except under extreme flow conditions. The Loop current intrudes in irregular intervals onto the shelf, and the water column can change from well mixed to highly stratified very rapidly. Discharges from the Mississippi River can be easily entrained in the Loop Current. The flood of 1993 provided an infusion of fresh water to the entire northeastern GOM shelf with some Mississippi River water transported to the Atlantic Ocean through the Florida Straits (Dowgiallo, 1994). Hypoxia is rarely observed on the Mississippi-Alabama shelf, although low dissolved oxygen values of 2.93-2.99 mg/l were observed during the MAMES cruises (Brooks, 1991).

The Mississippi-Alabama shelf sediments are strongly influenced by fine sediments discharged from the Mississippi River. The shelf area is characterized by a bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow. The West Florida Shelf has very little sediment input with primarily high-carbonate sands offshore and quartz sands nearshore. The water clarity is higher towards Florida, where the influence of the Mississippi River outflow is rarely observed.

A three-year, large-scale marine environmental baseline study conducted from 1974 to 1977 in the Eastern GOM resulted in an overview of the Mississippi, Alabama, and Florida (MAFLA) OCS environment to 200 m (SUSIO, 1977; Dames and Moore, 1979). Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources. Analysis of trace metal contamination for the nine trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination. A decade later, the continental shelf off Mississippi and Alabama was revisited (Brooks, 1991). Bottom sediments were analyzed for high-molecular-weight hydrocarbons and heavy metals. High-molecular-weight hydrocarbons can come from natural petroleum seeps at the seafloor or recent biological production as well as input from anthropogenic sources. In the case of the Mississippi-Alabama shelf, the source of petroleum hydrocarbons and terrestrial plant material is the Mississippi River. Higher levels of hydrocarbons were observed in the late spring, which coincides with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks, 1991).

The SAIC (1997) summarized information about water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to 200-m water depth. Several small rivers and the Loop Current are the primary influences on water quality in this region. Because there is very little onshore development in this area, the waters and surface sediments are uncontaminated. The Loop Current flushes the area with clear, low-nutrient water.

More recent investigations of the continental shelf east of the Mississippi River confirm previous observations that the area is highly influenced by river input of sediment and nutrients (Jochens et al., in preparation). Hypoxia was not observed on the shelf during the three years of the study.

Deepwater

Limited information is available on the deepwater environment. Water at depths greater than 1,400 m is relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin, 1972; Pequegnat, 1983; Gallaway et al., 1988). Of importance, as pointed out by Pequegnat (1983), is the flushing time of the GOM. Oxygen in deep water must originate from the surface and be mixed into the deep water by some mechanism. If the replenishment of the water occurs over a long period of time, the addition of nonnaturally occurring hydrocarbons through the discharge from oil and gas activities could lead to low oxygen and potentially hypoxic conditions in the deep water of the GOM. The time scales and mechanism for maintaining the high oxygen levels in the deep GOM are unknown.

Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefry, 1981; Gallaway et al., 1988). Hydrocarbon seeps are extensive throughout the continental slope and contribute hydrocarbons to the surface sediments and water column, especially in the Central GOM (Sassen et al., 1993a and b). MacDonald et al. (1993) observed 63 individual seeps using remote sensing and submarine observations. Estimates of the total volume of seeping oil vary widely from 29,000 bbl/yr (MacDonald, 1998) to 520,000 bbl/yr (Mitchell et al., 1999). These estimates used satellite data and an assumed slick thickness. In addition to hydrocarbon seeps, other fluids leak from the underlying sediments into the bottom water along the slope. These fluids have been identified to have three origins: (1) seawater trapped during the settling of sediments; (2) dissolution of underlying salt diapirs; and (3) deep-seated formation waters (Fu and Aharon, 1998; Aharon et al., 2001). The first two fluids are the source of authigenic carbonate deposits while the third is rich in barium and is the source of barite deposits such as chimneys.

3.2. Biological Resources

3.2.1. Sensitive Coastal Environments

3.2.1.1. Coastal Barrier Beaches and Associated Dunes

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

- a shoreface — which slopes downward and seaward from the low tidal waterline, under the water,

- a foreshore — usually nonvegated sloping up from the ocean to the beach berm crest, and
- a back shore — typically found between the beach berm-crest and dune area, sparsely vegetated. The berm-crest and backshore may occasionally be absent due to storm activity.

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

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

Larger changes to barrier landforms are primarily due to storms, subsidence, deltaic cycles, longshore currents, and human activities. Barrier landform configurations continually adjust, accreting and eroding, in response to prevailing and dynamic environmental conditions. Shifts in landform can be seasonal and cyclical, as seen in onshore movement of sand during the summer and offshore movement during the winter, which is due to seasonal meteorological and wave-energy differences. Non-cyclical changes in landforms can be progressive, causing landform movement landward, seaward, or laterally along the coast.

Lateral movement of barrier landforms is of particular importance. As headlands and beaches erode, sediments are transported laterally along the shoreline or offshore. Eroding headlands typically extend sand spits that may encape marshes or previously open, shallow GOM waters. By separating inshore waters from GOM waters and slowing the dispersal of freshwater into the GOM, movements of barrier landforms contribute to the area and diversity of estuarine habitat along a coast. Most barrier islands around the GOM are moving laterally to some degree. Where this occurs, the receding end of the island is typically eroding; the leading end accretes. These processes may be continuous or cyclic.

Accumulations and movements of sediments that make up barrier landforms are often described in terms of regressive and transgressive sequences. Although transgressive landforms dominate around the GOM, both transgressive and regressive barriers occur there. A regressive sequence deposits terrestrial sediments over marine deposits, building land into the sea, as would be seen during deltaic land-building processes. Regressive barriers have high and broad dune profiles. These thick accumulations of sand may form parallel ridges.

A transgressive sequence moves the shore landward, allowing marine deposits to form on terrestrial sediments. Transgressive coastal landforms around the GOM have low profiles and are characterized by narrow widths; low, sparsely vegetated, and discontinuous dunes; and numerous, closely spaced, active washover channels. Landward movement or erosion of a barrier shoreline may be caused by any combination of subsidence, sea-level rise, storms, channels, groins, seawalls, and jetties. These influences are discussed under the cumulative activities scenario (**Chapter 4.1.3.3.**, Other Major Influencing Factors on Coastal Environments). Movement of barrier systems is not a steady process because the passage rates and intensities of cold fronts and tropical storms, as well as intensities of seasons, are not constant (Williams et al., 1992).

Texas and Mexican Barrier Island Complex

The Texas GOM coastline is approximately 590 km long. The geomorphological structures we see today in the Laguna Madre of Texas are an expression of historical development as well as present day processes. The barrier islands in this region are mostly accreted sediments that were reworked from river deposits, previously accreted GOM shores, bay and lagoon sediments, and exposed seafloors (White et al., 1986). This reworking continues today as these barrier beaches and islands move generally to the southwest (Price, 1958).

The highest elevations on barrier islands in Texas occur along foredune ridges landward from GOM beaches. Padre Island has the highest dunes along the Texas coast; some are as high as 15.2 m (50 ft) above sea level (Weise and White 1980). However, average dune heights range from 6.1 to 7.6 m (20-25 ft) on north Padre Island (Brown et al., 1976).

The beaches of Galveston Island and Bolivar Peninsula are locally eroding or accreting. Accreting shorelines have a distinct beach berm and a wide back beach. Eroding beaches are relatively narrow, and the beach berm and back beach may be absent. Construction of seawalls and jetties on Galveston Island has contributed to erosion there, as discussed further in **Chapter 4.1.3.3.**

Exceptions to the above are the once regressive Matagorda Peninsula and Rio Grande Headland. The Matagorda Peninsula accreted as the Brazos-Colorado River Delta. Later, the peninsula became transgressive and the sediments were reworked to form flanking arcs of barrier sand spits. Washover channels cut the westward arc of the peninsula, forming barrier islands. The Rio Grand Headland has also become transgressive and sand spits formed to its north and south. Today, longshore drift is southerly at these sites. Their northern spits and southern spits are now eroding and accreting, respectively.

The Chenier Plain

The Chenier Plain region of Texas and Louisiana began developing during a period when the Mississippi River Delta sediments were sporadically eroded and reworked, ultimately, being deposited into the Chenier Plain region via storms and coastal currents.

This deposition gathered huge volumes of mud and sand, forming a shoreface that slopes very gently, almost imperceptiblydownward for an extended distance offshore. This shallow mud bottom is viscous and elastic, generating hydrodynamic friction (Bea et al., 1983). Hence, wave energies along the barrier shorelines of the Chenier Plain are greatly reduced, causing minimal longshore sediment transport along the Chenier Plain (USDOI, GS, 1988). More recently, this shoreline has been eroding as sea level rises, converting most of this coast to transgressive shorelines.

Present day, the Red River and about 30 percent of the Mississippi River are diverted to the Atchafalaya River. The diversions have increased the sediment load in the longshore currents, which generally move slowly westward along the coast.

The barrier beaches of the Chenier Plain are generally narrow, low, and sediment starved due to the natures of coastal currents and the shoreface. Here and there, beach erosion has exposed relic marsh terraces that were buried by past overwash events. West of Fence Lake, Texas, and no more than 200 ft wide, the beach is a fairly typical composition of shell and sand and similar shoreface sediments (Fisher et al., 1973).

East of Fence Lake, the shoreface contains discontinuous mud deposits among muddy sands. During low tides, extensive mudflats are exposed east and west of Fence Lake. The beach in this area is much narrower and becomes a low escarpment where wave action cuts into the salt marsh (Fisher et al., 1973). In the vicinity of Louisiana's Constance Beach and Peveto, the rapidly eroding beach may be as much as 60 ft wide, where it exists. In this vicinity, erosion threatens Louisiana State Highway 82 and a few houses. In these more rapidly eroding areas, the beach is replaced by rip-rap and bulkheads (Mann and Thompson, 2001). In 1988, the U.S Geological Survey reported that general shoreline retreat along the Chenier Plain had been three or more meters per year. Since then, a series of offshore wave breaks have been placed from Constance Beach to Holly Beach, Louisiana, to reduce erosion and to retain sediments. These circumstances and current remedies are discussed in greater detail in **Chapter 4.1.3.3.**

The dune ridges of the Chenier Plain's shoreline are generally well vegetated. Their elevations along the Texan segment are generally less than 5 ft (Fisher et al., 1973). Transects taken along the beach in the vicinity of Oceanview Beach to Holly Beach indicate that the dune ridge ranged between 7 and 12 ft National Geodetic Vertical Depth (NGVD). For comparison, the high-water shoreline position during October 1992 through July 1994 was estimated to be fairly stable, approximately 3.5 ft NGVD (Byrnes and McBride, 1995).

The Mississippi River Delta Complex

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

The shorefaces of the Mississippi River Delta complex generally slope very gently seaward, which reduces wave energies at the shorelines. Mud flats are exposed during very low tidal events. The slope here is not as shallow as that found off the Chenier Plain. The steepest shoreface of the delta is found at the Caminada-Moreau Coast, where the greatest rates of erosion are seen. At this site, the longshore currents split to the east and west, which removes sand from the area without replenishing it (Wolfe et al., 1988; Wetherell, 1992; Holder and Lugo-Fernandez, 1993).

Regressive shorelines do occur in Louisiana's deltaic region. The diversion of the Red River and about 30 percent of the Mississippi River to the Atchafalaya River has allowed transport of large volumes of sediment into shallow Atchafalya Bay. There, inland deltas are forming at the mouths of that river and Wax Lake Outlet, which are discussed more fully under **Chapter 4.1.3.3.** Recent satellite photography of these deltas reveal that dredge-disposal islands were constructed off Point au Fer in very shallow water (3-5 ft) at the mouth of Atchafalaya Bay. These islands and surrounding shallows are the foundations for a future barrier shoreline in this area, if the Atchafalaya River Delta continues to build seaward as expected.

Smaller shoreline regressions also occur as a result of jetties located on the eastern end of Grand Isle, the western end of Caminada-Moreau Beach, Empire navigational canal, and elsewhere. The circumstances of these situations are discussed more completely in **Chapter 4.1.3.3.**

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

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

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

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

Mississippi and Alabama Coasts

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

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

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

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

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

Florida

A 42-mi line of barrier islands extends north from the mouth of Tampa Bay. These islands are generally low and flat, without conspicuous dunes. Their foundations are mostly limestone about 12 ft below sea level. Historically, the littoral drift may have diverged at Indian Rocks, Florida, creating a southerly drift south of that site and a northerly drift north, building Anclote Keys, the northern most islands in this system. More recently, records indicate that the net sediment drift at the passes between all of these islands is southerly and that the offshore tidal range in the vicinity of these islands is between 76 and 88 centimeters (cm). North of Anclote Keys, the zero energy seas of the Big Bend begin; this area is discussed below (Kwon, 1969).

The Big Bend Coast of Florida is very different from the sandy coast around the rest of the GOM. The Big Bend Coast stretches about 300 km between the Ochlockonee River, on the western boundary of Wakulla County, and the Anclote Keys of Pasco County, Florida. This shoreline and its associated continental shelf have a very low gradient, which gently slopes out into the GOM. This gradient helps lower the wave energy and modifies the waves to a wide profile and low, average breaker height. The area also has a small tidal range. Together, these circumstances generally cause less sediment movement.

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

Historically, the Big Bend Coast has had very limited sediment cover because very few large streams carrying sediments discharged into this region. Today, the largest of these is the Suwannee River, which carries very little sediment since it largely drains limestone.

3.2.1.2. Wetlands

Wetland habitats found along the Central and Western GOM Coast include fresh, intermediates, brackish, and saline marshes; mud and sand flats; and forested wetlands of mangrove swamps, cypress-tupelo swamps, and bottomland hardwoods. Coastal wetland habitats occur as bands around waterways and as broad expanses. Saline and brackish habitats support sharply delineated, segregated stands of single plant species. Fresh and very low salinity environments support more diverse and mixed communities of plants. The plant species that occur in greatest abundance vary greatly around the GOM. According to the USDOI (Dahl, 1990; Henfer et al., 1994), during the mid-1980's, 4.4 percent of Texas (3,083,860 ha) (Henfer et al., 1994), 28 percent of Louisiana (3,557,520 ha), 14 percent of Mississippi (17,678,730 ha), and 8 percent of Alabama (1,073,655 ha) were considered wetlands. During the prior 10 years, these States' wetland areas decreased by 1.6-5.6 percent. Additionally, the coastal counties of Florida contain about 2,448,725 ac (994,950 ha) of wetlands. Reviewers of this document are referred to ecological characterization and inventory studies conducted by the FWS, in cooperation with other agencies; the Texas Bureau of Economic Geology; and other researchers (Gosselink et al., 1979; Gosselink, 1984; Smith, 1984; Fisher et al., 1972 and 1973; Brown et al., 1976 and 1977; Stout et al., 1981).

The importance of wetlands to the coastal environment has been well documented. See the above listed characterization and inventory studies. High organic productivity and efficient nutrient recycling are characteristic of coastal wetlands, providing habitat for a great number and wide diversity of resident plants, invertebrates, fishes, reptiles, birds, and mammals. Marsh environments are particularly important nursery grounds for many economically important fish and shellfish juveniles. The marsh edge, where marsh and open water come together, is especially important for higher productivity and greater concentrations of organisms. Emergent plants produce the bulk of energy that supports salt-marsh dependent animals. Freshwater-marsh environments generally contain a much higher diversity of plants and animals than do those of saline marshes.

The GOM coastal wetlands also support the largest fur harvest in North America, producing 40-65 percent of the nation's yearly total in Louisiana (Olds, 1984). They also support over two-thirds of the Mississippi Flyway wintering waterfowl population and much of North America's puddle duck population.

Texas

Landward of the barrier beaches of Texas, estuarine marshes largely occur as continuous and discontinuous bands around bays, lagoons, and river deltas. Broad expanses of emergent wetland vegetation do not commonly occur south of Baffin Bay because of the arid climate and hypersaline water. In the vicinity of southern Padre Island and compared to the more northern GOM, marshes are minimal and unstable.

Brackish marshes occur in less saline, inland areas and are divided into frequently and infrequently flooded marshes. Infrequently flooded marshes contain an assemblage of plants that are much more tolerant of dry conditions. Freshwater marshes in Texas occur inland above tidally delivered saline waters in association with streams, lakes, and catchments. Broken bands of black mangroves (*Avicennia germinans*) also occur in this area (Brown et al., 1977; White et al., 1986; Smith, 2001).

Wind-tidal flats of mud and sand are mostly found around shallow bay margins and in association with shoals. As one goes farther south from Corpus Christi, flats increasingly replace lagoonal and bay marshes. Laguna Madre of Texas is divided into northern and southern parts by the wind-tidal flats of the Land-Cut Area, just south of Baffin Bay. The Intracoastal Waterway is dredged through this area, as are a series of well access channels. Dredging has caused topographic and vegetative changes among the flats of Laguna Madre.

Frequently flooded flats usually remain moist and may have mats of blue-green algae and an area-specific assemblage of invertebrates. Infrequently flooded flats are at higher elevations where only tides that are driven by strong wind can flood them. These are better drained and much dryer. Higher tidal flats remain barren because of the occasional saltwater flooding and subsequent evaporation that raises salt concentrations in the soil, which inhibits most plant growth; however, various salt-marsh plants that are tolerant of dry conditions may be found there. Some higher flats are nontidal, barren fan deltas and barren channel margins along streams containing soils having elevated salt concentrations (Brown et al., 1977; White et al., 1986; Smith, 2001). Inland beaches of sand and shells are found along the shores of bays, lagoons, and tidal streams. The structure of these beaches is similar to barrier beaches, but much narrower and smaller in scale. Compared to sand beaches, shell features are typically piled to higher elevations by storm waves and generally more stable.

Few freshwater swamps and bottomland hardwoods occur in the general vicinity of OCS-related service bases and navigational channels of the Texas barrier island area. In the southern third of this area, they are nonexistent (Brown et al., 1977; White et al., 1986).

Chenier Plain

Beginning about 2,800 years ago and as sea level dropped during the last ice age, sediments from the Mississippi River and delta were intermittently modified and deposited by storms and coastal currents, ultimately forming the Chenier Plain between Port Bolivar, Texas, and Atchafalaya Bay, Louisiana. As the area developed, a series of shell and sand ridges were formed parallel or oblique to the present-day Gulf Coast and were later abandoned as sea level continued to fall. Mudflats formed between the ridges when localized hydrologic and sedimentation patterns favored deposition there. This intermittent deposition isolated entrenched valleys from the GOM, forming large lakes such as Sabine, Calcasieu, White, Grand, and others (Gosselink et al., 1979; Fisher et al., 1973). This reduces the tidal movement of saline water; consequently, few tidal passes are found along this coast as compared to central Texas and eastern Louisiana.

Because of the structure of the Chenier Plain and its beaches, salt marshes are not as widely spread there as elsewhere in the northern GOM. Generally in this area, salt marshes directly front the GOM and are frequently submerged by tides and storms. Therefore, they are considered high-energy environments when compared to most vegetated wetlands.

Brackish and intermediate salinity marshes are dominant in estuarine areas of the Chenier Plain. They are tidal, although wind-driven tides are more influential and occasionally inundate these areas. Since salinity in this area ranges broadly, these habitats support a mix of salt and salt-tolerant freshwater plants, although marsh-hay cordgrass is generally dominant. These habitats are the most extensive and productive in coastal Louisiana.

Plant communities of freshwater marshes are among the most diverse among sensitive coastal environments. Annuals have a much greater presence in freshwater marshes than in estuarine areas. Dominance often changes from season to season as a result of year-round seed-germination schedules. Freshwater wetlands are extensive in the Chenier Plain due to the abundant rainfall and runoff coupled with the ridge system that retains freshwater and restricts the inflow of saline waters. Tidal influences are generally minimal in these areas, although strong storms may inundate the area. Hence, detritus is not as readily exported and accumulates there, supporting additional plant growth. Freshwater marsh plants are generally more buoyant than estuarine plants. In areas where detritus collects thickly, marsh plants may form floating marshes, referred to as “flotants.” Flotants generally occur in very low-energy environments. They are held together by surrounding shorelines and a intermingling of slowly deteriorating plant materials and living roots.

Forested wetlands are not very common in the Chenier Plain, occurring only in the flood plain regions of major streams, along the northern margin of this area. There, cypress-tupelo swamps grade through stands of blackwillow to bottomland hardwoods.

Mississippi River Delta Complex

Over the past 6,000 years, the Mississippi River Delta Complex has formed a plain composed of a series of overlapping riverine deltas extending onto the continental shelf. Wetlands on this deltaic plain are the most extensive of those within this EIS’s area of attention.

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

Except for leveed areas and the delta and basin of the Atchafalaya River, all of these deltas are generally experiencing succession towards wetter terrestrial and deeper water habitats. This is due to deltaic abandonment and human actions and their ensuing erosion. Most of these wetlands are built upon highly organic soils, which are easily eroded, compacted, and oxidized. These problems are discussed in **Chapter 4.1.3.3.**

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

The less active delta is at the mouth of the Mississippi River, which is referred to as the Belize or Birdfoot Delta. The Mississippi River has been channelized throughout most of this delta, greatly reducing the volume of sediments that it contributes to the delta and longshore currents near the mouths of its distributaries. A few man-made diversions have been installed that are designed to deliver water rather than sediments to this delta.

The 1990 estimates of coastal Louisiana wetland acreage in a nine-basin area based on the COE database are described below:

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

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

Direct causes of Louisiana wetland loss may be attributed to the following activities:

- dredging and stream channelization for navigation channels and pipeline canals;
- filling for dredged material and other solid-waste disposal;
- roads and highways;
- industrial expansion; and
- accidental discharge of pollutants into wetlands.

Indirect causes of wetland loss may be attributed to the following:

- sediment diversion by dams, deep channels, and other structures;
- hydrologic alterations by canals, dredged-material disposal banks, roads, and other structures; and
- subsidence due to extraction of groundwater, oil, gas, sulfur, and other minerals.

Mississippi and Alabama

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

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

Florida

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

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

Florida Mangroves

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

Florida's estimated 469,000 ac of mangrove forests contribute to the overall health of the State's southern coastal zone. This ecosystem traps and cycles various organic materials, chemical elements, and important nutrients. Mangrove roots act not only as physical traps but provide attachment surfaces for various marine organisms. Many of these attached organisms filter water through their bodies and, in turn, trap and cycle nutrients.

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

Worldwide, more than 50 species of mangroves exist. Of the three species found in Florida, the red mangrove (*Rhizophora mangle*) is probably the most well known. It typically grows along the water's edge. The red mangrove is easily identified by its tangled, reddish roots called "prop-roots." These roots have earned mangroves the title "walking trees." This mangrove, in particular, appears to be standing or walking on the surface of the water. The black mangrove (*Avicennia germinans*) usually occupies slightly higher elevations upland from the red mangrove. The black mangrove can be identified by numerous finger-like projections, called pneumatophores, that protrude from the soil around the tree's trunk. The white mangrove (*Laguncularia racemosa*) usually occupies the highest elevations farther upland than either the red or black mangroves. Unlike its red or black counterparts, the white mangrove has no visible aerial root systems. The easiest way to identify the white mangrove is by the leaves. They are elliptical, light yellow green and have two distinguishing glands at the base of the leaf blade where the stem starts. All three of these species utilize a remarkable method of propagation. Seeds sprout while still on the trees and drop into the soft bottom around the base of the trees or are transported by currents and tides to other suitable locations.

Florida's mangroves are tropical species; therefore, they are sensitive to extreme temperature fluctuations as well as subfreezing temperatures. Research indicates that salinity, water temperature, tidal fluctuations, and soil also affect their growth and distribution. Mangroves are common as far north as Cedar Key on the Gulf Coast and Cape Canaveral on the Atlantic Coast. Black mangroves can occur farther north in Florida than the other two species. Frequently, all three species grow intermixed.

Mangroves provide many benefits to the people living along the south Florida coast. Mangrove forests protect uplands from storm winds, waves, and floods. The amount of protection afforded by mangroves depends upon the width of the forest. A very narrow fringe of mangroves offers limited protection, while a wide fringe can considerably reduce wave and flood damage to landward areas by enabling overflowing water to be absorbed into the expanse of forest. Mangroves can help prevent erosion by stabilizing shorelines with their specialized root systems. Mangroves also filter water and maintain water quality and clarity.

3.2.1.3. Seagrass Communities

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

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

Texas

Seagrasses along the Texas coast are widely scattered beds in shallow, high-salinity coastal lagoons and bays. The most extensive seagrass beds are found in both the Upper and Lower Laguna Madre along the Texas coast, as well as Baffin Bay. In the Texas Laguna Madre, seagrass meadows are the most common submerged habitat type. Although permanent meadows of perennial species occur in nearly all bay systems along the Texas Gulf Coast, most of the State's seagrass cover (79%) is found in the Laguna Madre (Pulich, 1998), with seagrasses currently covering about 243 km^2 in the upper portion of the Laguna Madre (Quammen and Onuf, 1993). Seagrasses are largely excluded from bays north of Pass Cavallo where rainfall and inflows are high and salinity's average less than 20 ppt, as well as the upper, fresher portions of most estuaries. Seagrasses in the Laguna Madre constitute a unique resource that cannot be duplicated elsewhere on the Texas coast (Withers, 2001). Lower-salinity, submerged beds of aquatic vegetation are found inland and discontinuously in coastal lakes, rivers, and the most inland portions of some coastal bays.

Louisiana, Mississippi, and Alabama

The turbid waters and soft, highly organic sediments of Louisiana's estuaries and offshore areas limit widespread distribution of higher salinity seagrass beds. Consequently, only a few areas in offshore Louisiana, mostly in Chandeleur Sound, support seagrass beds and associated fauna. In coastal Mississippi during 1973, about 8,100 ha of seagrass beds were reported. In 1985, about 1,800 ha of seagrass beds were associated with the State's barrier islands. Stout et al. (1981) reported 1,105 ha of submerged vegetation beds in the coastal zone of Alabama. These beds primarily occur in Mississippi Sounds and associated bays to the north along the islands to the south. A few beds are found along the shores on Mobile Bay and in the rivers and wetlands that feed into the bay.

Florida

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

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

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

3.2.2. Sensitive Offshore Benthic Resources

3.2.2.1. Continental Shelf Resources

3.2.2.1.1. Live Bottoms (Pinnacle Trend)

The Central GOM exhibits a region of topographic relief known as the "pinnacle trend," located offshore on the outer edge of the Mississippi-Alabama shelf between the Mississippi River and DeSoto Canyon. The pinnacles appear to be carbonate reefal structures in an intermediate stage between growth and fossilization (Ludwick and Walton, 1957). The region contains a variety of features ranging from low-relief rocky areas to major pinnacles, as well as ridges, scarps, and relict patch reefs. The heavily indurated pinnacles provide a remarkable amount of surface area for aggregating sessile invertebrates and attracting large numbers of fish. Additional hard-bottom features are located nearby on the continental shelf, outside the actual pinnacle trend area.

The features of the pinnacle trend provide a combination of topographic relief, occasionally in excess of 20 m, and hard substrate for the attachment of sessile organisms, thereby having greater potential to support significant live-bottom communities than surrounding areas on the Mississippi-Alabama Shelf. This potential to support live-bottom communities has made these features a focus of concern and discussion. The species composition of the pinnacle trend has been compared to the Antipatharian Zone and Nepheloid Zone described by Rezak and Bright (1978) and Rezak (CSA, 1985). The following description of the pinnacle-trend region is found in the Mississippi-Alabama Continental Shelf Ecosystems Study: Data Summary and Synthesis (Brooks, 1991).

Biological assemblages dominated by tropical hard-bottom organisms and reef fishes occupy a variety of topographic features that exist between 53 and 110 m in the northeastern GOM between the Mississippi River and DeSoto Canyon. The origins of the carbonate features vary. Some are small, isolated, low to moderate [relief] reefal features or outcrops of unknown origin. Some appear to be hard substrates exposed by erosion during sea level still-stands along late Pleistocene shorelines. Others appear to be small reefs that existed near these shorelines. The largest reefal features appear to have been offshore reefs. The structure of the summits of some reefs may also have been modified by Holocene erosional events following their initial period of growth (namely, the flat-topped reefs). Most appear to be deteriorating under the influence of bioerosional processes. Hard bottoms and associated organisms are evident on at least two salt domes within 50 km of the Mississippi River Delta.

The hermatypes that contributed to the development of these structures probably included coralline algae, reef-building corals, bryozoans, foraminiferans, and molluscs, among others. Present-day production of calcium carbonate is probably limited to an impoverished calcareous alga population on features cresting above 78 m (shallower in most areas). Features below this depth can most likely be considered completely drowned reefs.

Present-day biological assemblages on features in the northeastern GOM are dominated by suspension feeding invertebrates. Populations are depauperate on features of low topography, those habitats laden with fine sediments, and at the base of larger features (where resuspension of sediments limits community development). On larger features the diversity and development of communities appears to depend on habitat complexity; that is, the number of habitat types available to hard bottom organisms, and to some extent, the distance from the Mississippi River Delta. On reefs containing extensive reef flats on their summits, there are rich assemblages distinguished by a high relative frequency of sponges, gorgonian corals (especially sea fans), crinoids, and bryozoans. Due to the generally accordant depth of flat-topped reefs (62-63 m), coralline algae are also in abundance. Other organisms on reef flats include holothurians, basket stars, and myriads of fish (mostly, *Holanthias martinicensis* [roughtongue bass], *Hemanthias aureorubens* [streamer bass], and *Rhomboplites aurorubens* [vermilion snapper]). On reefs lacking this reef flat habitat, as well as on reef faces of flat-topped features, the benthic community is characterized by a high relative abundance of ahermatypic corals (both solitary and colonial scleractinians). Other frequently observed organisms on these rugged, often vertical reef faces include crinoids, gorgonians, sea urchins, and basket stars. Among other species, dense schools of *H. martinicensis*, *H. aureorubens* (streamer bass) and *Paranthias furcifer* (creole-fish) often occupy their summits.

Biological abundance and species diversity increase in relation to the amount of solid substrate exposed and to the variety of habitats available. Thus, low biological abundance and diversity characterize low relief features 2 m high. Features of intermediate relief (2-6 m high) may exhibit low or high abundance and diversity depending upon habitat complexity. High relief features (>6 m) have dense and diverse biotas whose composition varies with habitat type (i.e., flat reef tops vs. ragged reef sides). Depth in the water column appears not to play a major role in determining species composition except in the case of coralline algae, which have not been encountered below a depth of 78 m. Since most of the major species are suspension feeders, susceptibility to sedimentation does appear to limit species composition. Areas closest to the Mississippi River Delta are most affected, and this influence extends eastward for up to 115 km (70 mi) from the Delta. Living hermatypic corals have not been observed on topographic features of the Mississippi-Alabama shelf.

In assessing the overall health of the pinnacle trend live bottoms; Brooks (1991) concludes the following:

> Human impact in these environments appears to be minimal. Discarded debris or lost fishing gear (such as longlines), though present at many sites, was not abundant and, therefore poses little threat to the environment. Cables and lines can affect shallower reef communities, but probably have little impact at these depths once they become tangled on or lodged against reef structures. Fishing pressure on these relatively small features may reduce the population of the larger, commercially important species, which may explain the frequency of smaller individuals of unprofitable species on heavily fished reefs.

Continental Shelf Associates, Inc. (CSA, 1992a) investigated another portion of the Mississippi-Alabama continental shelf west and north of the areas investigated by Brooks. Three types of hard-bottom features were identified for biological characterization:

(1) pinnacle features present in approximately 80-90 m water depths;

(2) deepwater pinnacles and associated hard bottom located in approximately 110-130 m water depths; and

(3) suspected low relief, hard-bottom features in the central and eastern portions of the upper Mississippi-Alabama shelf in water depths shallower than 75 m.

Although the CSA biological investigations were fairly limited, they did study several significant topographic features.

Shinn et al. (1993) investigated an exploratory drill site in Main Pass Block 255. The drill site was located at 103-m water depth and was adjacent to a 4- to 5-m high rock pinnacle. The pinnacle feature had been impacted by drill muds and cuttings approximately 15 months prior to the investigation. In 1994, DelMar Operating Inc. re-investigated the disturbed site in Main Pass Block 255. Their findings (DelMar Operating, Inc., 1994) are summarized below:

> Locally the 330-ft (100 m) isobath appears to be the lower limit of any exposed carbonate material. Regionally, the 390-ft (120 m) isobath appears to be the lower limit regardless of pinnacle or mesa-like characteristics. Associated with the mesa-like features are carbonate RLM [reef-like mounds]. These RLM are typically less than 20 ft in length, 3 ft in height, and 4 ft in breadth.
>
> Throughout the area north and east of the existing template, the slope trends are locally interrupted by several RLM. The most significant seafloor feature in the site-specific area is the carbonate material at the edge of the mesa-like feature and the moderate slope break that it defines. Within this zone, several RLM can be identified sitting above the general local bathymetric trend. Current analysis of the RLM and the mesa-like features located throughout the region indicate that all of these features are believed to be more common than originally mapped.

A four-year study (1996-2000) characterizing and monitoring carbonate mounds on the Mississippi/Alabama OCS was recently completed by Continental Shelf Associates, Inc. and the Geochemical and Environmental Research Group (GERG) of Texas A&M University (TAMU) for USGS, Biological Resources Division (CSA and GERG, 2001). Five of the nine sites investigated during the four-year project are located in the CPA of the GOM and could potentially be affected by a proposed lease sale; the remaining four sites are outside the proposed lease sale area and will not be affected. Five sites investigated by CSA and GERG are included in this EIS. Each site is described as follows:

- Site 5 includes high relief with a tall, flattop mound near its center and a lower mound at its southwestern edge; a horseshoe shaped (100-m base diameter), medium-profile, flattop structure, with 8-m maximum relief and a base depth of 77 m (**Figure 3-4**). A fine sediment veneer occurred on all horizontal rock surfaces and was particularly evident on the top of the feature, filling all depressions. This pinnacle feature is known as Double-Top Reef and belongs to the shallow pinnacle trend in the central and northeastern GOM.

  There are distinct assemblages of organisms in different locations on these features. Organisms found on top of the large feature were family Stenogorgiinae, *Swiftia exserta*, *Stichopathes lutkeni*, *Antipathes* multiple species (spp.), Bebryce cinera/grandis, *Ctenocella* (*Ellisella*) spp., *Hypnogorgia pendula*, and other unidentified gorgonian corals. Hermatypic as well as ahermatypic corals were sparsely distributed on the top interior probably due to heavy accumulations of fine sediments. *Rhizopsammia manuelensis* was the dominant species on almost all surfaces of the smaller mounds associated with the feature. Other species found on the vertical face of the main feature and adjacent mounds included *Madracis/Oculina* species (sp.), *Madrepora carolina*, *Antipathes* spp., and *Stichopathes lutkeni*. Also present were the sea urchins *Stylocidaris affinis* and *Diadema antillarum*, a few unidentified sponge species, and small colonies of bryozoans.

- Site 6 is a low-relief site covering part of a large, carbonate hardground consisting of extensive areas of low-relief rock features. The features range up to about 1 m in height on a relatively flat seafloor and covered with a thin layer of fine sediments.

  There was a low-diversity biological community observed on these low-relief features. The most noticeable taxa include *Bebryce cinerea/grandis*, *Thesea* spp., *Ctenocella (Ellisella*) spp., *Antipathes*, and *Stichopates lutkeni*. *Rhizopsammia manuelensis* was relatively common on the few features with more than 1 m of relief, and *Madracis/Oculina* sp. and *Madrepora carolina* were also occasionally observed.

- Site 7 is a high-relief site located on a large, flat top mound. Known as "Alabama Alps," this pinnacle feature forms the northwestern terminus of a northwest to southeast aligned ridge and pinnacle arc paralleling the shelf edge (**Figure 3-4**) (USDOI, MMS, 2000). The sides of the feature range from nearly vertical walls stepping down to the seafloor to large attached monolithic structures that decrease in height farther from the site center. Along the western side of the site, there are numerous large rock overhangs and ledges several meters wide and deep, with some tilted at acute angles. Large, distinct sediment-filled depressions and channels were observed along the southern edge of the monitoring site.

  There is a distinct difference between the community on the flat top of the structure and that associated with the sloping sides and flanks. Biota observed on the top of the feature include *Bebryce cineriea/grandis*, *Ctenocella (Ellisella*) spp., *Nicella* spp., crinoids, *Antipathes* spp., *Stichopathes lutkeni*, coralline algae, several species of sponges; *Astrocyclus caecilia*, and *R. manuelensis*. The occurrence of *R. manuelensis* on the top of Site 7 may be due to the less uniform topography at this site. The species does not appear in the areas of lowest relief atop the feature. On the edges, sides, and adjacent rock structures, *R. manuelensis* is the dominant epibiota, with crinoids, *Antipathes* spp., *Stichopathes lutkeni*, coralline algae (down to approximately 76 m), *Madracis/Oculina* sp., the unidentified solitary scleractinian, and several sponges also observed. Along the exposed edges of the large rock overhangs, *Madracis/Oculina* sp. and unidentified scleractinian were abundant. In the areas of scattered shell and rubble surrounding the feature are crinoids, with small colonies of Antipathes spp. also in evidence.

- Site 8 is a medium-relief site with a rugged mound near its center and numerous crevices and overhangs associated with the feature. The mound is slightly elongated, approximately 40 m in north-south extent and 15 m in east-west extent, with a smaller mound located nearby to the east. The relief of the smaller mound is 7-8 m above the surrounding seafloor. The entire feature is covered by silt with areas of thicker deposits on horizontal surfaces and in depressions and crevices.

  Rhizopsammia manuelensis was evident on the entire structure from just above the base to the top, with lower densities observed on horizontal surfaces with a heavier silt accumulation. Other observed epibiota included the *Ctenocella* (*Ellisella*) spp., *Hypnogorgia pendula*, *Nicella* spp., Thesea spp., *Antipathes* spp., *Stichopathes lutkeni*, and *Madrepora carolina*. There is no obvious zonation of any of these taxa except for higher abundances of Hypnogorgia pendula occurring near the top of the feature. The arrow crabs, *Stenohynchus seticornis* and *Astrocyclus caecilia*, crinoids, and the sea urchins *Diadema antillarum* and *Stylocidaris affinis* were also observed on the mounds. The species colonizing the lower relief mounds appear similar in composition to those on the primary feature.

- Site 9 is low relief consisting of low subcircular mounds, generally 0.5-2 m in height with diameters of 5-20 m. There are a few features with up to 5-m relief with ledges, overhangs, and crevices. A few outcrops are much larger with heights up to 5 m and diameters greater than 10 m. Many of the medium to large structures are flattened and greatly undercut with wide overhangs and vertical holes down through the mounds. The bases of the features are covered with silt up to a height of about 0.5 m. Some areas of low rock are completely covered and the buried hard substrate is only apparent from the gorgonian fans and whips protruding through the silt.

Biota on the lower relief structures includes *Bebryce cinerea/grandis, Hypnogorgia pendula*, *Nicella* spp., *Swiftia exserta*, *Thesea* spp., *Ctenocella* (*Ellisella*) spp., *Antipathes* spp., *Madrepora carolina*, and occasional crinoids. *Ctenocella* (*Ellisella*) spp. had substantially higher abundances at this site than the other surveyed sites especially on the low-relief rock outcrops. Some smaller mounds (1 m in height) had few colonies of *R. manuelensis*; however, the larger mounds had very high numbers of *R. manuelensis* on the upper 2-3 m of the structure, along with larger octocoral fans.

3.2.2.2. Continental Slope and Deepwater Resources

The northern GOM is a geologically complex basin. It has been described as perhaps the most complex continental slope region in the world. This region has become much better known in the last three decades and the existing information is considerable, both from a geological and biological perspective. The first substantial collections of deep GOM benthos were made during the cruises of the U.S. Coast and Geodetic Steamer, *Blake*, between 1877 and 1880. Rowe and Menzel (1971) reported that their deep GOM infauna data was the first quantitative data published for this region. The first major study of the deep northern GOM was performed by a variety of researchers from Texas A&M University between 1964 and 1973 (Pequegnat, 1983). A total of 157 stations were sampled and photographed between depths of 300 and 3,800 m (the deepest part of the GOM). A more recent study was completed by LGL Ecological Research Associates and Texas A&M University in 1988, during which a total of 60 slope stations were sampled throughout the northern GOM in water depths between 300 and 3,000 m (Gallaway et al., 1988). As part of this multiyear study, along with trawls and quantitative box-core samples, 48,000 photographic images were collected and viewed.

The continental slope is a transitional environment influenced by processes of both the shelf and the abyssal (deep sea) GOM (>975 m). This transitional character applies to both the pelagic and the benthic realms. The highest values of surface primary production are found in the upwelling area north of the Yucatan Channel and in the DeSoto Canyon region. In general, the Western GOM is more productive in the oceanic region than is the Eastern GOM. It is generally assumed that all the phytoplankton is consumed by the zooplankton, except for brief periods during major plankton blooms. The zooplankton then egests a high percentage of their food intake as feces that sink toward the bottom. Most of the herbivorous zooplankton are copepods, calanoids being the dominant group (Pequegnat, 1983).

Compared to the shelf, there is less plankton on the slope and in the deep GOM. In addition, some of the planktonic species are specifically associated with either the slope or the deep sea. The biomass of plankton does not appear to be affected by seasonal changes. Some east-west variations noted among diatom species have been attributed to the effects of different watermasses, i.e., normal GOM waters versus those influenced by the Mississippi River (Pequegnat, 1983).

The 450-m isobath defines the truly deep-sea fauna. The aphotic zone at and beyond these depths (below the euphotic zone and extending to within a meter off the bottom) represents a huge mass of water. In these sunlight-deprived waters, photosynthesis cannot occur, and processes of food consumption, biological decomposition, and nutrient regeneration occur in cold and dark waters. The lowermost layer containing the last meter of water off the bottom and the bottom itself constitute the benthic zone. This zone is a repository of sediments where nutrient storage and regeneration take place in association with the solid and semisolid substrate (Pequegnat, 1983).

Most of the benthic fauna found on the deep slope and abyssal plain are endemic to those depths and have been grouped into seven faunal assemblages by Pequegnat (1983) and confirmed by LGL Ecological Research Associates, Inc. and Texas A&M University (1986). Although the number of distinct "zones" is now thought to be much fewer (probably only two, with a large transition between), these original descriptions are informative:

> The Shelf/Slope Transition Zone (150-450 m) is a very productive part of the benthic environment. Demersal fish are dominant, many reaching their maximum populations in this zone. Asteroids, gastropods, and polychaetes are common.
>
> The Archibenthal Zone has two subzones. The Horizon A Assemblage is located between 475 and 750 m. Although less abundant, the demersal fish are a major constituent of the fauna, as are gastropods and polychaetes. Sea cucumbers are more numerous. The Horizon B Assemblage, located at 775-950 m, represents a major change in the number of species of demersal fish, asteroids, and echinoids, which reach maximum populations here. Gastropods and polychaetes are still numerous.
>
> The Upper Abyssal Zone is located between 975 and 2,250 m. Although the number of species of demersal fish drops, the number that reach maximum populations dramatically increases. This indicates a group uniquely adapted to the environment. Sea cucumbers exhibit a major increase, and gastropods and sponges reach their highest species numbers here.
>
> The Mesoabyssal Zone, Horizon C Assemblage (2,275-2,700 m), exhibits a sharp faunal break. The number of species reaching maximum populations in the zone drops dramatically for all taxonomic groups.
>
> The Mesoabyssal Zone, Horizon D Assemblage (2,725-3,200 m), coincides with the lower part of the steep continental slope in the Western GOM. Since the Central GOM is dominated at these depths by the Mississippi Trough and Mississippi Fan, the separation of Horizon C and D Assemblages is not as distinct in the Central GOM. The assemblages differ in species constitution.
>
> The Lower Abyssal Zone (3,225-3,850 m) is the deepest of the assemblages. Megafauna is depauperate. The zone contains an assemblage of benthic species not found elsewhere.

Similar to the continental slope in general, the proposed lease sale area encompasses a vast range of habitats and water depths. The shallowest portion of the area is in the northwest corner at a depth of approximately 1,600 m. The deepest portion is in the southeastern corner reaching depths that could be considered abyssal for the GOM at a depth of about 3,000 m. The proposed lease sale area includes the lower portions of the DeSoto Canyon. This trough is the most notable sea-bottom feature on the upper slope in this area. Its formation has been attributed to a combination of erosion, deposition, and structural control of salt diapirs clustered in the vicinity (Harbison, 1968). Although the northeastern edge of the action area has a steep slope, unlike most submarine canyons, DeSoto Canyon has a comparatively gentle gradient; however, it does have significant impact on current structure, upwelling features, and resulting increases in biological productivity.

Contrary to a widely perceived view that very little is known about the deepwater environment in this area, numerous sample collections have been made inside the proposed lease sale area boundaries dating back to the mid-1960's. Pequegnat (1983) reported a total of six stations sampled within the proposed lease sale area ranging in depth from 2,140 to 2,743 m. Biological sampling was conducted at these stations between 1962 and 1969 using trawls, benthic skimmers, and camera lowering. An ongoing study recently funded by MMS, the Northern GOM Continental Slope Habitats and Benthic Ecology Study, includes seven additional sampling stations within the proposed lease sale area at a in depth of 2,300 m. Sampling at these stations includes box cores for sediment biota and chemistry, trawling, and bottom photography. All of the above-mentioned stations are listed in **Table 3-2** and depicted in **Figure 3-5.**

3.2.2.2.1. Chemosynthetic Communities

It should first be noted that no chemosynthetic communities have been discovered in the proposed lease sale area to date. The nearest known chemosynthetic community (and the farthest east of any known community) is located in Viosca Knoll (VK) Block 826 in water depths between 430 and 475 m, approximately 38 km to the west of the proposed lease sale area boundary. A large area of VK Block 826 (and parts of VK Blocks 825 and 870) has been well documented by ROV surveys performed in 1990 and reported by Oceaneering International, Inc. (1990) and Oceaneering and LGL (1991). Numerous areas of all three major types of chemosynthetic communities exist in the VK Block 826 including tube worms, clams, and mussels. There are also substantial colonies of the deep-sea coral, *Lophelia*, attached to areas of carbonate outcroppings, presumably resulting from biogenic precipitation of hydrocarbon gas seeps in the past. Although numerous chemosynthetic communities exist in the surveyed areas, many of these carbonate features are apparently not capable of supporting nonchemosynthetic megafauna at the present time or there has not been sufficient time for recruitment.

Discoveries of chemosynthetic communities in other parts of the GOM has been limited primarily by the diving depths of readily available research submersibles. Using simple extrapolation and some basic knowledge of geology of salt diapirism in the area, a relatively small area of the proposed lease sale area would be expected to support high-density chemosynthetic communities. The extreme deformation of salt formations seen throughout the Central GOM appears to abruptly end near the western boundary of the proposed lease sale area. Considering the geology of the area, the bulk of the proposed lease sale area is not conducive to hydrocarbon transport from deeper reserves to the surface. The area of the proposed lease sale that is most likely to have potential chemosynthetic communities would be a relatively small region of a few blocks in the northeastern corner of the proposed lease sale area, occupying water depths between 1,600 and 2,300 m. This area is in an area where the slope undergoes a rapid rise onto the western rim of the DeSoto Canyon. The discovery of the first chemosynthetic community in the GOM was made at the base of the Florida Escarpment, located to the southeast of the proposed lease sale area, during an Alvin dive in 1984 (Paull et al., 1984). This location is located at a considerable distance to the south of the proposed lease sale area at 26°02′ N. latitude and 84°55′ W. longitude (area of Vernon Basin Block 926), over 170 km to the southeast. These communities are supported by a different mechanism than those on the Central GOM slope. The escarpment community is exposed to high-salinity fluids rich in hydrogen sulfide originating from seeps coming from the adjacent carbonate platform rather than from hydrocarbon reserves migrating upward through faults below the communities.

Description

Chemosynthetic communities are remarkable in that they use a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth. Although the process of chemosynthesis is entirely microbial, chemosynthetic bacteria and their primary production can support thriving assemblages of higher organisms through symbiosis. The first discovery of deep-sea chemosynthetic communities (including higher animals) was made at hydrothermal vents in the eastern Pacific Ocean during geological explorations (Corliss et al., 1979). The principal organisms included tube worms, clams, and mussels that derive their entire food supply from symbiotic chemosynthetic bacteria, which obtain their energy needs from chemical compounds in the venting fluids. Similar communities were first discovered in the Eastern GOM in 1983 at the bottom of the Florida Escarpment in areas of "cold" brine seepage (Paull et al., 1984). The fauna here was found to be generally similar to vent communities including tube worms, mussels, and rarely, vesicomyid clams.

Chemosynthetic communities in the Central GOM were discovered concurrently by two groups in November 1984. During investigations by Texas A&M University to determine the effects of oil seepage on benthic ecology (until this investigation, all effects of oil seepage were assumed to be detrimental), bottom trawls unexpectedly recovered extensive collections of organisms thought to be chemosynthetic, including tube worms and clams (Kennicutt et al., 1985). At the same time, LGL Ecological Research Associates was conducting a research cruise as part of the multiyear MMS Northern GOM Continental Slope Study (LGL and Texas A&M University, 1986). Bottom photography resulted in a sequence of clear images of live vesicomyid clam communities similar to the larger species of chemosynthetic clams found near hydrothermal vents in the Pacific (images developed at sea). During the same LGL/MMS cruise (November 12, 1984, although not processed until a few weeks later) tube-worm communities were documented *in situ* for the first time in the Central GOM (Boland, 1986). This published image also described the unusual, possibly symbiotic, relationship between tube worms and the bivalve *Acesta* for the first time. These documented encounters occurred prior to the initial submersible investigations and first-hand descriptions of the Bush Hill community almost two years later in 1986 (Brooks et al., 1986; MacDonald et al., 1989).

Distribution

The northern GOM slope includes a stratigraphic section more than 10 km thick and has been profoundly influenced by salt movement. Mesozoic source rocks from Upper Jurassic to Upper Cretaceous generate oil in most of the GOM slope fields (Sassen et al., 1993a). Migration conduits supply fresh hydrocarbon materials through a vertical scale of 6-8 km toward the surface. The surface expressions of hydrocarbon migration are referred to as seeps. Geological evidence demonstrates that hydrocarbon and brine seepage has persisted in spatially discrete areas for thousands of years. The time scale for oil and gas migration (combination of buoyancy and pressure) from source systems is on the order of millions of years (Sassen, 1997).

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

The widespread nature of GOM chemosynthetic communities was first documented during contracted investigations by GERG of Texas A&M University for the Offshore Operators Committee (Brooks et al., 1986). The occurrence of chemosynthetic organisms dependent on hydrocarbon seepage has been documented in water depths as shallow as 290 m (very small and unsubstantial; Roberts et al., 1990) and as deep as 2,200 m (MacDonald, 1992). This depth range specifically places chemosynthetic communities in the deepwater region of the GOM, which is defined as water depths greater than about 300 m or 1,000 ft. Chemosynthetic communities are not found on the continental shelf. At least 43 communities are now known to exist in 41 blocks on the OCS (**Figure 3-6** and **Table 3-3**). Although a systematic survey has not been done to identify all chemosynthetic communities in the GOM, there is evidence indicating that many more such communities exist. The depth limits of discoveries probably reflect the limits of exploration (lack of submersibles capable of depths over 1,000 m). MacDonald et al. (1993 and 1996) have analyzed remote-sensing images from space that reveal the presence of oil slicks across the north-central GOM. Results confirmed extensive natural oil seepage in the GOM, especially in water depths greater than 1,000 m. A total of 58 additional potential locations were documented where seafloor sources were capable of producing perennial oil slicks (MacDonald et al., 1996). Estimated seepage rates ranged from 4 to 70 bbl/day (compared to less than 0.1 bbl/day for ship discharges; both normalized for 1,000 mi^2 [3,430 km^2]). This evidence considerably increases the area where chemosynthetic communities dependent on hydrocarbon seepage may be expected.

The densest aggregations of chemosynthetic organisms have been found at water depths of around 500 m and deeper. The best known of these communities was named Bush Hill by the investigators who first described it (MacDonald et al., 1989). It is a surprisingly large and dense community of chemosynthetic tube worms and mussels at a site of natural petroleum and gas seepage over a salt diapir in Green Canyon Block 185. The seep site is a small knoll that rises about 40 m above the surrounding seafloor of about 580-m water depth.

Stability

According to Sassen (1997) the role of hydrates at chemosynthetic communities has been greatly underestimated. The biological alteration of frozen gas hydrates was first discovered during the recent MMS study, "Stability and Change in Gulf of Mexico Chemosynthetic Communities." It is hypothesized (MacDonald, 1998) that the dynamics of hydrate alteration could play a major role as a mechanism for regulation of the release of hydrocarbon gasses to fuel biogeochemical processes and could also play a substantial role in community stability. Recorded, bottom-water temperature excursions of several degrees in some areas such as the Bush Hill site (4-5° Celsuis (C) at 500-m depth) are believed to result in dissociation of hydrates, resulting in an increase in gas fluxes (MacDonald et al., 1994). Although not as destructive as the volcanism at vent sites of the mid-ocean ridges, the dynamics of shallow hydrate formation and movement will clearly affect sessile animals that form part of the seepage barrier. There is potential of a catastrophic event where an entire layer of shallow hydrate could break free of the bottom and result in considerable impact to local communities of chemosynthetic fauna. At deeper depths (>1,000 m), the bottom-water temperature is colder (by approximately 3°C) and undergoes less fluctuation. The formation of more stable and probably deeper hydrates influences the flux of light hydrocarbon gases to the surface, thus influencing the surface morphology and characteristics of chemosynthetic communities. Within complex communities such as Bush Hill, oil seems less important than previously thought (MacDonald, 1998).

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

Precipitation of authigenic carbonates and other geologic events will undoubtedly alter surface seepage patterns over periods of 1-2 years; although based on direct observation, no changes in chemosynthetic fauna distribution or composition were observed at seven separate study sites (MacDonald et al., 1995). A slightly longer time period (12 years) can be referenced in the case of Bush Hill, the first community described *in situ* in 1986. No mass die-offs or large-scale shifts in faunal composition have been observed (with the exception of collections for scientific purposes) over the 16-year history of research at this site.

Biology

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

Individual lamellibranchid tube worms, the longer of two taxa found at seeps (the other is *Escarpia* sp.) can reach lengths of 3 m and live hundreds of years (Fisher et al., 1997). Growth rates determined from recovered marked tube worms have been variable, ranging from no growth of 13 individuals measured one year to a maximum growth of 20 mm per year in a Lamellibrachia individual. Average growth rate was 2.5 mm/yr for escarpids and 7.1 mm/yr for lamellibrachids. These are slower growth rates than their hydrothermal vent relatives, but Lamellibrachia individuals in the GOM can reach lengths

2-3 times that of the largest known hydrothermal vent species. Individuals of *Lamellibrachia* sp. in excess of 3 m have been collected on several occasions representing probable ages in excess of 400 years (Fisher, 1995). Vestimentiferan tube worm spawning is not seasonal and recruitment is episodic.

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

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

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

Preliminary information has been presented by Carney (1993) concerning the nonchemosynthetic animals (heterotrophs) found in the vicinity of hydrocarbon seeps. Heterotrophic species at seep sites are a mixture of species unique to seeps and those that are a normal component from the surrounding environment. Carney reports a potential imbalance that could occur as a result of chronic disruption. Because of sporadic recruitment patterns, predators could gain an advantage, resulting in exterminations in local populations of mussel beds.

Detection of Chemosynthetic Communities

Chemosynthetic communities cannot be reliably detected directly using geophysical techniques alone; however, hydrocarbon seeps that allow chemosynthetic communities to exist modify the geological characteristics in ways that can be remotely detected. These known sediment modifications include (1) precipitation of authigenic carbonate in the form of micronodules, nodules, or rock masses; (2) formation of gas hydrates; (3) modification of sediment composition through concentration of hard chemosynthetic organism remains (such as shell fragments and layers); (4) formation of interstitial gas bubbles or hydrocarbons; and (5) formation of depressions or “pockmarks” by gas expulsion. These features give rise to acoustic effects such as “wipeout zones” (no echoes), “hard bottoms” (strongly reflective echoes), bright spots (reflection-enhanced layers), or reverberant layers (Behrens, 1988; Roberts and Neurauter, 1990). Careful interpretation of remote-sensing evidence representing these various geophysical modifications can be used to predict potential locations for most types of communities, but, to date, this process remains imperfect.

As part of the recent MMS study “Stability and Change in Gulf of Mexico Chemosynthetic Communities,” Sager (1997) is characterizing the geophysical responses of seep areas that support chemosynthetic communities so that a protocol can be refined to use geophysical remote-sensing techniques to reliably locate chemosynthetic communities. One objective is to use geophysical mapping techniques to reduce the seafloor area that may require searching by much slower and expensive near-bottom techniques. An additional study involving groundtruthing of geophysical characteristics and observed chemosynthetic communities, which is currently underway (2000-2002), will also improve predicative capabilities.

3.2.2.2.2. Nonchemosynthetic Communities

Description

More than chemosynthetic communities are found on the bottom of the deep GOM. In contrast to early theories of the deep sea, animal diversity, particularly the smaller forms living in bottom sediments, rivals that of the richest terrestrial environments such as rain forests. Other types of communities include the full spectrum of living organisms also found on the continental shelf or other areas of the marine environment. Major groups include bacteria and other microbenthos, meiofauna (0.063-0.3 mm), macrofauna (greater than 0.3 mm), and megafauna (larger organisms such as crabs, sea pens, crinoids, and demersal fish). All of these groups are represented throughout the entire GOM—from the continental shelf to the deepest abyss at about 3,850 m (12,630 ft). Enhanced densities of these nonchemosynthetic heterotrophic communities have also been reported in association with chemosynthetic communities (Carney, 1993). Some of these heterotrophic communities found at and near seep sites are a mixture of species unique to seeps and those that are a normal component from the surrounding environment.

There are also rare examples of deepwater communities that would not be considered typical of the deep GOM continental slope. One example is represented by what was reported as a deepwater coral reef by Moore and Bullis (1960). In an area measuring 300 m in length and more than 20 nmi from the nearest known chemosynthetic community (Viosca Knoll Block 907), a trawl collection from a depth of 421-512 m retrieved more than 300 pounds of the scleractinian coral *Lophelia prolifera*. This type of unusual and unexpected community may exist in many other areas of the deep GOM.

Past Research

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

As previously mentioned, several stations from these two studies were located within the boundaries of the proposed lease sale area. Brief descriptions of each major group of benthic biological resources follow. Each group represents vastly different capacities for reproduction and recolonization and most have not typically been included in discussions of biological resources in the past.

Bacteria

Limited research has been done on bacteria in the deep sea and especially in the deep GOM. Environmental factors that control bacterial abundance in marine sediments remain poorly understood (Schmidt et al., 1998). Recent results also reported by Schmidt et al. (1998) suggest that sediment community bacterial abundance is relatively constant over a wide variety of geographic regions when direct bacterial counts are scaled to fluid volume (pore water) compared to the traditional dimension of dry sediment mass. In any event, the counts of bacteria in marine sediments center around 10^9 bacteria per ml fluid volume, in other words literally trillions per m^2.

Meiofauna

The density of meiofauna (size: <0.063 mm) was reported as approximately two orders of magnitude greater than the density of macrofauna (0.063-0.3 mm) throughout the depth range of the GOM continental slope by LGL/MMS (Gallaway et al., 1988). Overall mean abundance was 707 individuals per 10 cm^2 (707,000 per m^2) ranging from a low of 200 to a high of 1,100. These values are among the highest reported for the deep sea (Thiel, 1983). Densities were generally similar to those previously reported and generally decreased with increasing depth by a factor of three between 300 and 3,000 m. A total of 43 major groups were identified. Of these, representatives of five taxa of permanent meiofauna (Nematoda, Harpacticoidea, Polychaeta, Ostracoda, and Kinorhyncha), along with naupliar larvae (temporary meiofauna), comprised 98 percent of the collections as reported by Gallaway et al. (1988). The range of density values obtained for meiofauna varied by one order of magnitude. Some specific comparisons with depth showed a decisive decrease of abundance with depth (at the 5% statistical level), but this trend was not consistent through all seasons and areas of the GOM.

For the six stations located near the proposed lease sale area to the east, these trends were also true. Nematodes and harpacticoid copepods dominated the meiofauna groups. Stations E5 at 2,900-m water depth and E4 at 1,360 m had substantially lower densities than the other four stations at depths ranging from 625 to 850 m.

Macrofauna

Gallaway et al. (1988) reported a total of 1,569 different taxa of macrofauna on the continental slope, 90 percent of those identified to the level of genus or species. Nearly all macrofaunal species were infaunal invertebrates considered nominally epifaunal or surface dwelling, although some taxa were normally found in surficial sediments. The major group was annelid taxa including 626 polychete taxa. Overall abundance of macrofauna ranged from 518 to 5,369 individuals per m^2. Overall, there was also an approximate three-fold decrease in macrofaunal density with depth between 300 and 2,900 m similar to meiofauna (Pequegnat et al., 1990). Macrofauna abundance was somewhat lower on the eastern transect compared to the central slope transects.

Megafauna

Megafauna collections were made using two techniques in Gallaway et al. (1988): benthic photography and the use of an otter trawl ranging in depth between 300 and 2,882 m. Based on fish and invertebrates collected by trawling, invertebrates were 4-5 times more abundant than benthic fishes throughout all transects and designated depth zones. Other trends included higher densities of all megafauna in the study's Eastern GOM transect area (between 85°40′ and 85°15′ W. longitude) and lowest in the central area (between 89°40′ and 89°20′ W. longitude) and a tendency of densities to decrease below a depth of 1,550 m. Overall, benthic fish densities ranged from 0 to 704 fish per hectare (10,000 m^2). Overall megafauna invertebrates ranged from 0 to 4,368 individuals per hectare. Results of the MMS/LGL studies (Gallaway et al., 1988) supported the zonation scheme proposed by Pequegnat (1983).

All 60 stations in the MMS/LGL continental slope study (Gallaway et al., 1988) were also sampled by quantitative photographic methods. Although up to 800 images were obtained at each of the stations, due to the relatively small area "sampled" by each photograph (approximately 2 m^2), abundance of most megafauna taxa was low. Megafauna that did appear in benthic photographs generally indicated much higher densities than that obtained by trawling, with variations being more than four orders of magnitude in some cases. Overall density from photography was 8,449 animals per hectare. The highest density of any organism sampled by photography was that of a small sea cucumber (never obtained by trawling) resulting in a peak density of 154,669/ha.

Megafauna invertebrates captured during trawling were between four and five times more abundant than fishes at all depths on all transects in terms of average density (Pequegnat et al., 1990). The density of megafauna obtained by trawling was 3,241/ha on the central transect, 6,267/ha on the western transect, and 9,463/ha on the eastern transect.

Considering the six stations near the proposed lease sale area to the east, benthic photography yielded substantially higher megafaunal density (not including fish) at the shallower E2A station compared to the deeper suite of stations at 850 m (6,405/ha versus 990-1,590/ha, respectively). The deepest station, E5, resulted in an intermediate number of 2,293/ha. In general, the trawling results indicating substantially higher densities of fish and invertebrates on the eastern transect applies to the six stations inside the proposed lease sale area. This trend will be re-tested during the new Texas A&M University study mentioned previously (**Table 3-2**).

While the previous groups of sediment-dwelling organisms are considered immobile and unable to avoid disturbances caused by OCS activities, megafauna could be categorized into two groups: a nonmotile or very slow-moving group including many invertebrates; and a motile group including fish, crustaceans, and some types of invertebrates, such as semi-pelagic sea cucumbers, that can readily move over substantial distances.

3.2.3. Marine Mammals

Twenty-nine species of marine mammals occur in the GOM (Davis et al., 2000). The GOM's marine mammals (**Table 3-4**) are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales, dolphins, and their allies), as well as the order Sirenia, which include the manatee and dugong. Within the GOM, there are 28 species of cetaceans (7 mysticete and 21 odontocete species) and 1 sirenian species, the manatee (Jefferson et al., 1992). Various geographic locations referenced in this section are shown in **Figure 3-7.**

Prior to 1973, the California sea lion (*Zalophus californianus*) was sometimes reported in GOM waters (Gunter, 1977). These animals were likely escapees or released from sea life parks located in the region. It appears the animals did not form stable feral colonies, since extensive aerial and shipboard surveys conducted in the GOM during the last 10 years have not resulted in any sightings of this species. A California sea lion was photographed in November 1991 at the Marine Research Station at Holguin, Cuba (Laist, personal communication, 2001). The animal was captured two years earlier in a bay on the Caribbean coast of Cuba.

3.2.3.1. Nonendangered and Nonthreatened Species

Two of the seven species of mysticetes known to occur in the GOM are not presently listed as endangered or threatened. With the exception of the sperm whale, none of the odontocetes known to occur in the GOM are currently listed as endangered or threatened.

Cetaceans — Mysticetes

Bryde's Whale (Balaenoptera edeni)

The Bryde's whale (*Balaenoptera edeni*) is the second smallest of the balaenopterid whales; it is generally confined to tropical and subtropical waters (i.e., between latitude 40° N. and latitude 40° S) (Cummings, 1985). Unlike some baleen whales, it does not have a well-defined breeding season in most areas; thus, calving may occur throughout the year. The Bryde's whale feeds on small pelagic fishes and invertebrates (Leatherwood and Reeves, 1983; Cummings, 1985; Jefferson et al., 1993).

There are more records of Bryde's whale than of any other baleen whale species in the northern GOM. It is likely that the GOM represents at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997). Bryde's whale in the northern GOM, with few exceptions, has been sighted along a narrow corridor near the 100-m (328-ft) isobath (Davis and Fargion, 1996; Davis et al., 2000). Most sightings have been made in the DeSoto Canyon region and off western Florida, though there have been some in the west-central portion of the northeastern GOM. Group sizes range from one to seven animals. Abundance estimates are 29 and 25 individuals from ship and aerial surveys of the EPA slope, respectively, and 22 individuals for the oceanic northern GOM (Davis et al., 2000). These data suggest that the northern GOM may represent at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000).

Minke Whale (Balaenoptera acutorostrata)

The minke whale *(Balaenoptera acutorostrata*) is a small rorqual that is widely distributed in tropical, temperate, and polar waters. Minke whales may be found offshore but appear to prefer coastal waters. Their diet consists of invertebrates and fishes (Leatherwood and Reeves, 1983; Stewart and Leatherwood, 1985; Jefferson et al., 1993; Würsig et al., 2000).

At least three geographically isolated populations are recognized: North Pacific, North Atlantic, and Southern Hemisphere. The North Atlantic population migrates southward during winter months to the Florida Keys and the Caribbean Sea. There are 10 reliable records of minke whales in the GOM and all are the result of strandings (Jefferson and Schiro, 1997). Most records from the GOM have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro, 1997). Sightings data suggest that minke whales either migrate into GOM waters in small numbers during the winter or, more likely, that sighted individuals represent strays from low-latitude breeding grounds in the western North Atlantic (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000).

Cetaceans — Odontocetes

Pygmy and Dwarf Sperm Whales (Family Kogiidae)

The pygmy sperm whale (*Kogia breviceps*) and its congener, the dwarf sperm whale (*K. sima*), are medium-sized toothed whales that feed on cephalopods and, less often, on deep-sea fishes and shrimps (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Caldwell and Caldwell, 1989). Hence, they inhabit oceanic waters in tropical to warm temperate zones (Jefferson and Schiro, 1997). They appear to be most common in waters over the continental slope and along the shelf edge. Little is known of their natural history, although a recent study of *Kogia* in South Africa has determined that these two species attain sexual maturity much earlier and live fewer years than other similarly sized toothed whales (Plön and Bernard, 1999).

Kogia have been sighted throughout the GOM in waters that vary broadly in depth and seafloor topographies (Mullin et al., 1991; Davis et al., 1998a and 2000). The GulfCet I study reported these animals in waters with a mean bottom depth of 929 m (Davis et al., 1998a). *Kogia* have been sighted over the continental shelf, but there is insufficient evidence that they regularly inhabit continental shelf waters. *Kogia* sightings were made during GulfCet aerial surveys (1992-1997) in all waters between the 100-m and 2,000-m isobaths. Data also indicate that *Kogia* may associate with frontal regions along the shelf break and upper continental slope, areas with high epipelagic zooplankton biomass (Baumgartner, 1995). During the GulfCet II study, *Kogia* were widely distributed in the oceanic northern GOM, including slope waters of the Eastern GOM. *Kogia* frequently strand on the coastline of the northern GOM, more often in the Eastern GOM (Jefferson and Schiro, 1997). Between 1984 and 1990, 22 pygmy sperm whales and 10 dwarf sperm whales stranded in the GOM.

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

Beaked Whales (Family Ziphiidae)

Two genera and four species of beaked whales occur in the GOM. These encompass (1) three species of the genus *Mesoplodon* (Sowerby's beaked whale [*M. bidens*], Blainville's beaked whale [*M. densirostris*], and Gervais' beaked whale [*M. europaeus*]) and (2) one species of the genus *Ziphius*; Cuvier's beaked whale (*Ziphius cavirostris*). Morphological similarities among species in the genus *Mesoplodon* make identification of free-ranging animals difficult. Generally, beaked whales appear to prefer oceanic waters, although little is known of their respective life histories. Stomach content analyses suggest that these whales feed primarily on deepwater cephalopods, although they also consume some mesopelagic fishes and deepwater benthic invertebrates (Leatherwood and Reeves, 1983; Heyning, 1989; Mead, 1989; Jefferson et al., 1993).

In the northern GOM, beaked whales are broadly distributed in waters greater than 1,000 m over lower slope and abyssal landscapes (Davis et al., 1998a and 2000). Group sizes of beaked whales observed in the northern GOM comprise 1-4 individuals per group (Mullin et al., 1991; Davis and Fargion, 1996; Davis et al., 2000). Abundance estimates of mesoplodonts (Gervais', Blainville's, and Sowerby's beaked whales) are 0 and 59 individuals from ship and aerial surveys over the slope of the

Eastern GOM, respectively, and 150 individuals for the oceanic northern GOM (Davis et al., 2000). However, these estimates may include an unknown number of Cuvier's beaked whales. The species-specific abundance of Gervais', Blainville's, or Sowerby's beaked whale was not estimated due to the difficulty of identifying these species at sea. Abundance estimates for Cuvier's beaked whales are 0 and 22 individuals from ship and aerial surveys of the slope of the Eastern GOM, respectively, and 159 individuals for the oceanic northern GOM (Davis et al., 2000).

Sightings data indicate that Cuvier's beaked whale is probably the most common beaked whale in the GOM (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Würsig et al. (2000) indicates that there are 18 documented strandings of Cuvier's beaked whales in the GOM. The Gervais' beaked whale is probably the most common mesoplodont in the northern GOM, as suggested by stranding records (Jefferson and Schiro, 1997). Würsig et al. (2000) states that there are four verified stranding records of Blainville's beaked whales from the GOM. Additionally, one beaked whale sighted during GulfCet II was determined to be a Blainville's beaked whale (Davis et al., 2000). Sowerby's beaked whale is represented in the GOM by only a single record, a stranding in Florida; this record is considered extralimital since this species normally occurs much farther north in the North Atlantic (Jefferson and Schiro, 1997).

Dolphins (Family Delphinidae)

All remaining species of nonendangered and nonthreatened cetaceans found in the GOM are members of the taxonomically diverse family Delphinidae. Most delphinids, with exceptions of the bottlenose dolphin and the Atlantic spotted dolphin, inhabit oceanic waters of the GOM.

Atlantic Spotted Dolphin (Stenella frontalis)

The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the Atlantic Ocean within tropical to temperate zones. Surveys in the northern GOM documented the Atlantic spotted dolphin primarily over the continental shelf and shelf edge in waters that were less than 250 m in depth, although some individuals were sighted along the slope in waters of up to approximately 1,000 m (3,280 ft) (Würsig et al., 2000). Mills and Rademacher (1996) found the principal depth range of the Atlantic spotted dolphin to be much shallower at 15-100 m water depth. Griffin and Griffin (1999) found Atlantic spotted dolphins on the Eastern GOM continental shelf in waters greater than 20 m (30 km from the coast). A satellite-tagged Atlantic spotted dolphin was found to prefer shallow water habitat and make short dives (Davis et al., 1996). Atlantic spotted dolphins are sighted more frequently in areas east of the Mississippi River (Mills and Rademacher, 1996). Perrin et al. (1994a) relate accounts of brief aggregations of smaller groups of Atlantic spotted dolphins (forming a larger group) off the coast of northern Florida. While not well substantiated, these dolphins may demonstrate seasonal nearshore-offshore movements that appear to be influenced by prey availability and water temperature (Würsig et al., 2000). Abundance estimates are 1,827 and 1,096 individuals from ship and aerial surveys, respectively, of the shelf of the Eastern GOM (Davis et al., 2000). Abundance estimates are 1,055 and 1,800 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM, and 528 individuals for the oceanic northern GOM (Davis et al., 2000). They are known to feed on a wide variety of fishes, cephalopods, and benthic invertebrates (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Perrin et al., 1994a). This species has been seen feeding in a coordinated manner on clupeid fishes in the northern GOM, and in one instance, offshore the Florida Panhandle (Fertl and Würsig, 1995).

Bottlenose Dolphin (Tursiops truncatus)

The bottlenose dolphin *(Tursiops truncatus*) is a common inhabitant of the continental shelf and upper slope waters of the northern GOM. It is the most widespread and common cetacean observed in the northern GOM. Sightings of this species in the northern GOM are rare beyond approximately the 1,200-m (3,937-ft) isobath (Mullin et al., 1994a; Jefferson and Schiro, 1997; Davis et al., 2000). There appears to be two ecotypes of bottlenose dolphins, a coastal form and an offshore form (Hersh and Duffield, 1990; Mead and Potter, 1990). The coastal or inshore stock(s) is genetically isolated from the offshore stock (Curry and Smith, 1997). Genetic data also support the concept of relatively discrete bay, sound, and estuary stocks (Waring et al., 1999). In the northern GOM, bottlenose dolphins appear to have an almost bimodal distribution: a shallow water (16-67 m) and a shelf break (about 250 m) region. These regions may represent the individual depth preferences of the coastal and offshore forms (Baumgartner, 1995). Little is known of the behavior or ranging patterns of offshore bottlenose dolphins. Recently, two bottlenose dolphins that had stranded in Florida were fitted with satellite transmitters; these animals exhibited much more mobility than has been previously documented for this species (Wells et al., 1999a). One dolphin was stranded in northwestern Florida and was released in the GOM off central-west Florida. This dolphin moved around Florida northward to off Cape Hatteras, North Carolina, linking two regions previously considered inhabited by different continental shelf stocks. The second dolphin stranded off the Atlantic Coast of Florida and moved into waters more than 5,000 m deep, much deeper than the previously held concept of bottlenose dolphin movements. This dolphin also traveled well outside of U.S. waters, which suggests the need for a different management approach than for dolphin remaining within U.S. waters. These records demonstrate the range previously reported for the offshore stock of bottlenose dolphins inhabiting the waters off the southeastern United States is larger than previously thought, and underscore the difficulties of defining pelagic stocks. Abundance estimates are 1,056 and 1,824 individuals from ship and aerial surveys, respectively, of the shelf in the Eastern GOM (Davis et al., 2000). Abundance estimates are 1,025 and 3,959 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM, and 3,040 individuals for the oceanic northern GOM. Abundance estimates for various GOM bays, sounds, and estuaries are found listed in Waring et al. (1999). The best estimate by Würsig et al. (2000) for bottlenose dolphins in the northern GOM is 78,000. Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Wells and Scott, 1999). Mating and calving occurs primarily from February through May.

Clymene Dolphin (Stenella clymene)

The Clymene dolphin *(Stenella clymene*) is endemic to the Atlantic Ocean and found only in tropical and subtropical waters (Perrin and Mead, 1994). Data suggest that Clymene dolphins are widespread within deeper GOM waters (i.e., shelf edge and slope) (Davis et al., 2000; Würsig et al., 2000). The Clymene dolphin represents a significant component of the northern GOM cetacean assemblage (Mullin et al., 1994b). However, the few records of the Clymene dolphin in the northern GOM in the past were probably a result of this species' recently clarified taxonomic status and the tendency for observers to confuse it with other species (Jefferson and Schiro, 1997). Sightings made during GulfCet surveys indicate the Clymene dolphin to be widely distributed in the western oceanic GOM during spring and in the northeastern GOM during summer and winter. Also, most sightings tended to occur in the central portion of the study area, west of the Mississippi Delta and east of Galveston Bay. Clymene dolphins have been sighted in water depths of 612-1,979 m (Davis et al., 1998a). The Clymene dolphin was shown to have a relationship with the depth of the 15°C isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 0 and 2,292 from ship and aerial surveys, respectively, of the continental slope of the Eastern GOM and 10,093 for the oceanic northern GOM (Davis et al., 2000). This species appears to feed on fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994c), although knowledge of feeding habits is limited to stomach contents (small fish and squid) of two individuals (Perrin et al., 1981). The Clymene dolphin was observed employing a coordinated feeding strategy on schooling fish in the northern GOM (Fertl et al., 1997).

False Killer Whale (Pseudorca crassidens)

The false killer whale (*Pseudorca crassidens*) occurs in oceanic waters of tropical and warm temperate zones (Odell and McClune, 1999). Most sightings have been made in waters exceeding 200 m, although there have been sightings from over the continental shelf (Davis and Fargion, 1996). Although sample sizes are small, most false killer whale sightings have been east of the Mississippi River (Mullin and Hansen, 1999). Abundance estimates are 311 and 150 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 817 individuals for the oceanic northern GOM (Davis et al., 2000). False killer whales primarily eat fish and cephalopods, but they have been known to attack other toothed whales (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Fraser's Dolphin (Lagenodelphis hosei)

The Fraser's dolphin (*Lagenodelphis hosei*) has a pantropical distribution (Perrin et al., 1994b) in oceanic waters and in areas where deep water approaches the coast. Fraser's dolphins feed on fishes, cephalopods, and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Jefferson and Schiro, 1997). This species was previously known to occur in the northern GOM based on a mass stranding in the Florida Keys in 1981 (Hersh and Odell, 1986). From 1992 to 1996, there were at least three strandings in Florida and Texas (Würsig et al., 2000). GulfCet ship-based surveys led to sightings of two large herds (greater than 100 individuals) and first-time recordings of sounds produced by these animals (Leatherwood et al., 1993). Fraser's dolphins have been sighted in the Western and Eastern GOM at depths of around 1,000 m (3,281 ft) (Leatherwood et al., 1993; Davis and Fargion, 1996; Jefferson and Schiro, 1997; Davis et al., 2000).

Killer Whale (Orcinus orca)

The killer whale (*Orcinus orca*) is a cosmopolitan species that occurs in all oceans and seas (Dahlheim and Heyning, 1999). Generally, they appear to inhabit coastal, cold temperate and subpolar zones. Most killer whale sightings in the northern GOM have been in waters greater than 200 m deep, although there are sightings made from over the continental shelf (Davis and Fargion, 1996). Killer whales are found almost exclusively in a broad area of the north-central GOM (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Mullin and Hansen, 1999). There was a sighting in May 1998 of killer whales in DeSoto Canyon (Ortega, personal communication, 1998). Abundance estimates were 0 for both ship and aerial surveys for the slope of the Eastern GOM and 68 individuals for the oceanic northern GOM (Davis et al., 2000). Thirty-two individual killer whales have been photo-identified in the GOM; some individuals have a wide temporal and spatial distribution (some with a linear distance between sightings of more than 1,100 km) (O'Sullivan and Mullin, 1997). It is not known whether killer whales in the northern GOM remain within the GOM or range more widely (Würsig et al., 2000). Worldwide, killer whales feed on marine mammals, marine birds, sea turtles, cartilaginous and bony fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). An attack by killer whales on a group of pantropical spotted dolphins was observed during one of the GulfCet surveys (O'Sullivan and Mullin, 1997).

Melon-headed Whale (Peponocephala electra)

The melon-headed whale *(Peponocephala electra*) is a deepwater, pantropical species (Perryman et al., 1994) that feeds on cephalopods and fishes (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994a; Jefferson and Schiro, 1997). Sightings of this species in the northern GOM have been primarily in continental slope waters west of the Mississippi River (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000; Mullin and Hansen, 1999). The first two records of this species occurrence in the GOM are recent strandings, one in Texas in 1990, and the other in Louisiana in 1991 (Barron and Jefferson, 1993). GulfCet surveys resulted in many sightings of melon-headed whales, suggesting that this species is a regular inhabitant of the GOM (e.g., Mullin et al., 1994a). The abundance for the oceanic northern GOM is estimated to be 1,734 individuals (Davis et al., 2000).

Pantropical Spotted Dolphin (Stenella attenuata)

The pantropical spotted dolphin *(Stenella attenuat*a) is distributed in tropical and subtropical marine waters of the world (Perrin and Hohn, 1994). It is the most common cetacean in the oceanic northern GOM (Mullin et al., 1994c; Davis and Fargion, 1996; Davis et al., 2000). Pantropical spotted dolphins are typically found in waters deeper than 1,200 m deep (Mullin et al., 1994c; Davis et al., 1998a and 2000) but have been sighted over the continental shelf (Mullin et al., 1994c). Baumgartner (1995) did not find that pantropical spotted dolphins had a preference for any one habitat type; he suggested that this species might use prey species in each distinct habitat (e.g., within the Loop Current, inside a cold-core eddy, or along the continental slope). This ability may contribute to this species' success and abundance in the northern GOM. Abundance estimates are 7,432 and 13,649 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 46,625 individuals for the oceanic northern

GOM (Davis et al., 2000). It feeds on epipelagic fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Pygmy Killer Whale (Feresa attenuata)

The pygmy killer whale (*Feresa attenuata*) occurs in tropical and subtropical waters throughout the world (Ross and Leatherwood, 1994), although little is known of its biology or ecology. Its diet includes cephalopods and fishes, though reports of attacks on other dolphins have been reported (Leatherwood and Reeves, 1983; Jefferson et al., 1993). The pygmy killer whale does not appear to be common in the GOM; most records are of strandings (Jefferson and Schiro, 1997). Fourteen strandings have been documented from southern Florida to south Texas. Four ship sightings occurred during the GulfCet surveys, once off the south Texas coast in November and three in the spring in the west-central portion of the GulfCet study area. Sightings of this species have been at depths of 500-1,000 m (1,641-3,281 ft) (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Abundance estimates are 0 and 218 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 175 individuals for the oceanic northern GOM (Davis et al., 2000).

Risso's Dolphin (Grampus griseus)

The Risso's dolphin (*Grampus griseus*) is a pantropical species that inhabits deep oceanic and continental slope waters of tropical and warm temperate zones (Kruse et al., 1999). Risso's dolphins in the northern GOM have been frequently sighted along the shelf edge, along the upper slope, and most commonly, over or near the 200-m water isobath just south of the Mississippi River in recent years (Würsig et al., 2000). A strong correlation between Risso's dolphin distribution and the steeper portions of the upper continental slope is most likely the result of cephalopod distribution along the continental slope (Baumgartner, 1997; Davis et al., 2000). Risso's dolphins have been sighted over the continental shelf at water depths less than 200 m (Mullin et al., 1994c; Davis et al., 1998a). Strandings and GulfCet sightings have occurred in all seasons in the GOM, and it is likely that Risso's dolphins occur year round in the GOM. Abundance estimates are 679 and 1,317 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 3,040 individuals for the oceanic northern GOM (Davis et al., 2000). Risso's dolphins feed primarily on squid and secondarily on fishes and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Baumgartner, 1997; Würsig et al., 2000).

Rough-toothed Dolphin (Steno bredanensis)

The rough-toothed dolphin (*Steno bredanensis*) occurs in tropical to warm temperate marine waters globally (Miyazaki and Perrin, 1994). Sightings in the northern GOM occur primarily over the deeper waters (950-1,100 m) off the continental shelf (Mullin et al., 1994c; Davis et al., 1998a). Most sightings of the rough-toothed dolphin have been west of the Mississippi River (Mullin and Hansen, 1999); however, a mass stranding of 62 rough-toothed dolphins occurred near Cape San Blas, Florida, on December 14, 1997. Four of the stranded dolphins were rehabilitated and released; three carried satellite-linked transmitters (Wells et al., 1999b). Water depth at tracking locations of these individuals averaged 195 m. Data from the tracked individuals, in addition to sightings at Santa Rosa Beach on December 28-29, 1998 (Rhinehart et al., 1999), suggest a regular occurrence of this species in the northern GOM. Abundance estimates are 16 and 165 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 453 individuals for the oceanic northern GOM (Davis et al., 2000). This species feeds on cephalopods and fishes (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Short-finned Pilot Whale (Globicephala macrorhynchus)

The short-finned pilot whale (*Globicephala macrorhynchus*) is found in warm temperate to tropical marine waters of the world, generally in deep offshore areas (Bernard and Reilly, 1999). Based on historical records (mostly strandings), the short-finned pilot whale would be considered one of the most common offshore cetaceans in the northern GOM (Jefferson and Schiro, 1997). However, the short-finned pilot whale has only occasionally been sighted during recent surveys in the northern GOM. One potential explanation for the preponderance of pilot whales in the older records were misidentifications of other "blackfish" (e.g., false killer, killer, pygmy killer, and melon-headed whales) (Jefferson and Schiro, 1997). In the northern GOM, it is most commonly sighted along the continental slope at depths of 250-2,000 m (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Short-finned pilot whales have been sighted almost exclusively west of the Mississippi River (Mullin and Hansen, 1999). There was one sighting of short-finned pilot whales in the slope in the Eastern GOM during GulfCet II, in the extreme western part of the study area (Davis et al., 2000). Stranding records have declined dramatically over the past decade, which contributes to the evidence (though not conclusively) that this population may be declining in the GOM. Abundance estimates are 0 and 160 individuals from ship and aerial surveys, respectively, of the slope of the Eastern GOM and 1,471 individuals for the oceanic northern GOM (Davis et al., 2000). Squid are the predominant prey, with fishes being consumed occasionally.

Spinner Dolphin (Stenella longirostris)

The spinner dolphin *(Stenella longirostris*) occurs worldwide in tropical oceanic waters (Perrin and Gilpatrick, 1994; Jefferson and Schiro, 1997). In the northern GOM, most sightings of spinner dolphins have been east of the Mississippi River at depths of 500-1,800 m (1,641-5,906 ft) (Jefferson and Schiro, 1997; Mullin and Hansen, 1999; Davis et al., 2000). The distribution of spinner dolphins was shown to be related with the depth of the 15°C isotherm, thereby demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Spinner dolphins have mass stranded on two occasions in the GOM, each time on the Florida coast. Abundance estimates were 5,319 and 8,670 individuals from ship and aerial surveys, respectively, over the slope in the Eastern GOM and 11,251 individuals in the oceanic northern GOM (Davis et al., 2000). Spinner dolphins appear to feed on fishes and cephalopods (Würsig et al., 2000).

Striped Dolphin (Stenella coeruleoalba)

The striped dolphin *(Stenella coeruleoalba*) occurs in tropical and subtropical oceanic waters (Perrin et al., 1994c). Sightings in the northern GOM occur primarily over the deeper waters beyond the continental shelf (Jefferson and Schiro, 1997; Davis et al., 2000; Würsig et al., 2000). The striped dolphin appears to prefer waters where the 15°C isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 416 and 2,198 individuals from ship and aerial surveys, respectively, over the slope of the Eastern GOM and 4,381 individuals for the oceanic northern GOM (Davis et al., 2000). Striped dolphins feed primarily on small, mid-water squid and fishes (especially lanternfish).

3.2.3.2. Endangered and Threatened Species

Five mysticete (or baleen) whales (the northern right, blue, fin, sei, and humpback), one odontocete (or toothed) whale (the sperm whale), and one sirenian (the West Indian manatee) occur in the GOM and are listed as endangered. The sperm whale is common in oceanic waters of the northern GOM and is a resident species, while the baleen whales are considered rare or extralimital (Würsig et al., 2000). The West Indian manatee *(Trichechus manatus*) inhabits only coastal marine, brackish, and freshwater areas.

Cetaceans — Mysticetes

Blue Whale (Balaenoptera musculus)

The blue whale (*Balaenoptera musculus*) is the largest animal known. It feeds almost exclusively on concentrations of zooplankton (Yochem and Leatherwood, 1985; Jefferson et al., 1993). The blue whale occurs in all major oceans of the world; some blue whales are resident, some are migratory (Jefferson et al., 1993; USDOC, NMFS, 1998). Those that migrate move to feeding grounds in polar waters during spring and summer, after wintering in subtropical and tropical waters (Yochem and Leatherwood, 1985). Records of the blue whale in the northern GOM consist of two strandings on the Texas coast (Lowery, 1974). There appears to be little justification for considering the blue whale to be a regular inhabitant of the GOM (Jefferson and Schiro, 1997).

Fin Whale (Balaenoptera physalus)

The fin whale (*Balaenoptera physalus*) is an oceanic species that occurs worldwide in marine waters and is most commonly sighted where deep water approaches the coast (Jefferson et al., 1993). Fin whales feed on concentrations of zooplankton, fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). The fin whale makes seasonal migrations between temperate waters, where it mates and calves, and polar feeding grounds that are occupied during summer months. Their presence in the northern GOM is considered rare (Würsig et al., 2000). Sightings in the northern GOM have typically been made in oceanic waters, chiefly in the north-central region of the GOM (Mullin et al., 1991). There are seven reliable reports of fin whales in the northern GOM, indicating that fin whales are not abundant in the GOM (Jefferson and Schiro, 1997). Sparse sighting data on this species suggest that individuals in the northern GOM may be extralimital strays from their western Atlantic population (Jefferson and Schiro, 1997; Würsig et al., 2000).

Humpback Whale (Megaptera novaeangliae)

The humpback whale (*Megaptera novaeangliae*) occurs in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical banks, where they calve and presumably conceive (Jefferson et al., 1993). Humpback whales feed on concentrations of zooplankton and fishes using a variety of techniques that concentrate prey for easier feeding (Winn and Reichley, 1985; Jefferson et al., 1993). There have been occasional reports of humpback whales in the northern GOM off Florida: a confirmed sighting of a humpback whale in 1980 in the coastal waters off Pensacola (Weller et al., 1996); two questionable records of humpback whale sightings from 1952 and 1957 off the coast of Alabama (Weller et al., 1996); a stranding east of Destin, Florida, in mid-April 1998 (Mullin, personal communication, 1998); and a confirmed sighting of six humpback whales in May 1998 in DeSoto Canyon (Ortega, personal communication, 1998). Most recently, a lone humpback whale was photographed at Main Pass 281 in December 2001. Humpback whales sighted in the GOM may be extralimital strays during their breeding season or during their migrations (Würsig et al., 2000). The time of the year (winter and spring) and the small size of the animals involved in many sightings suggest the likelihood that these records are of inexperienced yearlings on their first return migration northward (Weller et al., 1996).

Northern Right Whale (Eubalaena glacialis)

The northern right whale (*Eubalaena glacialis*) inhabits primarily temperate and subpolar waters. Northern right whales range from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Five major congregation areas have been identified for the western North Atlantic right whale (southeastern United States' coastal waters, Great South Channel, Cape Cod Bay, Bay of Fundy, and Scotian Shelf). The distribution of approximately 85 percent of the winter population and 33 percent of the summer population is unknown. During the winter, a portion of the population moves from the summer foraging grounds to the calving/breeding grounds off Florida, Georgia, and South Carolina. Right whales forage primarily on subsurface concentrations of zooplankton such as calanoid copepods by skim feeding with their mouths agape (Watkins and Schevill, 1976; Leatherwood and Reeves, 1983; Jefferson et al., 1993).

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

Sei Whale (Balaenoptera borealis)

The sei whale (*Balaenoptera borealis*) is an oceanic species that is not often seen close to shore (Jefferson et al., 1993). They occur in marine waters from the tropics to polar regions, but they are more common in mid-latitude temperate zones (Jefferson et al., 1993). Sei whales feed on concentrations of zooplankton, small fishes, and cephalopods (Gambell, 1985; Jefferson et al., 1993). The sei whale is represented in the northern GOM by only four reliable records (Jefferson and Schiro, 1997). One stranding was reported for the Florida Panhandle and three strandings were in eastern Louisiana (Jefferson and Schiro, 1997). This species' occurrence in the northern GOM is considered most likely to be accidental.

Cetaceans — Odontocetes

Sperm Whale (Physeter macrocephalus)

The sperm whale (*Physeter macrocephalus*) inhabits marine waters from the tropics to the pack-ice edges of both hemispheres, although generally only large males venture to the extreme northern and southern portions of their range (Jefferson et al., 1993). In general, sperm whales seem to frequent certain areas within each major ocean basin, which historically have been termed "grounds" (Rice, 1989). As deep divers, sperm whales generally inhabit oceanic waters, but they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al., 1993). Sperm whales prey on cephalopods, demersal fishes, and benthic invertebrates (Rice, 1989; Jefferson et al., 1993).

The sperm whale is the only great whale that is considered common in the northern GOM (Fritts et al., 1983; Mullin et al., 1991; Davis and Fargion, 1996; Jefferson and Schiro, 1997). Sighting data suggest a northern Gulfwide distribution over slope waters. Aggregations of sperm whales are commonly found in waters over the shelf edge in the vicinity of the Mississippi River delta in waters that are 500-2,000 m (1,641-6,562 ft) in depth (Mullin et al., 1994c; Davis and Fargion, 1996; Davis et al., 2000). Sperm whale sightings in the northern GOM chiefly occur in waters with a mean seafloor depth of 1,105 m (Davis et al., 1998a). Mesoscale biological and physical patterns in the environment are important in regulating sperm whale habitat use (Griffin, 1999). Baumgartner (1995) noted that sperm whales avoided warm features characterized by a depressed 15°C isotherm and warm water at 100-m water depth; the highest sighting rates occurred in a cooler watermass characterized by intermediate to cool temperatures at 100 m and a moderately shallow 15°C isotherm. Sperm whales were found in waters with the steepest sea surface temperature gradient; sperm whales may forage along thermal fronts associated with eddies (Davis et al., 1998a). The GulfCet II study found that most sperm whales were concentrated along the slope in or near cyclones (Davis et al., 2000). Low-salinity, nutrient-rich water from the Mississippi River may contribute to enhanced primary and secondary productivity in the north-central GOM, and thus provide resources that support the year-round presence of sperm whales south of the delta.

Consistent sightings in the region indicate that sperm whales occupy the northern GOM throughout all seasons (Mullin et al., 1994a; Davis and Fargion, 1996; Sparks et al., 1996; Jefferson and Schiro, 1997; Davis et al., 2000), although it has yet to be demonstrated that a resident population exists. The composition of sperm whale social groups occurring off the mouth of the Mississippi River consists of adult females, calves, and immature individuals. Therefore, the area functions as nursery and mixed group feeding habitat. Sightings and biopsy sampling during the 2000 and 2001 Sperm Whale Acoustic Monitoring Program (SWAMP) cruises of solitary mature male sperm whales in and near the DeSoto Canyon (Lang, personal communication, 2001) indicate that this may also function as a mating area. Investigations of habitat use and impacts of anthropogenic activities on sperm whales in the GOM, particularly in the DeSoto and Mississippi Canyon vicinities, continued in 2002 as the Sperm Whale Seismic Study (SWSS). Minimum population estimates of sperm whales in the entire GOM totaled 411 individuals, as cited in the NOAA Fisheries stock assessment report for 1995 (Waring et al., 1997). Subsequent abundance estimates of sperm whales in the "oceanic northern GOM" survey area totaled 387 individuals (Davis et al., 2000). Sperm whales in the GOM are currently considered a separate stock from those in the Atlantic and Caribbean (Waring et al., 1997). The stock assessment for GOM sperm whales was not updated from 1995 estimates by NOAA in their most recent stock assessment report (USDOC, NOAA, 2001).

Distributions of Cetaceans within Offshore Waters of the Northern Gulf of Mexico

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

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

Studies conducted during the GulfCet I program demonstrated a correlation of cetacean distribution patterns with certain geomorphic features such as seafloor depth or topographic relief. These studies suggested that seafloor depth was the most important variable in habitat partitioning among cetacean species in the northern GOM (Baumgartner, 1995; Davis et al., 1998a). For example, GulfCet I surveys, along with other surveys (such as the subsequent GulfCet II program) and opportunistic sightings of cetaceans within the GOM, found that only the Atlantic spotted dolphin and the coastal form of the bottlenose dolphin were common inhabitants of the continental shelf. The remaining species of cetaceans known to regularly occur in the GOM (with possible exception of the Bryde's whale) were sighted on the continental slope (Mullin et al., 1994a; Jefferson, 1995; Davis et al., 1998a and 2000). During the GulfCet II program, the most commonly sighted cetaceans on the continental slope were bottlenose dolphins (pelagic form), pantropical spotted dolphins, Risso's dolphins, and dwarf/pygmy sperm whales. The most abundant species on the slope were pantropical spotted and spinner dolphins. Sperm whales sighted during GulfCet II surveys were found almost entirely in the north-central and northeastern GOM, and near the 1,000-m (3,281-ft) isobath on the continental slope (Davis et al., 2000).

An objective of the GulfCet II program was to correlate a number of environmental parameters such as selected hydrographic features with cetacean sighting data in an effort to characterize cetacean habitats in the GOM (Davis et al., 2000). Baumgartner et al. (2001) examined the distributions of bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), *Kogia* spp. (pygmy [*Kogia breviceps*] and dwarf sperm whales [*Kogia sima*]), pantropical spotted dolphins (*Stenella attenuata*), and sperm whales (*Physeter macrocephalus*) with respect to depth, depth gradient, surface temperature, surface temperature variability, the depth of the 15°C isotherm, surface chlorophyll concentration, and epipelagic zooplankton biomass. Bottlenose dolphins were encountered in two distinct regions: the shallow continental shelf (0-150 m) and just seaward of the shelf break (200-750 m). Within both of these depth strata, bottlenose dolphins were sighted more frequently than expected in regions of high surface temperature variability, which suggests an association with ocean fronts. Risso's dolphins were encountered over the steeper sections of the upper continental slope (200-1,000 m), whereas the *Kogia* spp. were sighted more frequently in waters of the upper continental slope that had high zooplankton biomass. The pantropical spotted dolphin and sperm whale were similarly distributed over the lower continental slope and deep GOM (≥1,000 m), but sperm whales were generally absent from anticyclonic oceanographic features (e.g., the Loop Current, warm-core eddies) characterized by deep occurrences of the 15°C isotherm.

Using a combination of visual cetacean sightings and hydrographic measurements from ships, TOPEX/POSEIDON and ERS satellite data (to determine eddy locations and interactions), hydrographic casts, acoustic and net determinators of zooplankton and micronekton biomass, and chlorophyll, Davis et al. (2002) correlated the distribution of cetaceans with oceanic features using data from 14 cruises during GulfCet I and II. Nineteen species, reduced to five ecological categories (1, all species; 2, sperm whales; 3, other squid eaters; 4, oceanic *Stenella* spp.; and 5, neritic dolphins) were analyzed as to habitat features that concentrate populations. The resulting analyses supported the hypothesis that hydrographic features in the study area supported differing levels of potential prey. Food stocks were locally concentrated in nutrient-rich areas offshore the Mississippi River, within and along high-shear edges of cyclonic eddies. Cetaceans in general were concentrated in cyclonic eddies on the upper slope. Sperm whales preferred the lower slope in cyclonic eddies with high biomass. Squid eaters frequented the upper slope in areas outside anticyclones, and oceanic *Stenella* preferred the deepest slope in cyclonic eddies and confluences. The neritic species were outside the influence of the investigated features.

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

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

Sirenians

West Indian Manatee (Trichechus manatus)

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

During warmer months, manatees are common along the Gulf Coast of Florida from the Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward. In winter, the GOM subpopulations move southward to warmer waters. The winter range is restricted to waters at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River in Citrus County, is typically the northern limit of the manatee's winter range on the Gulf Coast. Manatees are found at a few small sites farther north. There are 13 winter-aggregation sites on the west coast of Florida for manatees (USDOI, FWS, 2001c). The major sites commonly having aggregations of 100 or more manatees are (1) Crystal and Homasassa Rivers (natural springs) (Citrus County), (2) Tampa Electric Company Big Bend Power Plant (Hillsborough County), (3) Florida Power & Light Company Fort Myers Power Plant (Lee County), and (4) Port of the Islands Marina (Collier County). The number of manatees, and probably the proportion of the manatee population, using localized warm-water refuges has increased appreciably (MMC, 1999). It is not known to what extent the increasing use of refuges in the Tampa Bay area is due to manatee population growth and/or redistribution of the manatees formerly wintering in southern Florida. Manatees are uncommon west of the Suwannee River in Florida and are infrequently found as far west as Texas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998). During 2001, 10 sightings were reported in Alabama, 4 sightings in Mississippi, 6 sightings in Louisiana, and 7 sightings in Texas (Adimey, personal communication, 2002). A manatee was documented offshore at several OCS work barges where it was grazing on algae growing on the vessel's sides and bottom. Multiple sightings of the animal were made in October 2001 at the northwestern boundary of the EPA; the manatee was in waters exceeding 1,500 m in depth in Mississippi Canyon Block 85, south of Mobile Bay, Alabama.

Aerial surveys to estimate manatee populations are conducted during colder months when manatees aggregate at warm-water refuges in Florida. The highest two-day minimum count of manatees from winter syntoptic aerial surveys and ground counts of Florida Gulf Coast manatees is 1,520 manatees in January 2001 (USDOI, FWS, 2001c). One manatee that died in Louisiana waters was determined to be from Tampa Bay, Florida; this determination was based on a photoidentification rematch (Schiro et al., 1998). The manatees occasionally appearing in south Texas waters may be vagrants from Mexico rather than Florida (Powell and Rathbun, 1984). Few manatees are known to occur along the northeastern coast of Mexico close to Texas (Lazcano-Barrero and Packard, 1989); manatees in south Texas and northern Mexico may be vagrants from central Mexico. Manatees found in east Texas probably come from Florida.

Two important aspects of manatee physiology influence their behavior and distribution: nutrition and metabolism. Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation (USDOI, FWS, 2001c). Distribution of the manatee is limited to low-energy, inshore habitats supporting the growth of seagrasses (Hartman, 1979). Manatees have an unusually low metabolic rate and a high thermal conductance that leads to energetic stresses in winters, which are ameliorated by migrations to warmer areas and aggregations in warm water refugia (Hartman, 1979; O'Shea et al., 1995; Deutsch et al., 1999). Manatees primarily use open coastal (shallow nearshore) areas, estuaries, and they are also found far up freshwater tributaries. Shallow grass beds with access to deep channels are preferred feeding areas in coastal and riverine habitats (USDOI, FWS, 2001c). Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USDOI, FWS, 2001c). Notwithstanding their association with coastal areas, a manatee was documented offshore at several OCS work barges where it was grazing on algae growing on the vessel's sides and bottom. Multiple sightings of the animal were made in October 2001 and occurred in waters exceeding 1,500 m in depth south of Mobile Bay, Alabama. Natural and artificial freshwater areas are sought by manatees occurring in estuarine and brackish areas (USDOI, FWS, 2001c) for drinking. Florida manatees can exist for some time without freshwater, and it is believed that they require freshwater periodically to survive (Reynolds and Odell, 1991), although this is contested by some (USDOI, FWS, 2001c). Therefore, it may be important that adequate freshwater sources be a component of manatee conservation strategies. Manatee protection has focused on protecting essential manatee habitats (seagrass beds have declined substantially in most parts of the State), as well as reducing direct causes of human-related mortality, injury, and disturbance.

3.2.4. Sea Turtles

Of the seven or eight extant species of sea turtles, five are known to inhabit the waters of the GOM (Pritchard, 1997): the green turtle, the loggerhead, the hawksbill, the Kemp's ridley, and the leatherback (**Table 3-5**). Various geographic locations referenced in this section are shown in **Figure 3-7.**

As a group, sea turtles possess elongated, paddle-like forelimbs that are modified for swimming and shells that are streamlined (Márquez-M., 1990; Ernst et al., 1994; Pritchard, 1997). Sea turtles spend nearly all of their lives in the water and only depend on land (specifically sandy beaches) as nesting habitat. They mature slowly and are long-lived. Generally, their distributions are primarily circumtropical, although various species differ widely in their seasonal movements, geographical ranges, and behavior. There are also considerable differences in behavior among populations of the same species (Márquez-M., 1990).

Most sea turtles exhibit differential distributions among their various life stages—hatchling, juvenile, and adult (Márquez-M., 1990; Musick and Limpus, 1997; Hirth, 1997). After evacuating a nest and reaching the sea, hatchling turtles swim away from the nesting beach until they encounter zones of watermass convergence and/or sargassum rafts that are rich in prey and provide refuge (USDOC, NMFS and USDOI, FWS, 1991a and b; USDOC, NMFS and USDOI, FWS, 1992; Hirth, 1997). Most then undergo a passive migration, drifting with prevailing current systems such as oceanic gyres. After a period of years (the duration varies among species), juveniles actively move to juvenile habitats, which vary by species of sea turtle and are typically located in neritic waters. The term "habitat" is frequently used to communicate two very different perspectives of the concept of "home." When properly used, the term "habitat" actually refers to the "home area" utilized by a single species, population, or even individuals, and should convey both functionality and geographic area. The term is often misused to convey a biotic community that a species sometimes associates with (e.g., coral reef); the correct term for this is "biotope." Examples of biotopes that sea turtles might inhabit as older juveniles include estuaries, bays, and nearshore waters. When approaching maturity, subadult juvenile turtles move into adult foraging areas, which vary among species or populations, and are geographically distinct from their juvenile habitats (Musick and Limpus, 1997). Biotopes that adult sea turtles might forage in include coral reefs, bays, estuaries, nearshore waters, infralittoral, circalittoral, and oceanic waters.

All sea turtle species inhabiting the GOM are listed as either endangered or threatened under the Endangered Species Act of 1973 (Pritchard, 1997). Green, Kemp's ridley, leatherback, and hawksbill sea turtles are currently listed as endangered; the loggerhead sea turtle is currently listed as threatened.

Hard-shell Sea Turtles (Family *Cheloniidae*)

Green Sea Turtle (Chelonia mydas)

The green sea turtle (*Chelonia mydas*) is the largest hard-shelled sea turtle; adults commonly reach 100 cm in carapace length and 150 kg in weight (USDOC, NMFS, 1990). The green sea turtle inhabits tropical and subtropical marine waters with extralimital occurrences generally between 40° N. latitude and 40° S. latitude (USDOC, NMFS and USDOI, FWS, 1991a; Hirth, 1997). In U.S. Atlantic waters, green sea turtles are found around the U.S. Virgin Islands, Puerto Rico, and Atlantic and Gulf Coasts of the U.S. from Texas to Massachusetts. Areas in Texas and Florida were heavily fished for green sea turtles at the end of the last century (Hildebrand, 1982).

Green sea turtles primarily occur in coastal and infralittoral waters, where they forage on seagrasses, algae, and associated organisms (Carr and Caldwell, 1956; Hendrickson, 1980). Some green sea turtles may move through a series of juvenile habitats as they grow (Hirth, 1997). Small juvenile green sea turtles are omnivorous. Adult green sea turtles in the Caribbean and GOM are herbivores, feeding primarily on seagrasses and, to a lesser extent, on algae and sponges. The adult feeding areas typically include beds of seagrasses and algae in relatively shallow, protected waters; juveniles may forage in areas such as coral reefs, emergent rocky bottom, sargassum mats, and in lagoons and bays. Areas known as important feeding areas for green sea turtles in Florida include the Indian River, Florida Bay, Homosassa River, Crystal River, and Cedar Key (USDOC, NMFS, 1990). Green sea turtles in the Western GOM are primarily restricted to the Texas coast where seagrass meadows and algae-laden jetties provide them juvenile habitat, especially during warmer months (Landry and Costa, 1999). Movements between principal foraging areas and nesting beaches can be extensive, with some populations regularly conducting transoceanic migrations (USDOC, NMFS and USDOI, FWS, 1991a; Ernst et al., 1994; Hirth, 1997).

Statewide in Florida, nesting has been reported for greens as early as April 28 and as late as October 3 (Meylan et al., 1995). Nesting activity in Florida is increasing, however, this trend is not uniform for the entire state (FFWCC, 2002). Green turtle nesting activity is increasing in southwestern Florida counties (Monroe through Pinellas), as well as in all coastal Florida counties west of Franklin County (FFWCC, 2002).

Hawksbill Sea Turtle (Eretmochelys imbricata)

The hawksbill (*Eretmochelys imbricata*) is a small- to medium-sized sea turtle that inhabits tropical to subtropical waters of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. The hawksbill has been recorded in coastal waters of each Gulf State and along the Atlantic Coast from Florida to Massachusetts (USDOC, NMFS, 1993), although sightings north of Florida are rare (Hildebrand, 1982). They are considered more tropical than other sea turtle species and are the least commonly reported sea turtle species occurring in the northern GOM (Márquez-M., 1990; Hildebrand, 1995).

Older juveniles, subadults and adults generally utilize coral reefs as foraging habitat. Adult hawksbills feed primarily on sponges (Carr and Stancyk, 1975; Meylan, 1988) and demonstrate a high degree of selectivity, feeding on a relatively limited number of sponge species, primarily demosponges (Ernst et al., 1994).

Texas and Florida are the only states in the U.S. where hawksbills are sighted with any regularity (USDOC, NMFS, 1993). Stranded hawksbills have been reported in Texas (Hildebrand, 1982; Amos, 1989) and in Louisiana (Koike, 1996); these tend to be either hatchlings or yearlings. A hawksbill was captured accidentally in a purse seine net just offshore Louisiana (Rester and Condrey, 1996). Hawksbills found stranded in Texas are believed to originate from nesting beaches in Mexico (Landry and Costa, 1999). Northerly currents may direct juvenile hawksbills away from their natal beaches in Mexico northward into Texas (Amos, 1989; Collard and Ogren, 1990). Offshore at the Flower Garden Banks National Marine Sanctuary, seven sightings of the hawksbill were made between 1994 and 2000 (Hickerson, 2000). Hickerson (2000) determined that Stetson Bank, a midshelf bank that is part of the Flower Garden Banks National Marine Sanctuary, is more suitable habitat to the hawksbill sea turtle than either the East or West Flower Garden Bank. More recently, scientific divers at Stetson Bank observed an adult hawksbill sea turtle during the warmer months of 2001 (Hickerson et al., personal communication, 2001).

The hawksbill turtle is a solitary nester. Nesting within the continental U.S. is limited to southeastern Florida and the Florida Keys. Nesting by hawksbills in Florida is considered rare. Statewide, nesting has been reported as early as June 6 and as late as October 31 (Meylan et al., 1995). Juvenile hawksbills show evidence of residency on specific foraging grounds, although hawksbill migrations are possible (USDOC, NMFS, 1993). Some populations of adult hawksbills undertake reproductive migrations between foraging grounds and nesting beaches (Márquez-M., 1990; Ernst et al., 1994). The hawksbill is presently listed as an endangered species.

Kemp's Ridley Sea Turtle (Lepidochelys kempi)

The Kemp's ridley (*Lepidochelys kempi*) is the smallest sea turtle species and occurs chiefly in the GOM. It may also be found along the northwestern Atlantic Coast of North America as far north as Newfoundland. It is the most imperiled of the world's sea turtle species. The GOM's population of nesting females has dwindled from an estimated 47,000 in 1947 to a current nesting population of approximately 4,200 females (Shaver, personal communication, 2001). A population crash that occurred between 1947 and the early 1970's may have resulted from both intensive annual harvest of the eggs, and mortality of turtles in trawl fisheries (National Research Council (NRC), 1990). Recovery of the Kemp's ridley from the threat of extinction has been forestalled primarily by mortality attributed to the commercial shrimp fishery (USDOI, FWS and USDOC, NMFS, 1992).

In the northern GOM, Kemp's ridleys are most abundant in coastal waters from Texas to west Florida (Ogren, 1989; Márquez-M., 1990 and 1994; Rudloe et al., 1991). Kemp's ridleys display strong seasonal fidelity to tidal passes and adjacent beachfront environs of the northern GOM (Landry and Costa, 1999). There is little prolonged utilization of waters seaward of the 50-m isobath by this species (Renaud, 2001). Adult Kemp's ridley turtles usually occur only in the GOM, but juvenile and immature individuals sometimes occur in tropical and temperate coastal areas of the northwestern Atlantic and GOM (Márquez-M., 1990). Juveniles are more common than adults along the East Coast of the U.S., from Florida to New England and especially off eastern Florida and Georgia. Within the GOM, juvenile and immature Kemp's ridleys have been documented along the Texas and Louisiana coasts, at the mouth of the Mississippi River, and along the west coast of Florida, as quoted in stranding reports, (Ogren, 1989; Márquez-M., 1990).

The primary nesting area used by the Kemp's ridley sea turtle is near Rancho Nuevo, along the northeastern coast of Mexico in the State of Tamaulipas (USDOI, FWS and USDOC, NMFS, 1992, Márquez-M. et al., 2001), although secondary nest areas have also been reported in other areas of Mexico, Texas (specifically south Texas), Florida, and South Carolina (USDOI, FWS and USDOC, NMFS, 1992; Ernst et al., 1994; Márquez-M. et al., 2001). Eggs are laid annually, and following the nesting season, the adults disperse towards two feeding grounds: one northwest toward Florida and the other southeast to the Campeche Bank off the Yucatan Peninsula of Mexico. Some adult female Kemp's ridley sea turtles tagged at Rancho Nuevo have been recorded off Louisiana and Mississippi (Márquez-M., 1994). Two adult females bearing flipper tags applied at the Rancho Nuevo nesting beach were recaptured at Calcasieu and Sabine Passes, Louisiana. These post-nesting females may have been in transit to shallow GOM foraging areas to begin conditioning for their next reproductive cycle (Landry and Costa, 1999). Post-nesting females have also been tagged in Texas, and 17 of the 18 animals tagged with satellite transmitters between 1997 and 2001 were discovered to occupy waters along at least one of the Gulf Coast States (Shaver, personal communication, 2001). Only one post-nesting female that was tagged with a satellite transmitter in Texas moved south to Mexican waters (Shaver, personal communication, 2001). Juveniles, subadults, and adults are common off Big Gulley, an offshore area east of Mobile Bay, Alabama, where they have been sometimes captured in trawls since the mid-1970's (Carr, 1980; Ogren, 1989; Márquez-M., 1994). Some of the smallest Kemp's ridley sea turtles have been found off Wakulla and Franklin Counties, Florida (Ogren, 1989). Two sightings of Kemp's ridley turtles were reported over the continental shelf in the Eastern GOM during GulfCet II surveys (Davis et al., 2000).

Nesting in the U.S. occurs annually on Padre and Mustang Islands in south Texas from May to August (Thompson, 1988). A multiagency program initiated in 1978 to establish a secondary nesting colony in south Texas supplemented natural nesting. From 1948 through 1998, 45 Kemp's ridley nests on the Texas coast were documented (Shaver and Caillouet, 1998). Only 11 Kemp's ridley nests were found in Texas from 1979 to 1995 (Shaver, 1995). The first documented nesting of living-tagged Kemp's ridley in 1996 is the first documentation of any sea turtle nesting at an experimental imprinting site and outside of captivity after being released from a head-starting program (Shaver, 1996a and b). During the 1998 nesting season, 13 confirmed Kemp's ridley nests were found on the Texas coast (Shaver and Caillouet, 1998). A record 16 Kemp's ridley nests were found on Texas beaches during 1999. Twelve nests were documented in Texas during 2000; however, only eight Kemp's ridley nests were located in Texas during the 2001 nesting season (Shaver, personal communication, 2001).

The first confirmed nesting in the U.S. of a Kemp's ridley turtle that had previously nested in Mexico occurred in 1998 (Shaver and Caillouet, 1998). Kemp's ridleys that nest in south Texas today are likely a mixture of returnees from the experimental imprinting and head-starting project and others from the wild stock. Kemp's ridley sea turtles have been also documented nesting in Alabama and Florida, although less frequently than on Texas beaches. In 1998, one nest was confirmed in Alabama on Bon Secour National Wildlife Refuge (Baldwin County) (MacPherson, personal communication, 2000). In the same year, another nesting site was confirmed on Gulf Islands National Seashore (GINS) (Perdido Key Area, Escambia County, Alabama) (Nicholas, personal communication, 2000). Another nest was documented during the 2001 that yielded approximately 26 hatchlings (USDOI, FWS, 2001a). Kemp's ridley turtles have occasionally nested in Florida. There are two reports for Pinellas County, Florida: one on Madeira Beach in 1989 (Meylan et al., 1990) and the second on Clearwater Beach in 1994 (Anonymous, 1994). There were two nests for Volusia County on the southeast coast of Florida (May 14 and June 1, 1996) (Johnson et al., 2000). The Kemp's ridley sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For the one confirmed nest on GINS, the nest was laid on May 31 and eggs hatched on August 3, for an incubation period of 64 days (Nicholas, personal communication, 2000). Two adult female Kemp's ridleys found at Padre Island were satellite tagged to document post-nesting movements (Shaver, personal communication, 1998). Both females moved northward, spending most of their time in Louisiana waters; one female moved as far as western Florida, the other stayed in the vicinity of Louisiana.

Hatchlings appear to disperse offshore and are sometimes found in sargassum mats (Collard and Ogren, 1990). Two juvenile Kemp's ridleys released through the NOAA Fisheries' headstart program were found drifting in sargassum: one was found 46.3 km south of Mobile, Alabama; the other 4.6 km off Horseshoe and Pepperfish Keys on the north-central Gulf Coast of Florida (Manzella et al., 1991). During the pelagic life history stage, the Kemp's ridley sea turtle is dependent on currents, fronts, and gyres to determine their distribution. Hatchling and small juvenile habitats are hardly known due to lack of information. Some young turtles stay within the GOM, whereas others are carried by currents out of the GOM into the Gulf Stream current and up to the northeastern U.S. The latter migrate south and enter the GOM as they approach maturity. With growth, the turtles actively move to shallow coastal waters, especially off western Louisiana and eastern Texas or off northwestern Florida, where feeding on benthos occurs. Portions of the north and northeastern GOM are utilized as foraging habitat by juveniles, subadults, and post-nesting females (Ogren, 1989; Rudloe et al., 1991). Kemp's ridleys inhabiting coastal waters of Texas and Louisiana utilize sandy and muddy bottoms, feeding on portunids and other crabs (Ogren, 1989; Shaver, 1991), and possibly on bycatch generated by the shrimp fishery (Landry and Costa, 1999). Other Kemp's ridleys move to Cedar Key, Florida, an area where they also prey on portunid crabs. This is an area where seagrass communities are common, and Kemp's ridleys are known to penetrate bays and estuaries there (Carr and Caldwell, 1956; Lutcavage and Musick, 1985; Landry, personal communication, 2000). Strandings of Kemp's ridleys on Texas beaches indicate that they are mostly from Mexico (Shaver, personal communication, 1998).

Loggerhead Sea Turtle (Caretta caretta)

The loggerhead (*Caretta caretta*) is a large sea turtle that inhabits temperate and tropical waters of the Atlantic, Pacific, and Indian Oceans. This species is wide-ranging and is capable of living in a variety of biotopes (Márquez-M., 1990; USDOC, NMFS and USDOI, FWS, 1991b; Ernst et al., 1994). The loggerhead is the most abundant species of sea turtle occurring in U.S. waters of the Atlantic, from Florida to Cape Cod, Massachusetts. The loggerhead is probably the most common sea turtle species in the northern GOM (e.g., Fritts et al., 1983; Fuller and Tappan, 1986; Rosman et al., 1987b; Lohoefener et al., 1990) and is currently listed as a threatened species.

In the western North Atlantic, there are at least four loggerhead nesting subpopulations: the Northern Nesting Subpopulation (North Carolina to northeast Florida, about 29° N. latitude); the South Florida Nesting Subpopulation (29° N. latitude to Naples); the Florida Panhandle Nesting Subpopulation (Eglin Air Force Base and the beaches near Panama City); and the Yucatán Nesting Subpopulation (northern and eastern Yucatán Peninsula, Mexico) (Byles et al., 1996). Based upon the returns of tags applied at nesting beaches, non-nesting adult females from the South Florida Subpopulation are distributed throughout the Bahamas, Greater Antilles, Yucatán, Eastern GOM, and southern Florida (Meylan, 1982). Non-nesting adult females from the Northern Subpopulation occur occasionally in the northeastern GOM (Meylan, 1982). Limited tagging data suggest that adult females nesting in the GOM remain in the GOM (Meylan, 1982). Five transmitters were placed on loggerheads nesting at the Archie Carr National Wildlife Refuge on the eastern coast of Florida during August 2000. Each of these nesting females subsequently traveled south along the Florida coast and turned northward into the GOM after passing the Florida Keys. One female was tracked moving northward into the Big Bend area off Florida, where it then turned southward and was last detected offshore of the Ten Thousand Islands area of Florida. Female loggerheads have also been outfitted with satellite transmitters upon nesting at beaches of the Gulf Islands National Seashore and Pensacola Beach. Upon departing these beaches, females moved eastward to offshore waters of the Big Bend area or southward to the Florida Keys, remained in waters adjacent to the nesting beaches where tagged, or traveled westward past the mouth of the Mississippi River to waters offshore of Galveston, Texas. In 1999, satellite tags were also placed on three female adult loggerhead turtles after they finished nesting on Cape San Blas, St. Joseph Peninsula, in Gulf County, Florida. Before the tags expired, two of the three turtles were off the Yucatan in Mexico and the third was offshore the Ten Thousand Islands area of Florida. Information regarding these migrations can be found at the following website: www.cccturtle.org. However, little information is available regarding adult male activity; although, they have been observed year-round in south Florida (Byles et al., 1996).

The largest nesting concentration in the U.S. is on the southeast Florida coast from Volusia to Broward Counties. Statewide in Florida, nesting has been reported for loggerheads as early as March 16 and as late as October 16 (Meylan et al., 1995). Loggerheads are the most common nesting sea turtle in northwest Florida and account for over 99 percent of the nests. The loggerhead sea turtle nesting and hatching season for northwest Florida beaches generally extends from about May 1 through October 31. The earliest nest was documented on April 27 and the latest nest on November 1. Nest incubation ranges from about 49 to 95 days. On the Gulf Coast of Florida, nesting by loggerheads occurs from Monroe through Pinellas Counties (southwest Florida) and from Franklin through Escambia Counties (northwest Florida) (Brost, personal communication, 2001). The greatest density of loggerhead nests known per region occur in Sarasota and Charlotte Counties (southwest Florida), and Bay, Gulf, and Franklin Counties (northwest Florida).

On the Central Gulf Coast, limited monitoring of nesting activity has been conducted. A total of 107 loggerhead nests were documented during the 1999 and 2000 nesting seasons on the Bon Secour National Wildlife Refuge to Mobile Bay (Swilling, personal communication, 2001). The USFWS' Sea Turtle Volunteer Program documented 48 loggerhead nests in Alabama during 2001 (USDOI, FWS, 2001b).

Loggerhead nesting was reported at Biloxi, Mississippi, in 1991 (South and Tucker, personal communication, 1991). It is unknown whether the nesting sea turtles in Alabama, Mississippi, and Louisiana are genetically similar to the Florida Panhandle Subpopulation (Bowen et al., 1993). Nesting in Texas occurs primarily on North and South Padre Islands, although occurrences are recorded throughout coastal Texas (Hildebrand, 1982).

Based on aerial surveys conducted in the western North Atlantic, loggerheads are distributed about 54 percent in the southeast U.S. Atlantic, 29 percent in the northeast U.S. Atlantic, 12 percent in the eastern GOM, and 5 percent in the western GOM (Byles et al., 1996). Aerial surveys indicate that loggerheads are abundant in waters that are less than 100 m in depth (Shoop et al., 1981; Fritts et al., 1983). During GulfCet aerial surveys, loggerheads were sighted throughout the northern GOM continental shelf waters out to the 100-m isobath (Davis et al., 2000). Loggerheads were also sighted in waters seaward of the 1,000 m isobath. Sightings indicate that loggerheads are more widely distributed in shelf waters than Kemp's ridley and green sea turtles which are more closely associated with coastal waters (Landry and Costa, 1999). Loggerhead abundance in continental slope waters of the Eastern GOM increased appreciably during winter (Davis et al., 2000). It is not clear why adult loggerheads occur in oceanic waters, unless they travel between widely distributed foraging sites in the GOM or seek warmer waters during winter (Davis et al., 2000). Shoop et al. (1981) suggested that loggerheads in oceanic waters off the Atlantic Coast of the U.S. were probably in transit to other areas. Witzell and Azarovitz (1996) suggested that some turtles may move offshore in winter to seek warm-core eddies.

Loggerheads are abundant in Florida waters (Fritts and Reynolds, 1981; Fritts et al., 1983; Davis et al., 2000). Underwater surveys made near artificial reefs and a sunken offshore platform near Panama City, Florida, noted 17 sightings of loggerheads. All turtles sighted were usually resting in a shallow pit of sand where the artificial reef formed a sheltering overhang (Rosman et al., 1987b). In the Central GOM, loggerheads are abundant just offshore Breton and Chandeleur Islands (Lohoefener et al., 1990). Subadult loggerheads tagged with satellite transmitters at the Flower Garden Banks near the shelf-edge off Texas were found to persist there over several years (Hickerson, 2000).

Loggerheads feed primarily on benthic invertebrates, but will also forage on a wide variety of organisms (Ernst et al., 1994). Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988; Plotkin et al., 1993). Adult loggerheads forage on benthic invertebrates (Dodd, 1988). The banks off central Louisiana and near the Mississippi Delta are important sea turtle feeding areas (Hildebrand, 1982). Subadult loggerheads utilize the Flower Garden Banks near the shelf-edge off Texas as feeding habitat during all seasons (Hickerson, 2000). Genetic evidence suggests that at least two subpopulations intermingle on the foraging grounds of the U.S. Atlantic Coast (Byles et al., 1996).

Leatherback Sea Turtle (Family *Dermochelyidae*)

Leatherback Sea Turtle (Dermochelys coriacea)

The leatherback (*Dermochelys coriacea*) is the largest and most distinctive sea turtle. This species possesses a unique skeletal morphology, most evident in its flexible, ridged carapace. Leatherbacks maintain a core body temperature several degrees above ambient in cold water. They also have unique deep-diving abilities (Eckert et al., 1986). This species is the most wide-ranging sea turtle, undertaking extensive migrations from the tropics to boreal (cold-temperate regions of the northern latitudes) waters (Morreale et al., 1996; Hughes et al., 1998). Though considered oceanic, leatherbacks occasionally enter bays and estuaries (Hoffman and Fritts, 1982; Knowlton and Weigle, 1989; Shoop and Kenney, 1992). Using satellite telemetry, female leatherback turtles were tracked migrating through the Pacific Ocean following similar and in some cases virtually identical pathways or ocean corridors to travel (Morreale et al., 1996). Leatherbacks feed primarily on gelatinous zooplankton such as jellyfish, siphonophores, and salps (Brongersma, 1972), although they sometimes ingest some algae and vertebrates (Ernst et al., 1994). Contents from leatherbacks' stomachs have been analyzed and indicate that leatherbacks feed at the surface, at depth within deep scattering layers, and on benthos. Florida is the only site in the continental U.S. where leatherbacks regularly nest (USDOC, NMFS and USDOI, FWS, 1992; Ernst et al., 1994; Meylan et al., 1995). The leatherback is currently listed as an endangered species.

Sightings of leatherbacks are common in oceanic waters of the northern GOM (Leary, 1957; Fritts et al., 1983; Lohoefener et al., 1988 and 1990; Collard, 1990; Davis et al., 2000). Based on a summary of several studies, Davis and Fargion (1996) concluded that the primary area utilized by the leatherback in the northwestern GOM is oceanic waters (>200 m). In contrast, overall densities of leatherbacks in the Eastern GOM in shelf and slope waters were similar (Davis et al., 2000). It has been suggested that the region from Mississippi Canyon east to DeSoto Canyon appears to be an important habitat area for leatherbacks (Davis and Fargion, 1996). Most sightings made of leatherbacks during GulfCet surveys occurred slightly north of DeSoto Canyon (Davis and Fargion, 1996; Davis et al., 2000). Nearly disjunct summer and winter distributions of leatherback sightings in continental slope waters of the Eastern GOM during GulfCet II indicate that certain areas may be important to this species either seasonally or for shorter periods. These areas are most probably related to oceanographic conditions and concentrations of prey. Large numbers of leatherbacks in waters off the northeast U.S. have been associated with concentrations of jellyfish (Shoop and Kenney, 1992). Similar sightings with increased jellyfish densities have been made in the GOM: 100 leatherbacks were sighted just offshore Texas, and 7 were seen at a watermass boundary in the Eastern GOM (Leary, 1957; Collard, 1990). Other sightings of surfaced leatherback aggregations have been reported for the northern GOM: 8 leatherbacks were sighted one day in DeSoto Canyon (Davis and Fargion, 1996), 11 during one day just south of the Mississippi River Delta (Lohoefener et al., 1990), and 14 on another day in DeSoto Canyon (Lohoefener et al., 1990).

Leatherbacks nest on coarse-grain beaches in tropical latitudes (Pritchard, 1971). Analysis of haplotype frequencies has revealed that nesting populations of leatherbacks are strongly subdivided globally, despite the leatherback's highly migratory nature (Dutton et al., 1999). Those findings provisionally support the natal homing hypothesis for leatherbacks. Leatherbacks nest annually in U.S. territories within the Caribbean, principally at St. Croix (U.S. Virgin Islands) and Isla Culebra (Puerto Rico) (USDOC, NMFS and USDOI, FWS, 1992). Designated critical habitat for the leatherback includes the waters adjacent to Sandy Point, St. Croix. Other leatherback nesting beaches in the region are located in Georgia and Florida. Based on an average of 5-7 nests per female per season observed at other rookeries, Meylan et al. (1995) estimated there to be 16-31 individual leatherbacks nesting annually in small numbers on the East Coast of Florida.

On the Gulf Coast of Florida, documented leatherback nesting activity is rare, but increasing. One leatherback nest was reported between Phillips Inlet and Destin in September 1962 (Yerger, 1965). Another leatherback nest was documented in 1974 on St. Vincent Island, Franklin County. From 1993 to 2000, only 15 nests were reported—10 in Franklin County, 3 in Okaloosa County, 1 each in Gulf and Escambia Counties (Brost, personal communication, 2001). Seven leatherback nests were found during 2000 in Franklin, Okaloosa, and Escambia Counties. Eight nests were documented in Franklin, Gulf, and Bay Counties during 2001.

Nesting occurs from February through July from Georgia to the U.S. Virgin Islands. The leatherback sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For confirmed nesting, the earliest nest was documented on April 29 and the latest nest documented on June 19. Documented nest incubation in northwest Florida ranges from about 63 to 84 days (Brost, personal communication, 2001; Miller, personal communication, 2001; Nicholas, personal communication, 2001). Statewide in Florida, nesting has been reported for leatherbacks as early as February 22 (Meylan et al., 1995). Although the number of leatherbacks nesting on Florida beaches is small relative to those nesting in St. Croix and Puerto Rico, they are the only nesting beaches regularly utilized by this endangered species in the continental U.S.

Distributions of Sea Turtles in the Offshore Waters of the Northern Gulf of Mexico

Surveys conducted during the GulfCet I and II studies represent the most recent assessments of sea turtle distribution and abundance within the oceanic northern GOM (Davis et al., 1998a and 2000). During these surveys, only three species of sea turtles were sighted: loggerheads, Kemp's ridleys, and leatherbacks.

The GulfCet I and II surveys found the abundance of sea turtles in the northern GOM to be considerably higher over the continental shelf and within the Eastern GOM, east of Mobile Bay (Lohoefener et al., 1990; Davis et al., 2000). Kemp's ridleys were sighted only along the shelf. Sightings of loggerheads were considerably higher over the continental shelf than the continental slope. However, there were sightings of loggerheads in waters exceeding 1,000 m in depth. The importance of oceanic habitat to loggerheads was not clear from GulfCet surveys, although it was suggested that turtles cross these waters to distant foraging sites or seek warmer waters during winter (Davis et al., 2000). From historic sighting data, leatherbacks appear to utilize both shelf and slope habitat areas in the northern GOM (Fritts et al., 1983; Collard, 1990; Davis et al., 1998a). GulfCet studies suggested that the region from Mississippi Canyon to DeSoto Canyon, especially near the shelf edge, may be important habitat for leatherbacks (Davis et al., 2000).

Seasonally, loggerheads are widely distributed across the continental shelf during both summer and winter, though their abundance over the continental slope is considerably higher during winter surveys than summer (Davis et al, 2000). Temporal variability in leatherback distribution and abundance suggest that specific areas may be important to this species, either seasonally or for short periods. Overall, leatherbacks occurred in substantial numbers during both summer and winter surveys, and the high variability in the relative numbers of leatherbacks sighted within specific areas suggest that their distribution patterns were irruptive in nature (Davis et al., 2000).

3.2.5. Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice, and Florida Salt Marsh Vole

Hall (1981) recognizes 16 subspecies of field mouse (*Peromyscus polionotus*), 8 of which are collectively known as beach mice. Four of the Gulf Coast subspecies (Alabama, Perdido Key, Choctawhatchee, and St. Andrew beach mice) are federally protected and occupy coastal mature dunes of Florida and Alabama. The Alabama subspecies occurs in Alabama, the Perdido Key subspecies occurs in Alabama and Florida, and the Choctawhatchee and St. Andrew subspecies occur in Florida. The Alabama, Perdido Key, and Choctawhatchee beach mice were listed as endangered species in 1985. Critical habitat was designated for all three subspecies at the time of listing. The St. Andrew beach mouse was listed as endangered in 1998; no critical habitat was designated for the subspecies because it would not benefit the conservation of the species. Continued monitoring of populations of all subspecies along the Gulf Coast between 1985 and the present indicates that approximately 64.4 km (39.9 mi) of coastal dune habitat are now occupied by the four listed subspecies (1/3 of historic range). The distribution of Choctawhatchee beach mice has increased by 9.7 km (6 mi), and the Perdido Key beach mice has increased by 2.6 km (1.6 mi). Beach mice were listed because of the loss of coastal habitat from human development. The recovery of beach mice continues to be hampered by multiple habitat threats over their entire range (coastal development and associated human activities, military activities, coastal erosion, and weather events).

From 1996 to 1999, the FWS funded Auburn University to develop a PVA for beach mice. The Holler et al. (1999) work represented an entirely different approach to viability modeling. Four populations of Gulf Coast beach mice subspecies were modeled. They consisted of two populations of the Perdido Key beach mice—one at GINS and one at Florida Point—and two populations of the Alabama beach mice—one at Bon Secour National Wildlife Refuge (NWR) and one at Ft. Morgan State Park. The model, known as a stochastic exponential growth model, used data on the observed change in the beach population sizes between successive census periods. The model is “stochastic” because it incorporates the variable effects of the environment upon population change.

The Holler et al. (1999) analyses indicated that all four populations were at risk of extinction. At GINS, the Perdido Key beach mice had a 100 percent chance of reaching one individual (becoming functionally extinct) within 21-45 years. At Florida Point, the Perdido Key beach mice had a 1.3 percent chance of becoming functionally extinct within 13-20 years. At Fort Morgan, the Alabama beach mice population had a 49.4 percent chance of becoming functionally extinct within 5-20 years. At the Bon Secour NWR, the Alabama beach mice had a 0.2 percent chance of becoming functionally extinct between 16 and 23 years.

Reasons for possible extinction include habitat loss, fragmentation, or degradation from natural (hurricanes) or human (development and recreation) causes, genetic viability, and native and non-native depredation. Holler et al. (1999) noted that the PVA presented further evidence that habitat fragmentation will continue to exacerbate the risk of extinction. The FWS has contracted with the University of Southern California at Berkley to continue the PVA modeling and to produce a dispersal model for the Alabama beach mouse.

The Florida salt marsh vole is listed as endangered because of its extremely limited range encompassing one known population and because of the population’s potential extinction by a storm or other event.

Diet

Beach mice feed nocturnally in the dunes and remain in burrows during the day. Between seasons, availability of food changes within years, and so does diet. Between years, availability of food items varies within each season, as does diet. Management practices designed to promote recovery of dune habitat, increase food sources, and enhance habitat heterogeneity may aid in recovery of beach mouse populations.

Because of the rarity of the Florida salt marsh vole, its diet has not been well studied. Diet of the meadow vole has been well studied, and some aspects are expected to be similar to that of the Florida salt marsh vole. The meadow vole feeds on a variety of plant matter, including bark, grass, roots, and seeds.

Reproduction and Development

In wild populations, beach mice have an average life span of about nine months. Animals with short life spans typically reach reproductive age early. This is true of beach mice. Males and females reach adulthood and are able to reproduce at approximately 35 days of age. Females can nurse one litter while pregnant with another litter.

Information on reproduction in the meadow vole may hold true for the sparsely studied Florida salt marsh vole also. The meadow vole has a high reproductive rate and breeds throughout the year with a peak of breeding activity occurring in the spring (Golley, 1962). The gestation period for meadow voles is 21 days and the average litter size is five young. The life span is short; typically, few animals live longer than 6 months.

Range and Populations

Alabama beach mice historically ranged from the tip of the Fort Morgan peninsula in Mobile Bay east to Perdido Pass in Baldwin County, Alabama (Bowen, 1968). Their range is now reduced to disjunct private holdings and 7.7 km of coastal strand habitat protected by two units of the Bon Secour National Wildlife Refuge west of Gulf Shores, Baldwin County, Alabama.

The Choctawhatchee beach mouse's current distribution can be considered to consist of four populations: Topsail Hill Preserve State Park (and adjacent eastern and western private lands); Shell Island (includes St. Andrew State Park with private inholdings and Tyndall Air Force Base); Grayton Dunes (and adjacent eastern private lands); and West Crooked Island. Approximately 99.8 percent of the lands known to be occupied by Choctawhatchee beach mice are public lands. In addition, approximately 92 percent of habitat "available" (large enough to support a population adjacent to a population) for the Choctawhatchee beach mice are public lands. A current conservative total population estimate would be in the range of 600-1,000 Choctawhatchee beach mice.

The St. Andrew subspecies is the easternmost of the four Gulf Coast subspecies. This subspecies is restricted to Gulf County and to St. Andrew Sound Inlet in Bay County. Its current range is limited to a portion of the St. Joseph Peninsula in Gulf County and East Crooked Island, Tyndall Air Force Base, Bay County. Coastal tidal marshes and upland habitat between the mainland city of Port St. Joe and the St. Joseph Peninsula naturally divided the range into two segments. The historic range of the St. Andrew beach mouse included the dune habitats along the GOM beachfront from Money Bayou in Gulf County west and north along the St. Joseph peninsula, the coastal mainland adjacent to St. Joseph Bay and the GOM, and Crooked Island to the East Pass of St. Andrew Bay (Bowen, 1968; James, 1992).

The following is derived from information in Woods et al. (1982). The nearest known population of *Microtus pennsylvanicus* to the Florida salt marsh vole is located approximately 500 km or 313 mi to the north in Georgia. However, fossil *Microtus pennsylvanicus* have been found in late Pleistocene deposits at four sites in Alachua, Citrus, and Levy Counties, Florida, indicating a much more extensive ancestral range. The ages of these fossils may be from 8,000-30,000 years before present. The Florida salt marsh vole probably is a relict population that has persisted at the Waccasassa Bay site after a prehistoric, long-term reduction in range. The range reduction has not been attributed to modern man at all.

The Florida salt marsh vole is known to occur only at the type locality in a salt marsh habitat where the vegetation is dominated by salt grass (*Distichlis spicata*), with smooth cordgrass (*Spartina alterniflora*) and glasswort (*Salicornia* spp.) also present (Woods et al., 1982). This vegetation is some of the most salt tolerant of coastal wetlands.

General Habitat and Critical Habitat

Beach mouse populations have declined as a result of habitat loss from tropical storms, coastal development, competition, loss of genetic diversity, disease, and predation (Ehrhart, 1978; Holler and Rave, 1991; Humphrey and Frank, 1992; *Federal Register*, 1998). Some of the current beach-mice habitat is believed to no longer contain optimal elements (Meyers, 1983; Holler and Rave, 1991). Definitive estimates of minimum viable population size for beach mice are not yet available. Several recent estimates for small mammals based on mass/population density relationships indicate that continued survival of a self-sustaining population would require several thousand individuals (*Federal Register*, 1998). These estimates still may be low for beach mice since they reflect small rodent populations in more stable environments.

Beach mice are restricted to the mature coastal barrier sand dunes along the GOM. Optimal overall beach mouse habitat is currently thought to be comprised of a heterogeneous mix of interconnected habitats including primary dunes, secondary dunes, scrub dunes, and interdunal areas. Beach mice dig burrows mainly in the primary, secondary, and interior scrub dunes where the vegetation provides suitable cover. Most beach mouse surveys conducted prior to the mid-1990's were in primary and secondary dunes, which were typically thought to be the preferred habitat of beach mice. A limited number of surveys in scrub dunes and other interior habitat resulted in less knowledge of the distribution and relative abundance there. In coastal environments, the terms "scrub" and "scrub dune" refer to habitat or vegetation communities adjacent to and landward of primary and secondary dunes types where scrub oaks are visually dominant. Interior habitat can include vegetation types such as grass-like forbs (forbs are the herbs other than grasses).

The Alabama, Perdido Key, and Choctawhatchee beach mice were listed as endangered species under the Federal Endangered Species Act in 1985 (50 FR 23872, June 6, 1985). Critical habitat was designated for the three subspecies at the time of listing (50 CFR 1 Section (§) 17.95). The major constituent elements that are known to require special management considerations or protection are dunes and interdunal areas and associated grasses and shrubs that provide food and cover (USDOI, FWS, 1985a and b).

The St. Andrew beach mouse was listed as an endangered species on December 18, 1998 (63 FR 70053). No critical habitat was designated for the species.

The Florida salt marsh vole is of concern because of its extremely limited range with only one known population and the threat of losing this population to a storm or other event. The Florida salt marsh vole is known from only one site in Waccasassa Bay, near Cedar Key, Levy County, Florida (**Figure 3-8**). Additional searches for this species have not revealed any other populations of *M. p. dukecampbelli* (Woods, 1988; Bentzien, 1989; Doonan, personal communication, 1996). The latest search primarily included trapping in suitable habitat (coastal salt marsh dominated by salt grass) on road-accessible areas of public lands in Taylor, Dixie, and Levy Counties.

A single storm could drive the vole to extinction. The vole is restricted to a salt marsh of Waccasassa Bay, Levy County, Florida. Woods et al. (1982) were able to trap only 31 individuals; subsequent trapping efforts at the site located only one individual (Woods, 1988). Trapping elsewhere in the coastal salt marshes of Citrus and Levy Counties have yielded no voles (Bentzien, 1989). Additionally, recent (1996) trapping efforts yielded five voles (all male) from the type locality. This population of voles is vulnerable to storms.

Tropical Storms and Hurricanes

A predominant threat to beach mice is tropical storms and hurricanes. Tropical storms periodically devastate Gulf Coast sand dune communities, dramatically altering or destroying habitat, and either drowning beach mice or forcing them to concentrate on high scrub dunes where they are exposed to predators. The specific impact depends on a number of factors that include storm (wind, storm surge, and rainfall) intensity; the storm track; where the east side, eye, and west side of the storm make landfall; storm impacts on habitat and food sources; time of year (mid-summer is the worst); population size; and post-hurricane conditions.

Hurricanes can impact beach mice either directly (e.g., drowning) or indirectly (loss of habitat). Additionally, hurricanes can affect beach mice on either a short-term basis (temporary loss of habitat) or long-term basis (loss of food, which in turn may lead to increased juvenile mortality, which can lead to a depressed breeding season).

Hurricanes are a natural environmental phenomenon affecting the Atlantic and Gulf Coasts, and beach mice have evolved and persisted in coastal dune habitats since the Pleistocene. Hurricanes were probably responsible for maintaining coastal dune habitat upon which beach mice depend through repeated cycles of destruction, alteration, and recovery of dune habitat. The extensive amount of pre-development coastal dune habitat along the Gulf Coast allowed beach mice to survive even the most severe hurricane events to repopulate dune habitat as it recovered. It is only within the last 20-30 years that the combination of habitat loss to beachfront development, isolation of remaining habitat blocks and beach mouse populations, and destruction of remaining habitat by hurricanes have increased the threat of extinction of several subspecies of beach mice.

The four listed subspecies of beach mice along the Gulf Coast of Florida and Alabama responded in some similar and different ways to Hurricane Opal and hurricanes that passed subsequently. It appears from tracking or trapping studies that population(s) of all the subspecies survived recent hurricanes (1995-1999) and have recovered, are recovering now, or have low but stable population sizes (Auburn University, unpublished data, 1999; South, personal communication, 1999).

Following hurricanes, the dune system begins a slow natural repair process that may take 3-20 years depending on the magnitude of dune loss (Salmon et al., 1982). During this period, sea oats and pioneer dune vegetation become established, collecting sand and building dunes. As the dunes become stable, other successional dune vegetation colonizes the area (Gibson and Looney, 1994). As the dunes grow and become stable, beach mouse food sources and habitats are reestablished.

Depending on their intensity, size, and passage time, hurricanes making land fall in the western Panhandle of Florida can cause widespread destruction significantly impacting several, if not all, remaining populations of beach mice. For example, all subspecies of beach mice along the Gulf Coast of Florida and Alabama were impacted by Hurricane Opal in 1995 because the storm was over 100 mi (161 km) in width. Extensive damage to dune habitat, primarily from storm surge, occurred at areas supporting all five Gulf Coast subspecies from Ft. Morgan in Baldwin County, Alabama, to the St. Joseph Peninsula in Gulf County, Florida. Areas on barrier islands such as the Perdido Key Unit of the Gulf Islands National Seashore, the Ft. Pickens and Santa Rosa Units of the Gulf Islands National Seashore, and Shell Island off Panama City were overwashed by storm surge. Because of the narrow width of these islands, damage was extensive with an estimated 80-90 percent loss of dune habitat. In some cases (e.g., Ft. Pickens Unit on Santa Rosa Island and Shell Island), all dune structure and vegetation between the beach and the bayside of the area were completely overwashed, leaving long sections of denuded sand flats and blowouts. At areas with high primary dunes (e.g., Topsail Hill State Preserve, Grayton Beach SRA, St. Joseph State Park), the frontal dunes along the beach and the foreslope of the high primary dunes were washed away leaving 17-27 ft (5-8 m) high escarpments. Loss of frontal dune habitat in these areas ranged between 33 and 100 ft (10 and 30 m) deep. Some blowouts in the high primary dunes resulted in inundation of the secondary and scrub dune habitat north of the primary dunes (Leadon, 1996).

Reasons for Current Status

Coastal development continues to be the greatest threat. Habitat reduction and fragmentation have affected the ability of beach mice to quickly recover following tropical storms and have become a major threat to the recovery of the three subspecies. Hurricanes are a natural environmental phenomenon affecting the Gulf Coast, and beach mice have evolved and persisted in coastal dune habitats since the Pleistocene. Hurricanes were probably responsible for maintaining coastal dune habitat upon which beach mice depend through repeated cycles of destruction, alteration, and recovery of dune habitat. The extensive amount of predevelopment coastal dune habitat along the Gulf Coast allowed beach mice to survive even the most severe hurricane events to repopulate dune habitat as it recovered. The combinations of habitat loss to beachfront development, isolation of remaining habitat blocks and beach mouse populations, introduction of non-native predators, and destruction of remaining habitat by hurricanes continue to hamper the recovery of subspecies of beach mice. Habitat fragmentation and the low number of surviving beach mice compromise a beach mouse’s ability to quickly repopulate after a hurricane.

3.2.6. Coastal and Marine Birds

3.2.6.1. Nonendangered and Nonthreatened Species

The offshore waters, coastal beaches, and contiguous wetlands of the northern GOM are populated by both resident and migratory species of coastal and marine birds. They are herein separated into five major groups: diving birds, shorebirds, marsh birds, wading birds, and waterfowl. Many species are mostly pelagic, and therefore rarely sighted nearshore. The remaining species are found within coastal and inshore habitats and are more susceptible to potential deleterious effects resulting from OCS-related activities (Clapp et al., 1982). Recent surveys indicate that, of the affected states, Louisiana is among the primary states in the southern and southeastern U.S. for nesting colony sites and total number of nesting coastal and marine birds (Martin and Lester, 1991; Martin, 1991). Fidelity to these nesting sites varies from year to year along the Gulf Coast. Site abandonment along the northern Gulf Coast has often been attributed to habitat alteration and excessive human disturbance (Martin and Lester, 1991).

Diving birds are a diverse group. There are three main groups of diving birds: cormorants and anhingas (Pelecaniformes), loons (Gaviiformes), and grebes (Podicipediformes). Nesting diving birds on the GOM include cormorants.

Gulls, terns, and black skimmers make up the gull/tern group. Of these, colonies of laughing gulls, eight species of terns, and black skimmers nest in the GOM (Martin and Lester, 1991; Pashley, 1991).

Shorebirds are those members of the order Charadriiformes generally restricted to coastline margins (beaches, mudflats, etc.). The GOM shorebirds comprise five taxonomic families—Jacanidae (jacanas), Haematopodidae (oystercatchers), Recurvirostridae (stilts and avocets), Charadriidae (plovers), and Scolopacidae (sandpipers, snipes, and allies) (Hayman et al., 1986). An important characteristic of almost all shorebird species is their strongly developed migratory behavior, with some shorebirds migrating from nesting places in the far north to the southern part of South America (Terres, 1991). Both spring and fall migrations take place in a series of "hops" to staging areas where birds spend time feeding heavily to store up fat for the sustained flight to the next staging area; many coastal habitats along the GOM are critical for such purposes. Along the Central Gulf Coast, 44 species of shorebirds have been recorded; only 6 nest in the area, the remaining are wintering residents and/or "staging" transients (Pashley, 1991). Although variations occur between species, most shorebirds begin breeding at one to two years of age and generally lay 3-4 eggs per year. They feed on a variety of marine and freshwater invertebrates and fish, and small amounts of plant life.

Collectively, the following families of wading birds have representatives in the northern GOM: Ardeidae (herons and egrets), Ciconiidae (storks), Threskiornithidae (ibises and spoonbills), and Gruidae (cranes). Wading birds are those birds that have adapted to living in shallow water. They have long legs that allow them to forage by wading into shallow water, while their long bills, usually accompanied by long necks, are used to probe under water or to make long swift strokes to seize fish, frogs, aquatic insects, crustaceans, and other prey (Terres, 1991). The term "marsh bird" is a general term for a bird that lives in or around marshes and swamps. Seventeen species of wading birds in the Order Ciconiiformes are currently known to nest in the U.S., and all except the wood stork nest in the northern GOM coastal region (Martin, 1991). Within the Central Gulf Coast region, Louisiana supports the majority of nesting wading birds. Great egrets are the most widespread nesting species in the Central GOM region (Martin, 1991). Members of the Rallidae family (rails, moorhens, gallinules, and coots) have compact bodies, and therefore, they are labeled marsh birds and not wading birds. They are also elusive and rarely seen within the low vegetation of fresh and saline marshes, swamps, and rice fields (Bent, 1926; National Geographic Society, 1983; Ripley and Buehler, 1985).

Waterfowl belong to the taxonomic order Anseriformes and include swans, geese, and ducks. Many species usually migrate from wintering grounds along the Gulf Coast to summer nesting grounds in the north. Waterfowl migration pathways have traditionally been divided into four parallel north-south paths, or "flyways," across the North American continent. The Gulf Coast serves as the southern terminus of the Mississippi (Louisiana, Mississippi, and Alabama) flyway. Waterfowl are highly social and possess a diverse array of feeding adaptations related to their habitat (Johnsgard, 1975).

3.2.6.2. Endangered and Threatened Species

The following coastal and marine bird species that inhabit or frequent north-central and Eastern GOM coastal areas are recognized by FWS as either endangered or threatened: piping plover, bald eagle, brown pelican, and least tern.

Piping Plover

The piping plover (*Charadrius melodus*) is a migratory shorebird that is endemic to North America. The piping plover breeds on the northern Great Plains, in the Great Lakes, and along the Atlantic Coast (Newfoundland to North Carolina); and winters on the Atlantic and Gulf Coasts from North Carolina to Mexico and in the Bahamas West Indies. The final rule on critical habitat of piping plover was published July 10, 2001; there are 20 units of critical habitat in western Florida south to Tampa Bay, 3 areas in Alabama, 15 in Mississippi, 7 in Louisiana, and 37 in Texas (66 FR 132, pp. 36037-36086). Critical wintering habitat includes the land between mean lower low water and any densely vegetated habitat, which is not used by the piping plover. It has been hypothesized that specific wintering habitat, which includes coastal sand flats and mud flats in close proximity to large inlets or passes, may attract the largest concentrations of piping plovers because of a preferred prey base and/or because the substrate coloration provides protection from aerial predators due to chromatic matching, or camouflage (Nicholls and Baldassarre, 1990). This species remains in a precarious state given its low population numbers, sparse distribution, and continued threats to habitat throughout its range. Of the birds located on the U.S. wintering grounds during censuses of 1991 and 1996, about 89 percent were found on the Gulf Coast and 8 percent on the Atlantic Coast. Piping plovers begin arriving on the wintering grounds in July and keep arriving through September. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging. Primary prey for wintering plovers includes polychaete marine worms, various crustaceans, insects, and sometimes bivalve mollusks. They peck prey from on top of or just beneath the sediment. Foraging usually is on moist or wet sand, mud, or fine shell. In some cases, a mat of blue-green algae may cover this substrate. When not foraging, plovers can be found in aggressive encounters, roosting, preening, bathing, and moving among available habitat locations. The habitats used by wintering birds include beaches, mud flats, sand flats, algal flats, and washover passes (areas where breaks in the sand dunes result in inlets). Wintering plovers are dependent on a mosaic of habitat patches and move among these patches depending on local weather and tidal conditions. In late February, piping plovers begin leaving the wintering grounds to migrate back to their breeding sites. Northward migration peaks in late March, and by late May most birds have left the wintering grounds. The migration of the piping plover is poorly understood.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is the only species of sea eagle that regularly occurs on the North American continent (USDOI, FWS, 1984). Its range extends from central Alaska and Canada to northern Mexico. The bulk of the bald eagle’s diet is fish, though bald eagles will opportunistically take birds, reptiles, and mammals (USDOI, FWS, 1984). The historical nesting range of the bald eagle within the Southeast United States included the entire coastal plain and shores of major rivers and lakes. The current range is limited, with most breeding pairs occurring in Florida and Louisiana, and some in South Carolina, Alabama, and east Texas. There are no bald eagle nests within the coastal area of Louisiana (Fuller, personal communication, 2002). According to the Florida Fish and Wildlife Conservation Commission, there were approximately 125 bald eagle nests within 5 mi of the coast from the Alabama state line to Tampa, Florida, during the 2001 nesting season. The majority of the nests were found from Gulf County east to Sarasota County. The bald eagle was listed as endangered in 1967 in response to the declines due to DDT and other organochlorines that affected the species’ reproduction (USDOI, FWS, 1984). Recovery may be slowed by human disturbance if it affects the abundance of preferable trees for nesting and perching. Preferred perch trees may be relatively large in diameter, height, surrounding percent forest cover, surrounding size of block of forest, height of surrounding canopy above the ground, height of perch above surrounding canopy, and size of the angle of open flight path to the perch (Buehler et al., 1992; Chandler et al., 1995). For preferred nest trees, important features may be proximity to water (usually within 1/2 mile), a clear flight path to a close point on the water, an open view of the surrounding area and proximity to preferable perch trees. In July 1995, the FWS reclassified the bald eagle from endangered to threatened in the lower 48 states (*Federal Register*, 1995b) and proposed delisting the bald eagle in the same area in 1999 (64 FR 36453).

Brown Pelican

The brown pelican (*Pelicanus occidentalis*) is one of two pelican species in North America. It feeds entirely upon fishes captured by plunge diving in coastal waters. Organochlorine pesticide pollution apparently contributed to the endangerment of the brown pelican. Organochlorines like DDT accumulate up the food web and reach their highest concentrations in predators such as the brown pelican. The pesticides interfere with calcium metabolism, causing reduced calcification of egg shells, and potentially allowing the eggs to be crushed under the weight of an incubating parent. In recent years, there has been a marked increase in brown pelican populations within the former range of the species. The population of brown pelicans and their habitat in Alabama, Florida, Georgia, North and South Carolina, and points northward along the Atlantic Coast were removed from the endangered species list in 1985; however, within the remainder of the range, which includes coastal areas of Texas, Louisiana, and Mississippi, where populations are not secure, the brown pelican remains listed as endangered (*Federal Register*, 1985b). Ten thousand nests and an estimated 25,000 adults were found in Louisiana (Patrick, written communication, 1997). The Louisiana Department of Wildlife and Fisheries submitted a request in March 1994 to the FWS to officially remove the eastern brown pelican from the endangered species list in Louisiana (Louisiana Dept. of Wildlife and Fisheries, 1994).

Least Tern

The least tern (*Sterna antillarum*) is the smallest North American tern. Three subspecies of New World least terns were recognized by the American Ornithologists' Union (1957). These are the interior least tern (*Sterna antillarum athalossus*), the eastern or coastal least tern (*S. antillarum antillarum*), and the California least tern (*S. antillarum browni*). According to *Federal Register* (1985b), "Because of the taxonomic uncertainty of least tern subspecies in eastern North America, the [Fish and Wildlife] Service decides not to specify the subspecies in this final rule. Instead the Service designates as endangered the population of least terns (hereinafter referred to as interior least tern) occurring in the interior of the United States." Least terns within 50 mi of the Gulf Coast are not are listed as endangered and will not be further analyzed here.

3.2.7. Endangered and Threatened Fish

3.2.7.1. Gulf Sturgeon

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is the only listed threatened fish species in the GOM. The decline of the Gulf sturgeon is believed to be due to overfishing and habitat destruction, primarily the damming of coastal rivers and the degradation of water quality (Barkuloo, 1988).

Sturgeons are bottom suction feeders that have ventrally located, highly extrusible mouths. The sturgeon head is dorsoventrally compressed with eyes dorsal so benthic food under the sturgeon's mouth will not be visible. However, they have sensory chin barbels to detect prey. The barbels may locate food at night when visibility of prey is low from any direction.

A subspecies of the Atlantic sturgeon—Gulf sturgeon—is anadromous, with immature and mature fish participating in freshwater migrations. Gill netting and biotelemetry have shown that subadults and adults spend 8-9 months each year in rivers and 3-4 of the coolest months in estuaries or GOM waters. Sturgeons less than about two years old remain in riverine habitats and estuaries throughout the year (Clugston, 1991). According to Wooley and Crateau (1985), Gulf sturgeon occurred in most major riverine and estuarine systems from eastern Louisiana to the Suwannee River, Florida, and marine waters of the Central and Eastern GOM south to Tampa Bay. Important waters west-to-east and north-to-south are Biloxi Bay, Pascagoula Bay, Mobile Bay, Choctawhatchee Bay, the Apalachicola River, the Ohlockounee River, and the Suwannee River. It is not possible, at present, to estimate the size of the Gulf sturgeon populations throughout the range of the subspecies. Estimates have been completed recently for the Suwannee, Apalachicola, Pascagoula, West Pearl, and Choctawhatchee Rivers. The second year of a

3-year study is underway on the Yellow River, and the first year of a 3-year study is underway on the Escambia River. Surveys have not been conducted yet on the remaining river systems that historically contained Gulf sturgeon. Gulf sturgeon historically spawned in major rivers of Alabama, Mississippi, and the Florida northern Gulf Coast. Until recently only two spawning sites were known, both in the Suwannee River in Florida. Eggs have now been discovered in six locations within the Choctawhatchee River system in Florida and Alabama (Fox and Hightower, 1998). In spring, large subadults and adults that migrate from the estuaries or the GOM into major river passes feed primarily on lancelets, brachiopods, amphipods, polychaetes, and globular molluscs. Small sturgeons that remain in river passes during spring feed on amphipods, shrimp, isopods, oligochaetes, and aquatic insect larvae (Clugston, 1991). During the riverine stage, adults cease feeding, undergo gonadal maturation, and migrate upstream to spawn. Spawning occurs in freshwater reaches of the rivers, over coarse substrate in deep areas or holes with hard bottoms and some water current (Sulak and Clugston, 1998; Fox et al., 2000). Females lay large numbers of eggs, about 4,000,000-7,000,000 eggs. These eggs are adhesive and will attach to rocks, vegetation, or other objects. They hatch in about one week depending upon the temperature of the water.

Gulf sturgeon in the rivers and estuaries are interrupted when migrating by capture with nets suspended from floats in the rivers and river mouths. Gill nets with mesh wide enough not to close the very large opercula are used. Fish biologists use conventional fishing gear, tag-recapture techniques, and ultrasonic and radio telemetry to track migration up and down the rivers and to and from the estuaries and the GOM. Migration to the sea is recorded in fall when the fish disappear from river mouths and estuaries. No capture or tracking is feasible in the open GOM just when the fish migrate into it because cold fronts come every 2-3 days, with up to 9-ft seas. Conditions are dangerous for the size of vessel required, and the paths traveled in the open GOM cannot be followed beyond the estuaries. The offshore winter distribution of Gulf sturgeon relative to the location of the activities under a proposed action is unknown. Tagging studies suggest that Gulf sturgeon exhibit a high degree of river fidelity. Stabile et al. (1996) analyzed Gulf sturgeon populations from eight drainages along the GOM for genetic diversity. He noted significant differences among Gulf sturgeon stocks, and he suggested that they displayed region-specific affinities and may exhibit river-specific fidelity. Stabile et al. (1996) identified five regional or river-specific stocks (from west to east): (1) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers.

In the past, winter migration and distribution data have been unavailable because of harsh and unpredictable weather patterns causing high seas and rough weather conditions. However, recent cooperative research between the University of South Florida and USGS Biological Resources in Gainesville, Florida, using acoustic tags is beginning to provide data on Gulf sturgeon after they leave the rivers (Edwards et al., submitted). Relocations and active tracking of individual fish moving in the 3- to 12-mi area have been documented on a routine basis (Sulak, personal communication, 2002). Researchers suspect that many sturgeons move out beyond the 12 mi documented to date, and it is notable that in January and February all telemetry tagged fish disappear from the nearshore area. This indicates that the tagged sturgeons either move away from the area along the coast or they disperse into deeper water farther offshore.

3.2.7.2. Smalltooth Sawfish

On April 1, 2003, the NOAA Fisheries announced its final determination to list the smalltooth sawfish as endangered under ESA (50 CFR Part 224). The following information is excerpted from NOAA Fisheries' Office of Protected Resources web site (http://www.nmfs.noaa.gov/prot_res/species/fish/ Smalltooth_sawfish.html, USDOC, NMFS, 2001b) and the status review prepared by NOAA Fisheries. The December 2000 status review is also available for downloading at the cited website.

Sawfish, like sharks, skates and rays, belong to a class of fish called elasmobranchs, whose skeletons are made of cartilage. Sawfish are actually modified rays with a shark-like body and gill slits on their ventral side. Sawfish get their name from their "saws,"–which are long and flat snouts edged with pairs of teeth that are used to locate, stun, and kill prey. Their diet includes mostly fish but it also includes some crustaceans.

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

The smalltooth sawfish has a circumtropical distribution and has been reported from shallow coastal and estuarine habitats. In the western Atlantic, the smalltooth sawfish has been reported from Brazil through the Caribbean, the GOM, and the Atlantic Coast of the United States. The smalltooth sawfish has also been documented from Bermuda (Bigelow & Schroeder, 1953).

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

Smalltooth sawfish are generally about 2-ft (0.6 m) long at birth (Bigelow and Schroeder, 1953). Although no formal studies on the age and growth of the smalltooth sawfish have been conducted to date, growth studies of the largetooth sawfish (*Pristis perotteti*), a closely related species, suggest slow growth, late maturity (10 years), and long lifespan (30 years) (Thorson, 1982; Simpfendorfer, 2000a). These characteristics suggest very low intrinsic rates of increase (Simpfendorfer, 2000a) and rebound potentials (Smith et al., 1998).

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

Seasonal records of the smalltooth sawfish in the GOM from Texas to the Florida Panhandle exhibit a pattern of occurrence mainly from April through August. The smalltooth sawfish were described as "abundant" by Jordan and Evermann (1896) and "common" by Breder (1952) in the GOM. The smalltooth sawfish apparently was more common in the Texas to Florida Panhandle region than north of Florida in the Atlantic. Considering the paucity of winter records, it is not understood whether GOM smalltooth sawfish are members of a local subpopulation or represent seasonal immigrants from populations outside the GOM.

The smalltooth sawfish in the northern and western GOM have become rare in the last 30 years. Expansion of commercial fishing and an increase in scientific exploratory fishing in the GOM in the 1950's and 1960's produced many records of smalltooth sawfish, primarily from the northwestern GOM in Texas, Louisiana, Mississippi, and Alabama. Since 1971, however, there have been only three published or museum reports of smalltooth sawfish capture from this region, all from Texas (1978, 1979, 1984).

Sawfish catches have historically been reasonably common in Texas, Louisiana, and Mississippi. As a result, they may not have been viewed with as much curiosity and reported as often as in the Atlantic Coast north of Florida. Therefore, the catch documentation for these states may not be all-inclusive. Regardless, reports of captures have dropped dramatically and the trend of decline in the region is apparent. Louisiana, an area of historical localized abundance, has experienced a marked decline in sawfish landings and landings per unit effort (Simpfendorfer, 2000b). The lack of smalltooth sawfish records since 1984 from the area west of peninsular Florida is a clear indication of decline of the species abundance in the northwestern GOM.

Peninsular Florida has been the U.S. region with the largest numbers of capture records of smalltooth sawfish and apparently is the only area that historically hosted the species year-round. The region's subtropical to tropical climate and availability of desirable habitat, including large expanses of lagoons, bays, and nearshore reefs, are suitable for the species. Although no longer common, smalltooth sawfish were once characteristic and prominent elements of the inshore Florida ichthyofauna. While tagging studies have only been initiated in 2002 for the first time, it appears that there remains a resident population of smalltooth sawfish in south Florida. Most likely, summer-caught smalltooth sawfish taken along the U.S. East Coast north of Florida and from Texas to the Florida panhandle originated from this group. It is unlikely smalltooth sawfish from along the U.S. East Coast north of Florida and from Texas to the Florida panhandle are year-round residents, considering the paucity of winter records from that area. The most likely source of these fish is south Florida, which has the largest known population. The NOAA Fisheries does not have information supporting that there is a population in Mexico. Quantitative data are not available to conduct a formal stock assessment for smalltooth sawfish.

3.2.8. Fisheries

3.2.8.1. Fish Resources

Ichthyoplankton

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

Ichthyoplankton sampling in the Eastern GOM began in the early 1970's with routine surveys for king and Spanish mackerel larvae (Wollam, 1970; Dwinell and Futch, 1973). Houde et al. (1979) conducted major surveys of ichthyoplankton in the Eastern GOM from 1972 to 1974. They sampled 483 stations located on a grid extending from 24°30′ N. latitude to 29°30′ N. latitude and from depths of 10-200 m (33-656 ft). In 1977, the first comprehensive surveys of the Southeastern Area Monitoring and Assessment Program (SEAMAP) began collecting larval fishes in the GOM from a grid of sampling stations encompassing the entire northern GOM (Sherman et al., 1983; Richards et al., 1984; Kelley et al., 1986). More recently, larval fish researchers have been sampling well-defined hydrographic features such as the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991) and the Loop Current frontal boundary (Richards et al., 1989 and 1993). These studies have used real-time physical oceanographic data to guide sampling near the hydrographic features of interest. For the aforementioned surveys, most investigators sampled ichthyoplankton using towed bongo (water column) and neuston (sea surface) nets and occasionally discrete depth nets, with mesh sizes ranging from 0.333 to 1.00 mm (Ditty et al., 1988). Taxonomic resolution in most published studies is at the family level.

Richards (1990) estimates that there are 200 families with more than 1,700 species whose early life stages may occur in the GOM. In addition to the resident fauna, many eggs, larvae, and juveniles may be advected into the GOM from the Caribbean Sea via the Loop Current. In their study of the Loop Current front, Richards et al. (1993) identified 237 taxa representing 100 families. They considered this a remarkable family-level diversity when compared with previous surveys made in the GOM and other oceans. The diversity was attributed to a mix of fauna from tropical and warm temperate oceanic, mesopelagic, and coastal demersal and pelagic species. The larval sampling surveys by Houde et al. (1979) yielded over 200 taxa from 91 families in the Eastern GOM. Ditty et al. (1988) summarized information from over 80 ichthyoplankton studies from the northern GOM (north of 26° N) and reported 200 coastal and oceanic fishes from 61 families. Preliminary SEAMAP cruises collected 137 genera and species from 91 families (Sherman et al., 1983). The most abundant families collected in the Eastern GOM by Houde et al. (1979) were clupeids (herrings), gobiids (gobies), bregmacerotids (codlets), carangids (jacks), synodontids (lizardfishes), myctophids (lanternfishes), serranids (seabasses), ophidiids (cusk eels), and labrids (wrasses). These families contributed 64 percent of the total taxa collected by Houde et al. (1979). Sherman et al. (1983) compared the rank order of the 21 most abundant families overall and by quadrant (northeast, northwest, southeast, southwest) taken during early SEAMAP cruises (**Table 3-6**).

Two of the most important hydrographic features within or close to the proposed lease sale area are the Mississippi River discharge plume and the Loop Current. A series of investigations have shown that ichthyoplankton aggregate at the frontal zone of the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991; Govoni and Grimes, 1992). Grimes and Finucane (1991) sampled larval fishes, chlorophyll *a*, and zooplankton along transects traversing the discharge plume. Total ichthyoplankton catch per tow, individual surface chlorophyll *a* values, and zooplankton volumes were all considerably greater in frontal waters than adjacent shelf or plume waters. They found that when comparing catches of ichthyoplankton among shelf, frontal, and plume samples that frontal samples contained a higher average number of fish larvae than either plume or shelf waters. Hydrodynamic convergence and the continually reforming turbidity fronts associated with the discharge plume probably accounted for the concentration of larval fishes at the front. These investigators hypothesized that frontal waters provide feeding and growth opportunities for larvae. Bothids, carangids, engraulids, exocoetids, gobiids, sciaenids, scombrids, synodontids, and tetraodontids were the nine most frequently caught taxa in the plume/shelf samples off the Mississippi River Delta (Grimes and Finucane, 1991).

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

All of the studies previously mentioned were conducted in the open GOM in shelf or oceanic waters. One survey by Ruple (1984) concentrated on the surf zone ichthyoplankton along a barrier island beach offshore Mississippi. Over the course of a year, Ruple (1984) sampled inner and outer surf zone regions and collected almost 40,000 larval fishes represented by 69 taxa. The most abundant taxa collected from the outer surf zone were anchovies (Engraulidae), Atlantic bumper, and tonguefishes. From the inner surf zone, engraulids, spot, GOM menhaden, and hogchoker were most abundant. Seasonal peaks in abundance occurred at the outer surf zone stations during May and June and at the inner surf zone stations during December. The importance of the surf zone as habitat for larval fishes was not clear, but it appeared as though many of the larvae collected were large in size and may have been intercepted during their shoreward migration into Mississippi Sound, where they would normally take up residence as benthic juveniles.

Larval fishes are highly dependent on zooplankton until they can feed on larger prey. In the northern GOM, the diets of Atlantic croaker, Gulf menhaden, and spot consist mainly of copepods and copepod nauplii, larval bivalves, pteropods, and the dinoflagellate *Prorocentrum* sp. (Govoni et al., 1989).

Ichthyoplankton of DeSoto Canyon

Lyczkowski-Shultz (1999) summarizes observations on the kinds and abundance of fish larvae collected in the vicinity of the DeSoto Canyon. The SEAMAP Program collected 68 bongo and 99 neuston net samples from 14 sites over the Canyon proper during spring from 1986-1993. In addition, 81 bongo and 93 neuston net collections from 15 sites over the northernmost rim area and adjacent inner shelf were taken during fall from 1986-1994.

The diversity and overall abundance of fish larvae in DeSoto Canyon in the spring is comparable to Gulfwide values. Only 13 percent of all bongo and 15 percent of neuston net samples taken during total SEAMAP spring surveys were collected in the vicinity of the Canyon. Yet, these collections yielded 56 percent (bongo) and 53 percent (neuston) of all taxa caught Gulfwide. Mean abundance of larvae (all taxa combined) as measured by bongo and neuston nets exceeded Gulfwide abundances.

The percentage of total survey-collected taxa in the vicinity of DeSoto Canyon was even greater in the fall than in the spring. This was not unexpected since most sampling sites in the fall lie north of the Canyon proper. Mean abundance of larvae just north of the Canyon proper was somewhat less when compared to Gulfwide values.

Dominant taxa whose larvae occurred most frequently in collections in the vicinity of DeSoto Canyon were the same as the dominants found in the entire Gulfwide SEAMAP dataset (**Tables 3-7 and 3-8**). The only notable exceptions were goatfish (*Mullidae)* in the spring neuston samples and round scad (*Decapturus punctatus)* in fall neuston samples. Goatfish young were nearly twice as abundant in the Canyon area as Gulfwide. Young round scad occurred more than twice as frequently in collections from the Canyon as in Gulfwide collections.

Unfortunately, the larvae of only about 10-15 percent of the over 2,000 species of fishes occurring in the GOM and adjacent waters can be identified to the species level. However, comparisons between larvae occurrence and abundance found in the DeSoto Canyon vicinity vs. Gulfwide add insight into the relative importance of the DeSoto Canyon and surrounding area in the early life history of many GOM fishes.

Tuna larvae (*Thunnus spp.)* occurred more frequently outside the DeSoto Canyon region, but this difference was less evident in fall than in spring collections (**Table 3-9**). Specifically, Atlantic bluefin (*Thunnus thynnus)* occurred at a lower percentage of DeSoto Canyon sites in spring than Gulfwide but were no less abundant there especially in bongo collections. Dolphin fish (*Coryphaenidae*) and billfish *(Istiophoridae spp*.) occurred at about the same or greater frequency at Canyon sites in both spring and fall collections in the Canyon proper (**Table 3-10**). Dolphin fish larvae occurred at about the same or greater frequency at Canyon sites in both spring and fall neuston samples and in fall bongo samples. Billfish larvae were found at proportionately fewer DeSoto Canyon sites but their abundance was comparable to Gulfwide values. Snapper (*Lutjanidae)*, a group of fishes very difficult to differentiate species through larval identification, were abundant throughout the GOM and in the vicinity of DeSoto Canyon in the fall.

These data indicate that the ichthyoplankton assemblage in the vicinity of DeSoto Canyon reflects the high diversity of the fish fauna in the GOM. Despite the limited number of samples available, it is clear that the DeSoto Canyon region is likely an important spawning and/or nursery area for many species of fishes.

Ichthyoplankton of the West Florida Shelf

The eggs and larvae of sportfish and their prey food species in the Eastern GOM were studied for the waters of the West Florida Shelf known to be a major spawning ground (Tomas, 1995). As expected, ichthyoplankton distribution and abundance varies with season, latitude, longitude, and regional events such as the development of large chlorophyll plumes or "green rivers," terrestrial river outflows, and red tide. From 1990 through 1993, 15 regional cruises were made to determine the spatial distribution, abundance of eggs and larvae, and the physiological condition of larvae at 60 or more stations on the shelf. Throughout the study period, abundant fish larvae and eggs were found in most regions of the West Florida Shelf. During spring, highest densities were found in areas north of Tampa Bay and at midshelf to shallow inshore regions of the Big Bend area. Summer distributions, strongly influenced by intruding watermasses, had maximal abundance in the southeast inshore regions from Charlotte Harbor to areas off Florida Bay. Fall and winter maxima were found in the midshelf regions due west of Tampa Bay and to the south.

Regions of the northern shelf were consistently high in zooplankton. An extensive chlorophyll plume developed during January through April in most years, extending down the mid-axis of the West Florida Shelf from Cape San Blas to south of Tampa Bay. This "green river" chlorophyll plume is variable from year to year but appears to be a common spring feature of the shelf. In the Tomas study (1995), larval fish densities were highest at the southern edge of the plume and egg maxima are located yet farther south.

Summer conditions had larvae concentrated at the inner shelf areas southeast of Tampa Bay near Charlotte Harbor and Florida Bay. During summer, influences from river outflows were seen to decrease the overall abundance of larvae in the northwestern region of the shelf.

Fall and winter conditions were marked by egg and larval densities distributed throughout the shelf with increases in the northern midshelf area. The southern regions maintained the low plankton biomass.

As discussed by Houde et al. (1979), there are several species of fish larvae in the Eastern GOM that might be termed key species because of their abundance, occurrence during several months of the year, and widespread distributions. The frequent occurrence of these species in samples makes them useful as possible indicator species, which could be used to determine if changes in ichthyoplankton abundance and diversity have occurred in the Eastern GOM. Such changes would imply that changes in spawning success, spawning areas, or larval survival had occurred. Dusky flounder (*Syacium papillosum*) larvae are consistently abundant from spring through fall at depths from 10 m to greater than 200 m. This species, as juveniles and adults, was the most commonly collected demersal species in surveys performed by Alexander et al. (1977). Other flounder, like *Bothus robinsi*, *Etropus rimosus*, and the complex *Citharichthys spp*. also have many of the attributes required of species that might be used as reference species for future research.

The only other demersal species whose larvae fall into the key species category, is the serranid *Diplectrum formosum*. The abundant larvae of this fish are virtually all confined within the 100-m isobath. It was one of the most consistently collected larvae by Houde et al. (1979) at stations less than 50 m in depth, and it occurs commonly from spring through fall, indicating an extensive spawning season in the Eastern GOM. Other important larvae are those of pelagic species. Larvae of the carangid, *Decapterus punctatus,* are common, occur in nearly all months, and are distributed widely. Like the dusky flounder (*Syacium papillosum)*, this species would be a good indicator of change.

Clupeid larvae are abundant but most of the species are not widely distributed in the Eastern GOM. *Sardinella anchovia* is the most widespread of the clupeids and has the longest spawning season. The abundance and consistent occurrence of two species of bregmacerotids over the outer shelf and at offshore stations (Houde et al., 1979) indicates inclusion on key species lists of ichthyoplankton in the Eastern GOM.

Fishes

Finfish

The GOM supports a great diversity of fish resources that are related to variable ecological factors, including salinity, primary productivity, and bottom type. These factors differ widely across the GOM and between the inshore and offshore waters. Characteristic fish resources are associated with the various environments and are not randomly distributed. High densities of fish resources are associated with particular habitat types. Most finfish resources are linked both directly and indirectly to the vast estuaries that ring the GOM. Finfish are directly estuary dependent when the population relies on low-salinity brackish wetlands for most of their life history, such as during the maturation and development of larvae and juveniles. Even the offshore demersal species are indirectly related to the estuaries because they influence the productivity and food availability on the continental shelf (Darnell and Soniat, 1979; Darnell, 1988). Approximately 46 percent of the southeastern United States wetlands and estuaries important to fish resources are located within the GOM (Mager and Ruebsamen, 1988). Consequently, estuary-dependent species of finfish and shellfish dominate the fisheries of the Central and north-central GOM.

The life history of estuary-dependent species involves spawning on the continental shelf; transporting eggs, larvae, or juveniles to the estuarine nursery grounds; growing and maturing in the estuary; and migrating of the young adults back to the shelf for spawning. After spawning, the adult individuals generally remain on the continental shelf. Movement of adult estuary-dependent species is essentially onshore-offshore with no extensive east-west or west-east migration.

Estuary-related species of commercial importance include menhaden, shrimps, oyster, crabs, and sciaenids. Estuary communities are found from east Texas through Louisiana, Mississippi, Alabama, and northwestern Florida. Darnell et al. (1983) and Darnell and Kleypas (1987) found that the density distribution of fish resources in the GOM was highest nearshore off the central coast. For all seasons, the greatest abundance occurred between Galveston Bay and the Mississippi River. The abundance of fish resources in the far Western and Eastern GOM is patchy. The high-salinity bays of the Western GOM contain no distinctive species, only a greatly reduced component of the general estuary community found in lower salinities (Darnell et al., 1983).

Estuaries and rivers of the GOM export considerable quantities of organic material, thereby enriching the adjacent continental shelf areas (Grimes and Finucane, 1991; Darnell and Soniat, 1979). Populations from the inshore shelf zone (7-14 m) are dominated seasonally by Atlantic croaker, spot, drum, silver seatrout, southern kingfish, and Atlantic threadfin. Populations from the middle shelf zone (27-46 m) include sciaenids but are dominated by longspine porgies. The blackfin searobin, Mexican searobin, and shoal flounder are dominant on the outer shelf zone (64-110 m).

The degradation of inshore water quality and loss of GOM wetlands as nursery areas are considered significant threats to fish resources in the GOM (Christmas et al., 1988; Horst, 1992a). Loss of wetland nursery areas in the north-central GOM is believed to be the result of channelization, river control, and subsidence of wetlands (Turner and Cahoon, 1988). Loss of wetland nursery areas in the far Western and Eastern GOM is believed to be the result of urbanization and poor water management practices (USEPA, 1989).

The Gulf menhaden and members of the Sciaenidae family such as croaker, red and black drum, and spotted sea trout are directly dependent on estuaries during various phases of their life history. The occurrence of dense schools, generally by members of fairly uniform size, is an outstanding characteristic that facilitates mass production methods of harvesting menhaden. The seasonal appearance of large schools of menhaden in the inshore GOM waters from April to November dictates the menhaden fishery (Nelson and Ahrenholz, 1986). Larval menhaden feed on pelagic zooplankton in marine and estuarine waters. Juvenile and adult Gulf menhaden become filter-feeding omnivores that primarily consume phytoplankton, but also ingest zooplankton, detritus, and bacteria. As filter-feeders, menhaden form a basal link in estuarine and marine food webs and, in turn, are prey for many species of larger fish (Vaughan et al., 1988).

Sciaenids are opportunistic carnivores whose food habits change with size. Larval sciaenids feed selectively on pelagic zooplankton, especially copepods. Juveniles feed upon invertebrates, changing to a primarily fish diet as they mature (Perret et al., 1980; Sutter and McIlwain, 1987; USDOC, NOAA, 1986).

Shellfish

To a greater degree, estuaries determine the shellfish resources of the GOM. Life history strategies are influenced by tides, lunar cycles, maturation state, and estuarine temperature changes. Very few individuals live more than a year, and most are less than six months old when they enter the extensive inshore and nearshore fishery. Year-to-year variations in shellfish populations are frequently as high as 100 percent and are most often a result of extremes in salinity and temperature during the period of larval development. Shellfish resources in the GOM range from those located only in brackish wetlands to those found mainly in saline marsh and inshore coastal areas. Life history strategies reflect estuary relationships, ranging from total dependence on primary productivity to opportunistic dependence on benthic organisms. The GOM shellfish resources are an important link in the estuary food chain between benthic and pelagic organisms (Darnell et al., 1983; Darnell and Kleypas, 1987; Turner and Brody, 1983).

Up to 15 species of penaeid shrimp can be expected to use the coastal and estuarine areas in the GOM. Brown, white, and pink shrimp are the most numerous. Pink shrimp have an almost continuous distribution throughout the GOM but are most numerous on the shell, coral sand, and coral silt bottoms off southern Florida. Brown and white shrimp occur in both marine and estuarine habitats. Adult shrimp spawn offshore in high salinity waters; the fertilized eggs become free-swimming larvae. After several molts, they enter estuarine waters as postlarvae. Wetlands within the estuary offer both a concentrated food source and a refuge from predators. After growing into juveniles the shrimp larvae leave the saline marsh to move offshore where they become adults. The timing of immigration and emigration, spatial use of a food-rich habitat, and physiological and evolutionary adaptations to tides, temperature, and salinity differ between the two species (Muncy, 1984; Turner and Brody, 1983; USDOC, NOAA, 1986).

About eight species of portunid (swimming) crabs use the coastal and estuarine areas in the GOM. Blue crabs (*Callinectes sapidus*) are the only species, however, that is located throughout the GOM and comprises a substantial fishery. They occur on a variety of bottom types in fresh, estuarine, and shallow offshore waters. Spawning grounds are areas of high salinity such as saline marshes and nearshore waters.

Vast intertidal reefs constructed by sedentary oysters are prominent biologically and physically in estuaries of the GOM. Finfishes, crabs, and shrimp are among the animals using the intertidal oyster reefs for refuge and also as a source of food, foraging on the many reef-dwelling species. Reefs, as they become established, modify tidal currents and this, in turn, affects sedimentary patterns. Further, the reefs contribute to the stability of bordering marsh (Kilgen and Dugas, 1989). Additional information on shellfish and their life histories can be found in Gulf of Mexico Fishery Management Council Generic Amendment for Addressing Essential Fish Habitat (GMFMC, 1998).

Reef fishes

Reef fish species occur in close association with natural or manmade materials on the seafloor. Live-bottom areas of low or high vertical relief partition reefal areas from surrounding sand/shell hash/mud bottom. A number of important reef fish species share the common life history characteristics of offshore spawning and transport of larvae inshore to settle in seagrass meadows throughout the Big Bend of Florida, where they spend an obligatory nursery phase before recruiting to adult stocks offshore. Among these fishes are both winter and summer spawners, gag (*Mycteroperca micolepis*) and grey snapper (*Lutjanus griseus*), respectively, being good examples.

Gag spawn in February and March in a defined area west of the Florida Middle Ground, and larvae are transported inshore to settle in seagrass meadows 30-50 days later. Juveniles remain in the seagrass nursery areas until October or November when they recruit to adult stocks offshore. Spawning and settlement dates reveal distinct spatial and temporal patterns for young gag along the West Florida Shelf. Both spawning and settlement are 10-14 days later in the Panhandle region than that in the southwest Florida; settlement is relatively consistent in southwest Florida, but it is highly variable in the northern region. Two new reserves have been designated (described in **Chapter 3.3.1.**, Commercial Fishing) in the area where fishing activities have been prohibited.

Several mechanisms are proposed (Grimes et al., 1999) to account for the timing and magnitude of settlement: (a) a north-south timing gradient with spawning occurring earlier in the south than in the north; (b) limitation of settlement by seagrass habitat availability due to the annual cycle of seagrass die-back and regeneration; (c) changes in the main direction of larval transport due to the seasonal shift in the wind field from the winter to the spring pattern; and (d) the temporal and spatial match/mismatch between the primary production cycles on the west Florida shelf and spawning and larval production.

Trajectories of satellite-tracked surface drifters support a strong role for the transport mechanism (Grimes et al., 1999). Drifters reveal seasonally changing surface circulation of the West Florida Shelf that would result in high settlement in the north and low settlement in the south during the later part of the spawning season. The "green river" phenomenon is an interannually persistent area of high primary productivity on the West Florida Shelf that coincides temporarily and spatially with gag spawning west of the Florida Middle Ground. It is likely that this production initiates a trophic cascade that supports feeding, growth, and survival of gag larvae during the presettlement phase. The temporal and spatial match/mismatch between the "green river" and gag spawning and larval production may also influence the timing and magnitude of settlement.

Other reef fish species are considered nonestuary dependent such as the red snapper, which remain close to underwater structure. Red snapper feed along the bottom on fishes and benthic organisms such as crustaceans and mollusks. Juveniles feed on zooplankton, small fish, crustaceans, and mollusks (Bortone and Williams, 1986; USDOC, NOAA, 1986).

Pelagics

Pelagic fishes occur throughout the water column from the beach to the open ocean. Water-column structure (temperature, salinity, and turbidity) is the only partitioning of this vast habitat. On a broad scale, pelagic fishes recognize different watermasses based upon physical and biological characteristics. Three ecological groups, delineated by watermass, will be discussed individually:

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

Coastal pelagic species occur in waters from the shoreline to the shelf edge. Oceanic species occur mainly in oceanic waters offshore from the shelf break; however, some species venture onto the shelf with watermass (e.g., Loop Current) intrusions. Mesopelagic fishes occur below the oceanic species group in the open ocean, usually at depths of 200-1,000 m (656-1,280 ft) depending upon absolute water depth.

For coastal pelagic fishes, commercial fishery landings are one of the best sources of information because these species are an important component of nearshore net and hook-and-line fisheries. Some smaller nektonic fishes occupying the surf zone along exposed beaches have been collected with seines (Naughton and Saloman, 1978; Ross, 1983). Information on the distribution and abundance of oceanic species comes from commercial longline catches and recreational fishing surveys. In addition, NOAA Fisheries has conducted routine surveys of the GOM billfishery since 1970 (Pristas et al., 1992). Mesopelagic species are not harvested commercially but have been collected in special, discrete-depth nets that provide some quantitative data on relative abundance (Bakus et al., 1977; Hopkins and Lancraft, 1984; Hopkins and Baird, 1985; Gartner et al., 1987).

Recently, additional restrictions have been placed on the harvest of some sharks. Effective July 1, 2000, it is prohibited to retain, possess, sell, or purchase the following sharks: white, basking, sand tiger, bigeye sand tiger, dusky, bignose, Galapagos, night, Caribbean reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin, mako, bigeye thresher, sevengill, sixgill, and bigeye sixgill.

Coastal Pelagics

The major coastal pelagic families occurring in the region are Carcharhinidae (requiem sharks), Elopidae (ladyfish), Engraulidae (anchovies), Clupeidae (herrings), Scombridae (mackerels and tunas), Carangidae (jacks and scads), Mugilidae (mullets), Pomatomidae (bluefish), and Rachycentridae (cobia). Coastal pelagic species traverse shelf waters of the region throughout the year. Some species form large schools (e.g., Spanish mackerel), while others travel singly or in smaller groups (e.g., cobia). The distribution of most species depends upon water-column structure, which varies spatially and seasonally. Some coastal pelagic species show an affinity for vertical structure and are often observed around natural or artificial structures, where they are best classified as transients rather than true residents. This is particularly true for Spanish sardine, round scad, blue runner, king mackerel, and cobia (Klima and Wickham, 1971; Chandler et al., 1985).

Some coastal pelagic species are found along high-energy sandy beaches from the shoreline to the swash zone (Ross, 1983). Most surf zone habitat in the region is found along the seaward shore of barrier islands in Mississippi, Alabama, and Florida. An estimated 44-76 species, many of them coastal pelagics, occur in the surf zone assemblage. Surveys have shown a high degree of dominance, with 4-10 species accounting for 90 percent of the numbers collected. In the northern GOM, pelagic species such as scaled sardine, Florida pompano, and various anchovies are among the numerically dominant species in seine collections (Ross, 1983). Surf zone fish assemblages show considerable seasonal structuring in the northern GOM (Naughton and Saloman, 1978; Ross and Modde, 1981). The lowest abundance of all species occurs in winter, with peak numbers found during summer and fall. Larger predatory species (particularly bluefish, Spanish mackerel, and blue runner) may be attracted to large concentrations of anchovies, herrings, and silversides that congregate in the surf zone.

Coastal pelagic fishes can be divided into two ecological groups. The first group includes larger predatory species such as king and Spanish mackerel, bluefish, cobia, jacks, and little tunny. These species typically form schools, undergo migrations, grow rapidly, mature early, and exhibit high fecundity. The second group exhibits similar life history characteristics, but the species are smaller in body size and are planktivorous. This group is composed of GOM menhaden, thread herring, Spanish sardine, round scad, and anchovies. Species in the second group are preyed upon by the larger species in the first group; thus, the two are ecologically important in energy transfer in the nearshore environment (Saloman and Naughton, 1983 and 1984).

Commercial purse seine fisheries generate high landings of several coastal pelagic species in the region. The Gulf menhaden fishery in the western portion of the region produces the highest fishery landings in the U.S. (USDOC, NMFS, 2002). Menhaden form large, surface-feeding schools in waters near the Mississippi Delta from April through September. Fishermen take advantage of this schooling behavior, capturing millions of pounds each year with large purse nets. Other coastal pelagic species contributing high commercial landings in the region are round scad and ladyfish, both among the top species landed off the Florida Panhandle during 1991 (Florida Dept. of Natural Resources, 1993).

Most of the large-bodied, predatory coastal pelagic species are important to commercial or recreational fisheries. King and Spanish mackerel, cobia, and jacks are sought by the charter and head-boat fisheries in the region. King mackerel occurring in the shelf waters of the region may actually come from two distinct populations (Johnson et al., 1994). The eastern population migrates from near the Mississippi Delta eastward, then southward around the Florida peninsula, wintering off southeastern Florida (Sutter et al., 1991). The western population travels to waters off the Yucatan Peninsula during winter. In summer, both populations migrate to the northern GOM, where they intermix to an unknown extent (Johnson et al., 1994). Spanish mackerel, cobia, bluefish, jack crevalle, and coastal sharks are migratory, but their routes have not been studied.

Oceanic Pelagics

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

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

Mesopelagics

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

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

3.2.8.2. Essential Fish Habitat

The entire proposed lease sale area is in deep water. The shallowest water depth is located in the northwestern corner of the area in DeSoto Canyon Block 133 at approximately 1,690 m. The deepest portion of the action area is in the southeastern corner in Lloyd Ridge Block 492 reaching depths of around 2,940 m. All of the proposed lease sale area is normally defined as EFH. At this time, there are no known hard-bottom areas in the action area that would be considered EFH (only coral would be considered a managed species group for purposes of defining EFH that could potentially occur on hard bottom in this deepwater area). Within this area, the only species (managed by FMP's) are pelagic species as described below. Additional habitat areas in the vicinity of the proposed lease sale area are also discussed here, as they will be included in later discussions and impact analyses.

Shore-parallel ledges represent the greatest natural topographic relief on the inner west-central Florida continental shelf. For many years, these ledges have been popular fishing sites. The Florida Middle Ground (FMG), located about 160 km west-northwest of Tampa, is probably the best known and most biologically diverse of the Eastern GOM fish habitat, with extensive habitation by reef fish and shellfish.

The FMG was visited by scientists from the University of South Florida in October of 1995. Greater than 350 nmi of seismic and side-scan-sonar data were acquired, and bottom reconnaissance by a remotely operated vehicle was performed. Seismic surveys extend west to the 200-m isobath. These data reveal the FMG reef complex and underlying geology to be more complex than previously recognized. The deepest continuous reflector exhibits a high amplitude return and shows 4 m of vertical relief. ROV reconnaissance reveals a fauna consisting predominantly of sponges, Gorgonian corals, and hydrozoans, with few head corals. The presence of abundant reef rubble on slopes and the lack of carbonate producers indicate a degradational environment.

At present, the FMG area is affected by periodic upwelling (Austin and Jones, 1974) and seasonal high-chlorophyll plumes indicating high productivity and eutrophic water conditions (Gilbes et al., in press). These plumes have been recognized by Coastal Zone Color Scanner imagery every spring between 1979 and 1986. Green river plumes begin north of the FMG area near Apalachicola Bay and migrate south-southeast directly over the FMG. The origin of the plume is not known, but several mechanisms have been proposed including Loop Current interactions with the platform margin producing upwelling and entrainment of high-nutrient watermasses from fluvial discharge. The productivity plume certainly has a substantial influence on biogenic sediment production directly, and indirectly by contributing resources to higher trophic levels. The resulting organic, carbonate, and siliceous materials become part of the shelf sediment budget. These eutrophic water conditions inhibit modern coral production and have appreciable bearing on the development of the FMG reef complex and implications for paleocirculation patterns. The massive FMG carbonate buildups indicate that water column conditions, existing at the time of FMG formation, were considerably different from those that exist today. The change in trophic conditions indicates that different physical processes operated during the lower sea-level stands.

Much of the snapper and groupers harvested in the GOM are captured from the west Florida shelf. These fishes are an important resource, as they comprise a major target of marine fishing in Florida. Several species that could benefit from habitat protection can be identified as economically important shelf-edge species and include groupers such as gag (*Mycteroperca microlepis*), scamp (*Mycteroperca phenax*), and black grouper (*Mycteroperca bonaci*) along with several species of snappers (Lutjanidae) and porgies (Sparidae). On the shelf-slope, the deepwater grouper complex includes speckled hind (*Epinephelus drummondhayi*), yellowedge grouper (*Ephinephelus flavolimbatus*), warsaw grouper (*Epinephelus nigritus*), snowy grouper (*Epinephelus niveatus*), and misty grouper (*Epinephelus mystacinus*). For some species that aggregate, fishing mortality has caused a severe decline in the abundance of male fish warranting concerns about protection of spawning aggregations. For several species, declines in landings, mean size, and size at maturity are indicators of overfished conditions. Speckled hind (*Epinephelus drummondhayi*) and warsaw grouper (*Epinephelus nigritus*), inhabiting steep cliffs and rocky ledges on the continental slope, warrant particular concern and were added to a list of candidate species for endangered/threatened status in 1999 (Grimes et al., 1999).

While there may be some promise for protecting habitat to conserve reef fish stocks, there is still a lack of documentation on specific hard-bottom and high-relief areas in the Eastern GOM. In general, the West Florida Shelf contains the greatest amount of reef habitat (38% consisting of rock, coral, and sponge) of the U.S. coast along the south Atlantic and GOM (Parker et al., 1983). Continental Shelf Associates (CSA, 1992a) refined this estimate to between 17 and 20 percent hard bottom with about 3 percent making up high-relief (>1 m in height) features along the west Florida shelf. However, the CSA report pointed to several areas where data were lacking and estimated that only 9 percent of this entire shelf region had been surveyed in a manner allowing calculation of habitat area.

In reviewing historical and current fishing patterns, it becomes apparent that there are high-relief shelf-edge regions that are generally not mapped or documented, but are well known to fishermen. Moe (1963) conducted a survey of offshore fishing in Florida and reported habitat features and place names common at that time. Outer shelf areas were targeted principally by commercial fishermen although these areas were considered remote and lightly fished during the early 1960's. High-relief pinnacle and ridge areas were identified along the 70-m contour west of the Big Bend region and west of the Florida Everglades. These high-relief features were not reported along the shelf edge from west-central Florida. Topographic surveys also show the potential for extensive high-relief shelf-edge habitats in the same two areas (CSA, 1992a). Two more recent NOAA Fisheries fishery surveys conducted using on-board observers, obtaining fishing locations, indicates that these areas are still targeted by hook-and-line (bandit and electric reels) and longline gear (Denton and Davenport, 1995). These commercial fisheries are known to target hard-bottom areas. The fishing locations generally overlap with the 70-m contour west of Big Bend and the Everglades (Grimes et al., 1999).

Today, most of the effort expended on understanding what controls fishery populations focuses on the effects of fishing. Recent proposals by the NOAA Fisheries are examples of attempts to conserve fish populations by increasing constraints on fishing efforts in particularly vital GOM habitats (GMFMC, 2000).

The Essential Fish Habitat Program in the Gulf of Mexico

As outlined in **Chapter 1.3.** (Regulatory Framework), the Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended through 1998, places new requirements on any Federal agency EFH. The MMS must now describe how actions under their jurisdiction may affect EFH. All Federal agencies are encouraged to include EFH information and assessments within NEPA documents.

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

The requirements for an EFH description and assessment are as follows: (1) description of a proposed action; (2) description of the action agency's approach to protection of EFH and proposed mitigation, if applicable; (3) description of EFH and managed and associated species in the vicinity of a proposed action; and (4) analysis of the effects of a proposed and cumulative actions on EFH, the managed species, and associated species. **Chapters 1. and 2.** contain a detailed description of a proposed action. **Chapter 1.3.** discusses MMS's approach to the preservation of EFH with specific mitigations. **Chapter 3.2.1.**, Sensitive Coastal Environments, details coastal areas that are considered EFH including wetlands and areas of submerged vegetation. **Chapter 3.2.2.**, Sensitive Offshore Benthic Resources, describes offshore areas that are considered EFH including live-bottom formations followed by a description of their biotic assemblages. Below is a discussion of managed species and additional mitigating factors. **Chapter 4.2.1.10.** contains the impact analysis of a proposed action on EFH from routine operations. **Chapter 4.4.3.10.** contains the impact analysis for accidental spills on EFH. **Chapter 4.5.10.** contains the impact analysis of cumulative actions.

Managed Species

The GMFMC currently describes Fishery Management Plans for the following species. These species or species complexes are brown shrimp (*Penaeus aztecus)*, pink shrimp (*Penaeus duorarum)*, white shrimp (*Penaeus setiferus*), royal red shrimp (*Pleoticus robustus*), red drum (*Sciaenops ocellata*), black grouper (*Mycteroperca bonaci*), red grouper (*Epinephelus morio*), gag grouper (*Mycteroperca microlepis*), scamp (*Mycteroperca phenax*), red snapper *(Lutjanus campechanus*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lujanus syngagris*), vermilion snapper (*Rhomboplites aurorubens*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), lesser amberjack (*Seriola fasciata*), tilefish (Branchiostegidae), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), dolphin (*Coryphaena hippurus*), little tunny (*Euthynnus alleteratus*), stone crab (*Menippe *spp*.), spiny lobster (*Panulirus spp*.), and coral (Anthoza). None of the stocks managed by the GMFMC are endangered or threatened.

Occurrence of these managed species, along with major, adult prey species and relationships with estuary and bay systems in the Eastern GOM, is outlined in **Table 3-11**. As previously discussed, the occurrence of managed species in the actual space of the proposed lease sale area is limited to the pelagic species, in this case, mackerels. Detailed presentations of species abundance, life histories, and habitat associations for all life history stages are presented in the generic Amendment for Essential Fish Habitat by the GMFMC (1998).

Tuna (Scombridae), billfish (Istiophoridae), swordfish (Xiphiidae), and sharks (Squaliformes) are under the direct management of NOAA Fisheries and are not included as Fishery Management Council managed species. The EFH areas for these HMS are described in separate FMP, including the FMP for Atlantic tunas, swordfish, and sharks (USDOC, NMFS, 1999b) and the Atlantic billfish FMP Amendment 1 (USDOC, NMFS, 1999a). These separately managed species include albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Euthynnus pelamis*), yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*), a suite of 32 shark species (Squaliformes), and billfish (Istiophoridae) species including the blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), sailfish (*Istiophorus platypterus*), and longbill spearfish (*Tetrapturus pfluegeri*). All of the highly migratory species in **Table 3-12** could occur inside the boundaries of the proposed lease sale area. Many of these highly migratory species such as billfishes are associated with upwelling areas where canyons cause changes in current flow (upwelling) and create areas of higher productivity.

As described by NMFS documents (USDOC, NMFS, 1999a and b), the current status of the scientific knowledge of these species is such that habitat preferences are largely unknown or are difficult to determine. As in the case with shark species, it is difficult to define the habitat of sharks of this temperate zone in the GOM because most species are highly migratory, using diverse habitats in apparently nonspecific or poorly understood ways. Temperature is a primary factor affecting the distribution of sharks, and their movement in coastal waters is usually correlated with unpredictable seasonal changes in water temperature. Similar to the species managed by the GMFMC described above, the occurrence of these 14 species managed by NOAA Fisheries, along with major prey species, is outlined in **Table 3-12**. Bay and estuary relationships are not cited in the FMP's, except in one instance of the bull shark where estuary areas are used as a nursery area. As additional, life history information is developed, additional use of inshore and estuary area may be included as EFH in the future.

The GMFMC *Generic Amendment for Addressing Essential Fish Habitat Requirements* (GMFMC, 1998) identifies threats to EFH and makes a number of general and specific habitat preservation recommendations for pipelines and oil and gas exploration and production activities within State waters and OCS areas.

The general recommendations for State waters and wetlands are as follows:

(1) Exploration and production activities should be located away from environmentally sensitive areas such as oyster reefs, wetlands, seagrass beds, endangered species habitats and other productive shallow water areas. Use of air boats instead of marsh buggies should be implemented whenever possible.

(2) Upon cessation of drilling or production, all exploration/production sites, access roads, pits and facilities should be removed, backfilled, plugged, detoxified, revegetated and otherwise restored to their original condition.

(3) A plan should be in place to avoid the release of hydrocarbons, hydrocarbon-containing substances, drilling muds, or any other potentially toxic substance into the aquatic environment and the surrounding area. Storage of these materials should be in enclosed tanks whenever feasible or, if not, in lined mud pits or other approved sites. Equipment should be maintained to prevent leakage. Catchment basins for collecting and storing surface runoff should be included in the project design.

Individual states, the Army Corps of Engineers, and the USEPA have review and permit authority over oil and gas development and production within State waters. All oil and gas activities in coastal or wetland areas must adhere to numerous conservation measures before receiving permits from these agencies. In order to minimize potential coastal impacts from OCS-related activities, MMS has numerous safety, inspection, and spill-response requirements in place to prevent an accidental release of hydrocarbons from either happening at all or from reaching land (**Chapters 1.5. and 4.3.1.1.**).

The *Generic Amendment* lists a number of measures that may be recommended in association with exploration and the production activities located close to hard banks and banks containing reef-building coral on the continental shelf. These recommendations are:

(1) Drill cuttings should be shunted through a conduit and discharged near the seafloor, or transported ashore, or to less sensitive, NOAA Fisheries-approved offshore locations.
(2) Drilling and production structures, including pipelines, generally should not be located within 1 mi of the base of a live reef.
(3) All pipelines placed in waters less than 200 ft deep should be buried to a minimum of three feet beneath the seafloor, where possible. Pipeline alignments should be located along routes that minimize damage to marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.
(4) In anchorage areas, all abandoned structures must be cut off 25 ft below the mud line. If explosives are to be used, the NOAA Fisheries should be contacted to coordinate marine mammal and endangered species concerns.
(5) All natural reefs and banks, as well as artificial reef areas, should be avoided.

The *Generic Amendment* makes an additional specific recommendation regarding OCS oil and gas activities under review and permit authority by MMS and USEPA. Specifically, for the conservation of EFH, activities should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the seafloor. The MMS lease sale stipulations and regulations already incorporated many of the suggested EFH conservation recommendations. Lease sale stipulations are considered a normal part of the OCS operating regime in the GOM. Compliance with stipulations from lease sales is not optional; application of a stipulation(s) is a condition of the lease sale. In addition, MMS may attach mitigating measures to an application (exploration, drilling, development, production, pipeline, etc.) and issue a NTL.

The MMS Topographic Features, Pinnacle Trend, and Live Bottom (Low Relief) Stipulations were formulated more than 20 years ago and were based on consultation with various Federal agencies and comments solicited from State, industry, environmental organizations, and academic representatives. These stipulations address conservation and protection of essential fish habitat/live-bottoms areas. The stipulations include exclusion of oil and gas activity (structures, drilling, pipelines, production, etc.) on or near live bottom areas (both high-relief and low-relief), mandatory shunting near high-relief features, relocation of operations including pipelines away from essential fish habitat/live bottoms, and possible monitoring to assess the impact of the activity on the live bottoms.

Mitigating measures that are a standard part of the MMS OCS Program limit the size of explosive charges used for platform removal; require placing explosive charges at least 15 ft below the mudline; establish No Activity and Modified Activity Zones around high-relief live bottoms; and require remote-sensing surveys to detect and avoid biologically sensitive areas such as low-relief live bottoms, pinnacles, and chemosynthetic communities.

In consideration of existing mitigation measures, lease stipulations, and a submitted EFH assessment document, MMS entered into a programmatic consultation agreement with NOAA Fisheries on July 1, 1999, for petroleum development activities in the CPA and WPA of the GOM. The NOAA Fisheries considered an EFH assessment describing OCS development activities, an analysis of the potential effects, MMS's views on those effects, and proposed mitigation measures as acceptable and meeting with the requirements of EFH regulations at 50 CFR Subpart K, 600.920(g). The MMS has requested and received an amendment to the programmatic-level consultation to include the proposed EPA lease sale area. The same mitigation measures and lease stipulations were evaluated by NOAA Fisheries as part of the EFH assessment contained in this EIS. No new conservation recommendations were made for the EPA lease sale area. Although none apply to the EPA lease sale area, the following programmatic consultation recommendations were made by NOAA Fisheries in 1999, which MMS has accepted and adopted:

> When the Live Bottom (Pinnacle Trend) Stipulation is made a part of a pipeline laying permit, MMS shall require that: No bottom-disturbing activities, including anchors from a pipeline laying barge, may be located within 100 ft of any pinnacle trend feature with vertical relief greater than or equal to 8 ft.
>
> When the Topographic Features Stipulation is made a part of a permit that proposes to use a semi-submersible drilling platform, MMS shall require that: No bottom-disturbing activities, including anchors or cables from a semisubmersible drilling platform, may occur within 500 ft of the No Activity Zone boundary.
>
> When the Topographic Features Stipulation is made a part of a permit that proposes exploratory drilling operations, MMS shall require that: Exploratory operations that drill more than two wells from the same surface (surface of the seafloor) location at any one or continuous time and within the 3-Mile Restricted Activity Zone must meet the same requirements as a development operation (i.e., drilling discharges must be shunted to within 10 m of the seafloor).
>
> When the Topographic Features Stipulation is required for any proposed permit around Stetson Bank, now a part of the Flower Gardens Banks National Marine Sanctuary (FGBNMS), the protective requirements of the East and West Flower Garden Banks shall be enforced.
>
> Where there is documented damage to EFH under the Live Bottom (Pinnacle Trend) or Topographic Features lease stipulations, MMS shall coordinate with the NOAA Fisheries Assistant Regional Administrator, Habitat Conservation Division, Southeast Region for advice. Based on the regulations at 30 CFR Subpart N, 250.200, "Remedies and Penalties." the Regional Director of MMS may direct the preparation of a case file in the event that a violation of a lease provision (including lease stipulations) causes serious, irreparable, or immediate harm or damage to life (including fish and other aquatic wildlife) or the marine environment. The conduct of such a case could lead to corrective or mitigative actions.
>
> The MMS shall provide NOAA Fisheries with yearly summaries describing the number and type of permits issued in the CPA and WPA, and permits for activities located in the Live Bottom (Pinnacle Trend) and Topographic Features blocks for that year. Also, the summaries shall include a report of any mitigation actions taken by MMS for that year in response to environmental damage to EFH.

Mitigating Factors

As discussed above, the GMFMC EFH conservation recommendations for oil and gas exploration and production activities are specified and are currently being followed by MMS as mitigating actions to EFH. The MMS regulations and lease sale stipulations already incorporate many of the suggested EFH conservation recommendations. In some cases MMS works with other Federal agencies to mitigate effects in an area. In addition, MMS may attach mitigating measures to an application (exploration, drilling, development, production, pipeline, etc.) and issue a NTL.

The subsurface portions of any structures in the proposed lease sale area will act as reef material and a focus for many reef-associated species. The State of Florida recognizes the value of artificial reefs as demonstrated through the designation of three artificial reef areas off the Florida Panhandle. Approximately one-half of the permitted 250 sites for development of manmade reefs in the Atlantic and GOM occur off the coast of Florida. Two platforms donated to the State of Florida by Tenneco and Chevron are already located in Florida's Escambia artificial reef area. Fisheries Management Plans specifically describe the use of artificial reefs as EFH. The EFH amendment from the South Atlantic Fishery Management Council (1998) describes how manmade reefs are deployed to provide fisheries habitat in a location that provides measurable benefit to man. When manmade reefs are constructed, they provide new primary hard substrate similar in function to newly exposed hard bottom, with the additional benefit of substrate extending from the bottom to the surface. Reef structures of high profile seem to yield generally higher densities of managed and non-managed pelagic and demersal species than a more widespread, lower profile natural hard bottom or reef (South Atlantic Fishery Management Council, 1998). The benefits of artificial reefs created by the installation of energy production platform structures are well documented in GOM waters off the coast of Texas and Louisiana.

3.3. Socioeconomic Activities

3.3.1. Commercial Fishing

The GOM provides nearly 20 percent of the commercial fish landings in the continental U.S. on an annual basis. The most recent, complete information on landings and value of fisheries for the U.S. was compiled by NOAA Fisheries for 2000. During 2000, commercial landings of all fisheries in the GOM totaled nearly 1.8 billion pounds, valued at over $994 million (USDOC, NMFS, 2002).

Menhaden, with landings of about 1.3 billion pounds and valued at $80.7 million, was the most important GOM species in terms of quantity landed during 2000. Landings decreased by 226.6 million pounds (15%) in the Gulf Coast States compared to 1999. Shrimp, with landings of nearly 655 million pounds and valued at about $478 million, was the most important GOM species in terms of value landed during 2000. The 2000 GOM oyster fishery accounted for nearly 64 percent of the national total of all oysters and 86 percent of Eastern GOM oysters with landings of 50 million pounds of meats, valued at about $28 million. The GOM blue crab fishery accounted for 37 percent of the national total with landings of 69 million pounds, valued at about $51 million (USDOC, NMFS, 2002).

Nearshore and offshore waters east of the Mississippi River Delta support a diverse assemblage of valuable fishery resources. These resources, in turn, support important commercial fisheries for the region. Coastal fishes of commercial importance to the northeastern GOM include sheepshead, red snapper, scad, ladyfish, sardines, spotted seatrout, grouper, and mullet. Pelagic fishes of commercial importance make seasonal movements up and/or down the west Florida coast and back and forth between nearshore and offshore waters. Pelagic fishes of commercial importance include Spanish and king mackerel, amberjack, and several species of tuna. Important invertebrates landed along the west coast of Florida include American oyster, blue crab, and four species of shrimp (pink, white, brown, and rock).

Louisiana’s total commercial landings in 2000 were 1.4 billion pounds, valued at $419 million. Shrimp was the most important fishery landed, with about 145 million pounds valued at $171 million. In addition, during 2000, the following marine species each accounted for landings valued at over $1 million: Atlantic menhaden, black drum, blue crab, Eastern oyster, red snapper, yellowfin tuna, and swordfish (USDOC, NMFS, 2002). Yellowfin tuna were not reported in the previous year’s landings.

Mississippi’s total commercial landings in 2000 were 217.7 million pounds, valued at $58.7 million. Shrimp was the most important fishery landed, with 14.5 million pounds valued at $34 million. In addition, during 2000, the following three species each accounted for landings valued at over $250,000: Atlantic menhaden, blue crab, Eastern oyster, and striped mullet (USDOC, NMFS, 2002).

Alabama’s total commercial fishery landings for 2000 were 30.5 million pounds, valued at $64.1 million. Shrimp was the most important fishery, with about 20.1 pounds landed valued at about $56.7 million. In addition, during 2000, the following two species each accounted for landings valued at over $750 thousand: blue crab, Eastern oyster, and striped mullet (USDOC, NMFS, 2002).

Total commercial landings for the west coast of Florida in 2000 were 76.7 million pounds, valued at $158.9 million. Shrimp was the most important fishery landed, with 13.6 million pounds valued at $ 40.4 million. In addition, during 2000, the following species each accounted for landings valued at over $5 million: Quahog clam (from aquaculture), stone crabs, red grouper, gag, striped mullet, and Caribbean spiny lobster (USDOC, NMFS, 2002).

In April 1997, Continental Shelf Associates (CSA, 1997a) completed a study characterizing recreational and commercial fishing east of the Mississippi Delta for the period 1983-1993. A synopsis of some of the conclusions concerning commercial fisheries for the region from 1983 to 1993 is included below (CSA, 1997a), although the study emphasized the panhandle area of Florida.

Baitfishes accounted for the highest commercial landings in the region during the period 1983-1993. Menhaden contributed the greatest proportion of the entire finfish landings; however, the Florida Panhandle landings for menhaden are orders of magnitude lower than those reported in Louisiana and Mississippi. The baitfish fishery showed signs of overfishing (fishing effort increased, landings decreased) or at least great stress. If user demand continues as it has over the 1983-1993 period, a collapse in the bait fishery is a distinct possibility.

Coastal pelagic fishes, including king and Spanish mackerel, cobia, and jacks, are an important group to the commercial fisheries of the northeastern GOM. The ladyfish or tenpounder accounted for the highest portion of the coastal pelagic landings. Gill nets and purse nets are the primary gear type used for coastal pelagic fishes. The Florida Panhandle is probably the most important fishing area for this species in the entire GOM (Joyce, 1983). Coastal pelagic landings fell during the period of 1983-1993. This is to be expected since both nominal and real income of the fishers is rising at rapid pace, thereby inducing more fishers and vessels into this fishery. The increase in fishing effort places stress on the coastal pelagic fishery resource, which eventually leads to overfishing.

Ranking third in landings over the period 1983-1993, behind the baitfishes and coastal pelagic fishes, were reef fishes. This species group was sought after by more fishers and included many more species than the other groups. The reef fishery also generated the highest valued finfish landings for the region. Hook-and-line, bottom longline, and traps were the most important gear types used to catch reef fishes in the northeastern GOM waters. Reef fishing for snappers, groupers, gray triggerfish, and amberjacks takes place in offshore shelf waters (20-200 m) over natural or artificial bottom. Certain deepwater reef fishes such as snowy, yellowedge, and warsaw groupers are fished exclusively in waters off the shelf break. Reef fishes, along with coastal pelagic fishes, are the most sought after groups by fishermen from Alabama and Florida who venture over to the oil and gas platforms off the adjacent States. The reef fish fishery showed a decline during the early years of 1983-1993 but finished the period on the rise. According to the GMFMC (1995), this may be explained by the overfishing of red snapper in the early 1980's and recent recovery in the stocks of this species due to various fishery management measures to protect this population. The rise in reef fish landings during the 1990's may also be due to a switch in fishing effort from red snapper to vermilion snapper, which became the most frequently landed reef fish during the period. Both these species have been experiencing intense fishing pressure from fishermen in Alabama and Florida regions within the past several years.

Oceanic pelagic fishes were not landed in high quantities relative to other finfish groups during 1983-1993; however, they were very valuable, ranking second to reef fishes in average dollar value of landings. The most important species, yellowfin tuna and swordfish, were caught primarily by surface longline in oceanic waters offshore of the shelf break. Because these fisheries operate in the open GOM, catches responsible for landings in a specific State could have been made in waters outside the region. The demand for oceanic pelagic fishes accelerated very rapidly over the 1983-1986 period and leveled off over the rest of the study period remaining rather static in terms of catch, price, and dockside value from 1987 to 1993.

The remaining group of finfishes landed by commercial fishers in the northeastern GOM—the demersal fishes—was taken almost exclusively from inland (estuarine) waters. The primary gear types used in this fishery are purse nets and gill nets. For the period 1983-1993, striped mullet was the key species in the demersal landings, followed by spotted seatrout. These species were caught mostly by gill nets, and the number of fishing trips made annually was high compared with the other net fisheries. The mullet fishery is relatively valuable, due in part to the recent increases in demand for the roe in foreign markets. Most coastal counties in Alabama and the Florida Panhandle reported sizeable landings of striped mullet. Important variables impacting fishery landings include fishing pressure, management measures, loss of habitat, and pollution. Many of the demersal species are estuarine-dependent so the quality of the estuarine habitats is critical to maintaining catch levels. Little data is available on trends in various pollutants that could impact the juvenile and adult segments of the population in the vast system of northeastern GOM estuaries. However, the trend from 1983 to 1993 for demersal species shows that the landings stabilized with an increase in value toward the latter part of the period. Several members of this species group, including red drum, striped mullet, and spotted seatrout, were subject to legislation during the period.

The dominant invertebrate species groups in the northeastern GOM fisheries were shrimp, oysters, and blue crab. These three species groups were almost exclusively fished in inland (estuarine) waters.

Little shrimping is done in shelf waters offshore Alabama or Florida. Some shrimping (royal red shrimp) does occur in DeSoto Canyon and in Louisiana, Mississippi, Alabama (primarily brown shrimp with some white shrimp catches), and Florida State waters (primarily pink shrimp). The value of shrimp landings exceeded that of all other fish or invertebrate species group. Shrimp were caught with otter trawls, butterfly nets, and beam trawls.

Blue crab was an important component of the invertebrate fishery. Blue crab was caught mostly by trap, but the shrimp trawl fishery contributed a small proportion to the number of landings. The value of the blue crab landings was considerably less than the value of the shrimp landings. The blue crab catch in Mississippi and Alabama is an important part of the U.S. supply of this food commodity; therefore, changes in this catch greatly impact prices. However, price analysis for the period 1983-1993 shows that crab catches appear to be suffering from overfishing or environmental variables, and this is making it difficult for crab fishing to be profitable no matter what the capital outlay.

Oyster landings ranked third in weight and second in value behind shrimps for Alabama and northwest Florida. Oysters were harvested with tongs, a traditional method that is labor intensive, but allows for more a sustainable fishery than would be possible if more efficient means were to be used. The most common factor limiting the harvesting of oysters is high coliform counts or bacterial levels forming in bays and inlets, especially where the water is confined or receives limited flushing into the GOM. Oysters are plagued by marketing problems in that the public is increasingly aware of public health problems associated with eating oysters. The static nature of the fishing effort and technology in the oyster industry from 1983 to 1993 is consistent with a lack of productivity. The static character makes it difficult for oyster fishermen to increase profits despite increased fishing efforts.

Important finfish groups landed at ports in Alabama and along Florida's northwest coast include snapper, porgies, mullet, baitfish, jacks, triggerfish, grouper, tuna, and other pelagics. Important shellfish groups landed at ports in Alabama and along Florida's northwest coast include shrimp, oysters, and crab. In July 1995, the State of Florida enacted a ban upon the use of entanglement nets (gill and purse nets but not trawls) in State waters (14.5 km offshore on the GOM side of the state). This law has caused a substantial drop in the landings of baitfishes, coastal pelagic, and demersal fishes throughout the Florida Panhandle.

Twelve commercial species harvested from Federal GOM waters are considered to be at or near an overfished condition in 2000 (USDOC, NMFS, 2001b). Continued fishing at the present levels may result in rapid declines in commercial landings and eventual failure of certain fisheries. Commercial landings of traditional fisheries, such as red snapper, vermilion snapper, spiny lobster, jewfish, and mackerel, have declined over the past decade despite substantial increases in fishing effort. Commercial landings of fisheries such as shark, black drum, and tuna, have increased exponentially in the recent years, and those fisheries are thought to be in need of conservation (Grimes et al., 1992; USDOC, NMFS, 1997).

Most recently, gag grouper and vermilion snapper were added to the 2001 NOAA Fisheries report's list of stocks for which overfishing is occurring in the GOM. Six other species—red snapper, red grouper, Nassau grouper, jewfish, king mackerel, and red drum—were listed in the report as overfished in the GOM. Shrimp stocks, the primary cash catch in the Gulf Coast States, remain strong according to the report. The status of another 40 GOM fishery species is described as "unknown," but at least one-third of U.S. marine fishery stocks are considered overfished (USDOC, NMFS, 2001a). The number of species considered to be overfished will likely continue to rise under new, more stringent requirements of the Magnuson-Stevens Fisheries Management and Conservation Act. See **Chapter 1.3.**, Regulatory Framework, for details on the Act.

Nearly all species substantially contributing to the GOM's commercial catches are estuarine dependent. The degradation of inshore water quality and loss of GOM wetlands as nursery areas are considered significant threats to commercial fishing (USEPA, 1992 and 1994; Christmas et al., 1988; Gulf States Marine Fisheries Commission, 1988). Natural catastrophes may change the physical characteristics of offshore, nearshore, and inshore ecosystems and destroy gear and shore facilities. Hurricane Andrew, in August 1992, caused extensive damage to GOM wetlands and killed at least $7.8 million worth of saltwater finfish and $3.5 million worth of oysters. Commercial fishery losses were estimated at $54 million for the months of September and October 1992 alone (Horst, 1992a). Over $10 million in damages to fisheries product, seafood plants, and vessels were incurred (USDOC, NMFS, 1994a). Hurricane Opal in October 1995 caused extensive damage to offshore fishing grounds in the northeastern GOM. Examination of artificial reefs off the Florida Panhandle one year after the passage of

Hurricane Opal revealed storm-related deterioration and destruction of fishing reefs (Maher, written communication, 1996).

The GOM shrimp fishery is the most valuable in the U.S., accounting for 69 percent of the total domestic production (USDOC, NMFS, 2002). Three species of shrimp—brown, white, and pink—dominate landings by weight. The shrimp fishery is facing several problems: too many vessels given available yields of shrimp; imports of less expensive shrimp from foreign countries, accounting for 35 percent of the value of total edible imports in 2000 (USDOC, NMFS, 2000); continued decline in ex-vessel price of domestic shrimp; other related fishing needs; increases in fuel prices; excessive costs of marine casualty insurance; regulations regarding the use of turtle excluder devices and by-catch devices; excessive bycatch of finfish; and conflicts with other targeted fisheries (Gulf States Marine Fisheries Commission, 1988; Louisiana Dept. of Wildlife and Fisheries, 1994; USDOC, NMFS, 1996). Without the use of by-catch reduction devices, it has been estimated that for every pound of shrimp landed, several pounds of valuable finfish are killed and discarded as bycatch (Sports Fishing Institute, 1989). The red drum fishery was closed to all harvest in Federal GOM waters on January 1, 1988. Stock assessment concluded that red drum were heavily fished prior to moving offshore to spawn and that red drum less than 12 years of age were poorly represented in the offshore spawning population. Continued harvest of adults from Federal waters would further reduce spawning stock and increase the risk of a collapse of the red drum fishery (USDOC, NMFS, 1989). The red drum fishery has remained closed through 2001.

Red and vermilion snapper resources in the GOM are believed to be severely overfished from both directed and bycatch fisheries. Red snapper is the most important species off the Central GOM Coast in the reef fish complex managed under an FMP in terms of value and historical landings. Vermilion snapper is the second most important snapper species off the Florida west coast after yellowtail snapper. Both red and vermilion snapper are presently considered to be in worse condition than was the red drum when that fishery was closed to all further harvest in Federal waters (Goodyear and Phares, 1990; Horst, 1992b; USDOC, NMFS, 1989).

The major concern of the stone crab fishery is whether harvest has reached or exceeded maximum sustainable yield. Until recently, the fishery has been expanding in terms of increasing catch within traditional fishing areas, as well as previously unfished or underfished regions. However, the total harvest has declined steadily over the past several years. The GMFMC is considering limitations on the number of fishermen and traps in the stone crab fishery.

Spiny lobster fishing is practiced exclusively in the Eastern GOM. It is believed that the stock is showing signs of growth overfishing. The Florida Fish and Wildlife Commission reports, however, that the spiny lobster stock is stable and not overfished. Fishing mortality is high due to the number of undersized lobsters used to bait lobster fishing traps and the number of traps in the fishery that far exceed that number required to harvest the present yield. Fishermen contend that the present fishery practices are the most optimal for their objectives. The GMFMC is considering limitations on the number of fishermen and traps in the spiny lobster fishery.

The coastal pelagic FMP addresses a number of species. Two of the more important species are king and Spanish mackerels. Both species have been extensively overfished in the past and are now under a managed rebuilding program. The commercial fishery for king mackerel is closed in the Eastern GOM when a quota of 2.25 million pounds is reached. From the early 1980's to 1990's, there has been a marked absence of a strong year-class of king mackerel. Spawning stock biomass has exhibited gains. There is concern about the possible need for two management units for king mackerel within the GOM and about the impact of the increasing Mexican fishery. Spanish mackerel stocks are showing positive signs of recovery. Spawning stock biomass and recruitment appear to be increasing. Both commercial and recreational bag limits were increased in June 2000 by the GMFMC. Most of the Spanish mackerel catch is taken off Florida. Capture of 50-80 percent of the yearly commercial allocation within a period of three weeks by southeast Florida fishermen has raised questions of conflict with recreational fishermen who believe their allocation should be increased.

Commercial landings of swordfish have increased steadily over the past several years with serious implications for the future. The percentage of older fish and spawning biomass has declined significantly. The GMFMC is developing a number of alternatives to better manage this resource.

Blue marlin and white marlin are believed to be at or near the point of full exploitation. There is concern about the increasing mortality of marlin as bycatch associated with the escalating yellowfin tuna longline fishery (Sports Fishing Institute, 1989). The tuna fishing industry has expanded at an alarming rate in the GOM over the past five years. Tuna are now included under MFCMA, and the GMFMC can begin to manage the tuna fishing industry and address the marlin bycatch issue.

The taking of stony corals or gorgonian sea fans is prohibited. Fishing for soft coral octocorals is presently below the limits of maximum yield. There are major concerns about the butterfish fishery in that butterfish trawlers allegedly destroy coral reef habitat and take a large number of snappers and groupers as bycatch. In addition, a newly formed fishery of “live rock” for the ornamental trade is receiving attention due to the allegation that “live rock” fishing may purposefully or inadvertently include the harvest of stony coral. Amendment 2 to the FMP for coral and coral reefs specifically addresses the concerns of “live rock” harvest in the GOM (GMFMC, 1994). The coral/live rock resources were originally managed jointly by the GOM and South Atlantic Fishery Management Councils (SAFMC). This changed in 1995 when the Councils separated their management of this group. The SAFMC passed a further amendment to the SAFMC Coral FMP in 1995 that established a separate fishery management plan for “live rock.” The FMP restrictions apply only to the Atlantic Coast of Florida and not to the GOM. No amendments for “live rock” management have been issued by the GMFMC since 1994.

The present concern with the condition of the black drum fishery stems directly from the closure of the red drum fishery. Almost immediately after closure, black drum and sheepshead were accepted as a substitute for red drum within the commercial market. The intensive fishing effort for red drum was switched to black drum and sheepshead without need to change fishing gear or technique. As a result, stocks of these two fish species are believed to be fast approaching a seriously depleted condition. Louisiana, Mississippi, and Alabama have instituted interim management measures in State waters to reduce black drum catches while an FMP is developed and implemented (Horst, 1993).

A strong market for shark has resulted in soaring catches over the past several years, though the value is low. Shark stocks are unable to sustain the present heavy fishing pressure, and without management, the fishery is expected to collapse within the near future. The GMFMC requested that the Gulf Coast States consider management measures within State waters and issued an FMP for both coastal and pelagic sharks (Justen, 1992).

Today, most of the effort expended on understanding what controls fishery populations focuses on the effects of fishing. Although most population models used in fisheries management take into account natural mortality, fishing mortality is the only variable that can be accurately estimated and controlled. Thus, while management focuses almost exclusively on controlling fishing effort, the success of any management scheme is dependent on understanding factors other than fishing that influence or regulate population abundance. Recent proposals by the NOAA Fisheries are examples of attempts to conserve fish populations by increasing constraints on fishing efforts (GMFMC, 2000).

Grouper species can be overfished because they aggregate in great numbers, year after year in the same locations during spawning; during that time the males are especially susceptible to being caught. The NOAA Fisheries hopes to spare the spawning population by using closed seasons and Marine Protected Areas (MPA) as a management tool. Two MPA’s have been designated in the west Florida shelf; the MPA’s are now closed to all fishing except for pelagics. They are named the Madison and Swanson site (115 nmi^2), south of Panama City, Florida, and Steamboat Lumps (104 nmi^2), west of Tarpon Springs, Florida. The two grouper reserves are now a reality and went into effect on June 19, 2000. In addition, a sunset provision has been added after four years so that the effects of the closed areas can be evaluated. Both of the areas are along the 70- to 80-m depth contour. The Madison and Swanson site south of Panama City is a high-relief site. Steamboat Lumps, west of Tarpon Springs, is the lower portion of the original 423-nmi^2 closed-area proposal. It is a low-relief site that has been reported by fishermen to be a good area for gag spawning.

On August 4, 2000, NOAA Fisheries announced new regulations to reduce bycatch and bycatch mortality in the pelagic longline fishery. On November 1, 2000, NOAA Fisheries put into effect a new regulation to reduce bycatch and bycatch mortality in the pelagic longline fishery. Two rectangular areas in the GOM (one of which lies over a portion of the region known as DeSoto Canyon) are closed year-round to pelagic longline fishing. These closed areas cover 32,800 mi^2 (**Figure 3-9**). This region has been identified by NOAA Fisheries as a swordfish nursery area, where there has historically been a low ratio of swordfish kept to the number of undersized swordfish discarded, which over the period of 1993-1998 has averaged less than one swordfish kept to one swordfish discarded. The area closure is expected to produce approximately a 4 percent reduction in GOM and Atlantic undersized swordfish bycatch. The DeSoto Canyon area coordinates are as follows:

Upper Area

North boundary:	30^{o} N. latitude
South boundary:	28^{o} N. latitude
East boundary:	86^{o} W. longitude
West boundary:	88^{o} W. longitude

Lower Area

North boundary:	28^{o} N. latitude
South boundary:	26^{o} N. latitude
East boundary:	84^{o} W. longitude
West boundary:	86^{o} W. longitude

The “upper area” encompasses a large portion of the proposed lease sale area leaving only 96 blocks outside the exclusion zone south of 28^{o} N. latitude.

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

Despite encouragement from NOAA Fisheries, fewer than 10 commercial fishermen are known to harvest benthic species from the DeSoto Canyon region. Royal red shrimp has been harvested by fishers for at least a decade from areas in DeSoto Canyon. Due to the depth (200-400 m), which requires specialized gear, time involved, and the localized, spotty nature of this shrimp species, trawling and harvest have been the effort of a very small number of focused fishermen. It is unlikely that fishing for this species will increase in the future.

Commercial fishing for tilefish in the Eastern GOM is done with bottom longlines. Tilefish species represent a typical deep-sea resource that is long-lived, slow to develop, and reproduce with limited numbers of offspring (Moore, 1999). Tilefish show an affinity for a sandy bottom, where they sit in indentations or burrows in the ocean floor. Because of their life history, tilefish are easily overfished and depleted. A sporadic, commercial harvest of golden tilefish on the eastern shoulder of DeSoto Canyon and along the Florida shelf-slope break is several decades old. Harvest is intermittent and limited within the GOM due to depleted populations. Tilefish are found in water from 240 to 400 ft (73-122 m) in depth, which requires the use of highly selected gear.

3.3.2. Recreational Fishing

Marine recreational fishing in the GOM from Louisiana to Florida is a major industry important to these states’ cultures and economies. The marine recreational fishing industry in the GOM accounts for nearly a billion dollars in sales (equipment, transportation, food, lodging, insurance, and services) and for thousands of jobs. The Gulf Coast States from Louisiana to Florida account for about 1.6 million registered motorboats with almost 4 million anglers making more than 16 million saltwater fishing trips in 1998 (USDOC, NMFS, 1999c). Many of these trips depart from Florida and Alabama, accounting for over 800 charter boats. The largest charter fleets closest to the proposed lease sale area are located in Orange Beach, Destin, and Panama City, Florida. As noted in **Table 3-13**, only a small portion of the marine recreational fishing trips in the GOM extend into offshore water under Federal jurisdiction. Few recreational trips directly use the proposed lease sale area due to the relatively extreme distances from land involved for small recreational vessels. The proposed lease sale area is 138 nmi from Panama City, Florida; 100 nmi from Pensacola, Florida; and 123 nmi from Biloxi, Mississippi. Seatrout, drum, grunts, bluefish, and mackerel are some of the more popular inshore and nearshore fish harvested in coastal marine waters. Snapper, grouper, and dolphin fish are some of the more popular fish sought and caught more frequently in offshore waters; however, only dolphin fish would be found in the deep water of the proposed lease sale area. Billfish and tuna would also be sought by recreational fishermen in the more-distant deep offshore waters. Although GOM oil and gas structures were cited as an important target of recreational fishing by Hiett and Milon (2002) in other parts of the GOM (mostly on the continental shelf), only pelagic species such as tuna and billfish are target species in the proposed lease sale area due to the deeper depths of the area, which starts at 1,690 m. Recreational diving trips (including spearfishing) are also popular in nearshore and offshore waters near natural and artificial reefs such as OCS structures. It is doubtful that recreational diving would occur on any of the large deepwater structures that will be located in the proposed lease sale area. A more detailed analysis of trends in marine recreational fishing between 1983 and 1993 in the vicinity of the Florida Panhandle can be found in a special report funded by MMS and USGS (CSA, 1997a).

3.3.3. Recreational Resources

The northern GOM coastal zone has become increasingly developed over the past 20 years. In addition to homes, condominiums, and some industry, this coastline supports one of the major recreational regions of the United States, particularly for marine fishing and beach activities, both of which are viewed as public assets. There is a diversity of natural and developed landscapes and seascapes, including coastal beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes. Other recreational resources are publicly owned and administered, such as national and State seashores, parks, beaches, and wildlife lands, as well as designated preservation areas, such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, research reserves, and scenic rivers. Gulf Coast residents and tourists from throughout the nation, as well as from foreign countries, use these resources extensively and intensively for recreational activity. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, also serve as primary-interest areas. Locating, identifying, and observing coastal and marine birds, is a recreational activity of growing interest and importance all along the Gulf Coast.

The U.S. coastline along the GOM runs from Brownsville, Texas, and the southern tip of Padre Island, north, east, and south to the Dry Tortugas off Key West, Florida. Along this portion of the shoreline, two of the largest delta systems in the United States flow into the GOM (Alabama State Docks Dept., 2001). More than 25 years ago, Congress set aside GOM coastal beach and barrier island ecosystems to be managed by the National Park Service for the preservation, enjoyment, and understanding of their inherent natural, cultural, and recreational values. State and county legislation added to this preservation program so that today there is a lengthy list of reserves, refuges, and public parks.

The shorefront of the GOM is diverse. It consists of national seashores such as Gulf Islands, beachfront cities such as Biloxi, State parks, marshland, casino-dotted beaches, the migratory bird habitats of Fort Morgan, and the sugar white sands of Gulf Shores, Alabama and Pensacola Beach, Florida. Eco-tourism in national estuarine research reserves and beach recreation are interspersed with condominiums, hotels, planned communities, and private residences. Tourists and travelers are also attracted to the sites, sounds, shopping, and dining associated with developed marine areas. The value of recreation and tourism in the GOM coastal zone from Texas through Florida has been estimated in the tens of billions of dollars annually (USDOI, MMS, 2001e; pages III-101 and III-102). A significant portion of these expenditures is made in coastal counties, where major shoreline beaches are primary recreational attractions. For example, the Alabama Bureau of Tourism ad Travel recently reported that Baldwin County and its beaches at Gulf Shores attracted nearly 3.8 visitors who spent almost $1.5 billion in 2001 (*Mobile Register*, May 10, 2002, page 1B).

In this section, the coastline has been divided into segments according to topography, discrete human and other biological populations, barrier island formations, and special preservation areas. This gives the reader the chance to put in geographical context the textual descriptions.

Texas — Sea Rim

This stretch of the Texas coast includes Jefferson County and Sea Rim State Park. Nearby is the Sabine Pass Battleground State Historical Park.

Louisiana — Beaches

The three parishes of Cameron, Lafourche, and Jefferson comprise this segment. Spanning part of this coastline is the Barataria-Terrebonne National Estuary, the Atchafalaya National Wildlife Refuge, and the Jean Lafitte National Historic Park and Reserve.

Mississippi and Alabama — Gulf Islands

Gulf Islands National Seashore in this part of the GOM stretches some 40 mi from Hancock, Harrison, and Jackson Counties in Mississippi to neighboring Mobile County and Dauphin Island in Alabama and over into the Florida Panhandle. This part of the National Seashore accommodates more than 1 million recreational visits a year. In addition to beaches, the Seashore harbors historic forts, shipwrecks, wetlands, lagoons and estuaries, seagrass, fish and wildlife, and archeological sites. In 1978, Congress designated approximately 1,800 ac on Horn and Petit Bois Islands, part of Gulf Islands National Seashore in Mississippi, as components of the National Wilderness System. There is also a national estuarine research reserve at Grand Bay (Weeks Bay Reserve Foundation, 1999).

Alabama — Gulf Shores

The southernmost part of Baldwin County is also known as Pleasure Island. It was a peninsula until the COE built the Gulf Intracoastal Waterway (GIWW) and cut the land ties to the mainland. Mobile Bay is part of the national estuary program, and Weeks Bay, at the southeastern end of the bay, is also part of the national estuarine research reserve system.

Florida Panhandle — West

This segment encompasses the three counties of Escambia, Santa Rosa, and Okaloosa. The area includes the eastern portion of Gulf Islands National Seashore, which is known as the Emerald Coast. Grayson State Park in Escambia County is near the Alabama/Florida state line.

Florida Panhandle — East

The four counties of Walton, Bay, Gulf, and Franklin are adjacent to Florida's Big Bend. St. George's Island is the easternmost of the system of barrier islands in the GOM. The Apalachicola National Estuarine Research Reserve has been established in this area to preserve the delta, river, and bay.

3.3.4. Archaeological Resources

Archaeological resources are any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest (30 CFR 250.105(5)). The Archaeological Resources Regulation (30 CFR 250.194) provides specific authority to each MMS Regional Director to require archaeological resource surveys, analyses, and reports. Surveys are required prior to any exploration or development activities on leases within the high probability areas (NTL 2002-G01).

3.3.4.1. Historic

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

Garrison et al. (1989) list three shipwrecks that fall within the proposed lease sale area. Two shipwrecks are reported in the DeSoto Canyon Area and one in the Lloyd Ridge Area (**Table 3-14**). All of these wrecks may be considered to be historic and could be eligible for nomination to the National Register of Historic Places. These wrecks are known only by historical record and, to date, have not been located on the ocean floor. Additionally, nearly 100 potentially important shipwrecks near the approaches to Mobile Bay have been documented in the historic record (Mistovich and Knight, 1983; Marx, 1983; Irion, 1990). The precise locations of these vessels remain unknown. These wrecks are listed in **Table 3-15**. This list should not be considered exhaustive. Regular reporting of shipwrecks did not occur until late in the 19th century, and losses of several classes of vessels, such as small coastal fishing boats, were largely unreported in official records.

Submerged shipwrecks off the coasts of Alabama and Florida are likely to be moderately well preserved. Wrecks occurring in or close to the mouth of Mobile Bay would have been quickly buried by transported sediment and therefore protected from the destructive effects of wood-eating shipworms (*Teredo navalis*) or storms (Anuskiewicz, 1989; page 90). Wrecks occurring in deeper water also have a moderate to high preservation potential. In deepwater, temperature at the seafloor is extremely cold, which slows the oxidation of ferrous metals. The cold water would also eliminate wood-eating shipworms.

Aside from acts of war, hurricanes cause the greatest number of wrecks in the GOM. Wreckage occurring as a result of a violent storm is more likely to be scattered over a broader area than in the shallower water near shore. The wreckage of the 19th century steamer *New York*, which was destroyed in a hurricane, lies in 16 m of water and has been documented by MMS (Irion and Anuskiewicz, 1999) as scattered over the ocean floor in a swath over 1,500 ft long. Shipwrecks occurring in shallow water nearer to shore are more likely to have been reworked (modified by tides and storms) and scattered by subsequent storms. Wrecks occurring at greater depths on the OCS are usually not affected by reworking. Historic research indicates that shipwrecks occur less frequently in Federal waters. These wrecks are likely to be better preserved, less disturbed, and, therefore, more likely to be eligible for nomination to the National Register of Historic Places than are wrecks in shallower State waters.

3.3.4.2. Prehistoric

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

During periods that the continental shelf was exposed above sea level, the GOM coastal area was open to habitation by prehistoric peoples. The advent of early man into the GOM region is currently accepted to be around 12,000 years B.P. (Aten, 1983). According to the sea-level curve for the northern GOM proposed by Coastal Environments, Inc. (CEI), sea level at 12,000 B.P. would have been approximately 45-60 m below the present day sea level (CEI, 1977 and 1982). On this basis, the continental shelf shoreward of the 45-60 m bathymetric contours has potential for prehistoric sites dating after 12,000 B.P. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, MMS adopted the 12,000 years B.P. and the 60-m water depth as the seaward extent of the prehistoric archaeological high-probability area.

Water depths in the DeSoto Canyon and Lloyd Ridge Areas range from approximately 1,600 to 3,000 m. Based on the current acceptable seaward extant of the prehistoric archaeological high-probability area for this part of the GOM, the extreme water depth precludes the existence of any prehistoric archaeological resources within the proposed lease sale area.

3.3.5. Human Resources and Land Use

The addition of any new human activity, such as oil and gas development resulting from a proposed lease sale, can affect local communities in a variety of ways. Typically, these effects are in the form of people and money, which can translate into changes in local social and economic institutions and land use. In this section, MMS describes the current socioeconomic analysis area baseline in order to differentiate the effects of a proposed action described in **Chapter 4.2.1.15.**, Impacts on Human Resources and Land Use.

3.3.5.1. Socioeconomic Analysis Area

3.3.5.1.1. Description of the Analysis Area

The MMS defines the analysis area for potential impacts on population, labor, and employment as that portion of the GOM coastal zone whose social and economic well-being (population, labor, and employment) is directly or indirectly affected by the OCS oil and gas industry (**Figure 3-10**). This analysis area is based on the results of the recent MMS socioeconomic study "Modeling the Economic Impacts of Offshore Oil and Gas Activities in the Gulf of Mexico: Methods and Applications" (Dismukes et al., 2003). Geographically, the analysis area is defined as all coastal counties and parishes along the U.S. portion of the GOM and any inland counties and parishes where offshore oil and gas activities are known to exist, offshore-related petroleum industries are established, or one or more counties or parishes within a Metropolitan Statistical Area (MSA) are on the coast. For examination purposes, MMS has divided the analysis area into coastal subareas. The counties and parishes included in each coastal subarea are presented in **Figure 3-10.**

One of the objectives of the above-mentioned study was to allocate expenditures from the offshore oil and gas industry to the representative onshore coastal subarea where the dollars are spent. **Table 3-16** presents these findings in percentage terms. The IMPLAN number is the code given to the industry (sector) by the input-output software (IMPLAN) used to calculate impacts in **Chapters 4.2.1.15. and 4.4.14.** It is analogous to the standardized industry code (SIC). **Table 3-16** makes clear the reasons for including all of the GOM coastal subareas in the economic analysis area. Expenditures to several sectors are either exclusively found in Texas or make up a very large percentage of the total. In addition, a large percentage of total sector expenditures is allocated to each Louisiana coastal subarea. As shown in **Table 3-16**, very little has been spent in the Florida coastal subareas. This is to be expected given the lack of offshore leasing in this area and the State of Florida's position of no oil and gas development within 100 mi of its shoreline.

With respect to a proposed action, the focal area includes coastal Subareas TX-2, LA-1, LA-2, LA-3, and MA-1, areas where coastal infrastructure has the most potential to be impacted.

3.3.5.1.2. Land Use

The primary region of geographic influence of a proposed action is coastal Louisiana and Alabama, with a lesser influence on coastal Texas and Mississippi. Few offshore oil and gas activities occur in the Florida area. The coastal zone of the northern GOM is not a physically, culturally, or economically homogenous unit (Gramling, 1984). The counties and parishes along the coasts of Texas, Louisiana, Mississippi, and Alabama represent some of the most valuable coastline in the United States. Not only does the coastline include miles of recreational beaches and the protection of an extended system of barrier islands, but it also has deepwater ports, oil and gas support industries, manufacturing, farming, ranching, and hundreds of thousands of acres of wetlands and protected habitat. These counties and parishes vary in their histories and in the composition and economic activities of their respective local governments.

Figure 3-11 illustrates the analysis area's key infrastructure. Major cities in the analysis area include Houston, Texas; Baton Rouge and New Orleans, Louisiana; Mobile, Alabama; and Tampa, Florida. Several international and regional airports are located throughout the analysis area. One major interstate (I-10) traverses the area along the inner margin of the coastal zone while six interstate highways access the area longitudinally. There are numerous highways into and across the analysis area. On November 28, 1995, Louisiana Highway 1 (LA Hwy 1) was designated as part of the National Highway System (NHS). The NHS Act designated 160,955 mi of interstate, highways, and other roads that are critical for the economy, defense, and mobility of the Nation as the NHS. "These highways provide access to major ports, airports, rail stations, public transit facilities, and border crossings. They comprise only 4 percent of total highways in the country; however, they carry nearly 50 percent of total highway traffic including the majority of commercial and tourism traffic. They are estimated to service more than 90 percent of businesses and industries through out the nation." (LA Hwy 1 Project Task Force, 1999).

LA Hwy 1 was designated because of "its intermodal link to this Nation's energy supply" (LA Hwy 1 Project Task Force, 1999). The area's railroad configuration is similar to the highway system. An extensive maritime industry exists in the analysis area. Major ports and waterways are discussed in detail in **Chapter 3.3.5.6.**, while **Chapter 3.3.5.8.** describes OCS-related coastal infrastructure. A listing of major public, recreational, and conservation areas are presented in **Chapter 3.3.3.**

The Gulf Coastal Plain of Texas in the analysis area makes up most of northeastern coastal Texas. Near the coast this region is mostly flat and low-lying. The region is made up of farmland (cotton, rice, and citrus fruit), forest, cattle ranches, major cities of commerce (Houston) and education, tourist locales, Federal installations (e.g., Lyndon B. Johnson Space Center), and major ports. The oil and gas industry has also been part of the local economies since the early 1900's. Today, the majority of oil and gas corporations have headquarters in Houston, while numerous oil and gas industries are located in the area (OCS waste facilities, refineries and petrochemical plants, and the manufacture of OCS equipment and structures). In addition to oil and gas, the area has aggressively pursued technology companies such as computers and aerospace.

The Louisiana coastal area includes broad expanses of coastal marshes and swamps interspersed with ridges of higher well-drained land along the courses of modern and extinct river systems. Most of the urban centers in coastal Louisiana are located along major navigable rivers and along the landward edge of the coastal zone (i.e., Lafayette and Lake Charles). Southwestern Louisiana is Acadian country. The area's natural features vary from marshland, waterways, and bayous in the coastal areas to flat agricultural lands in the northern part of the same parishes. While the area's traditionally strong ties to agriculture, fishing, and trapping are still evident, they are no longer the mainstay of the economy. Southeastern Louisiana, from Jefferson Parish east to St. Tammany Parish and the state border with Mississippi, is a thriving metropolitan area with shipping, navigation, U.S. Navy facilities, and oil and chemical refineries, all vying with local residents for land. Historically, Terrebonne and Lafourche Parishes have been the primary staging and support area for offshore oil and gas exploration and development. The Port of Fourchon, at the mouth of Bayou Lafourche on the GOM, is a major onshore staging area for OCS oil and gas activities in the CPA and WPA and the headquarters of LOOP. **Chapter 3.3.5.8.1.**, Service Bases, discusses the Port Fourchon area in detail.

Coastal Mississippi is characterized by bays, deltas, marshland, and waterways. Two-thirds of this coast is devoted to State-chartered gambling barges and heavy tourism along the beachfront. The remaining third (Jackson County) is industrial—oil refining and shipbuilding. Upland portions of the three coastal counties—Hancock, Harrison, and Jackson—are timberlands. Jackson County has a strong industrial base and designated industrial parks. Pascagoula, in Jackson County, is home to Ingalls Shipyard and Chevron's Pascagoula Refinery. Bayou Casotte, also in Jackson County, currently has boat and helicopter facilities, and the onshore support base for drilling and production.

Southwestern Alabama's coastline is comprised of Mobile and Baldwin Counties, which oppose each other across Mobile Bay. Coastal resource-dependent industries in this area include navigation, tourism, marine recreation, commercial fishing, and most recently, offshore natural gas development and production. Large quantities of natural gas were discovered in Alabama's offshore waters in 1979. Baldwin County has a strong tourism economy and a large retiree population. The important commercial fishing industry in the area is located in southeastern Mobile County. The Port of Mobile, the largest seaport in Alabama, is also in Mobile County. The military has had a long presence in the area. The buildup and downsizing of military installations has handed the area some special challenges. The area's second port, Mobile Middle Bay Port, is a former Naval Station. Major manufacturers in Mobile include three paper mills, a German-owned chemical plant, and two large shipbuilding and repair yards. There are several oil- and gas-related businesses, including Mobil's MaryAnn/823 plant, established in 1990, and Shell's Yellowhammer plant, founded in 1989; both of these plants process natural gas (Harris InfoSource, 1998). Mobile County has a strong industrial base and designated industrial parks, especially at Theodore Industrial Park and Canal and the recently built Naval Homeport site now under the auspices of the Alabama State Docks. In addition, Bayou LaBatre in south Mobile County has a dozen shipbuilding firms (Foster and Associates, Inc., 1997). Theodore, in Mobile County, currently has boat and helicopter facilities, and the onshore support base for drilling and production.

The Florida counties along the Gulf Coast comprise the remainder of the analysis area. These counties have been largely uninvolved in OCS development. The GOM coastal area of Florida includes bays, estuaries, wetlands, an extensive barrier island system, and increasing concentrations of human settlement. This area ranges from heavily urbanized areas, such as Escambia County and Panama City in Bay County with shipping ports and Naval air bases, to scarcely populated areas along the coastal rim, such as the towns of Port St. Joe, Apalachicola, and Carrabelle in Gulf and Franklin Counties. Eglin and Tyndall Air Force Bases and Hurlburt Field are also located along the Florida Gulf Coast, which precludes heavy commercial development in that area. Most importantly, the area is also known for its "sugar sand beaches." Tourism and recreation are extremely important to the area, along with both commercial and recreational fishing activities. The military has had a substantial presence in the Florida Panhandle since World War II. The four main military installations are the Pensacola Naval Air Station, Eglin Air Force Base (Fort Walton Beach), Tyndall Air Force Base, and the Coastal Systems Station (both in Panama City). The three air bases use the northern GOM as a weapons testing and training range. These bases were largely untouched by the downsizing of the military in the 1990's and are expected to remain an important part of the Florida Panhandle for the foreseeable future.

The development of the Florida Panhandle as a major tourist area began in the mid-1930's and grew rapidly after World War II, becoming a key industry in area. "Sugar-white" beaches, fishing, other water-based activities, and natural habitats are key parts of the tourist experience in the Florida Panhandle.

The Panhandle has two major deep water ports—the Port of Pensacola and the Port of Panama City. While the Port of Pensacola has a history extending back into the nineteenth century, the present-day location of the Port of Panama City opened only after World War II. These two ports were among the top 100 U.S. ports in the dollar value of goods exported in 1995. The Port of Panama City served as an onshore support base for exploratory drilling in the GOM in the early 1980's and in 1990 and has an adjacent industrial park (Luke et al., 2002).

3.3.5.2. How OCS Development Has Affected the Analysis Area

The following section presents a brief, general narrative of how OCS development has affected the analysis area over the last 20 years. This narrative is followed by a specific account of how OCS development has affected certain locales in the analysis area.

1980-1989

In the oil and gas industry, drilling-rig use is employed as a barometer of economic activity. Between the end of 1981 and mid-1983, drilling-rig activity in the GOM took a sharp downturn. By 1986, the demand for mobile drilling rigs had suffered an even greater decline. Population and net migration paralleled these fluctuations in mobile drilling rig activity. Population growth rates for all coastal subareas were relatively high prior to 1983; families moved to the Gulf Coast looking for work in the booming oil and gas industry. Lower rates of population growth accompanied the decline in drilling activity as workers were laid off and left the area in search of work elsewhere. After 1983, all coastal subareas experienced several years of significant net migration out of the region. In 1986, the demand for mobile rigs declined to its lowest level in over a decade and the price of oil collapsed. This negative trend on population continued through the late 1980's.

1990-1997

In the early to mid-1990's, the analysis area experienced a major resurgence in oil exploration and drilling in response to advances in technology and the enactment of the Deep Water Royalty Relief Act in 1995. The renewed interest in oil and gas exploration and development in the GOM produced a modest to significant recovery from the high unemployment levels experienced after the 1986 downturn. Ironically, the Gulf Coast encountered a shortage of skilled labor in the oil and gas industry because of the restructuring of the oil industry to centralize management, finance, and business services, and because of the use of computer technology that occurred during the downturn (Baxter, 1990). Workers who previously lost high-paying jobs in the oil industry (or oil-service industry) during the 1980's downturn were reluctant to return. This "shadow effect," coupled with the shortage of skilled labor where the core problems were lack of education and/or training for requisite skills, created a situation where temporary communities of workers from out of the area (some from out of the country) were established. Furthermore, the higher skill levels required by deepwater development drilling could not be completely met by the existing impact areas' labor force, causing in-migration. Unemployment in the analysis area, though, declined due to increased economic diversification by the region.

1998-Present

In early 1998, crude oil prices were hovering near 12-year lows due in part to economic developments in East Asia and resulting oversupply of oil (USDOE, EIA, 2001a). This restrained the resurgence of exploration and development activity in the GOM. While offshore development strategy varied by company, most major oil companies, diversified firms, and small independents cut back production and curtailed exploration projects. Several large integrated companies resorted to layoffs and mergers as ways to assail low prices; a redistribution of industry personnel from the New Orleans area to the Houston area occurred. Unemployment in the analysis area rose. Offshore drilling strategies focused on mega and large prospects, foregoing small prospects, and only considering medium prospects when prices rose (Rike, 2000). A few companies, though, took advantage of lower drilling rates during this period and increased their drilling. Concurrently, technological innovations (such as 3-D seismic surveying, slim-hole drilling, and hydraulic rigs) decreased the cost of exploration and thus stimulated the discovery and development of large or mega prospects that were considered economic at low prices.

In March 1999, the Organization for Petroleum Exporting Countries (OPEC), which produces 40 percent of the world's oil, announced crude oil production cutbacks. Full member compliance increased oil prices to 20-year highs, encouraging moderate exploration and development spending during the 1999 fiscal year. Crude oil prices continued to increase during 2000 and into 2001. It is generally believed that the increase in price is being driven by two major factors. First is the continued OPEC compliance to maintain prices within their current output targets of a $22 minimum and a $28 maximum per barrel crude oil price. The second factor, according to the Federal Reserve Bank of Dallas, is the "world capacity to supply oil has not kept pace with the growth of oil demand spurred by a resurgent world economy. Furthermore, a short supply of oil tankers, rising shipping rates, and low inventories of refined product and crude oil have added upward pressure to spot crude oil prices" (Brown, 2000). The prices throughout much of the 1990's were too low to stimulate additions to capacity. In addition, many tankers were scrapped in the 1990's when weak demand, low shipping rates, and increasing environmental regulation put a lot of pressure on the tanker industry (Brown, 2000).

Federal environmental/clean-air efforts in the 1990's and high oil prices in the late 1990's prompted some industries to switch from crude oil to natural gas. This development was and continues to be especially prevalent in the electricity generating industry. Natural gas, in addition to heating about 53 percent of American homes, is also being used to generate about 16 percent of the country's electricity — a percentage that is still growing (Simmons, 2001). Like crude oil, the supply of natural gas did not keep up with demand, which pushed prices higher. In December 2000, the price of natural gas broke record highs, closing at $10.10. In 2001, however, natural gas prices decreased dramatically (75.25%). Several factors have kept a downward pressure on natural gas prices. These factors include moderate weather in most of the Nation, keeping the demand for gas by electricity generators in check; relatively low oil prices; and the general economic slowdown, which has reduced demand for gas by the industrial sector (FERC, 2001). Even without this pronounced drop in price, demand growth for natural gas is expected to be strong during the next 20 years. The 2001 Update of the Fueling the Future: Natural Gas and New Technologies for a Cleaner 21st Century report projects that natural gas demand would increase by 53 percent by the year 2020 (American Gas Foundation, 2001).

Recent technological advances and the passage of the Deep Water Royalty Relief Act in 1995 have stimulated deepwater leasing and subsequent exploration and development activities. Needs specific to these deepwater projects have resulted in more focused stresses placed on areas that are capable of supporting large-scale development projects (e.g., ports that can handle deeper draft service vessels such as Port Fourchon, Louisiana), which in turn has resulted in stresses to infrastructure servicing these focal points (particularly highways and ports), as well as placing stresses on the infrastructure associated with the focal point. This is what has occurred at Port Fourchon.

Port Fourchon, Louisiana, located at the mouth of Bayou Lafourche, is one of the main service-supply bases for offshore oil and gas exploration and development in the GOM. While the port has maintained steady growth over the last 25 years, the escalation of deepwater activities has produced rapid growth at the port in the last 5 years, as the port has become one of the OCS Program's focal points. More than 82,500 offshore workers use the port for helicopter transportation each year. Approximately 170 OCS-related vessels travel in and out of the port each day (based on monthly helicopter and daily vessel logs). In addition to more than 130 OCS oil- and gas-related businesses, the Louisiana Offshore Oil Port (LOOP) facilities are located at the port. The LOOP is the only offshore oil terminal in the U.S.; it transports an estimated 13-15 percent of the Nation's imported crude oil. The LOOP is expanding its storage capabilities with three large, above-ground tanks in Galliano, Louisiana. Shell and BP operations are based from the port, while all three major helicopter companies (ERA, PHI, and Air Logistics) have heliports at the port. The ERA is currently building a larger $4 million heliport at the port; it is expected to be completed in 2002. Air Logistics is planning to build a similar facility. Halliburton, another port tenant, recently completed a state-of-the-art drilling liquids facility. Chevron and Texaco have tank farms at the port. Seven ship and barge repair facilities are located at the port. In addition, the port has five barge lines and six barge fleeting operations.

In 1996, Edison Chouest Offshore (Chouest or ECO) built its highly successful C-Port at Port Fourchon. The C-Port is a multi-services port terminal facility supplying offshore vessels that operate in the GOM. The C-Port can load/offload deck cargoes, fuel, water, cements, barite muds, liquid muds, and completion fuels simultaneously. These services are provided under the protection of a covered building, eliminating weather and darkness, while improving safety and efficiency, making it a highly cost-effective, cost-saving solution (Edison Chouest, 2001). Prior to C-Port, it took 2-3 days to service a vessel; today, service time is down to a few hours. This results in huge dollar savings for offshore companies. In addition, the companies need to lease fewer service boats because of the larger, technologically advanced ships that Chouest is building. In 1999, Chouest completed a second C-Port at Port Fourchon, C-Port 2; three additional slips are planned for C-Port 2 in 2002. Together, C-Port and C-Port 2 are servicing 90 percent of OCS deepwater activity. In addition to the port expansion, Chouest began an aggressive "new build" program in the late 1990's for their offshore service vessels. The company has produced over 50 new generation offshore vessels to serve deepwater oil and gas production. The new vessels are larger (260 ft in length) and faster than their predecessors servicing shallow-water activities. The C-Ports and the new deepwater service vessels have increased activity at Port Fourchon significantly. Chouest has also started constructing a C-Port at Galveston, Texas, to service deepwater activities in the WPA and is looking into locations in Mississippi and Alabama to build a C-Port to service deepwater activities in the EPA.

Based on OCS activity at the port, the COE justified deepening Port Fourchon's channel from 12 ft to 24 ft. The port had been maintaining the channel at 20 ft for the larger OCS supply vessels. In August 2001, the COE dredged the channel to a depth of 26 ft (24 ft plus 2 ft of advance maintenance) and will maintain this depth in the future.

To date, this focusing of offshore service activities at Port Fourchon has resulted in both positive and negative impacts on the area. Lafourche Parish, where the port is located, has one of the lowest unemployment rates in the nation, but its citizens' quality of life has decreased. The most significant negative impacts include

- increased OCS activity is straining the local infrastructure;
- the area is suffering with a substandard highway (LA Hwy 1) that will not be able to handle the truck traffic increase anticipated from OCS activities;
- severe coastal erosion is eating away the State's hurricane protection, endangering the infrastructure and industry;
- saltwater intrusion from coastal erosion is impacting the drinking water supply; and
- increased demand for water by deepwater OCS activities is taxing the local freshwater district.

LA Hwy 1 is the only land-based transportation route to Port Fourchon. The highway is a rural substandard two-lane road. The extensive deterioration of LA Hwy 1 is mostly due to coastal landloss from wave forces; LA Hwy 1 divides the Barataria and Terrebonne estuaries, the Nation's two most productive estuaries. Port Fourchon has been active in building up the embankment with channel dredging materials, but it is a short-term fix to a long-term problem that grows worse every day. At present, Golden Meadow, Louisiana, to Larose, Louisiana, is the only section of the highway that is four lanes. While the State and local governments have received revenue from the increased OCS activity at Port Fourchon, the cost of impacts from OCS operations have exceeded growth in the revenue stream. The Louisiana Department of Transportation and Development (DOTD), which manages LA Hwy 1, and Port Fourchon have completed an EIS on a new four-lane highway.

Results from an MMS-funded study on the infrastructural impacts of expanding OCS oil and gas activities in south Lafourche Parish, *An Analysis of Louisiana Highway 1 in Relation to Expanding Oil and Gas Activities in the Central Gulf of Mexico*, indicate that the levels of service provided by LA Hwy 1 will decline significantly through time (Guo et al., 2001). The study estimated a 3-6 percent growth in daily vehicle traffic along LA Hwy 1. Actual 2000 growth was 24 percent; more than 1,000 OCS supply and equipment trucks travel LA Hwy 1 to the port each day. The average national growth in daily vehicle traffic is 2-5 percent. In addition to servicing the OCS, LA Hwy 1 serves as an evacuation and oil-spill response route for offshore spills. In the event of an impending storm, more than 3,000 offshore workers, 1,000 port personnel, and 5,000 citizens from Grand Isle and Leeville (south of the bridge) must evacuate the area by LA Hwy 1. Offshore companies also take valuable equipment, such as bagged drilling fluids, off offshore rigs and bring it to safety inland. This increases the truck traffic along LA Hwy 1 during the evacuation process. Furthermore, statistics from the DOTD reveal LA Hwy 1 is twice as deadly as any similar class highway in the state. The number of fatalities on LA Hwy 1 has increased directly with the growth of the OCS and, therefore, the port.

The south Lafourche Parish study concluded that deterioration of LA Hwy 1 will be exacerbated with expanding oil and gas activities, particularly those in deep water. The size and complexity of these deepwater projects, along with the limited number of service bases capable of handling their unique needs, and the addition of the C-Ports at Port Fourchon, will likely result in continued stresses on port infrastructure and associated stresses placed on the local infrastructure, especially LA Hwy 1 and the parish's water supply (Guo et al., 2001).

Exacerbating the traffic problems on LA Hwy 1 are delays caused by the six bridge openings necessary to accommodate barge traffic on Bayou Lafourche. Fifty percent of all oil and gas materials brought to Port Fourchon is barged. On average, each bridge is opened 16 times a day resulting in bottlenecks, increased accidents, and a lower quality of life. Part of the increased barge traffic is from shipping an average of 500,000 gallons of fresh water per day to the port for offshore activities. Deepwater expansion has significantly increased the demand for water, taxing the local freshwater district. Port Fourchon uses 30 percent of the local water supply, but comprises only 1 percent of the serving population.

The demand for OCS-related labor in the area has resulted in the presence of in-migration. This temporary importation of labor, particularly in south Lafourche, is a unique situation exacerbated by the shadow effect. The unusual work schedules in the oil and gas extraction industry also supports employment outside the analysis area because long-distance commuting can be reasonably accomplished on such an infrequent basis. Therefore, while employment opportunities are growing in the oil and gas extraction and supporting industries within the GOM analysis area, some of that employment has been met from outside the area. This has resulted in net positive migration in some focal point locales and has caused a scarcity of housing, a shortage of municipal personnel (i.e., policemen, firemen, engineers, etc.), stresses on the capabilities of available infrastructure, and an increase in the cost of living. Chouest, which owns C-Port and C-Port 2 in Port Fourchon, North American Shipbuilding in Larose, Louisiana, and North American Fabricators in Houma, Louisiana, have experienced these impacts first hand. Unable to find housing for their workers, Chouest built an apartment complex for the workers they had to recruit from outside of Louisiana because of the labor and skills shortage within the State.

In the EA prepared for CPA Lease Sale 182 and the Multisale EIS for the CPA and WPA, MMS recognized Port Fourchon and LA Hwy 1's importance to the Nation's energy infrastructure and emphasized its desire for impact assistance to ameliorate effects of the OCS Program. As the port has grown, its importance to the nation's energy infrastructure has increased significantly. Twenty percent of the Nation's oil and 25-27 percent of the natural gas are located offshore Louisiana. The port services 90 percent of the GOM's deepwater activity. In addition, as of March 2002, Port Fourchon is servicing about 34 percent of all offshore mobile rigs working in the GOM OCS. Of this total, nearly 47 percent are located in deepwater (One Offshore, 2002). Furthermore, LOOP is connected to 30 percent of the U.S.'s refineries. With the increasing importance of deepwater development and the potential for FPSO's working in the GOM in the near future, LOOP will become even more important to the U.S. energy intermodal system and, therefore, so will Port Fourchon.

LA Hwy 1 has also been recognized on the national level. In 1995, LA Hwy 1 was selected as part of the NHS because of its intermodal link to this nation's energy supply. The NHS Act designates roads that are critical for the economy, defense, and mobility of the nation. In December 2001, Congress designated LA Hwy 1 as one of only 44 high priority corridors in the U.S. based on its significance to the nation's energy infrastructure.

Several other service bases have also seen a large increase in OCS-related activity and concomitant stresses placed on their local infrastructure. These ports include Venice, Morgan City, and Cameron, Louisiana, which are servicing 18 percent, 15 percent, and 11 percent of OCS-related offshore mobile rig activity, respectively (One Offshore, 2002). The limited number of service bases capable of servicing deepwater activities suggests that stresses placed on local infrastructure at these bases will continue to the extent that deepwater tracts are leased, explored, and developed. Recent leasing history has shown an increase in deepwater interest.

3.3.5.3. Current Economic Baseline Data

Oil and natural gas prices are used to evaluate the oil and gas industry's ability to economically develop resources. During September 2001, natural gas futures plummeted below $2 per thousand cubic feet for the first time since April 1999. Although natural gas prices remain substantially below the $10/MMBtu high of three years ago, prices have moved moderately higher over the last six months with spikes over $9/MMBtu in February 2003 due to the unusually cold winter. As of April 7, 2003, Henry Hub natural gas was priced at $5.134/MMBtu. Futures prices for Henry Hub natural gas, given the seasonal highs and lows, remained stable over the next 12 months (May 2003-April 2004) with an average of $5.142/MMBtu (Oilnergy, 2003).

Immediately following the September 11, 2001, terrorist attacks on the United States, oil and gold prices surged (COMTEX, 2001). Crude oil prices then dropped, taking their biggest hit in 10 years during September 2001 (Houston Chronicle On-line, 2001a). Oil prices increased sharply toward the end of 2002 and into 2003 due to the national oil strike in Venezuela and the impending war in Iraq; the price of crude oil hit a high of nearly $40/bbl on February 27, 2003. Since the war began in March 2003, oil prices have tumbled nearly 20 percent; OPEC increased its output to offset the disruption in supplies from Iraq and Venezuela. As of April 7, 2003, the price of light sweet crude ($27.96/bbl) fell within the OPEC price band ($22-$28). Futures prices for light sweet crude decreased slowly over the next 12 months (May 2003-April 2004), with an average of $25.49/bbl (Oilnergy, 2003). Current crude oil and natural gas prices are above the economically viable threshold for drilling in the GOM.

Drilling rig use is employed by the industry as another barometer of economic activity. Marketed utilization rates (based on marketed supply) in the GOM hovered around 90 percent or better for most of 2000 through May 2001 before beginning a downward spiral to a low of nearly 50 percent in November 2001. Over the last year (April 2002-April 2003), fleet utilization rates (based on total supply as opposed to marketed supply) have remained stable in the 60 percent range. Operators are moving excess rigs overseas where demand is greater than in the GOM. Offshore drilling rig day rates in the GOM have remained flat or declined; too much excess rig capacity remains in the market for rates to increase significantly. Much of the short-term inactivity is contributed to uncertainty about the economy and the war in Iraq (*Workboat*, 2003a and Gulf of Mexico Newsletter On-line, 2003).

A depressed offshore rig market historically has meant fewer offshore service vessels (OSV) working since demand for OSV's is positively correlated with demand for offshore rigs. In the past, as demand for rigs has decreased, the industry has offered break-even rates or lower on rigs and OSV's in an effort to increase utilization rates. This downturn though is different. Industry is dry-docking rigs and OSV's in order to increase day rates. While this strategy has worked for larger supply vessels, smaller crewboats have experienced both lower utilization and day rates (*Workboat*, 2002). Day rates were lower in every category of OSV's in January 2003 except larger crewboats. Crewboats were also the only category of OSV's that posted utilization increases (*Workboat*, 2003a).

Another indicator of the direction of the industry is the exploration and development (E&D) expenditures of the major oil and gas companies. After substantially cutting their E&D budgets during the 1998 and 1999 fiscal years, majors and independents increased their spending in 2000 and 2001. This trend changed in 2002 and is expected to continue its downward trend in 2003. Based on Salomon Smith

Barney and Lehman Brothers' annual survey of major and independent U.S. oil and gas companies, 2003 E&D upstream spending is expected to range between an increase of only 0.01 percent and a decrease 0.07 percent over 2002 levels (*WorkBoat,* 2003b).

Lease sales are another indicator of the offshore oil and gas industry. Sales over the last several of years have resulted in a relative increase in the number of blocks leased. In addition, recent lease sales show a continued strong interest in deepwater and a renewed interest in shallow water. In December 2001, the EPA Lease Sale 181, in which all of the blocks are in deepwater, averaged more than 2 bids per block leased. This is the first time since 1984 that this has occurred. While new royalty-relief provisions for shallow-water natural gas have increased activity in this water depth, industry remains cautious due to low natural gas prices.

3.3.5.4. Demographics

Tables 3-17 through 3-32 contain the analysis area's baseline projections for population, age, race and ethnic composition, and education over the life of a proposed action. These tables present the projections by coastal subarea, each GulfState, and the United States. Projections, through 2040, are based on the Woods and Poole Economics Inc.'s *Complete Economic and Demographic Data Source* (2002). These baseline projections assume the continuation of existing social, economic, and technological trends. Therefore the projections include population associated with the continuation of current patterns in OCS leasing activity, which encompasses a proposed action.

In some analysis area locales, i.e., Port Fourchon and Lockport, Louisiana, there has been an influx of workers from Mexico, India, and other parts of the U.S. because of the shortage of local workers in the local community (Keithly, 2001). While these new residents present stresses on communities' infrastructure and government services, they have only minimally changed local demographics (i.e., population, educational attainment, age, and race distribution have only changed negligibly with respect to OCS activities).

3.3.5.4.1. Population

The analysis area consists of highly populated metropolitan areas (such as the Houston MSA, which predominates coastal Subarea TX-2) and sparsely populated rural areas (as is much of coastal Subarea TX-1). Some communities in the analysis area experienced extensive growth during the late 1970's and early 1980's when OCS activity was booming. Following the drop in oil prices, many of these same areas experienced a loss in population (Gramling, 1984; Laska et al., 1993). All coastal subarea populations are expected to grow at a higher rate than the United States' average annual population growth rate over the life of a proposed action, reflecting the region to region migration pattern of favoring the south and west over the northeast and midwest (USDOC, Bureau of the Census, 2001). This is a continuation of historic trends. Average annual population growth projected over the life of a proposed action range from a low of 0.45 percent for coastal Subarea LA-3 (dominated by the Orleans MSA) to a high of 3.27 percent for coastal Subarea FL-3. Over the same time period, the population for the United States is expected to grow at about 1.36 percent per year.

The population in the analysis area throughout the life of a proposed action is expected to remain a fairly even mix of male/female, with the female population having a slight edge over the male population (particularly over time as the population ages). The population mix of the coastal subareas is only slightly more female than that of the United States.

3.3.5.4.2. Age

The median age for the coastal subareas in Texas, Louisiana, Mississippi, and Alabama compare favorably with the median age of the United States as a whole, with a slight tendency toward an older population moving eastward across the coastal subareas. The median age in the Florida analysis area (particularly the southernmost coastal subareas) is about 5-10 percent higher than the national average consistently over the life of a proposed action. Florida attracts retirees and therefore has higher percentages of older residents. Nationwide there is an expected aging tendency with the percentage of the population in the 65 years and over category doubling. By 2011, the baby boomers will start to turn 65, and by the year 2025, the percentage of older people projected to live in the United States as a whole will be greater than the current percentage in Florida (AmeriStat, 2001). Over the same 40 years, all of the coastal subareas, with the exception of coastal Subarea FL-3, are expected to show a similar trend. The percent of the population in the 65 years and over category in coastal Subarea FL-3 is much higher in 2002 (the base year) yet still slightly increases over time. While the rest of the Florida analysis area displays the national aging trend, the percent of the population in the Florida coastal subarea is higher than both the Nation and the other Gulf Coast areas.

3.3.5.4.3. Race and Ethnic Composition

The racial and ethnic composition of the analysis area reflects both historical settlement patterns and current economic activities. For example, those counties in Texas where Hispanics are the dominant group—Cameron to Nueces (Brownsville to Corpus Christi)—were also settled by people from Mexico. Their descendants remain, typically working in truck farming, tending cattle, or in low-wage industrial jobs. From Aransas to Harris County (Houston), the size of the African-American populace increases, indicating more urban and diverse economic pursuits. In Jefferson County, Texas, adjacent to Louisiana, African-Americans outnumber Hispanics, reflecting the dominant minority status of African-Americans throughout the rest of the analysis area. Despite the larger number of white, non-Hispanic people in coastal Texas, Louisiana, Mississippi, and Alabama, together African-Americans and Hispanics outnumber whites, a trend which is national, not just regional, and which is increasing in intensity. Compared with the United States, there is a higher non-white racial composition to the Texas, Louisiana, Mississippi, and Alabama coastal areas with the exception of coastal Subarea TX-1. This coastal subarea borders Mexico and has the highest concentration of Hispanic population. Southwestern Louisiana is Acadian country. Settlers included Houma Indians, French, Spanish, English, and African. The Florida coastal subareas' racial composition predominantly mirrors that of the United States with the exception of coastal Subarea FL-2, which has a higher African-American population. (See **Chapter 3.3.5.10.**, Environmental Justice, for further discussion of minority and low-income populations.)

3.3.5.4.4. Education

At present, the 2000 U.S. Census data for education at the county/parish level have not been released. The last available data at this level is the 1990 Census data. Therefore, this analysis uses the 2000 U.S. Census Supplementary Survey Profile educational attainment data for States. For people 25 years and over, 75.2 percent of the population in the U.S. has graduated from high school, while 20.3 percent has received a bachelor's degree. Texas' educational attainment percentages are higher than the national average for both categories: 76.8 and 23.5 percent, respectively. Louisiana, while higher than the national average for high school graduates, 76.7 percent, is lower for college degrees, 19.5 percent. Mississippi's educational attainments are lower than the Nation's for both categories—74.3 and 18.6 percent, respectively. Alabama, like Louisiana, has a higher than national high school graduation rate (76.0%), but a lower rate for bachelor's degree (20.2%). Florida mirrors Texas; its educational attainments are higher than the national rates—81.9 and 23.2 percent, respectively.

"The local school system in [Greater Lafourche Parish] is now facing the issues and challenges related to bilingual education as Spanish speakers [from increased OCS activities] begin to move to the area. This is often a difficult task for large metropolitan school system and the community in this case is rather small and strongly French in its background and history" (Keithly, 2001). Furthermore, this has resulted in additional costs to the school system.

3.3.5.5. Economic Factors

Tables 3-17 through 3-32 contain the analysis area's baseline projections for employment, business patterns, and income and wealth over the life of a proposed action. These tables present the projections by coastal subarea, each Gulf Coast State, and the Unites States. Projections through 2040 are based on the Woods and Poole's "Complete Economic and Demographic Data Source" (Woods and Poole Economics, Inc., 2002). These baseline projections assume the continuation of existing social, economic, and technological trends. Therefore, the projections include employment associated with the continuation of current patterns in OCS leasing activity, which encompasses a proposed action, as well as the continuation of trends in other industries important to the region. **Chapter 3.3.5.1.2.**, Land Use, discusses the analysis area's major employment sectors.

While the OCS industry may not be the dominant industry in a coastal subarea, it can be in a specific locale within a coastal subarea, causing that focal point to experience impacts. For example, in Port Fourchon and Lockport, Louisiana, there has been an influx of workers from Mexico, India, and other parts of the U.S. because of the shortage of local workers in the local community. While these new residents are expected to only negligibly impact the coastal subarea's demographics, they have presented the communities with added stress to infrastructure and government services. Many of these increased costs to local governments are hard to quantify. Some locally provided services are tied to the unique needs of the oil and gas offshore industry. For example, schools, city water, law enforcement, and roads have been particularly affected by the growth of offshore development (Keithly, 2001). Furthermore, the cyclical nature of the oil and gas industry (boom/bust) makes allocating budgetary monies and personnel to these services difficult.

3.3.5.5.1. Employment

Average annual employment growth projected over the life of a proposed action range from a low of 1.19 percent for coastal Subarea LA-3 (predominated by the Orleans MSA) to a high of 5.43 percent for coastal Subarea FL-3. Over the same time period, employment for the United States is expected to grow at about 2.25 percent per year, while the GOM analysis area is expected to grow at about 2.06 percent per year. As stated above, this represents growth in general employment for the coastal subareas. Continuation of existing trends, both in OCS activity and other industries in the area, are included in the projections. (See **Chapter 3.3.5.8.**, OCS-Related Coastal Infrastructure, for more a more complete examination of employment and labor issues with respect to each OCS industry.)

3.3.5.5.2. Income and Wealth

Median household income in the United States was $42,148 in the year 2000. This value equaled the value for 1999 in real terms, the highest level ever recorded in the Current Population Survey. Median incomes for Hispanic (who may be of any race) and Black (African American) households hit new all-time highs of $33,447 and $30,439, respectively. The median household incomes of white non-Hispanic ($45,904) and Asian and Pacific Islander ($55,521) households equaled their highest level ever (USDOC, Bureau of the Census, 2001).

Income associated with the industrial sectors for the WPA coastal subareas and that of the CPA are similar. Because the service industry is a major employer in the analysis area, this industry contributes significantly (percentage-wise) to income. The manufacturing and construction industries also contribute greatly, in percentage terms, towards income earned for the coastal subareas.

Using the Woods and Poole Wealth Index, all coastal subareas within the GOM analysis area, with the exception of coastal Subareas FL-3 and FL-4, rank considerably below the United States in terms of wealth. Coastal Subareas FL-3 and FL-4 rank slightly higher than the U.S. Ironically, coastal Subarea FL-2 ranks lowest on the wealth scale of all coastal subareas in the region. The Florida counties are the least influenced by OCS development in the analysis area. All other coastal subareas range from the low 70's to upper 80's for their respective wealth indices throughout time, with the United States being 100. The Wealth Index is the weighted average of regional income per capita divided by U.S. income per capita (80% of the index), plus the regional proportion of income from dividends/interest/rent divided by the U.S. proportion (10% of the index), plus the U.S. proportion of income from transfers divided by the regional proportion (10% of the index). (See **Chapter 3.3.5.10.**, Environmental Justice, for further discussion of minority and low-income populations.)

3.3.5.5.3. Business Patterns by Industrial Sector

The industrial composition for the coastal subareas is similar. With the exception of coastal Subareas LA-2, LA-3, and FL-4, the top four ranking sectors in terms of employment in the analysis area are the service, manufacturing, retail trade, and State and local government sectors. In coastal Subareas LA-2 and LA-3, construction replaces manufacturing as one of the top four industries on the basis of employment. In coastal Subarea FL-4 transportation, communication, and public utilities replaces manufacturing as one of the top four industries on the basis of employment. The service industry employs more people in all coastal subareas. The service industry is also the fastest growing industry.

3.3.5.6. Non-OCS-Related Marine Transport

An extensive maritime industry exists in the northern GOM. **Figure 3-12** shows the major ports and domestic waterways in the analysis area, while **Tables 3-33 and 3-34** present the 1999 channel depth, number of trips, and freight traffic of OCS-related waterways. Maritime traffic is either domestic or foreign. There is a substantial amount of domestic waterborne commerce in the analysis area through the GIWW, which follows the coastline inshore and through bays and estuaries, and in some cases offshore. In addition to coastwise transport between GOM ports, foreign maritime traffic is extensive. Major trade shipping routes between GOM ports and ports outside the northern GOM occur via the Bay of Campeche, the Yucatan Channel, and the Straits of Florida.

Fourteen of the 50 leading U.S. ports (based on millions of short tons in 1999) are located on the GOM. All five Gulf Coast States, when ranked by state tons in 1999, are in the top 20 (1-Louisiana, 2-Texas, 5-Florida, 16-Alabama, and 20-Mississippi), reflecting the importance of the analysis area's ports to U.S. waterborne traffic. Major ports in the analysis area by port tons (for 1999) include: 1-South Louisiana, Louisiana; 2-Houston, Texas; 4-New Orleans, Louisiana; 6-Beaumont, Texas; 7-Baton Rouge, Louisiana; and 8-Port of Plaquemines, Louisiana. The ports of Lake Charles, Louisiana; Texas City, Texas; Mobile, Alabama; Pascagoula, Mississippi; and Port Arthur, Texas, are also in the top 50 ports. Major inland waterways include the GIWW; the Houston-Galveston Ship Channel; the Sabine River; the Calcasieu River; the Atchafalaya River; the Morgan City-Port Allen Route; the Chene, Bouef, and Black Waterway; the Houma Navigation Canal; the Bayou Lafourche/West Belle Pass; the Mississippi River; the Tombigbee River; the Alabama River; and the Mobile Ship Channel (U.S. Dept. of the Army, COE, 2001a).

In terms of tonnage for all commodities, including domestic or foreign, inbound or outbound, the top six ports (in 1999), in decreasing order, were the Port of South Louisiana, Sabine-Neches, Port of New Orleans, Beaumont, Port of Baton Rouge, and Port of Plaquemines. As seen in **Table 3-35**, crude and petroleum products make up a large portion of total commodities transported through the analysis area's ports. Extensive refinery capacity, easy port access, and a well-developed transportation system have contributed to the development of the Gulf Coast region as an important center for handling oil to meet the world's energy needs. Both crude oil and petroleum products travel through the GOM and these ports. Crude oil is tankard into area refineries from domestic production occurring in the Atlantic and Pacific Oceans. Crude oil produced within the GOM region is barged among GOM terminals to reach refineries and onshore transportation routes. Petroleum products are barged, tankered, piped, or trucked from the large refinery complexes. Between 60 and 65 percent of the crude oil being imported into the United States comes through GOM waters. The area also includes the Nation's Strategic Petroleum Reserve and LOOP, the only deepwater crude-oil terminal in the country.

In 1999, there was a considerable amount of waterborne commerce along the GOM Coast from Pensacola Bay, Florida, to the Mexican border (U.S. Dept. of the Army, COE, 2001a). Review of non-OCS-related vessel and freight traffic during 1999 (**Tables 3-33 and 3-34**) shows that vessel trips and waterborne commerce occurred primarily west of the mouth of the Mississippi River. More than 42 percent of the vessel trips recorded in 1999 within the Pensacola Bay to Mexican border segment of the GIWW took place between the Mississippi and Sabine Rivers. Vessel trips from Mobile Bay, Alabama, to New Orleans, Louisiana, accounted for 16 percent of total GIWW trips, while the Sabine to Galveston route accounted for 21 percent. Tanker traffic was most intense between the Mississippi and Sabine Rivers.

The 1999 statistics for vessel trips in harbors, channels, and waterways located between Pensacola Bay and Sabine Pass show that there were eight major locations of vessel activity. These locations, in decreasing order of activity, were as follows: Port of South Louisiana, Port of New Orleans, Sabine-Neches Waterway, Port of Baton Rouge, Port of Plaquemines, Mobile Harbor, Calcasieu River and Pass, and Bayou Lafourche. The top seven waterways in terms of tanker trips during 1999 were (in decreasing order by number of tanker trips inbound and outbound trips combined) as follows: Sabine-Neches, Port of South Louisiana, Port of Baton Rouge, Port of New Orleans, Morgan City to Port Allen, Calcasieu River, and Beaumont.

The transport of crude petroleum was concentrated in four locations: Sabine-Neches, Beaumont, Port of South Louisiana, and Calcasieu River. The transport of crude petroleum was mostly imported. The four major petroleum products locations were (in descending order) Port of South Louisiana, Sabine-Neches, Port of New Orleans, and Port of Baton Rouge.

Tanker imports and exports of crude and petroleum products into the GOM are projected to increase (USDOE, EIA, 2001a). In 2000, approximately 2.08 BBO of crude oil (38% of U.S. total) and 1.09 BBO of petroleum products (13% of U.S. total) moved through analysis area ports. By the year 2020, these volumes are projected to grow to 2.79 BBO of crude oil and 1.77 BBO of petroleum products. Crude oil will continue to be tankered into the GOM for refining from Alaska, California, and the Atlantic.

3.3.5.7. OCS-Related Offshore Infrastructure

3.3.5.7.1. Exploration and Production Structures

Structures used in a proposed lease sale area are either short term or long term in nature. Short-term structures used in the proposed lease sale area include exploration infrastructure such as semisubmersibles and drillships. Both of these types of structures may be moored or dynamically positioned. Long-term structures are used for development and production. Within a proposed lease sale area, there is only one type of long-term structure, a subsea gas well that is currently shut-in awaiting a flowline. A subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through a pipeline and manifold systems. At present, subsea systems are used in water depths exceeding 5,000 ft.

Tables in Appendix A.4. present information on platforms operating in the OCS.

3.3.5.7.2. Offshore Transport

Service Vessels

Unless otherwise indicated, the following information is from "The Gulf of Mexico Supply Vessel Industry, A Return to the Crossroads" (Simmons & Company International, 2000).

Service vessels are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. In addition to offshore personnel, service vessels carry cargo (i.e., freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, and food) offshore. As of November 2000, there are 376 supply vessels (platform supply vessels (PSV) and anchor handling tugs/supply vessels (AHTS)) in the GOM analysis area (up from a 1993 low of 247 units). One hundred and sixteen (or 35%) of the 376 supply vessels were built since 1996. This breaks down as 83 PSV's, 15 AHTS, and 18 units for specialty services. The first newbuilds commenced construction in late 1996 when dayrates were in the $6,000-7,000 range and utilization was steady at 95 percent; a primary driver of supply vessel demand is rig activity. The first deliveries were in early 1997. As dayrates continued to accelerate during 1997, reaching the $8,000-9,000 range, more orders were placed. With an average delivery time of 12-16 months (and an average cost of $8-10 million), most newbuilds entered the market during the second half of 1998 and 1999, just as the Asian crisis and falling oil prices began to take hold, leading to demand, utilization, and dayrates ($2,400) falling dramatically.

Although the traditional workhorse of the GOM has been the standard 180-ft supply vessel, none of the boats built were less than 190 ft in length. Eighty-seven percent of the newbuilds were 200 ft in length or greater while over half were 220 ft in length or greater. The increasing size of the newbuild fleet is directly related to the emergence of deepwater drilling in the GOM over the past six years. At present, nearly three-quarters of the supply fleet in the analysis area is less than 200 ft long and work primarily in the shallow waters; 28 percent of the fleet is 200 ft or larger and works primarily in deepwater. Although length is typically used to describe supply vessels, it is actually the liquid mud capacity and dynamic positioning capability that are the most important criteria for deepwater operators. Most operators view 220-ft boats as the minimum for work in supporting drilling operations. Typical GOM vessel specifications are shown in **Table 3-35**. The GOM supply boat industry does not have a young fleet. Nearly 40 percent of the entire fleet is at least 20 years old. Only 26 percent of the fleet is 10 years old or younger. The average age of the fleet in 1997 was 17.9 years. At present, the average age is 15.7 years, reflecting the newbuild expansion of the last cycle. The estimated life of a service vessel is 25 years.

Since the last industry downturn that began in 1998, the supply boat market has experienced a great deal of consolidation. During the last two years, numerous smaller players exited the industry via bankruptcy, asset sales to larger competitors, or asset sales to outside the industry. More than half of the smaller boat operators that operated three or fewer boats in the last cycle are no longer in the business. The resulting GOM supply boat industry is very fragmented. There are 24 boat operators in the analysis area. Sixteen of these operators own fleets of less than 10 boats. Nine own three boats are less. Of the 24 operators, 6 are public and 18 are privately held. The six public companies (Tidewater, 40%; Trico Marine, 13%; Ensco Marine, 7%; Seacor Smith, 7%; Sea Mar, 7%; and Seabulk Offshore, 6%) control 70 percent of the total fleet. Edison Chouest is the largest private boat operator with 11 percent of the total supply-vessel fleet. Chouest was the first company to undertake major newbuilding projects and was the most significant builder in the last cycle with respect to the number of units (49) and total capital invested ($677 million). Over 8 percent of the 220-ft newbuilds were Edison Chouest vessels. The modern, high-capacity fleet has given Chouest a strong presence in deepwater. The second most active newbuild participant was Seacor, which spent over $222.5 million on 14 vessels. The market share for several major companies has experienced significant changes. The most noticeable change is the decline in Tidewater's market share from 42 percent in 1997 to 30 percent in 2000. This decline is a result of Tidewater's restraint from building in the last cycle, although Tidewater has recently announced that it has committed up to $300 million to a program that will bring 21 crew and fast crew/supply vessels into its fleet by the year 2003. Chouest almost doubled their market share over the last three years through their aggressive newbuild program.

The emergence of deepwater drilling has become the most important factor going forward in the GOM supply boat industry. As a result of newbuilds and conversions, the number of drilling rigs capable of drilling in over 3,000 ft of water has quadrupled sine 1996. Compared to the shallow waters of the GOM, deepwater drilling support requires a significantly enhanced supply boat. In deep water, more drilling mud is required to fill wellbore and risers. Thus, deepwater supply vessels need large liquid mud capacities. Deepwater drilling rigs generally operated farther from shore than conventional shallow-water units. Weather patterns can be extreme, and the sea conditions are typically rougher. Therefore, in order for a supply vessel to safely maintain its position near a deepwater rig, dynamic positioning (DP) is required. With DP capability, a supply vessel uses global positioning satellites to determine an exact location and small engines or thrusters to maintain the boat's position.

Given the relative youth of the GOM deepwater industry, E&P operating practices have not been standardized. Some E&P companies have chosen to employ two boats of the 200- to 205-ft class for support of a deepwater drilling rig. This allows the operator to shuttle boats between the rig and port, while still having a boat on location at all times. If additional items are required that are not at the rig location, the boat in port can bring the items to the rig on its next trip, effectively reducing the time needed to get supplies had only one large boat been contracted. It generally takes supply vessels 10-15 hours (one way) to get to deepwater locations compared to only a few hours for wells drilling on the shelf. While some E&P operators are using two vessels, it appears that most are moving toward the use of one larger boat (220+ ft) to support activities. Industry is increasingly using the 200-205 ft class in shallower waters. This obviously has implications for the 180-ft supply boat category.

Several E&P companies in the analysis area are currently undertaking the concept of boat pooling. Rather than assigning specific boats to specific rigs, E&P companies are experimenting with the use of several boats for a pool of rigs. Some operators will share their contracted boats with other E&P companies, while others are utilizing boat pooling specifically for their own rigs. Initial indications are that E&P companies have been successful in reducing their boat usage. Along the same vein, there is a growing interest among E&P customers toward the issue of logistics as a way to improve efficiency and reduce costs. The larger boats that have been added by the industry have the capacity and capability to serve multiple rigs on one trip from port. This is a critical factor in the logistics business. Edison Chouest recently introduced a logistics company, C-Logistics. Their first customer, Shell, was able to generate higher boat utilization and lower costs. ASCo Group and Baker Energy are also establishing logistics products.

Helicopters

Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In addition, equipment and supplies are sometimes transported. For small parts needed for an emergency repair or for a costly piece of equipment, it is more economical to transport it to and from offshore fast rather than by supply boat. Normal offshore work schedules involve two-week (or longer) periods with some crew changes on a weekly basis; therefore, helicopters will travel to some facilities at least once a week. According to the Helicopter Safety Advisory Conference (Osborne, 2000), the number of helicopter trips in support of Gulfwide OCS operations have been increasing steadily since 1994 to over 1.7 million trips annually, carrying 3.7 million passengers during 417,000 flight hours.

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

Deepwater drilling farther offshore is the growth area for helicopters. The offshore helicopter industry is purchasing new helicopters to meet the demands of deepwater: travel farther and faster, carry more personnel, all-weather capability, and lower operating costs. The helicopters in service today have travel ranges up to 450 nmi, can attain speeds over 200 miles per hour (mph), carry up to 20 passengers, and may cost $10 million or more. Bell Helicopter Textron is the leading manufacturer of helicopters in the world. Other major manufacturers include Eurocopter, MD Helicopters, Sikorsky, and Agusta Westland.

Many of the platforms offshore Texas, Louisiana, Mississippi, and Alabama serve as helicopter refueling stations. At present, aircraft fuel is barged to these offshore refueling stations. While there are offshore fueling sites, it saves the industry time and money not to stop. Transportation is one of the exploration and production industry's top three costs. The newer helicopters operating in the GOM, though, have the range and capacity to fly without stopping to refuel, but they are more costly to operate.

Since the tasks the offshore helicopter industry provides are the same tasks supply vessels provide, they are competition for one another. While exploration and production companies prefer helicopters, the industry is outsourcing more and more operations to oilfield support companies, such as Baker Hughes, who are much more cost conscious and skeptical about the high cost of helicopters. Fast boats are beginning to erode the helicopter industry's share of the offshore transportation business, particularly in shallow water. Another consideration for the helicopter industry is new technology such as subsea systems. As discussed in **Chapter 4.1.1.3.3.1.**, Types of Production Structures, a subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through pipeline and manifold systems. These systems decrease the number of platforms and personnel needed offshore, therefore reducing the amount of transportation needed.

3.3.5.8. OCS-Related Coastal Infrastructure

Unless otherwise indicated, the following information is from the MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

The OCS development is supported by a large onshore infrastructure industry consisting of thousands of small and large contractors responsible for virtually every facet of the activity, including supply, maintenance, and crew bases. These contractors are hired by majors and independents alike to service production areas, provide material and manpower support, and to repair and maintain facilities along the coasts. The offshore support industry employs thousands of workers and is responsible for billions of dollars in economic activity in the analysis area. Virtually all of these support industries are found adjacent to ports.

Throughout the last 50 years, the fabrication industry in the analysis area has been the cornerstone for the offshore oil and gas industry. There are hundreds of onshore facilities in the analysis area that support the offshore industry. The fabrication corridor stretches approximately 1,000 mi from the Texas/Mexico border to the Florida panhandle. Other offshore support industries are responsible for such products and services as engine and turbine construction and repair, electric generators, chains, gears, tools, pumps, compressors, and a variety of other tools. Additionally, drilling muds, chemicals, and fluids are produced and transported from onshore support facilities. Many types of transportation vessels and helicopters are used to transport workers and materials to and from OCS platforms. As technology matures, additional support industries will evolve.

With the expanding interest in deepwater activities, many onshore facilities have migrated somewhat to areas that have capabilities of handling deepwater vessels, which require more draft. Since fewer ports have such access, dredging operations at existing facilities or contractor expansion to areas that can handle such vessels has occurred. This has also led to heated competition between port facilities. Many support industries have multiple locations among the key port facilities. For instance, Bollinger Shipyards has locations in Texas City, Galveston, Calcasieu, Morgan City, Houma, Lockport, and Fourchon, as well as many other locations.

Shipbuilding and repair facilities are located in key ports along the Gulf Coast. A typical shipbuilding facility consists of a variety of structures, including maintenance and repair facilities. These yards are typically found adjacent to a deep ship channel that allows them to serve deepwater vessels. Additionally, these facilities also serve other commercial and military needs in order to diversify and protect themselves against leaner oil industry times.

Pipelaying and burial contractors are also found near port facilities. Though there has been a consolidation of sorts, at least five companies account for almost 90 percent of the total footage laid as recently as 1999, resulting in sufficient competition. As offshore production enters deeper water, it requires contractors to retool because thicker-walled pipe is required to withstand the pressures exerted at such depths. This has also led to an evolution of sorts for pipelaying vessels.

Other support facilities are located near ports, including warehouses for chemicals, muds, tools, and other equipment. Crew quarters and bases are also near ports, but some helicopter facilities are located farther inland. Transportation to and from offshore rigs is a major expense for producers, and many transportation companies exist to provide this service. Often one or two supply ships and at least one helicopter are used to support each platform.

In the exploration and development stage, the majority of costs are associated with exploration (19.2%), drilling (16.1%), steel pipe (10.3%), specialized machinery (7.1%), chemicals (6.9%), and water transport (6.7%). The majority of expenses in the pipelaying segment are associated with construction (52.8%) and steel pipe (26%), while the largest expenses associated with the platform operations include instrumentation (44.3%), pipeline construction (15.9%), specialized machinery (13.7%), and pumps and compressors (10.2%). In the ongoing operation and maintenance stage, the largest expenses are associated with operations (36.3%), followed by other services (18.4%) and environmental engineering services (14.7%). The percentage of expenses associated with each of these areas is indicative of the size of the supporting industries.

Like onshore development, OCS exploration and production is driven by oil and gas prices. The 1986 collapse of oil prices forced many offshore companies to close their doors, while the remaining companies often consolidated and expanded operations to include commercial and military business. This was true throughout the entire supporting industry infrastructure.

During slow times, all areas feel the effects. Fewer rigs are built and maintained, fewer boats are needed, fewer chemicals are manufactured and purchased, and much less research and development (R&D) is conducted. Perhaps the most detrimental result of a downturn is the flight of many experienced personnel. This has led to severe problems for an industry closely tied to the price volatility of oil and natural gas. When experienced workers leave it is very difficult to entice them back to an industry that is so volatile.

One of the results of fewer R&D dollars is that producers, who are saddled with billion dollar projects, are forced to push much of the R&D expenditures for new technologies onto their suppliers. For example, it is common to see many suppliers shoulder the burden of seismic surveys today. Unfortunately, no single company can adequately fund and support such activities. It is important to realize that new technologies have led to the development of unrecognized, unreachable or uneconomic reserves, which often lead to significant work for the onshore support industry.

Following the massive shift in the industry in the mid-1980's, subsequent price downturns have not been as decimating to the industry, though the 1998-1999 price drop did force companies to lay off employees and to close a few facilities. Drilling declined significantly but did not cause the massive contractor flight evidenced in the mid-1980's. During this downturn, activity shifted somewhat to platform removal, maintenance, renovations, and rig surveys. Some fabrication yards diversified in order to keep their doors open, often taking in non-oil-related work such as barge repair and even military work.

The move into deepwater has increased activity and has led to a significant transformation for some contractors. Since ports with sufficient draft to accommodate deepwater-servicing equipment are limited; onshore effects appear to be concentrated in a few communities. This contrasts with earlier, nearer-shore developments that are supported by many ports and coastal communities.

3.3.5.8.1. Service Bases

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel that are needed at offshore work sites. Although a service base may primarily serve the OCS planning area and subarea in which it is located, it may also provide significant services for the other OCS planning areas and subareas.

The oil and gas industry has thrived in the GOM. With the industry has come a logistical support system that links all phases of the operation and extends beyond the local community. Land-based supply and fabrication centers provide the equipment, personnel, and supplies necessary for the industry to function through intermodal connections at the Gulf Coast ports. The necessary onshore support segment includes inland transportation to supply bases, equipment manufacturing, and fabrication. The offshore support involves both waterborne and airborne transportation modes.

States along the GOM provide substantial amounts of support to service the oil and gas industry that is so active on the OCS. Many ports offer a variety of services and support activities to assist the industry in its ventures. Personnel, supplies, and equipment must come from the land-based support industry. All of those services must pass through a port to reach the drilling site. **Table 3-36** shows the 50 service bases currently used for the OCS. These facilities were assessed from the MMS Platform Plans' primary service base designation. As can be seen from **Table 3-36**, 33 of the service bases (or 66%) are located in the CPA. Of these, 29 reside in Louisiana. In addition to servicing the offshore, several of the services bases are commercially oriented ports: Mobile, Alabama; Pascagoula, Mississippi; Lake Charles, Morgan City, and Port of Plaquemines/Venice, Louisiana; and Corpus Christi, Freeport, Galveston, and Port Arthur, Texas. These activities are discussed in **Chapter 3.3.5.6.**, Non-OCS-Related Marine Transport. The other service bases are a combination of local recreation and offshore service activity. With respect to the proposed lease sale area, primary service bases include Port Fourchon and Venice, Louisiana, and Mobile, Alabama. Secondary service bases include Cameron, Houma, Intracoastal City, and Morgan City, Louisiana; and Pascagoula, Mississippi.

Based on numbers provided by Offshore Data Services, the ports of Cameron, Fourchon, Morgan City, and Venice, Louisiana, service over 81 percent of all GOM mobile rigs and over 91 percent of all deepwater rigs (One Offshore, 2001). While some service bases focus primarily on supplies, others focus on transportation.

This extensive network of supply ports includes a wide variety of shore-side operations from intermodal transfer to manufacturing. Their distinguishing features show great variation in size, ownership, and functional characteristics. Basically, two types of ports provide this supply base. Private ports operate as dedicated terminals to support the operation of an individual company. They often integrate both fabrication and offshore transport into their activities. Public ports lease space to individual business ventures and derive benefit through leases, fees charged, and jobs created. These benefits spread throughout the entire area and are viewed as economic development impacts. Thus, the public ports play a dual role by functioning as offshore supply points and as industrial or economic development districts. An efficient network of ports lowers costs associated with oil and gas production and significantly boosts the well being of citizens of the adjacent communities.

The significant prosperity that has followed the industry has resulted in issues and concerns that must be addressed at the local community level. For example, additional commercial traffic associated with offshore supplies has caused worsening road conditions at Port Fourchon. While local governments near the service bases have gained revenue from the increased activity within their jurisdictions, the demands for additional services and facilities resulting from oil and gas operations have exceeded growth in the revenue stream. Local tax dollars cannot meet the demand for so many improvements in such a short time. State and Federal matching funds are sought where possible, but the acquisition of those funds often has built-in delaying factors. Nevertheless, communities are attempting to meet the demands of the offshore industry. Thus, the oil and gas industry is influencing the direction and scope of improvements being made at local levels. Communities, just like the ports, must be able to anticipate future demands for their services. In order to plan for this growth, communities need timely information about trends in the industry.

Rapidly developing offshore technology has placed an additional burden on service-base ports. As OCS operations have progressively moved into deeper waters, larger vessels with deeper drafts have been phased into service, mainly for their greater range of travel, greater speed of travel, and larger carrying capacity. Services bases with the greatest appeal for deepwater activity have several common characteristics: a strong and reliable transportation system; adequate depth and width of navigation channels; adequate port facilities; existing petroleum industry support infrastructure; a location central to OCS deepwater activities; adequate worker population within commuting distance; and an insightful strong leadership. Typically, deeper draft service vessels require channels with depths of 6-8 m.

Edison Chouest, in 1996, built their C-Port facility in Fourchon, Louisiana, as a one-stop shopping service base for the offshore. This facility is described in **Chapter 3.3.5.6.** The success of the C-Port caused Port Fourchon to emerge as the deepwater service-base port for the OCS. In September 2001 the Corps of Engineers deepened Bayou Lafourche at Port Fourchon to accommodate the larger supply vessels. In order to service the EPA, Chouest has started scouting sites for a C-Port in either Pascagoula, Mississippi, or Mobile/Theodore, Alabama. Construction on this facility will depend on successful exploration in the EPA. Based on Edison Chouest's C-Port locations and the trend for the industry to consolidate, Port Fourchon and either Pascagoula or Mobile/Theodore will serve as the primary deepwater service-base ports for the OCS.

The following are profiles of three ports that are involved in offshore support. These profiles are representative of OCS supply/crew bases. An effort has been made to describe their operational structure as well as to describe their facilities and equipment.

Morgan City, Louisiana

The Port of Morgan City is located within the community of Morgan City in St. Mary Parish, Louisiana. With immediate access to I-49, it is one hour away from New Orleans, Lafayette, and Baton Rouge. Two thousand linear feet of rail spur and 1,500 linear feet of sidings connect the port warehouses with Burlington Northern mainline. Daily rail service is provided by Burlington Northern. The port was created in 1952. Since 1957, it has been active in both domestic and international trade. It is governed by a nine-member Board of Commissioners, who are appointed by the Governor and serve for a nine-year term. Morgan City is the only medium draft harbor between New Orleans and Houston on the GOM. Its 400-ft wide channel is maintained by the COE to a constant depth of 20 ft. Its docking and cargo handling facilities serve a wide variety of medium draft vessels.

Centrally located along the Gulf Coast, the port is only 18 mi from the open waters of the GOM at the intersection of the GIWW and the Atchafalaya River. It is on the east bank of the Atchafalaya River in a natural wide and deep harbor known as Berwick Bay. The Atchafalaya River, the GIWW, and Bayous Boeuf, Black, and Chene are the connections to traffic throughout the continental United States and abroad. The Atchafalaya River has its beginnings at the junction of Old River and the Red River in east-central Louisiana. Old River is a short connection between the head of the Atchafalaya and the Mississippi Rivers. The Atchafalaya River flows southward a distance of 135 mi and empties into the Atchafalaya Bay. Traffic between points in the southwestern United States and the Upper Mississippi River Valley saves approximately 342 mi per round trip by using the Atchafalaya River rather than the alternate link of the GIWW via the Harvey Locks at New Orleans.

The port is suitable to handle container, general, and bulk cargo. There are over 200 private dock facilities located in the Morgan City vicinity, most of which are oil and gas related. These facilities have heavy-lift, barge-mounted cranes with capacities to 5,000 tons, track cranes to 300 tons, and mobile cranes to 150 tons. Facilities include a 500-ft dock with a 300-ft extension, a 20,000ft^2 warehouse with rail access, a large marshalling yard, a 50 ton capacity mobile track crane, 3 forklifts, a 35-ton cherry picker, and a rail spur. In addition to 3.75 ac of on-dock storage, about 12 ac of auxiliary yard storage is available. Bulk cargo loading/unloading from/to barge and from/to yard from trucks and rail is also offered.

The port plans to expand facilities with a 30,000-lb forklift, 3 yard jockeys, 6 flat-bed trailers, and 6 chassis trailers. The Board of Commissioners is also working with the COE to determine if there is justification for dredging the channel to 35 ft. McDermott, who uses the channel, can not compete with foreign companies to manufacture the larger platforms required by deepwater because of the lack of channel depth necessary to transport the platforms to open waters.

Port Fourchon, Louisiana

Port Fourchon, Louisiana, is located at the mouth of Bayou Lafourche where it empties into the GOM. It is approximately 60 mi south of New Orleans. Its easy accessibility from any area in the GOM has made it one of the most active oil and gas ports on the coast. Port Fourchon's location at the end of LA Hwy 1 is in the center of one of the richest and most rapidly developing industrial areas of the GOM region. While the growth of other ports has slowed, Port Fourchon has been expanding to meet the changing needs of the offshore oil-field industry. Port Fourchon has been designated as one of Louisiana's Enterprise Zones and therefore offers many tax advantages. Its close proximity to the GOM, along with its planned development and multidimensional services, make Port Fourchon one of the most significant oil and gas ports on the Gulf Coast.

The development and supervision of Port Fourchon is under the authority of the Board of Commissioners of the Greater Lafourche Port Commission (GLPC) with headquarters in Galliano, Louisiana. The Commission regulates commerce and vessel traffic within the Port Fourchon area, owns land and lease facilities, establishes 24-hr law enforcement through its Harbor Police Division, maintains paved roads, and provides facilities for governmental coordination such as the U.S. Customs Service and U.S. Coast Guard. Over its 40-year history, the GLPC has cultivated opportunities for businesses and steady economic growth for Port Fourchon and the surrounding area.

Port Fourchon is a multiuse port primarily servicing the needs of oil and gas development. Other uses include commercial fishing, recreation, and shipping as well as serving as the land base for LOOP. Today, the port is comprised of approximately 600 ac and has nearly 25,000 ft of waterfront facilities. The port has grown at a phenomenal rate due to the growth in the oil and gas industry and its development in the deepwater areas of the GOM. There are approximately 125 businesses located at the port.

The port is connected to the GIWW via Bayou Lafourche, the Houma Navigation Canal, and the Barataria Waterway. The port's channel is 26 ft deep, enabling it to accommodate the larger supply vessels. The port also houses a large number of docks with crane service, loading/unloading equipment, warehouses, refrigerated warehouse, and numerous storage yards. Improved and unimproved property is available.

Planned expansions at the port include the Northern Expansion Project. This is a 700-acre development consisting of 600-ft wide slips and over 1 mi of waterfront. While location on the GOM is an advantage to Port Fourchon, it has limited water access to major metropolitan centers. In addition, the two-lane LA Hw 1, the ports only access, and the lack of rail access are major impediments for the port. **Chapter 3.3.5.2.**, How OCS Development Has Affected the Analysis Area, also discusses the port and its conditions.

Port of Mobile, Alabama

With its deepwater seaport facilities at the Port of Mobile, the Alabama State Docks are conveniently located on the Central GOM. It is closer to open water than any other major port on the GOM. The current navigation channel, maintained by the COE, provides a navigational depth of 45 ft from the GOM to the mouth of the Mobile River. Four trunkline railroads (Burlington Northern/Santa Fe, CSX, Illinois Central, and Norfolk Southern) serve the port, which is situated at the intersection of two major interstate highways. The State offers 1,500 mi of navigable inland barge routes and is served by the Tennessee-Tombigbee Waterway, which connects 16,000 mi of interstate barge lanes with the Port of Mobile.

For the first 200 years of its existence, the Port of Mobile did not have a central organization to guide the development and operation of the port. In 1922, the State Docks Commission was established with the power to build, operate, and maintain wharves, piers, docks, quays, grain elevators, cotton compresses, warehouses, and other water and rail terminals, structures, and facilities. Since that time, the Alabama State Docks have been a part of Alabama State government and functions as an independent department with a board of directors. Today, the Department operates as a self-supporting enterprise agency of the Executive branch of State government.

About 375 employees operate, maintain, and market the facilities at the port. In 1999, the Port of Mobile was the 14th largest port in the nation in total tonnage. The economic impact to the State of Alabama was over $3 billion statewide. Tax payments of $467 million were made from activities in the international trade sector. And most importantly, the Alabama State Docks supports the jobs of more than 118,000 Alabamians.

The port offers 29 general cargo and 6 bulk berths with about 4 million ft^2 of covered storage space and an additional 4 million ft^2 of open storage area adjacent to piers and tracks. The general cargo capabilities have been enhanced in recent years, with about $80 million invested in capital improvement projects. New state-of-the-art wharves and warehouses include the 360,000-ft^2 Forest Products Terminal at Pier C, the 152,000-ft^2 Blakeley Terminal on the east bank of the Mobile River, the Steel & Heavy Lift Operations Berth at Pier North C, two warehouses with a combined space of 253,000 ft^2, a new pier for Roll On-Roll Off operations, and a concreted marshaling area. The port also provides a container port operation and other Roll O/Roll Off berths, accommodating some of the largest ocean-going vessels afloat.

As the industry continues to evolve, so do the requirements of the onshore support network. With advancements in technology, the shore-side supply network continues to be challenged to meet the needs and requirements of the industry and will be challenged in the future. All supplies must be transported from land-based facilities to marine vessels or helicopters to reach offshore destinations. This uses both water and air transportation modes. The intermodal nature of the entire operation gives ports (who traditionally have water, rail, and highway access) a natural advantage as an ideal location for onshore activities and intermodal transfer points. Therefore, ports will continue to be a vital factor in the total process and must incorporate the needs of the offshore oil and gas industry into their planning and development efforts, particularly with regard to determining their future investment needs. In this manner, both technical and economic determinants influence the dynamics of port development.

3.3.5.8.2. Navigation Channels

The analysis performed to identify current OCS service bases (**Chapter 3.3.5.8.1.**, Services Bases) was also used to identify relevant navigation waterways that support OCS activities. **Table 3-33** identifies the waterways and their project depth, while **Figure 3-13** shows their locations throughout the analysis area. In addition to OCS activities, navigation waterways also attract recreational and commercial developments along their banks. These developments are generally dependent upon the water resources or transportation that those waterways make accessible. With respect to the proposed lease sale area, the channels associated with the primary and secondary service bases are utilized.

3.3.5.8.3. Helicopter Hubs

Helicopter hubs or “heliports” are facilities where helicopters can land, load, and offload passengers and supplies, refuel, and be serviced. These hubs are used primarily as flight support bases to service the offshore oil and gas industry. There are 7 heliports in TX-1 that support OCS activities, 32 in TX-2, 29 in LA-1, 28 in LA-2, 27 in LA-3, and 5 in MA-1. With respect to the proposed lease sale area, primary hubs include Port Fourchon and Venice, Louisiana. Secondary hubs include Cameron, Houma, Intracoastal City, and Morgan City, Louisiana; Pascagoula, Mississippi; and Mobile, Alabama. Three helicopter companies dominate the GOM offshore helicopter industry: Air Logistics, Era Aviation (Era), and Petroleum Helicopters, Inc. (PHI). A few major oil companies operate and maintain their own fleets, although this is a decreasing trend.

Offshore helicopter business volume is linked to drilling activity, which is in turn tied to the price of oil. When there is more cash flowing in the oil and gas industry, there is more drilling and therefore more helicopter trips (Craig, personal communication, 2001). As discussed in **Chapter 3.3.5.2.**, How OCS

Development Has Affected the Analysis Area, due to the low price of oil ($10) during 1998-1999, the offshore oil and gas industry experienced a slowdown that resulted in a slowdown for the helicopter industry. During this time the oil and gas industry merged, consolidated, and formed alliances. Also, instead of running their own fleets, oil and gas companies are increasingly subcontracting all helicopter support to independent contractors. This trend is occurring largely because of oil-industry consolidation (Persinos, 1999). Also during this downturn, PHI's core business changed profoundly. In 1990, about 84 percent of PHI's core business came from the GOM oil and gas industry; now it is 76 percent. The company has increased its aeromedical market services.

The offshore helicopter business improved during 2000; this increase is attributed to increasing deepwater activity. Deepwater drilling, which is farther offshore, is the growth area for helicopters. At present, about 35 percent of PHI's business is in support of deepwater oil and gas activities. Era, the first of the three major helicopter companies to provide helicopter support of deepwater operations, has 50-60 percent of the deepwater market. Most of Era's work is in support of deepwater activities; they only have twin-engine helicopters rather than the single-engine helicopters that generally operate in shallower waters. To meet the demands of deepwater (travel further and faster, carry more personnel, all-weather capabilities, and the need for lower operating costs), the offshore helicopter industry is purchasing new helicopters. For example, Air Logistics recently purchased 38 helicopters: 10 new ones, 16 from Horizon, and Mobil's 12 helicopters. In 2001, Air Logistics enlarged its fleets at Venice, Louisiana. The helicopters operating in the GOM have travel ranges up to 450 nmi, can attain speeds over 200 mph, carry up to 20 passengers, and may cost $10 million or more.

While some heliports located farther inland have closed or consolidated, some heliports are expanding or opening due to more of the industry's work being farther offshore. Air Logistics has leased 90 additional acres at their heliport in Fourchon, Louisiana. Further, Air Logistics just completed a new heliport in Cameron (Creole), Louisiana, because of offshore activity. This is Air Logistics first new heliport in the last 20 years. Era Aviation is also expanding their facilities at Fourchon and Venice. The heliport in Fourchon will hold 1,500 cars and 15 helicopters, while the facility in Venice will increase three-fold.

Transportation is one of the offshore oil and gas industry's top three costs. Adding to this cost is the 30 percent rate increases levied by the three majors in the past year. While exploration and production companies like helicopters, the industry is outsourcing more and more operations to oilfield support companies, such as Baker Hughes, who are much more cost conscious and skeptical about the high cost of helicopters. Surface transportation, though, is not as feasible in deepwater. Another consideration for the helicopter industry is new technology such as subsea systems. As discussed in **Chapter 4.1.1.3.3.1.**, Types of Production Structures, a subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through a pipeline and manifold system. These systems decrease the number of platforms and personnel needed offshore, therefore reducing the amount of transportation needed.

Seventy-five percent of the helicopter pilots in the GOM are members of the Office Professional Employees International Union (OPEIU). While pilots at PHI and Air Logistics have voted for the union, Era's pilots have not. Since unionization, pilots' salaries have increased. At the same time, however, the industry has experienced a pilot shortage that has also contributed to the larger salaries. Most helicopters need at least two pilots per helicopter. A majority of the pilots in the 50-60 age group, mostly Vietnam War pilots, are retiring. In addition, because of the decreasing size of the military, fewer pilots are available from the military pool. Furthermore, the offshore helicopter industry has trouble getting pilots and keeping them because of the shadow effect. People are leery of the oil and gas industry because of past layoffs. In response to this last problem, Air Logistics started a 'grow your own program' in which they are training pilots themselves.

3.3.5.8.4. Construction Facilities

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

Platform Fabrication Yards

Platforms are fabricated onshore then towed to an offshore location for installation. Facilities where platforms are fabricated and serviced are called platform-fabrication yards. There are 43 platform fabrication yards located in the analysis area. **Table 3-37** shows the distribution of platform fabrication yards by coastal subarea. Most of the yards are located in Louisiana (31). Major fabrication yards in the analysis area include Atlantic Marine, Friede Goldman, Gulf Island Fabricators, J. Ray McDermott, and Unifab International. The structure of the platform fabrication industry is currently undergoing a period of restructuring characterized by the transformation from privately to publicly held companies on the one hand to the consolidation of the industry through mergers and acquisitions.

A platform consists of two major components: an underwater part (jackets and towers in shallow water and hulls in deepwater such as the proposed lease sale area) and an above water part (the deck and its modules). The deck and modules are fabricated separately, and possibly at different fabrication yards, from the underwater components. The deck provides the necessary surface to place the different modules (crew quarters, control building, storage facilities, etc.). Once completed, the deck and its modules are loaded onto derrick barges and transported to the site of the platform. Derricks lift the deck and attach it to the already installed underwater component. The modules are then installed on top of the deck.

The location of platform fabrication yards is tied to the availability of a navigable channel sufficiently large to allow for towing of bulky and long structures such as offshore drilling and production platforms. Thus, platform fabrication yards are located either directly on the coast of the GOM or inland, along large navigable channels, such as the Intracoastal Waterway. Average bulkhead depth for water access for fabrication yards in the GOM is 15-20 ft. Most fabrication yards in the analysis area are located along the Intracoastal Waterway and within easy access to the GOM. At least 12 of these plants have deep channel access to their facilities, which allows them to easily handle deeper draft vessels required in deepwater. Several fabricators in the analysis area, though, have lost contracts to foreign competition for large, deepwater platforms due to the lack of water depth.

For the most part, each yard has a specialty, whether it is the fabrication of separator or heater/treater skids, the construction of living quarters, the provision for hookup services, or the fabrication of jackets, decks and topside modules. Few facilities have complete capabilities for all facets of offshore projects. Despite the longer-term outlook most producers take toward offshore exploration and production, activity is still closely tied to the price of oil and gas. As prices drop, supporting industries such as fabrication become less busy, often resulting in layoffs that tend to drive experienced workers to other industries.

Due to the size of the fabricated product and the need to store a large quantity of materials such as metal pipes and beams, fabrication yards typically occupy large areas, ranging from a just few acres to several hundred acres. Typical fabrication yard equipment includes lifts and cranes, various types of welding equipment, rolling mills, and sandblasting machinery. Besides large open spaces required for jacket assembly, fabrication yards also have covered warehouses and shops. Because the construction of platforms is not likely to be standardized, an assembly-line approach is unlikely and most fabrication yards work on projects one at a time. Once a platform is completed, it is towed to its offshore location; work then begins on a new platform. The number of employees between fabrication yards varies from less than a hundred to several thousands, and due to the project-oriented type of work, temporary workers account for a significant portion of the workforce.

As mentioned, platform fabrication is not a mass production industry; every platform is custom built to meet the requirements of a specific project. This feature has given rise to a great degree of specialization in platform fabrication. No two fabrication yards are identical; most yards specialize in the fabrication of a particular type of platform or platform component. Examples of specialization include construction of living quarters, provision of hook-up services, and fabrication of jackets and decks. According to a published survey of fabrication yards in the GOM, 23 yards fabricate jackets, 15 fabricate decks, 29 fabricate modules, 22 fabricate living quarters, and 20 fabricate control buildings. Despite the specialization of these yards, most facilities do include the following:

- steel stockyards and cutting shops that supply and shape steel;
- assembly shops that put together a variety of components such as deck sections, modules, and tanks;
- paint and sandblasting shops;

- drydocks that work on small vessels;
- piers that work on transportation equipment and the platform components that are mobile and can be transported onto barges; and
- pipe and welding shops.

Despite the large number of platform fabrication facilities in the analysis area, only a few facilities can handle large-scale fabrication. Nine yards have single-piece fabrication capacity over 100,000 tons and 12 have capacity to fabricate structures for water depths over 1,000 ft. Only a few yards fabricate structures other than fixed platforms: one fabricates compliant towers (J. Ray McDermott, Inc. in Amelia, Louisiana) and two fabricate tension-leg platforms (Gulf Island Fabrication Inc. in Houma, Louisiana, and Friede Goldman Offshore in Pascagoula, Mississippi). Another important characteristic of the industry is the high degree of interdependency and cooperation among the fabrication yards. Offshore platforms, particularly the ones destined for deep water, are such complex engineering projects that most facilities do not have the technical capabilities to complete the entire projects "in-house."

Over the history of its existence, the platform fabrication industry has been closely tied to the fortunes of the oil and gas industry. Drilling and production activities are sensitive to the changing prices for oil and gas. This sensitivity, in turn, is translated into "boom and bust" cycles for the fabrication industry, where a period of no work follows a period of more fabrication orders than a yard can complete. In order to shield themselves from the volatility inherent in the oil and gas industry, platform fabrication yards in the analysis area have started to implement various diversification strategies. These diversification strategies, coupled with the new challenges brought about by deepwater oil and gas exploration and development, are significantly changing the industry.

In order to use the existing equipment and to retain their highly-skilled workforce during periods of low or no fabrication orders, many fabrication yards are expanding their operations into areas such as maintenance and renovations of drilling rigs, fabrication of barges and other marine vessels, dry-docking, and surveying of equipment. These projects, although much smaller in scale and scope than platform fabrication, allow the yards to survive during low periods. Another avenue of diversification is pursuit of international platform fabrication. For example, McDermott does fabrication for offshore waters in the Far East and Middle East. Fabrication yards in the analysis area have the advantages of vast experience in fabrication work and good climatic conditions that allow for year-round operations. Fabrication companies have also developed new offshore management software and company specific systems for managing and monitoring offshore sites onshore. New and improved platforms or platform upgrades and revamps complement many of these systems and software.

The platform fabrication industry has experienced a lack of skilled workers at the beginning of an upswing in the business cycle; during the downswing, the skilled labor migrates to other jobs. Having learned from past mistakes, some fabrication companies have organized technical training programs in the local communities. A locally trained workforce provides a readily available pool of skilled labor for the fabrication yards. Other companies have found a solution to the workforce problem through the acquisition of several individual fabrication yards located within the commuting area. This allows companies to dispatch their personnel to several yards to accommodate the existing need at any given time.

Pipecoating Plants and Yards

Pipecoating plants generally do not manufacture or supply pipe. They receive the manufactured pipe by rail or water at either their plant or pipe yard depending on their inventory capabilities. At the plant, pipe surfaces are coated with metallic, inorganic, and organic materials to protect from corrosion and abrasion. This process also adds weight to counteract buoyancy. Sometimes the inside of the pipe is also coated for corrosion control. Two to four sections of pipe are then welded at the plant into 40-ft segments. The coated pipe is stored (stacked) at the pipe yard until it is needed offshore. It is then placed on barges or layships where the pipeline contractor welds the 40-ft sections together, and cleans and coats the newly welded joints. Finally, the pipe is laid. **Chapter 4.1.1.8.1.**, Pipelines, provideds more detail on this activity.

There are currently 19 pipecoating plants in the analysis area (**Table 3-37**). Twelve of the 19 plants are located in coastal Subareas TX-2 and LA-2. There are two pipecoating plants in the Mississippi-Alabama area, two in the Florida Panhandle area, and one near Tampa, Florida. To meet deepwater demand, pipecoating companies have been expanding capacity or building new plants. Major pipecoating companies in the analysis area are Bayou, Bredaro Price, eb, and Womble. Many pipecoating plants also handle pipe for non-OCS companies, other countries, and non-petroleum-related industries.

The pipecoating industry is labor intensive. The coatings are mostly applied by hand. The companies try to maintain a core base of laborers, then either scale up or down with temporary labor according to workload. Due to the cyclical nature of the business, maintaining labor is a problem for the industry. In addition, pipecoating companies compete with other infrastructure industries for welders. In order to reduce this problem, several companies have started welding training programs. For example, Bredaro Price has brought international labor to their Mobile plant in an effort to bring in experience and knowledge. They were also able to hire labor from a local paper mill that closed. Safety is a big part of the pipecoating business. Bredaro Price recently added money to their Mobile plant to automate rolling pipe. This has decreased the amount of labor needed, increased the amount of skilled labor needed, and decreased the number of accidents at the plant.

Some pipecoating plants are affiliated with a mill. These are American mills that manufacture high-grade pipe with light walls that can be used in shallow water. Foreign mills, mostly in Europe and Japan, manufacture heavy-walled pipe needed for deepwater pressure. U.S. Steel in Youngstown, Ohio, currently has the capability to manufacture the thick pipe necessary for deepwater, but it lacks the processing needed to heat-treat the pipe. Pipecoating customers are both exploration and production operators (direct) and pipelaying contractors (subcontracting). A new trend in deep water (such as the proposed lease sale area) is single-source contracts where the pipe manufacturing, coating, welding, and laying are all under one contract. This results in a more efficient, less costly operation. At present, only foreign companies have this capability.

Shipyards

The 1980's were dismal times for the shipbuilding industry. This was brought about by a combination of factors that included lack of a comprehensive and enforced U.S. maritime policy, failure to continue funding subsidies established by the Merchant Marine Act of 1936, and the collapse of the U.S. offshore oil industry, which not only hurt the shipbuilding industry but all support industries such as small shipyards and repair yards. Approximately 120,000 jobs for shipyard workers and shipyard suppliers were lost.

At present, there are about 106 shipyards in the United States with the capability of repairing oceangoing ships greater that 400 ft in length. Only 19 are capable of building large oceangoing vessels, while the rest deal mainly in repairs. This is a decrease of approximately 40 percent from what was available at the start of the 1980's. Several mergers, acquisitions, and closings occurred during the downturn. In addition to the major shipyards, there are about 2,600 other companies that build or repair other craft such as tugboats, supply boats, ferries, fishing vessels, barges, and pleasure boats. Within the analysis area, there are 94 shipyards (**Table 3-37**). Major shipyards in the analysis area include Bollinger Shipyards; Harrison Brothers Dry Dock & Repair Yard, Inc.; First Wave/Newpark Shipyards; Edison Chouest Offshore: North American Shipbuilding in Larose, Louisiana (an ECO affiliate); North American Fabricators in Houma, Louisiana (an ECO affiliate); and Litton Ship Systems: Avondale\The Shipyards Division and Ingalls Shipyard.

The American Shipbuilding Association is the professional organization for those in the industry who are capable of constructing mega vessels that are in excess of 400 ft in length and weigh in excess of 20,000 dead weight tonnage (dwt). For this reason, their membership consists of only six companies. Of those six, two have a presence in the GOM. Both Avondale Shipyard of New Orleans, Louisiana, and Ingalls Shipyard of Pascagoula, Mississippi, have enormous capabilities and expertise in the design, construction, and repair of vessels. This highly developed level of specialized knowledge has made these two companies ideal contractors for the nation's defense efforts. Therefore, most of the work that has been accomplished in these two yards has been for the U.S. military.

The existence of enormous commercial needs has led to the development of a very large number of boat and barge builders. These companies have directed their efforts toward the requirements of specific industries such as the offshore oil and gas industry, which is undergoing a recovery from the marked decline of the 1980's. The vessels they produce are not as large as those being built by Avondale and Ingalls. However, as the oil and gas industry has evolved and become more sophisticated, particularly with deepwater drilling, so too has the capability of this segment of the boat-building industry. The need for supply and other types of industry support vessels has increased. With changing technology has come the need for more sophisticated and higher capacity vessels. Many of these companies are now producing ships in the 300-ft range. As discussed in **Chapter 3.3.5.2.**, How OCS Development Has Affected the Analysis Area, service-vessel operators ordered over 100 vessels during the last newbuild cycle. Over a dozen shipyards participated, with Halter Marine (now part of Friede Glodman) being the most active. Other shipyards participating included (in decreasing order): Ingalls, North American, Leevac, Bender, Atlantic Marine, Service Marine, Eastern, Conrad, Houma Fabrication, Bollinger, Seafab, Steiner, and McDermott. Five of the six most active shipyards are still in the commercial business and all are actively pursuing further supply-vessel opportunities. Ingalls has narrowed its focus to government work and is no longer building commercial vessels.

Several pertinent issues have affected and will continue to affect shipbuilding in the U.S. and particularly in the analysis area—maritime policy, declining military budget, foreign subsidies, USCG regulations, OPA 90, financing, and an aging fleet. These issues are discussed below.

Since the 1980's, military spending for new ship construction has declined. During the Reagan administration, a 600-vessel fleet was envisioned. During the Bush tenure that figure dropped to 420 vessels. The current vessel fleet is less than 350 ships. Despite the downsizing, there will continue to be military associated work. Downsizing itself will provide deactivation work for many shipyards. There should be an increase in overhauls, repairs, and service life extensions. In addition, the Navy has affirmed a need for Sealift capabilities. Some vessels will be converted for this usage.

Most foreign nations subsidize their shipbuilding industries. Methods to accomplish this include construction subsidies, investment subsidies, research and development subsidies, preferential tax policies, officially financed export credits, reduced financing rates, loans, and loan guarantees. The type and amount of government support varies from country to country. At present, the U.S. does not have a subsidy or incentive program available for a foreign or domestic owner to build a large vessel in this country.

All U.S.-built vessels must comply with USCG rules and regulations. This automatically increases the cost of the vessel by 10-12 percent over the cost of a vessel built outside of the U.S. for international trade. In addition, OPA 90 requires that all new tank vessels trading in U.S. waters be equipped with double hulls and that existing tankers without double hulls be retrofitted or removed from oil production transportation. A phase-out schedule was established to implement the requirements of this legislation. Passage of OPA 90 resulted in some new construction of double-hulled tank vessels. This helped to bring about a slight upturn in the industry.

Lastly, it is difficult to obtain financing to build large ships in the U.S. Rules and regulations of the Export-Import Bank are complex and difficult to interpret. The aging fleet, together with increasing environmental concerns, will provide an opportunity for additional construction and repair activities. The Jones Act requires that vessels that transport cargo between ports or points in the U.S. be constructed in the United States.

3.3.5.8.5. Processing Facilities

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

Refineries

Petroleum is a mixture of liquid hydrocarbons usually formed beneath the earth's surface. Found in both gaseous and liquid form, the exact composition of these hydrocarbons varies according to locality. Because it is of little use in its raw state, further processing of crude oil is necessary to unlock the full potential of this resource.

A refinery is an organized arrangement of manufacturing units designed to produce physical and chemical changes to turn crude oil into petroleum products. Refineries vary in size, sophistication, and cost depending on their location, the types of crude they refine, and the products they manufacture.

Because crude oil is not homogeneous (varying in color, viscosity, sulfur content, and mineral content), oil produced from different fields or geographic areas have different quality characteristics that give rise to different economic values.

In the refinery, most of the nonhydrocarbon substances are removed from crude oil, and the oil is broken down into its various components and blended into useful products. Every refinery begins with the separation of crude oil into different fractions by distillation. The fractions are further treated to convert them into mixtures of more useful saleable products by various methods such as cracking, reforming, alkylation, polymerisation, and isomerisation. These mixtures of new compounds are then separated using methods such as fractionation and solvent extraction.

Because there are various blends of different crude oils available, different configurations of refining units are used to produce a given set of products. A change in the availability of a certain type of crude oil can affect a refinery's ability to produce a particular product. For example, one important crude quality is gravity. Stated in API degrees (API^{o}), gravity is a measure of the density of the crude oil and can affect the complexity of a refinery. The higher the gravity, the lighter the crude; conversely, the lower the gravity, the heavier the crude. A second quality measure is sulfur content. Sulfur content is usually measured in terms of the percentage of the crude's weight that is comprised by sulfur. Low-sulfur or "sweet" crudes typically have less than 0.5 percent sulfur content. Crude oil considered high sulfur or "sour" typically has over 0.5 percent sulfur content.

These two qualities are important in refining. Heavy crudes require more sophisticated processes to produce lighter, more valuable products; therefore, they are expensive to manufacture. Because of its corrosive qualities, higher sulfur content makes a crude more expensive to handle and process. In general, light crudes are more valuable, i.e., they yield more of the lighter, higher-priced products than heavy crudes. The product slate at a given refinery is determined by a combination of demand, inputs and process units available, and the fact that some products are the result (co-products) of producing other products.

In the early 1970's, the Federal Government set price controls that gave an economic advantage to refineries that had access to low-cost domestic oil. In 1975, the "Crude Oil Entitlements Program" was implemented to distribute oil supplies among refiners. This program basically provided a subsidy to small refining companies, many of which had simple "topping" facilities and little or no downstream processing capability. (A simple "topping" refinery will have a distillation tower and possibly a reformer and some sulfur treating capability, while complex refineries will have more extensive downstream facilities.) A refiner who had access to light crude oils needed only a distillation tower to produce motor gasoline. Therefore, many simple refineries sprang up across the country, most notably in the analysis area.

In the early 1980's, the Crude Oil Entitlements Program ended and crude oil prices were no longer controlled. This caused the number of petroleum refineries to drop sharply, leading to 13 years of decline in U.S. refining capacity. Between 1981 and 1989, the reduction in the number of refineries from 324 to 204 represented a loss of 3 million barrels (MMbbl) per day in operable capacity. Another 41 refineries (mainly small) shut down between 1990 and 1997. Since the 1980's, the refining industry's focus has turned from increasing crude oil distillation capacity to investment in downstream charge capacity, thereby increasing overall refinery complexity. This transition began several years before the passage of the Clean Air Act Amendments in 1990 as a result of increased demand for lighter, cleaner products that have to be produced from increasingly heavier and more-sour crude oils.

The decade of the 1990's was characterized by low product margins and low profitability. Stiff environmental mandates stemming from 1990 amendments to the Clean Air Act (**Chapter 3.1.1.**, Air Quality) heaped capital costs on the industry at a time of relatively flat product demand. By implementing massive capital spending programs, refiners met and surpassed plant emission goals while retooling to produce a new generation of cleaner burning fuels. Low profitability was also partially due to the narrowing of the spread between petroleum product prices and raw material input costs. Additionally, persistently low profits prompted domestic refiners and marketers to make concerted efforts to realize greater value from their fixed assets and to reduce their operating costs. Refining operations were consolidated, the capacity of existing facilities was expanded, and several refineries were closed.

The analysis area hosts over one-third of the petroleum refineries in the U.S. Most of the region's refineries are located in Texas and Louisiana (**Table 3-37**). Texas has 19 refineries, with a combined crude oil operating capacity of 3.9 MMbbl/day, while Louisiana has 14 refineries with 2.7 MMbbl/day of operating capacity, representing 55.04 and 38.49 percent, respectively, of total U.S. refining capacity. Most refineries are part of major, vertically integrated oil companies that are engaged in both upstream and downstream aspects of the petroleum industry. These companies dominated the refining industry, although most majors are spinning off their refinery facilities to independents or entering joint ventures to decrease the risk associated with low refining returns. The top 10 U.S. refiners, all of them major, integrated oil companies, account for about 60 percent of the total domestic refinery operating capacity.

By consolidating operations and sharing assets and operations, downstream petroleum companies hope to be able to increase the value of their fixed assets and reduce their costs. The largest of the recent joint ventures affecting U.S. refining and marketing was announced in late 1996 but was not completed until early 1998. That venture merged Texaco, Star Enterprise (a joint venture between Texaco and Aramco, the Saudi Arabian state oil company), and Shell Oil (the U.S. subsidiary of Royal Dutch/Shell). The joint venture resulted in the creation of two companies, Equilon Enterprises L.L.C. and Motiva Enterprises L.L.C. (in January and May 1998, respectively). Equilon consists of the companies' western and midwestern U.S. operations as well as their nationwide trading, transportation, and lubricants businesses. Motiva consists of the companies' eastern and Gulf Coast operations (with the exception of Shell's Deer Park, Texas, refinery, which is operated as a joint venture between Shell Oil and the state oil company of Mexico, Petroleos Mexicanos (PEMEX)).

Significant mergers have also occurred between independent refiners and marketers. However, unlike the major U.S. petroleum companies, which are consolidating their refining and marketing operations through joint ventures, the independent refiners and marketers are expanding their operations through mergers and, at least in one case, joint ventures. For example, in 1997 Ultramar Diamond Shamrock (itself created by a late 1996 merger) acquired Total Petroleum North America, gaining three refineries, more than 2,100 marketing outlets, and hundreds of miles of pipelines, in addition to other associated assets.

Petrochemical Plants

The chemical industry converts raw materials such as oil, natural gas, air, water, metals, and minerals into more than 70,000 different products. The non-fuel components derived from crude oil and natural gas are known as petrochemicals. Petroleum is composed mostly of hydrogen and carbon compounds (called hydrocarbons). It also contains nitrogen and sulfur, and all four of these components are valuable in the manufacture of chemicals.

The industrial organic chemical sector includes thousands of chemicals and hundreds of processes. In general, a set of building blocks (feedstocks) is combined in a series of reaction steps to produce both intermediate and end products. The processes of importance in petrochemical manufacturing are distillation, solvent extraction, crystallization, absorption, adsorption, cracking, reforming, alkylation, isomerization, and polymerization.

The boundaries of the petrochemical industry are rather unclear. On the upstream end, they blend into the petroleum refining sector, which furnishes a major share of petrochemical feedstocks; downstream it is often impossible to draw a clear line between petrochemical manufacturing and other organic chemistry-based industries such as plastics, synthetic fibers, agricultural chemicals, paints and resins, and pharmaceuticals. Operating in this field are petroleum companies who have broadened their interests into chemicals, chemical companies who buy raw petroleum materials, and joint ventures between chemical and petroleum companies.

Texas, New Jersey, Louisiana, North Carolina, and Illinois are the top U.S. chemical producers. However, most of the basic chemical production is concentrated in the analysis area, where petroleum and natural gas feedstocks are available from refineries. About 70 percent of all primary petrochemicals are produced in Texas and Louisiana. At present, there are 29 petrochemical plants in the analysis area, all of which are in Texas or Louisiana. The distribution of these plants by subarea is shown in **Table 3-37**.

Chemical manufacturing facility sites are typically chosen for their access to raw materials and to transportation routes. In addition, because the chemical industry is its own best customer, facilities tend to cluster near such end-users. A small number of very large facilities account for the majority of the industry's value of shipments. The 16 largest plants (greater than 1,000 employees) manufacture about 25 percent of the total value of shipments.

Laid out like industrial parks, most petrochemical complexes include plants that manufacture any combination of primary, intermediate, and end-use products. Changes in market conditions and technologies are reflected over time in the changing product slates of petrochemical complexes. In general, petrochemical plants are designed to attain the cheapest manufacturing costs and thus are highly synergistic. Product slates and system designs are carefully coordinated to optimize the use of chemicals by products and to use heat and power efficiently.

The transformation of raw materials into chemical products requires chemical, physical, and biological separation and synthesis processes. These processes use large amounts of energy for heating, cooling, or electrical power. The industry is the single largest consumer of natural gas (over 10% of the domestic total) and uses virtually all the liquefied petroleum gas (LPG) consumed in U.S. manufacturing. Other energy sources include by-products produced onsite, hot water, and purchased steam. Physical and biological separation plays a critical role in processing and accounts for 40-70 percent of both capital and operating costs. The most widely used separation process is distillation, which accounts for as much as 40 percent of the industry's energy use. Chemical synthesis is the backbone of the industry; process heat is integral and supports nearly all chemical operations.

Gas Processing Plants

After raw gas is brought to the earth's surface, it is processed at a gas processing plant to remove impurities such as water, carbon dioxide, sulfur, and inert gases, and it is transformed into a sellable, useful energy source. It is then moved into a pipeline system for transportation to an area where it is sold. Because natural gas reserves are not evenly spaced across the continent, an efficient, reliable gas transportation system is essential. At present, there are 35 gas processing plants in the analysis area that process OCS-produced gas; 28 of these are in Louisiana. The distribution of these plants by coastal subarea is shown in **Table 3-37**. Major operators include BP, Exxon, Dynergy, Duke Energy, and El Paso.

Natural gas is found below the earth's surface in three principal forms. Associated gas is found in crude oil reservoirs, either dissolved in the crude oil, or combined with crude oil deposits. This gas is produced from oil wells along with the crude and is separated from the oil at the head of the well. Non-associated gas is found in reservoirs separate from crude oil; its production is not a result of the production of crude oil. It is commonly called "gas-well gas" or "dry gas." Today about 75 percent of all U.S. natural gas produced is nonassociated gas. Gas condensate is a hydrocarbon that is neither true gas nor true liquid. It is not a gas because of its high density, and it is not a liquid because no surface boundary exists between gas and liquid. Gas condensate reservoirs are usually deeper and have higher pressures, which pose special problems in the production, processing, and recycling of the gas for maintenance of reservoir pressure.

The quality and quantity of components in natural gas vary widely by the field, reservoir or location from which the natural gas is produced. Although there is not a "typical" makeup of natural gas, it is primarily composed of methane (the lightest hydrocarbon component) and ethane. In general, there are four types of natural gas: wet, dry, sweet, and sour. Wet gas contains some of the heavier hydrocarbon molecules and water vapor. When the gas reaches the earth's surface, a certain amount of liquid is formed. A wet gas may contain five or more gallons of recoverable hydrocarbons per thousand cubic feet; the water has no value. If the gas does not contain enough of the heavier hydrocarbon molecules to form a liquid at the surface, it is a dry gas. Sweet gas has very low concentrations of sulfur compounds, while sour gas contains excessive amounts of sulfur and an offensive odor. Sour gas can be harmful to breathe or even fatal.

Centrally located to serve different fields, natural-gas processing plants have two main purposes: (1) remove essentially all impurities from the gas; and (2) separate the gas into its useful components for eventual distribution to consumers. The modern gas-processing industry uses a variety of sophisticated processes to treat natural gas and extract natural-gas liquids from the gas stream. The two most important extraction processes are the absorption and cryogenic expander process. Together, these processes account for an estimated 90 percent of total natural-gas liquids (NGL) production.

The total number of natural-gas processing plants operating throughout the U.S. has been declining over the past several years as companies have merged, exchanged assets, and closed older, less efficient plants. This trend was reversed in 1999; Louisiana's capacity is undergoing significant increases as a wave of new plants and expansions try to anticipate the increased volumes of natural gas coming ashore from new gas developments in the GOM. New plants were also built in Mobile, Alabama, and Pascagoula, Mississippi. There are approximately 581 operating gas-processing plants in the U.S., most of which are located in eight states: California, Colorado, Louisiana, Michigan, New Mexico, Oklahoma, Texas, and Wyoming. Louisiana continues to lead other U.S. States in the number of gas-processing plants, followed closely by Texas. Between them, the two states hold more than 52 percent of the nation's gas-processing capacity. In 1999, the two states produced more than half of the NGL produced in the U.S. Texas produced nearly 43.5 percent (up from 41% in 1998) while Louisiana produced over 17.8 percent (up from 15% in 1998).

3.3.5.8.6. Pipeline Shore Facilities

The term "pipeline shore facility" is a broad term describing the onshore location where the first stage of processing occurs for OCS pipelines carrying different combinations of oil, condensate, gas, and produced water. These facilities may also be referred to as a separation or field facilities. Pipelines carrying only dry gas do not require pipeline shore facilities; the dry gas is piped directly to a gas processing plant (**Chapter 3.3.5.8.5.**, Processing Facilities). Although in some cases some processing occurs offshore at the platform, only onshore facilities are addressed in this section.

Pipeline shore facilities may separate, process, pump, meter, and store oil, water, and gas depending on the quality of the resource carried by the pipeline. After processing and metering, the liquids are either piped or barged to refineries or storage facilities. The gas is piped to a gas processing plant for further refinement, if necessary; otherwise, it is transported via transmission lines for distribution to commercial consumers. Water that has been separated out is usually disposed into on-site injection wells.

A pipeline shore facility may support one or several pipelines. Typical facilities occupy 2-25 ha. The distribution of existing pipeline shore facilities associated with the OCS Program is given in the table below.

Existing Pipeline Shore Facilities for the OCS Program (2003-2042) by Coastal Subarea

TX-1	TX-2	LA-1	LA-2	LA-3	MA-1	FL-1	Total
6	7	18	10	9	0	0	50

3.3.5.8.7. Disposal and Storage Facilities for Offshore Operations

Unless otherwise stated, the following information is from the 2001 MMS study "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

At present, OCS operators have four RCRA-exempt, waste disposal alternatives:

(1) offshore on-site discharge into the sea disposal;

(2) offshore subsea bed disposal;

(3) onshore surface land disposal

  (a) landfarming and

  (b) landfill; and

(4) onshore subsurface land disposal

  (a) porous rock formation injection — includes depleted producing wells, and

  (b) salt cavern injection.

Most OCS waste is disposed offshore. A very small amount of OCS waste is disposed onshore at landfarms and landfills. In general, offshore waste that is disposed onshore is disposed using subsurface techniques. Waste that is not disposed of offshore is transferred to supply boats by OCS operators and then shipped to a waste receiving service base. Approximately 50 percent goes to Port Fourchon, Louisiana. At the service base, waste operators transfer the offshore waste to barges and then ship it to

Port Arthur, Texas, via the GIWW. At Port Arthur, the waste operators transfer the waste to tank trucks and haul it the 20 mi to the waste disposal facilities in Jefferson County, Texas. Approximately 99-100 percent of the time the OCS operator pays the cost to transfer the waste to the service base (via supply boat — usually a back haul). The waste operator pays the cost to transfer the waste from the service base to Port Arthur (via barge) and from Port Arthur to the waste facilities (via tank truck). Different disposal fees are charged for different types of waste (average price of $12 per barrel at the service base port). Transportation cost (average of $5-6 per barrel) is approximately 50 percent of the waste companies' total operating cost. Profit margins average 15-20 percent. In addition, landowners where the waste facilities are located receive a per barrel royalty from the waste facility operator. The amount of this fee is generally negotiated and depends on each negotiator's bargaining power.

The infrastructure network needed to manage the spectrum of waste generated by OCS exploration and production activities and returned to land for management can be divided into three categories:

(1) transfer facilities at ports, where the waste is transferred from supply boats to another transportation mode, either barge or truck, toward a final point of disposition;

(2) special-purpose, oil-field waste management facilities, which are dedicated to handling particular types of oil-field waste; and

(3) generic waste management facilities, which receive waste from a broad spectrum of American industry, of which waste generated in the oil field is only a small part.

The first two categories lend themselves to a capacity analysis while the third does not. **Table 3-37** shows the waste disposal facilities in the analysis area by subarea.

The capacity of a waste facility has two dimensions. The first is the throughput capacity over a given period of time. In the short term, a waste facility can face limits to the volume of waste it accepts either from permit conditions or from physical limitations to the site, such as unloading bays, traffic conditions, or equipment capacity. Life-of-site capacity is also a limiting factor for disposal facilities. Limitations of storage space or, in the case of an injection well, service life of the well make it necessary to consider what must happen after existing facilities have exhausted their capacity.

A number of different types of waste are generated as a result of offshore exploration and production activity. The different physical and chemical character of these wastes make certain management methods preferable over others. The types of waste include:

- solids, such as drill cuttings, pipe scale, produced sand, and other solid sediments encountered during drilling, completion, and production phases;
- aqueous fluids having relatively little solids content, such as produced waters, waters separated from a drilling mud system, clear brine completion fluids, acids used in stimulation activities, and wash waters from drilling and production operations. (Although most of these are potentially dischargeable under the NPDES general permit, the possibility always exists that some amount of material will become contaminated beyond the limits of treatment capabilities and will require disposal in a land-based facility. A minute percentage of the total volume consists of chemicals (such as zinc bromide), which do not meet discharge criteria.);
- drilling muds (oil-based, synthetic, or water-based);
- naturally occurring radioactive materials (NORM), such as tank bottoms, pipe scale, and other sediments that contain naturally high levels of radioactive materials. (NORM occurs in sludge and as scale on used steel vessels and piping when equipment has been exposed to other NORM materials after very long periods of use.);
- industrial hazardous wastes, such as solvents and certain compounds, with chemical characteristics that render them hazardous under Subtitle C of RCRA and thus not subject to the exemption applicable to wastes generated in the drilling, production, and exploration phases of oil and gas activities;

- nonhazardous industrial oily waste streams generated by machinery operations and maintenance, such as used compressor oils, diesel fuel, and lubricating oils, as well as pipeline testing and pigging fluids. (Wastes from marine transportation as well as pipeline construction and operations are always classified as industrial wastes, while some operators and State regulators may choose to handle or classify waste from drilling and production machinery this way. Used oil generated by exploration and production operations may legally be mixed with produced oil, but refineries discourage the practice. These streams often become commingled with wash water. They may be handled in drums or in bulk as part of a larger waste stream.); and
- municipal solid waste generated by the industry's personnel on offshore rigs, platforms, tankers, and workboats.

Federal regulations govern what may be discharged in GOM waters and set different standards in different parts of the Gulf Coast. Transportation, packaging, and unloading of the waste at ports are governed by DOT regulations while the USCG regulates vessel fitness. Once on the dock, transportation and packaging is subject to an overlay of DOT and State laws. State regulations governing reporting and manifesting requirements may vary somewhat, but Federal law has, for the most part, preempted the field of transportation waste regulation. Dockside facilities that serve as transfer points from water to land modes of transportation are regulated by both USCG and State regulations covering the management of oil-field wastes.

Once at a waste management facility, regulations regarding storage, processing, and disposal vary depending on the type of waste. Most would fall under the oil and gas waste exemption of RCRA Subtitle C and would be subject only to State regulations regarding the disposal of oil-field wastes. A minute volume of the waste would be subject to Federal regulation as hazardous waste under RCRA Subtitle C. State laws governing hazardous wastes are allowed to be more restrictive than Federal law, but no material differences exist between State and Federal law in Texas, Louisiana, Mississippi, or Alabama. For the most part, the wastes generated by oil-field activities, called nonhazardous oilfield waste (NOW), are exempt from hazardous waste regulation by Federal law because they are produced from the exploration, development, or production of hydrocarbons and thus fall under what is generally referred to as the oil and gas waste exemption found in 40 CFR 261.

Waste fluids and solids containing NORM are subject to State regulations that require special handling and disposal techniques. There are currently no Federal regulations governing NORM. The special handling and disposal requirements for NORM generally result in the segregation of these materials from NOW and in substantially higher disposal costs when managed by commercial disposal firms.

Commercial disposal of NORM is available in Texas at two different sites. Alabama has not fully developed its NORM regulatory program, but waste within 5 picocuries (pCi) per gram (g) of background is considered acceptable for on-site disposal. The NORM waste generated in Mississippi, Alabama, and Florida is typically shipped to Louisiana or Texas.

Differences in laws among the states lead to differences in waste management methods as well as industry preferences in the siting of waste facilities in certain states. The substantive differences that distinguish the states are comparatively few. Texas allows and regulates salt dome disposal of waste, while no other state does. Louisiana, Alabama, and Mississippi allow the landfilling of used oil filters and oil-based drilling muds, while Texas requires them to be recycled. Texas generally has stricter limits on the hydrocarbon content of waste going into municipal landfills. Texas also has regulations allowing oil-based drilling mud to be recycled through bioremediation into road-building material. None of the other Gulf Coast States have enabled oil-field waste land application recycling operations in their regulatory framework.

The USEPA has established a hierarchy of waste management methods that it deems preferentially protective of the environment. For those technologies applicable to oil and gas production waste, the following general waste management techniques are described in order of USEPA's preference:

- Recycle/Reuse—When usable components such as oil or drilling mud can be recovered from a waste, these components are not discarded and do not burden the environment with impacts from either manufacturing or disposal.

- Treatment/Detoxification—When a waste cannot be recycled or reused, it can sometimes be treated to remove or detoxify a particular constituent prior to disposal. The neutralization of pH or the removal of sulfides are examples of technologies that are used with oil and gas wastes.
- Thermal Treatment/Incineration—Wastes with organic content can be burned, resulting in a relatively small amount of residual ash that is incorporated into a product or sent to disposal. This technology results in air emissions, but the residuals are generally free of organic constituents.
- Subsurface Land Disposal—This technology places waste below usable drinking water resources and is viewed as superior to land filling because of the low potential for waste migration. Injection wells and salt cavern disposal are examples of this type of technology.
- Surface Land Disposal/Treatment—This type of technology involves the placement of wastes into a landfill or onto a land farm. Although well-designed and constructed landfills minimize the potential for waste migration, generators remain concerned about migration of contaminants into water resources and avoid it whenever practical. The USEPA classifies surface land disposal as the least desirable disposal method.

Several waste management methods are used to handle the spectrum of wastes generated by OCS activity, and most types of wastes lend themselves to more than one method of management. Each option has a different set of environmental impacts, regulatory constraints, costs, and capacity limitations.

Subsurface injection is the management method used for more than 90 percent of the 16 billion barrels of saltwater produced by onshore oil and gas production each year in the U.S.

Nonhazardous Oil-field Waste Sites

The lion's share of OCS solids-laden waste streams is presently injected at one facility, Newpark Environmental Services near Fannett, Texas. It is the most important NOW facility for the offshore industry, having received some 5 million barrels of offshore waste in 1998, constituting about 75 percent of the total offshore NOW streams shipped ashore. This facility has a number of injection wells, not all of which are needed at any given time. Any number of other injection wells is available on the Gulf Coast, but few have Newpark's capability to handle solids-laden streams, and few have focused on the logistical requirements of the offshore market to the extent Newpark has. These factors account for the Newpark facility's very large share of the offshore market. Newpark appears to have some economies of scale that serve to offset the cost of a long barge trip back from transfer points such as Port Fourchon.

The Newpark facility near Winnie, Texas, has five wells completed into the caprock of a salt dome that is permitted to inject up to 17.5 million barrels per year of slurried solids. A separate Newpark facility near Big Hill, Texas, also in Jefferson County, has three injection wells dedicated to injecting NORM. It received 13,900 bbl of NORM solids in 1999 and 16,500 bbl in 1988. The NORM waste receipts are trending down because operators are careful to segregate NORM to minimize the volumes that must be disposed of at a comparatively high commercial price.

One commercial salt cavern, operated by Trinity Field Services, has recently opened near Hamshire, Texas, on the Trinity River. It presently receives waste only by truck, although management expects a barge mooring to be permitted within a year. If the company is successful in obtaining additional permits that would allow receipt by barge and in securing dock space in ports to serve as transfer points, then the company may present a significant source of new capacity—perhaps on the scale of Newpark's. Four other commercial salt domes are operational in northeastern and western Texas. One commercial salt dome, Lotus, L.L.C. in Andrews County near the New Mexico border, accepts NORM, some of which comes from offshore operations. Due to their distance from the Gulf Coast, no others receive any OCS waste. With the addition of Trinity Field Services bringing 6.2 million barrels of available space to the market, enough to take 8-10 years' worth of OCS liquids and sludges at current rates, the OCS has its first salt dome disposal operation in a competitive location.

Landfills

Workers on a rig or production platform generate the same types of waste as any other consumer in industrial society and are therefore responsible for their fair share of municipal solid waste (MSW). Landfarm facilities are available to accept offshore waste but actually accept very little because offshore operators prefer other methods. The MSW disposal from OCS activities currently imposes only a small incremental load on landfills in the analysis area, probably no more than 5 percent of total receipts by all the landfills serving south Louisiana.

3.3.5.8.8. Coastal Pipelines

This section discusses OCS pipelines in coastal waters (State offshore and inland waters) and coastal onshore areas. The OCS pipelines near shore and onshore may join pipelines carrying production from State waters or territories for transport to processing facilities or to distribution pipelines located farther inland. See **Chapter 3.3.5.9.2.** for a discussion of pipelines supporting State oil and gas production.

Nearly 400 OCS pipelines cross the Federal/State boundary into State waters from Texas to Alabama. There are nearly 1,700 km of OCS pipelines in State waters, with an average of 5 km per pipeline. Over half of the pipelines in State waters are directly the results of the OCS Program.

Where a pipeline crosses the shoreline is referred to as a pipeline landfall. Gulfwide, two-thirds of OCS pipelines entering State waters tie into existing pipeline systems and do not result in new pipeline landfalls. About 85 percent of OCS pipeline landfalls are in Louisiana. The oldest pipeline systems are also in Louisiana; some dates back to the 1950's. A small number of OCS gas pipelines make landfall in Mississippi and Alabama. There are no OCS pipeline landfalls in Florida.

The OCS pipelines making landfall have resulted in 700 km of pipelines onshore, with an average of 10 km per pipeline. A small percentage of onshore pipelines in the coastal subareas are directly the results of the OCS Program.

3.3.5.9. State Oil and Gas Activities

3.3.5.9.1. Leasing and Production

Louisiana

The Office of Mineral Resources holds regularly scheduled lease sales on the second Wednesday of every month. The March 2002 sale jumped dramatically over totals from the February 2002 sale. In February, there were 11 tracts nominated as compared to 215 tracts for March. The sale brought in $5.9 million and let 62 leases. Of that total, 11 State offshore leases were awarded for $1.3 million. There are 45 tracts nominated in April, 58 tracts in May, and 97 tracts in June 2002 (Louisiana Dept. of Natural Resources, 2002a).

The first oil production in commercial quantities occurred in 1901 and it marked the beginning of the industry in the State. The first over-water drilling in America occurred in 1910 in Caddo Lake near Shreveport. The State began its offshore history in 1947. The territorial waters of Louisiana extend Gulfward for 3 mi and its shoreline extends nearly 350 mi.

Louisiana is the nation's third leading producer of natural gas and the number four producer of crude oil in the country as of 2000. When including the oil and gas production in the GOM, Louisiana becomes the second leading natural gas producer in the country and the leader (number one) crude oil producer. Among the 50 states in 2000, Louisiana is second in refining capacity and second in primary petrochemical production. Louisiana's average active rotary rig count for 2000 (excluding OCS) was 87, while its OCS average was 17, the highest ever recorded (Louisiana Dept. of Natural Resources, 2001b).

As of January 1, 2001, there were 15 refineries in Louisiana with a combined operable atmospheric crude oil distillation capacity of 2,195,200 bbl per calendar day. This represents about 13 percent of the United States Refineries distillation capacity. The ExxonMobil Refining and Supply Company in Baton Rouge, Louisiana is the 2nd largest refinery in the United States in terms of distillation capacity (USDOE, Energy Information Administration (EIA), 2001e).

In 2000, Louisiana offshore production totaled 13.4 MMbbl of crude oil from about 561 offshore oil wells and 148.95 Tcf of natural gas from about 122 natural gas wells. In the same year (average through March 2000), 43,292 persons were employed in the oil and gas production industry, 28,479 persons in the chemical industry, 10,468 persons in the oil refining industry, and 728 persons in the oil pipeline industry (Louisiana Dept. of Natural Resources, 2000). In fiscal year 2000-2001, $309,200,305 of royalties and $434,274,993 in severance tax were collected by the State on all oil and natural gas production taking place on State-owned lands and water bottoms (Louisiana Dept. of Natural Resources, 2002b).

Mississippi

The State of Mississippi only has an onshore oil and gas leasing program. In 1994, the State of Mississippi passed legislation allowing companies to enjoy substantial tax breaks based on the types of discovery involved and the methods they use onshore. Those tax breaks range from a 5-year exemption from the State's 6-percent severance tax for new discoveries to a 50-percent reduction in the tax for using 3D technology to locate new oil and gas fields, or using enhanced recovery methods.

As a result of the incentive program, 84 new oil pools have received the exemption, 108 inactive wells have been brought back into production, 13 development wells have been drilled in existing fields, 34 enhanced wells have received exemption, and 14 have received exemptions for using 3D technology (Sheffield, 2000).

Mississippi's petroleum infrastructure includes four refineries and a moderately extensive network of crude oil, product, and liquefied petroleum gas pipelines. As of January 1, 2001, the four refineries combined had a 334,000 bbl per calendar day capacity. In terms of operable atmospheric crude oil distillation capacity, the Chevron refinery in Pascagoula is the 8th largest refinery in the Nation with 295,000 bbl per calendar day. Mississippi ranks 11th in the nation, including Federal offshore areas, in crude oil production, with 54,000 bbl per day. A major propane supply hub is located at Hattiesburg, Mississippi, where the Dixie Pipeline has a network of terminals and storage facilities.

Alabama

Alabama has no established schedule of lease sales. The limited number of tracts in State waters has resulted in the State not holding regularly scheduled lease sales. The last lease sale was held in 1997.

The territorial waters of Alabama extend Gulfward for 3 nmi and its shoreline extends nearly 52 mi. The first wells drilled for oil in the southeastern United States were drilled in Lawrence County in 1865, just six years after the first oil well was drilled in the United States. The first commercially marketed natural gas production in the southeastern United States occurred in the early 1900's near Huntsville. In 1979, gas was first discovered by MOEPSI in the mouth of Mobile Bay.

Alabama owns oil, gas, and mineral interests on small upland tracts, submerged river bottoms, estuaries, bays, and in the 3-nmi area offshore. Most significant economically are the natural gas reserves lying within the 3-nmi offshore area of Mobile and Baldwin Counties. The Alabama State Oil and Gas Board was created after the oil discovery in 1944 in Choctaw County and is responsible for regulating the exploration and development of these natural resources. The discovery of Alabama's giant Citronelle Field in Mobile County in 1955 focused national attention on the State's oil and gas potential. Major discoveries of natural gas in the 1980's led to the development of an array of natural gas reservoirs, and Alabama became a world leader in the development of coalbed methane gas as an energy resource. The Norphlet development, which started in November 1978, results in high production rates of Norphlet Formation gas. This gas is a hot, sour, high-pressure, corrosive mixture of methane, hydrogen sulfide, carbon dioxide, and free water.

Alabama has reaped tremendous financial benefits from the development of offshore mineral resources. Revenues include severance taxes, bonuses, royalties, and rentals. At present, Alabama is considered a major oil- and gas-producing state.

As of August 2001, a total of 69 test wells have been drilled in Alabama coastal waters. Forty of these wells were permitted to test the Norphlet Formation below a depth of 20,000 ft. The two earliest wells were drilled to test undifferentiated rocks of Cretaceous age and 27 wells have targeted shallow Miocene gas reservoirs generally at depths of less than 3,500 ft. Operators have experienced a high success rate in drilling wells in Alabama coastal waters. A total of 28 of the 40 Norphlet Formation wells drilled to date have tested gas, and 23 of the 27 Miocene wells drilled have tested gas. Sixteen gas fields have been established in the offshore region of the State, with seven fields being productive from the Norphlet Formation and nine fields being productive from sands of Miocene age (Alabama State Oil and Gas Board, 2001). Indigenous crude oil production totals 29,000 bbl per day, ranking Alabama 16th out of the 32 producing states and Federal offshore areas. The State's three refineries have a combined crude oil distillation capacity of 130,000 bbl per calendar day, while several crude oil, product, and liquefied petroleum gas pipelines pass through the State (USDOE, EIA, 2001c).

Production of gas from the State's coastal waters flows through 44 fixed structures and platforms and now exceeds 220 Bcf annually. This accounts for approximately 50 percent of the total gas production in Alabama, which now ranks as one of the top 10 gas-producing states in the nation. Production capabilities for individual wells range from a few million to more than 110 million cubic feet (MMcf) per day (Alabama State Oil and Gas Board, 2001).

Florida

The State of Florida has experienced very limited drilling in coastal waters. At present, a moratorium has stopped drilling activity in Florida State waters, and the State has no plans for lease sales in the future. At present, no drilling rigs are operating within the State waters. Although Florida does not have any refineries, the State does have some indigenous crude oil production onshore, totaling 13,000 bbl per day in 2000. This ranks Florida 20th out of the 32 oil-producing states including Federal offshore areas. There were 70 producing oil wells in 2000.

3.3.5.9.2. Pipeline Infrastructure for Transporting State-Produced Oil and Gas

The pipeline network in the Gulf Coast States is extensive. Pipelines transport crude oil and natural gas from the wellhead to the processing plants and refineries. Pipelines transport natural gas from producing states such as Texas and Louisiana and to a lesser extent Mississippi and Alabama to utility companies, chemical companies, and other users throughout the nation. Pipelines are used to transport refined petroleum products such as gasoline and diesel from refineries in the GOM region to markets all over the country. Pipelines are also used to transport chemical products (Louisiana Mid-Continent Oil and Gas Association, 2001).

The natural gas pipeline network has grown substantially since 1990 nationwide. The increasing growth in natural gas demand over the past several years has led to an increase in the utilization of pipelines and has resulted in some pressure for expansion in several areas. In the GOM, after several consecutive years of extensive pipeline development, installation of additional offshore GOM pipeline capacity has slowed. In 1997 and 1998, 14 natural gas pipeline projects were completed. These projects added a total of 6.4 Bcf per day of new pipeline capacity, most of which represented large-capacity pipelines connecting onshore facilities with developing offshore sites, particularly in the deepwater areas of the GOM. During 1999-2000, eight significant projects were completed, adding 1.8 Bcf per day to the area's pipeline capacity. The majority of these projects were built primarily to improve gathering operations and to link new and expanding producing platforms in the GOM with recently completed offshore mainlines directed to onshore facilities (USDOE, EIA, 2001d).

Louisiana

As in Texas, the pipeline industry is a vital part of the oil and gas industry in Louisiana. There are about 25,000 mi of pipe moving natural gas through interstate pipeline and about 7,600 mi of pipelines carrying natural gas through intrastate pipelines to users within the State's boundaries. Another 3,450 mi of pipeline in Louisiana transport crude oil and crude oil products. There are thousands of miles of flow lines and gathering lines moving oil and gas from the wellhead to separating facilities, while other pipelines transport chemical products with no petroleum base. Louisiana is home to the world's only offshore superport, LOOP, which enables supertankers to unload crude oil away from shore so that it can be transported via pipeline to onshore terminals. The Henry Hub in Louisiana is a hub of pipelines and is the point where financial markets determine the value of natural gas (Louisiana Mid-Continent Oil and Gas Association, 2001).

Mississippi

The petroleum infrastructure in Mississippi includes a moderately extensive network of crude oil, product, and liquefied petroleum gas pipelines. A major propane supply hub is the Dixie Pipeline; it has a network of terminals and storage facilities. Major pipelines for crude oil are operated by EOTT Energy, Genesis, Hunt, Shell, Mid-Valley, Scurlock-Permian, and BP. Major pipelines for liquefied petroleum gas are operated by Dixie, Plantation, Enterprise BP Dixie, and Enterprise (USDOE, EIA, 2001c).

Alabama

The petroleum infrastructure in Alabama includes a somewhat extensive network of crude oil, product, and liquefied petroleum gas pipelines. Major pipelines for crude oil are operated by Hess, Hunt, Genesis, Citronelle-Mobile, and Miller. Major pipelines for liquefied petroleum gas are operated by Dixie and Enterprise (USDOE, EIA, 2001c).

Florida

The petroleum infrastructure in Florida includes a limited network of crude oil, product, and liquefied petroleum gas pipelines. Genesis and Sunniland operate major pipelines for crude oil. Enterprise operates major pipelines for liquefied petroleum gas (USDOE, EIA, 2001c).

3.3.5.10. Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, which directs Federal agencies to assess whether their actions have disproportionate environmental effects on people of ethnic or racial minorities or with low incomes. Those environmental effects encompass human health, social, and economic consequences. The Federal agency in charge of a proposed action must provide opportunities for community input during the NEPA process (See **Chapter 5** for a discussion of scoping, and community consultation and coordination.).

There are no environmental justice issues in the actual offshore GOM OCS planning areas; however, environmental justice concerns may be related to nearshore and onshore activities that result from a proposed action. These concerns are addressed in two categories—those related to routine operations and those related to non-routine events (accidents). Concerns related to routine operations center on increases in onshore activity (such as employment, migration, commuter traffic, and truck traffic) and on additions to or expansions of the infrastructure supporting this activity (such as fabrication yards, supply ports, and onshore disposal sites for offshore waste). Concerns related to non-routine events focus on oil spills.

The geographic analysis area for environmental justice is from Jefferson County, Texas, east to Franklin County, Florida. The infrastructure associated with these areas is identified in **Table 3-37** and discussed in **Chapters 3.3.5.8. and 4.1.2.1.**

The OCS Program in the GOM is large and has been ongoing for more than 50 years. During this period, substantial leasing has occurred off Texas, Louisiana, Mississippi, and Alabama. An extensive support infrastructure system exists, consisting of platform fabrication yards, shipyards, repair and maintenance yards, onshore service bases, heliports, marinas for crew and supply boats, pipeline coating companies, waste management facilities, gas processing plants, petrochemical plants, and gas and petroleum pipelines. This infrastructure system is both widespread and concentrated. Much infrastructure is located in coastal Louisiana, less in nearby Jefferson County, and less still in Mississippi's Jackson County and Alabama's Mobile County. While many fabrication and supply facilities are concentrated around coastal ports, downstream processing is concentrated more in industrial corridors farther inland. Support system infrastructure is described in **Chapter 3.3.5.8.**, OCS-Related Coastal Infrastructure. The potential impacts to and from infrastructure is an ongoing concern for Gulf Coast States and communities. The MMS is currently conducting several studies to obtain and refine pertinent information. An ongoing study of infrastructure (Louis Berger Group, Inc., in preparation) is coding each facility and developing a database describing its functions and capacity. Ongoing cooperative agreements with Louisiana State University and the University of New Orleans are developing better descriptions and measures of the concentrated functions at specific coastal locations. **Chapter 3.3.5.8.** describes the even more widespread multitude of companies that provide goods and services to this system. One study (Applied Technology Research Corporation, 1994) counted 6,600 businesses that served oil and gas production companies. These vendors were distributed over 38 states, but they were concentrated in Texas, Mississippi, Alabama, and particularly Louisiana.

The U.S. Census data aggregated at the county/parish level are too broad to reveal relationships between OCS leasing effects and geographic distributions of minority and low-income populations. Therefore, this environmental justice analysis considers the population distributions at the smaller, more detailed census tract level, which raises a data problem because tract-level household income data from the 2000 Census was not available at the time this analysis was concluded. Because of the importance of geographic detail to the environmental justice analysis, MMS has opted to use 1997 projections of 1990 Census data for comparable and valid distributions for minority and low-income populations. While the 1997 projections are not expected to differ significantly from 2000 Census results, use of these projections raise additional issues. First, MMS purchased these data in 1997 and they do not include county/parishes recently added to the study area. Second, the U.S. Census 1997 nationwide definition of poverty was a household income of less than $16,276, while MMS data include figures for income of less than $15,000. The MMS has chosen to use the lower figure since it is closer to the nationwide definition and since the cost of living is generally lower in the South than for the Nation as a whole.

Figure 3-14 shows the census tracts that are 50 percent or more minority for the coastal areas of Texas, Louisiana, Mississippi, Alabama, and Florida's Panhandle counties. The MMS chose this percentage based on CEQ (1997) guidelines that defined a minority population of an affected that area exceeds 50 percent as an appropriate definition for environmental justice analysis. Most of these concentrations occur in large urban areas such as Beaumont, Texas; Lafayette, Baton Rouge, and New Orleans, Louisiana; and Mobile, Alabama or in smaller coastal urban areas such as Morgan City, Louisiana; Gulfport, Biloxi, Pascagoula, Mississippi; and Pensacola, Florida. Large, rural, agricultural, predominantly minority census tracts are found in Texas, Louisiana, Alabama, and Florida. The Louisiana census tracts around Morgan City and along the Mississippi River below New Orleans are areas of mixed industry and agriculture; both coastal areas are sparsely inhabited. These pockets of minority populations do not necessarily match the distribution of the offshore oil industry and its supporting infrastructure. Instead, they are the product of urbanization and of the historical role African-Americans had in southern agriculture.

Figure 3-15 gives the census tracts that have 50 percent or more of low-income households. The CEQ (1997) guidance for defining low-income areas is less explicit than it is for minority areas. The MMS selected the 50-percent level as comparable to the minority definition. In almost every case, these census tracts are neighborhoods in large or coastal urban areas such as Beaumont, Lafayette, Baton Rouge, New Orleans, Biloxi, Mobile, and Pensacola. Low-income census tracts are also minority census tracts. Again, like the concentrations of minority population, these pockets of poverty are a product of urbanization and southern agriculture.

As noted above, certain offshore fabrication and support functions are concentrated in coastal areas, particularly in Louisiana. Lafourche Parish, Louisiana, is described here because the analysis in **Chapter 4.2.1.15.1.**, Land Use and Coastal Infrastructure, identifies it as a coastal area with a concentration of OCS-related infrastructure and with possible environmental justice concerns. Like its neighbors, Lafourche Parish is heavily involved in the offshore oil industry, particularly fabrication and support sectors. The founding and continued expansion of Port Fourchon, a port designed for deepwater OCS support, has added to the industry's presence (Keithly, 2001; Hughes, 2002). Agriculture (primarily sugar cane and cattle) and commercial fishing make up smaller parts of the Lafourche Parish economy. In 2000, the parish's population was 89,974. Thibodaux, the parish seat and largest city, had a population of 15,730; Larose, Raceland, and Cut Off had over 5,000 inhabitants; Galliano over 4,000; and Lockport and Golden Meadow over 2,000. The parish's population was 83 percent white (many of Cajun descent), 13 percent African-American, 2 percent American Indian, and 1 percent Hispanic.

Much of Lafourche Parish is coastal wetlands. Habitable land—high ground—comprises narrow natural levees formed by existing and ancient bayous. Roads are built on top of these levees and communities are built along the roads and in the long, narrow bands described as "string settlements" (Davis and Place, 1983). This settlement pattern has tended to mix residential and business activities and to limit residential segregation by ethnicity and income. For example, the Houma, a State-recognized Indian tribe in the parish, resides interspersed among the dominant population group and is physically indistinguishable (Gibson, 1982; Fischer, 1970). Both the rich and the poor of Port Fourchon in Lafourche Parish have experienced the effects of port-related truck traffic; MMS scoping for this EIS and past EIS's has identified this as an issue of community-wide concern.