Generic Amendment
for
Addressing Essential Fish Habitat Requirements
in the following
Fishery Management Plans
of the Gulf of Mexico:

- ***Shrimp Fishery of the Gulf of Mexico, United States Waters***
- ***Red Drum Fishery of the Gulf of Mexico***
- ***Reef Fish Fishery of the Gulf of Mexico***
- ***Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic***
- ***Stone Crab Fishery of the Gulf of Mexico***
- ***Spiny Lobster in the Gulf of Mexico and South Atlantic***
- ***Coral and Coral Reefs of the Gulf of Mexico***

(Includes Environmental Assessment)

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APPENDIX A - FIGURES

ABBREVIATIONS

bbl	barrels
BOD	biological oxygen demand
CAPA	chlor-alkali process area
CEQ	Council on Environmental Quality
COE	Corps of Engineers (U.S. Army)
CPUE	catch per unit effort
CWA	Clean Water Act
CWPPRA	Coastal Wetlands Protection, Planning and Restoration Act
CZM	Coastal Zone Management
DDT	dichloro-diphenyl-trichloto-ethane
DO	dissolved oxygen
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	environmental impact statement
EPA	Environmental Protection Agency
FMP	fishery management plan
FMU	fishery managment unit
FWPCA/CWA	Federal Water Pollution Control Act/Clean Water Act
FWS	Fish and Wildlife Service
GE	greenhouse effect
GIS	Geographic Information System
GIWW	Gulf Intracoastal Waterway
GMEI	Gulf of Mexico Estuarine Inventory
GMFMC	Gulf of Mexico Fishery Management Council
GW	global warming
HAPC	habitat area of particular concern
HRP	habitat research plan
MHW	mean high water
MLW	mean low water
MMS	Minerals Management Service
MPRSA	Marine Protection Research and Sanctuaries Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality Standards
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollution and Discharge Elimination System
NST	National Status and Trends Program
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCO	Point Comfort Operations
ppm	parts per million

ppt	parts per thousand
SAV	submerged aquatic vegetation
SMZ	special management zone
sp.	species
spp.	multiple species
tcf	trillion cubic feet
TDH	Texas State Department of Health
TMDL	total maximum daily loads
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
TXGLO	Texas General Land Office
ULM	Upper Laguana Madre
U.S.	United States
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

CONVERSION CHART

From	To	Multiply by
millimeter (mm)	inch (in)	0.03937
centimeter (cm)	inch (in)	0.3937
meter (m)	foot (ft)	3.281
kilometer (km)	mile (mi)	0.6214
$meter^2$ (m^2)	$foot^2$ (ft^2)	10.76
$meter^2$ (m^2)	acre (ac)	0.0002471
hectare (ha)	acre (ac)	2.47
$kilometer^2$ (km^2)	acre (ac)	247
$kilometer^2$ (km^2)	$mile^2$ (mi^2)	0.3861
$meter^3$ (m^3)	$yard^3$ (yd^3)	1.307
kilogram (kg)	pound (lb)	2.2046
metric ton (t)	short ton	1.102
liter (l)	gallon (gal)	0.2642
degree Celcius (˚C)	degree Fahrenheit (˚F)	˚F = (1.8 x ˚C) + 32

GLOSSARY

Ahermatypic coral - Non-reef building coral that are not restricted by depth, temperature, or light penetration.

Alluviual - Of or relating to clay, sand, silt, gravel, or similar detrital material transported and deposited by running water.

Anticyclonic - Referring to a rotation that is clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

Aragonite - A white, yellowish, or gray mineral species of calcium carbonate.

Bathymetric - Pertaining to depth measurement.

Beach - A sloping landform on the shore of larger water bodies, generated by waves and currents and extending from the water to a distinct break in landform or substrate type.

Benthic - Organisms living on or in the bottom of the sea; associated with live bottoms, hardbottom banks, patch reefs and reef complexes.

Bioherm - A circumscribed mass of rock exclusively or mainly constructed by marine sedimentary organisms such as corals, algae, and stromatoporoids.

Biota - Animal and plant life characterizing a given region.

Bioturbation - reworking or disruption of sediments by animals burrowing or feeding.

Brackish - Marine and estuarine waters with salinities ranging from 0.5 to 30 ppt.

Calcareous - Formed of calcium carbonate or magnesium carbonate by biological deposition. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets.

Cenozoic Era - The latest major subdivision of the geologic time scale that began 60 - 70 million years ago.

Clastic - Made up of fragments of preexisting rocks.

Coastal waters - Inshore waters within the geographical areas defined by each State's Coastal Zone Management Program.

Coastal wetlands - Forested and nonforested habitats, mangroves, and all marsh islands that are exposed to tidal activity. Included in forested wetlands are hardwood hammocks, mangrove swamps, spoil banks, cypress-tupelo gum swamps, and bottomland hardwoods. Nonforested wetlands include fresh, brackish, and salt marshes. These areas directly contribute to the high biological productivity of coastal waters by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, and by serving as habitat for many birds and other animals.

Community - A group of plants and animals living in a specific region under relatively similar conditions.

Continental shelf - The ocean floor province that lies between the shoreline and the abrupt change in slope called the shelf edge, which generally occurs around a water depth of 200 m. The shelf is characterized by a gentle slope (around 0.1˚).

Continental slope - The ocean floor province that lies between the continental shelf and continental rise, characterized by a steep slope (around 3˚-6˚) and located in water depths of 200-4,000 m.

Coquina - A soft whitish limestone formed of broken shells and corals.

Coralline - Any of a family of calcareous red algae.

Cretaceous Period - The last major division of the Mesozoic Era of the geologic time scale that began 110 million years ago and ended 60 million years ago.

Crustose - Having a thin thallus adhering closely to the substratum of rock.

Demersal - Living at or near the bottom of the sea.

Detritus - Particulate organic matter originating primarily from the physical breakdown of dead animal and plant tissue.

Diurnal - Having a daily cycle.

Dolomitic - Of or relating to a limestone rich in magnesium carbonate

Ecosystem - A complex, interactive community of organisms and its environment functioning as an ecological unit in nature.

Effluent - The liquid waste of sewage and industrial processing.

Epibenthic - Located on the bottom, as opposed to in the bottom.

Epibiota - Animal or plant life living on the surface of other plants or animals

Epifauna - Animals living on the surface of a substrate.

Epipelagic - The upper sunlit zone of oceanic water extending to depths of approximately 200 m.

Epiphytic - Refers to organisms that live on the surface of a plant.

Erosion - The wearing away of a land surface by water, wind, ice, or other geologic agents.

Estuarine - Of or relating to an estuary.

Estuary - Coastal semienclosed body of water that has a free connection with the open sea and where freshwater meets and mixes with seawater.

Eutrophication - Enrichment of nutrients in the water column by natural or artificial methods accompanied by an increase of respiration, which may create an oxygen deficiency.

Exclusive Economic Zone (EEZ) - The maritime region adjacent to the territorial sea, extending 200 nautical miles from the baseline of the territorial sea, in which the United States has exclusive rights and jurisdiction over living and nonliving natural resources.

Fauna - A group of animals representative of a particular region.

Flocculent - Pertaining to a material that is cloudlike and noncrystalline.

Flora - Plant life characteristic of a particular region.

Fouling - Occurs when large numbers of marine plants and animals attach and grow on various submerged structures, often interfering with their use.

Fresh - Term applied to water with salinity less than 0.5 ppt.

Graben - A depressed segment of the crust of the earth bounded on at least two sides by faults.

Groundfish - Fish species that live on or near the bottom.

Gyre - A closed circulatory system.

Habitat - A specific type of environment that is occupied by an organism, a population, or a community.

Hermatypic coral - Reef building corals that produce hard, calcium carbonate skeletons and that possess symbiotic, unicellular algae within their tissues.

Hummock - A rounded knoll or hillock.

Hydrologic - Of or relating to the properties, distribution, and circulation of water.

Hypersaline - Term to characterize waters with salinity greater than 40 ppt, due to land derived salts.

Hypoxia - Depressed levels of dissolved oxygen in water.

Impoundment - A water body or wetland area that is denied normal exchange of water with surrounding area as a result of man-made impediments (e.g., dikes, dams, weirs and other water control structures).

Inner shelf - The continental shelf extending from the mean low tide line to a depth of 20 m.

Inquiline - Shells that provide habitat or shelter for other animals.

Isobath - A contour mapping line that indicates a specified constant depth.

Jurassic Period - A major subdivision of the Mesozoic Era that began 150 million years ago and lasted until 110 million years ago.

Leachate - A solution or product obtained by leaching; the removal of nutritive or harmful substances from the soil by percolation of a liquid.

Lithified - Of or pertaining to being turned to rock.

Lithoherm - A type of deepwater reef composed of surface hardened layers of lithified sandy carbonate sediments supporting a diverse array of benthic fauna.

Littoral - Of or relating, or situated, or growing on or near a shore of the sea.

Macroalgae - Algal plants large enough either as individuals or communities to be readily visible without the aid of optical magnification.

Marine - Of, pertaining to, living in, or related to the seas or ocean.

Marl - A loose or crumbling earthy deposit (as of sand, silt, or clay) that contains a substantial amount of calcium carbonate.

Marshes - Persistent, emergent, nonforested wetlands characterized by vegetation consisting predominantly of cordgrasses, rushes, and cattails.

Mesopelagic - Of or relating to oceanic depths of from about 200 m to 1000 m.
Mitigation - A method or action to reduce or eliminate adverse environmental impacts.

Mudstone - An indurated shale produced by the consolidation of mud.

Nepheloid layer - A layer of water near the bottom that contains significant amounts of suspended sediment.

Neritic - An oceanic zone extending from the mean low tide level to the edge of the continental shelf.

Nonpoint source - Type of pollution originating from a combination of sources.

Oligohaline - Term to characterize water with salinity of 0.5 to 5 ppt, due to ocean derived salts.

Organic - Of, relating to, or containing carbon compounds.

Palustrine - Being, living, or thriving in a marsh.

Pangea - Postulated former supercontinent composed of all the continental crust of the earth that later fragmented into Laurasia and Gondwana.

Pelagic - Associated with open water beyond the direct influence of coastal systems.

pH - The negative logarithm of the effective hydrogen ion concentration or hydrogen ion activity in gram equivalents per liter used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity.

Phanerogam - A seed plant or flowering plant.

Plankton - Passively floating or weakly motile aquatic plants (phytoplankton) and animals (zooplankton).

Primary production - Organic material produced by photosynthetic or chemosynthetic organisms.

Produced water - Total water discharged from the oil and gas extraction process; production water or production brine.

Population - All individuals of the same species occupying a defined area during a given time.

Point source - A distinct and identifiable source, such as a sewer or industrial outfall pipe, from which a pollutant is discharged.

Range - The geographic range is the entire area where a species is known to occur or to have occurred.

Relict - A persistent relief feature of an otherwise extinct flora or fauna or kind of organism.

Relief - The difference in elevation between the high and low points of a surface.

Riparian - Relating to or living or located on the bank of a natural waterway.

Salinity - The total amount of solid material in grams contained in 1 kg of water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all the organic matter completely oxidized.

Salt diapir - A piercement structure in which a mobile plastic core of salt has ruptured the more brittle overlying rock.

Salt dome - A diapir or piercement structure in which there is a central, equidimensional salt plug.

Saltwater intrusion - Phenomenon occurring when a body of saltwater, because of its greater density, invades a body of freshwater; occurs in either surface or groundwater sources.

Sandstone - A sedimentary rock consisting of quartz sand united by some cement (silica or calcium carbonate).

Sediment - Material that has been transported and deposited by water, wind, glacier, precipitation, or gravity; a mass of deposited material.

Sessile - Permantly attached or established; not free to move about.

Sideritic - Of or relating to an iron carbonate.

Sound - A body of water that is usually broad, elongate, and parallel to the shore between the mainland and one or more islands.

Substrate - The base upon which an organism lives.

Terrigenous - Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or as a result of biological activity (biogenous).

Topographic highs - Geologic features on the Louisiana/Texas continental shelf that trend east to west along the shelf break. Many of these are the surface expression of salt domes, and nearly all are hard, rocky outcrops; many are drowned coral reefs.

Topography - The configuration of a surface including its relief and the position of its natural and man-made features.

Turbidity - Reduced water clarity due to the presence of suspended matter.

Upland - Any land area other than wetland.

Upwelling - The process whereby prevailing seasonal winds create surface currents that allow nutrient rich cold water from the ocean depths to move into the euphotic or epipelagic zone. This process increases primary productivity, and ultimately fish abundance.

Wetlands - Lands or areas that either contain much soil moisture or are inundated by surface or groundwater with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Windrow - A row heaped up by or as if by the wind.

1.0 PREFACE

This document is designed to provide information for the identification and description of essential fish habitat (EFH) for species under federal management in the Gulf of Mexico. It also considers threats to EFH and identifies options for the conservation and enhancement of EFH. Distributional information for selected species under management by the Gulf of Mexico Fishery Council has been assembled to produce a compendium of information on all of the habitats used. This document should be considered as a generic amendment in which Sections 3.0, 4.0, 6.0, 7.0 and 8.0 are common and should be paired with each subsection of Section 5.0 to represent complete amendments to the respective seven Fishery Management Plans (FMPs) of the Gulf of Mexico Fishery Management Council.

1.1 List of Preparers

Gulf of Mexico Fishery Management Council:
- William N. Lindall, Jr., Biologist

Gulf States Marine Fisheries Commission:
- Jeff Rester, Biologist (Section 4.2)

National Marine Fisheries Service:
- William Jackson, Fishery Management Specialist (Sections 6 and 7)
- Dr. Herb Kumpf, Biologist (Coordinated preparation of Habitat Tables)
- Andreas Mager, Biologist (Section 8)

National Ocean Services (EFH Figures)
- Dr. Mark Monaco
- Dr. Steve Brown

1.2 List of Agencies and Persons Consulted

The following agencies have been consulted on the provisions of this amendment:

Gulf of Mexico Fishery Management Council:	Habitat Protection Committee Habitat Protection Advisory Panels Scientific and Statistical Committee Technical Review Panel for EFH
Gulf States Marine Fisheries Commission:	Habitat Subcommittee
Coastal Zone Management Programs:	Florida

Alabama
Mississippi
Louisiana
Texas

National Marine Fisheries Service: Southeast Regional Office
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1.3 Persons to contact regarding EFH

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2.0 SUMMARY

This document amends the seven fishery management plans (FMP) of the Gulf of Mexico Fishery Management Council. Essential fish habitat (EFH) is identified and described based on areas where various life stages of 26 representative managed species and the coral complex commonly occur. The 26 representative species are shrimp (brown shrimp, *Penaeus aztecus;* white shrimp, *Penaeus setiferus;* pink shrimp, *Penaeus duorarum;* and royal red shrimp, *Pleoticus robustus*; red drum, *Sciaenops ocellatus;* reef fish (red grouper, *Epinephelus morio*; gag grouper, *Mycteroperca microlepis;* scamp grouper, *Mycteroperca phenax*; black grouper, *Mycteroperca bonaci*; red snapper, *Lutjanus campechanus;* vermilion snapper, *Rhomboplites aurorubens*; gray snapper, *Lutjanus griseus;* yellowtail snapper, *Ocyurus chrysurus;* lane snapper, *Lutjanus synagris*; greater amberjack, *Seriola dumerili;* lesser amberjack, *Seriola fasciata;* tilefish, *Lopholatilus chamaeleonticeps;* and gray triggerfish, *Balistes capriscus*), coastal migratory pelagic species (king mackerel, *Scomberomorus cavalla;* Spanish mackerel, *Scomberomorus maculatus;* cobia, *Rachycentron canadum;* dolphin, *Coryphaena hippurus;* bluefish, *Pomatomus saltatrix;* and little tunny, *Euthynnus alleteratus*), stone crab, *Menippe mercenaria;* spiny lobster, *Panulirus argus;* and the coral complex.

The selected species account for about a third of the species under management by the Gulf of Mexico Fishery Management Council. They were selected because they are considered to be ecologically representative of the remaining species within their respective Fishery Management Units (FMUs). Their selection was further supported because sufficient information was available in most cases to document and map their habitat associations and use. Collectively, these selected species commonly occur throughout all of the marine and estuarine waters of the Gulf of Mexico. Thus, even if maps and tables of additional species were available, they would not encompass any habitat that is not already included and identified as EFH for one or more of the selected species. EFH for the remaining managed species, as well as additional refinement of the available information on the representative species, will be addressed in future FMP amendments, as appropriate

EFH is defined as everywhere that the above managed species commonly occur. The EFH determination is based on species distribution maps and habitat association tables presented in Section 5. In estuaries, the EFH of each species consists of those areas depicted in the maps as "common", "abundant" and "highly abundant." In offshore areas, EFH consists of those areas depicted as "adult areas," "spawning areas" and "nursery areas." Because these species collectively occur in all estuarine and marine habitats of the Gulf of Mexico, EFH is separated into estuarine and marine components. For the estuarine component, **EFH is defined as all estuarine waters and substrates (mud, sand, shell, rock and associated biological communities), including the sub-tidal vegetation (seagrasses and algae) and adjacent inter-tidal vegetation (marshes and mangroves)**. In marine waters of the Gulf of Mexico, **EFH is defined as all marine waters and substrates (mud, sand, shell, rock, hardbottom, and associated biological communities) from the shoreline to the seaward limit of the EEZ.**

Threats to EFH from fishing and nonfishing activities are identified. Options to conserve and enhance EFH are provided. Research needs also are identified.
New management measures and regulations are not proposed at this time. Fishing-related management measures to minimize any identified impacts are deferred to future amendments when the Council has the information necessary to decide if the measures are practicable.

3.0 INTRODUCTION

Section 305(b)(1)(A and B) of the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq.), as amended, requires that the Regional Fishery Management Councils submit, by October 11, 1998, amendments to their fishery management plans (FMP) that identify and describe essential fish habitat (EFH) for species under management. The Act also requires identification of adverse impacts on EFH and the actions that should be considered to ensure that EFH is conserved and enhanced. This document represents the Gulf of Mexico Fishery Management Council's response to those requirements by serving as a generic amendment to the following FMPs:

- Fishery Management Plan for the **Shrimp** Fishery of the Gulf of Mexico, United States Waters
- Fishery Management Plan for the **Red Drum** Fishery of the Gulf of Mexico
- Fishery Management Plan for the **Reef Fish** Fishery of the Gulf of Mexico
- Fishery Management Plan for the **Coastal Migratory Pelagic Resources (Mackerels)** in the Gulf of Mexico and South Atlantic.[1]
- Fishery Management Plan for the **Stone Crab** Fishery of the Gulf of Mexico
- Fishery Management Plan for **Spiny Lobster** in the Gulf of Mexico and South Atlantic[1]
- Fishery Management Plan for **Coral and Coral Reefs** of the Gulf of Mexico

The Council decided that a single, generic amendment was the only practical means of meeting the requirement to amend all seven FMPs by the October 1998 deadline for several reasons. First, the FMPs contain more than 450 species (about 400 in the Coral FMP). Information on habitat requirements does not exist or is severely limited for many species. Thus, many species would have to be grouped anyway. Second, because almost every FMP contains species that occupy estuarine habitat during some phase of their life cycle, the identification and description of estuarine EFH would be the same for most of the FMPs. Likewise, identification and description of the offshore EFH would be the same for many managed species. A generic amendment, therefore, would eliminate much duplication. Finally, to meet the October 1998 submission deadline, the Council would have to prepare the initial draft documents by March 1998, only 10 weeks after NMFS published the interim final rule establishing the guidelines for Councils to respond to the EFH requirements. Thus, there simply was not sufficient time for the Council to prepare, review, seek public comment and approve seven individual and separate FMP amendments.

This document contains the following actions for each of the above referenced FMPs:

- Identifies and describes EFH (Section 4) based primarily on the areas where the various life stages of species under management are known to commonly occur (Sections 5).

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[1] Note: this amendment applies only to habitat for managed species within the boundaries of Gulf Council authority. Habitat for coastal migratory pelagic species and spiny lobster occurring in the south Atlantic will be described by the South Atlantic Fishery Management Council.

- Identifies adverse impacts to EFH from fishing and non-fishing activities (Section 6).

- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities (Section 7).

- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities (Section 7).

- Identifies needed research to better identify and describe EFH (Section 8).

Essential fish habitat (EFH) is identified and described based on areas where various life stages of 26 selected managed species and the coral complex commonly occur. The EFH determination is based on species distribution maps and habitat association tables presented in Section 5. In estuarine areas the EFH of each species consists of those areas depicted in the maps as "common", "abundant" and "highly abundant." EFH in offshore areas are those depicted as "adult areas," "spawning areas" and "nursery areas." The 26 representative species are shrimp (brown shrimp, *Penaeus aztecus;* white shrimp, *Penaeus setiferus;* pink shrimp, *Penaeus duorarum;* and royal red shrimp, *Pleoticus robustus*); red drum, *Sciaenops ocellatus;* reef fish (red grouper, *Epinephelus morio*; gag grouper, *Mycteroperca microlepis;* scamp grouper, *Mycteroperca phenax*; black grouper, *Mycteroperca bonaci*; red snapper, *Lutjanus campechanus;* vermilion snapper, *Rhomboplites aurorubens*; gray snapper, *Lutjanus griseus;* yellowtail snapper, *Ocyurus chrysurus;* lane snapper, *Lutjanus synagris*; greater amberjack, *Seriola dumerili;* lesser amberjack, *Seriola fasciata;* tilefish, *Lopholatilus chamaeleonticeps;* and gray triggerfish, *Balistes capriscus*), coastal migratory pelagic species (king mackerel, *Scomberomorus cavalla;* Spanish mackerel, *Scomberomorus maculatus;* cobia, *Rachycentron canadum;* and dolphin, *Coryphaena hippurus;* bluefish, *Pomatomus saltatrix;* and little tunny, *Euthynnus alleteratus*), stone crab, *Menippe mercenaria;* spiny lobster, *Panulirus argus;* and the coral complex.

The selected species account for about a third of the species under management by the Gulf of Mexico Fishery Management Council. Nevertheless, they are the more important species in terms of commercial and recreational harvest. They were selected because they are considered to be ecologically representative of the remaining species within their respective FMUs. Their selection was further supported because sufficient information was available in most cases to document and map their habitat associations and use. Collectively, these selected species commonly occur throughout all of the marine and estuarine waters of the Gulf of Mexico. Thus, even if maps and tables of additional species were available, they would not encompass any habitat that is not already included and identified as EFH for one or more of the selected species. EFH for the remaining managed species, as well as additional refinement of the available information on the representative species, will be addressed in future FMP amendments, as appropriate.

New management measures are not proposed at this time. Thus, regulations are not associated with this amendment. NMFS guidelines state that FMPs must include management measures that minimize adverse effects on EFH from fishing, to the extent practicable. To decide if minimization of an adverse effect from fishing is practicable, the Council has to consider: 1) whether, and to what extent, the fishing activity is adversely impacting EFH, including the fishery; 2) the nature and extent of the adverse effect on EFH; and, 3) whether the management measures are practicable, taking into consideration the long and short-term costs as well as benefits to the fishery and its EFH, along with other appropriate factors consistent with national standard 7. The Council concluded that any attempt to develop and set up fishing-related management measures at this time is premature because information necessary to analyze the practicability of such measures does not exist at this time. Therefore, consideration and adoption of fishing-related management measures concerning EFH are deferred to future amendments.

Information presented in this document is consistent with and supports the Gulf Council's long-standing habitat policy. The policy, as set forth in the Council's Statement of Organization Practices and Procedures, states:

> Recognizing that all species are dependent on the quantity and quality of their essential habitats, it is the policy of the Gulf of Mexico Fishery Management Council to:
>
> Protect, restore and improve habitats upon which commercial and recreational marine fisheries depend, to increase their extent and to improve their productive capacity for the benefit of present and future generations. (For purposes of this policy, habitat is defined to include all those things physical, chemical and biological that are necessary to the productivity of the species being managed).
>
> This policy shall be supported by three policy objectives which are to:
>
> a. Maintain the current quantity and productive capacity of habitats supporting important commercial and recreational fisheries, including their base. (This objective may be accomplished through the recommendation of no loss and minimization of environmental degradation of existing habitat).
>
> b. Restore and rehabilitate the productive capacity of habitats which have already been degraded.
>
> c. Create and develop productive habitats where increased fishery productivity will benefit society.
>
> The Council shall assume an aggressive role in the protection and enhancement of habitats important to marine and anadromous fish. It shall actively enter federal decision-making processes where proposed actions may otherwise compromise the productivity of fishery resources of concern to the Council.

The Council's procedures for participating in the decision-making process is defined in the full Habitat Policy presented in Appendix D.

Finally, it is appropriate to note that the fish and shellfish under management of the GMFMC are valuable and renewable natural resources. These resources contribute to the food supply, economy, and health of the nation and provide recreational opportunities. Commercial and recreational fishing are a major source of employment and contribute significantly to the economy of the gulf states and to the nation. Certain stocks of fish (e.g., king mackerel, red snapper, red drum) have been reduced in number because of fishing pressure and/or habitat losses that have resulted in a diminished capacity to support existing fishing levels. To rebuild these diminished stocks the GMFMC has implemented measures to reduce fishing mortality (i.e., quotas, bag limits, closed area/seasons, etc.) and is actively involved in protecting habitat. The Gulf of Mexico, therefore, is an integral part of a national program of conservation and management that is necessary to realize the full potential of the Nation's fishery resources.

4.0 <u>IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT (EFH)</u>

As defined in the interim final rule (62FR 66551), **"<u>Essential fish habitat</u> means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: 'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hardbottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle."**

To identify and describe EFH following the above definition, NMFS guidelines call for analysis of existing information at *four levels* of detail. At *Level 1* the presence/absence of distributional data is available for some or all portions of the geographic range of the species; at *Level 2* habitat-related densities of the species are available; at *Level 3* growth, reproduction, or survival rates within habitats are available; and at *Level 4* production rates by habitat are available. The guidelines also call for applying this information in a risk-averse fashion to ensure adequate areas are protected as EFH of managed species.

The available information is only *Level 1* for most of the managed species in the Gulf of Mexico. Level 2 information exists for the selected species that occur in estuaries. That is, relative abundance information is available to allow mapping of estuarine areas where the species are rare, common, abundant, and highly abundant (see Section 5.0). For purposes of this amendment EFH is defined as everywhere that the managed species commonly occur and is described based on distributional information provided in Section 5.0. Research needs identified in Section 8.0 should help increase knowledge to higher analytical levels and perhaps better define and describe EFH in the future. When future information permits such analysis, the Council will amend the FMPs as appropriate.

For the purposes of identifying and describing EFH, this section of the amendment is separated into ***estuarine*** and ***marine*** components. This simplistic breakdown was chosen because many of the managed species in the Gulf of Mexico occupy estuaries during some phase of their life cycle, usually the early phase (see Section 5.0). Arguments could be made for other, more complex treatments (e.g., estuarine, nearshore, offshore, depth zones, etc.), but this would only complicate the amendment and require more time to complete than is available. Future amendments can provide more complex treatment, if necessary.

4.1 Habitat Types and Distribution: Estuarine

Given the broad definition of EFH, the extensive estuarine distribution of the managed species (see Section 5.0), and NMFS guidance to be risk averse in face of uncertainty, ***all of the estuarine systems of the Gulf of Mexico are considered essential habitat for fish managed by the Gulf of Mexico Fishery Management Council.*** The difficulty lies in deciding where to draw the EFH boundaries. From an ecosystem viewpoint, all biological and hydrological components of an estuary are interrelated with the biological and hydrological components of the freshwater drainage basin, and with those of the adjacent marine component. For example, the Mississippi River, which drains about two thirds of the U.S., has a large influence on the estuaries of Louisiana and Mississippi and a large portion of the marine waters of the northern Gulf. It could be argued, therefore, that from an ecosystem perspective EFH should include the Mississippi River and floodplain along with other rivers and floodplains draining into the Gulf's estuaries, because these systems are necessary to support sustainable fisheries and a healthy ecosystem. Nevertheless, for the purposes of this amendment the boundaries of estuarine EFH follow those identified in the Cooperative Gulf of Mexico Estuarine Inventory (GMEI) conducted in each state, as discussed in Section 4.1.1. That is, the landward boundary of estuarine EFH is the limit of permanent fresh water bottom; seaward limits are the coastal barrier islands -- in the absence of barrier islands, other lines of demarcation were used after Pearcy (1959). Thus, ***EFH is all waters and substrates (mud, sand, shell, rock and associated biological communities) within these estuarine boundaries, including the sub-tidal vegetation (seagrasses and algae) and adjacent tidal vegetation (marshes and mangroves)***.

Omission of riverine systems from the EFH definition does not imply that these systems are unimportant to fishery resources under management by the Gulf Council and do not need protection. To the contrary, the quantity, quality and timing of the stream discharge into the estuaries is very important (e.g., a source of nutrients, maintenance of salinity gradients, flushing of pollutants, etc.) and should not be altered in a manner that would adversely affect living marine resources (see Sections 6.0 and 7.0).

4.1.1 State-By-State Description

In this section estuarine habitat is described by state. Figure 1 shows the general location of the Gulf's major estuaries. Where information readily exists, it is presented on individual bays and bay systems. Gulfwide, the GMEI measured 5.62 million hectares (13.9 million acres) of estuarine habitat among the five states (Lindall and Saloman, 1977). This includes some 3.2 million ha (7.9 million acres) of open water and 2.43 million ha (6.0 million acres) of emergent tidal vegetation (including about 162,000 ha (400,000 acres) of mangroves). Submerged vegetation covers nearly 324,000 ha (800,000 acres) of bay bottom.

Estuaries provide essential habitat for many species managed by the Gulf of Mexico Fishery Management Council, serving primarily as nursery areas for the juveniles and also as habitat for adults in certain seasons of the year (see Section 5.0 for species accounts). Vegetated areas are emphasized because of their importance to fish production and because of their vulnerability to man's activities (see Section 6).

Emergent vegetation is not evenly distributed along the Gulf coast (see Figure 2). Some 63 percent of the marsh is found in Louisiana as the result of an abundant sediment supply transported by the Mississippi River. Some 160,000 ha (395,000 acres) of mangrove are found almost exclusively along the southern Florida coast. While substrate and currents (to carry germinated seeds) are generally favorable along the entire Gulf coast, mangrove distribution is limited to areas where hard freezes do not occur.

Emergent vegetation provides essential habitat for many of the Gulf's managed fish species (see Section 5.0). Marsh and mangroves are an integral part of the estuarine system, serving as nursery grounds for larvae, postlarvae, juveniles and adults of several species. The brown shrimp is a notable example of a species that is intimately linked to the nursery aspects of emergent vegetation. The role of nursery, however, is but one important function of marshes and mangroves. They also 1) export nutrients that are vital to adjacent waters; 2) provide an important water quality function in the form of secondary and tertiary waste treatment through removal and recycling of inorganic nutrients; 3) serve as an in important buffer against storms by absorbing energy of storm waves and acting as a water reservoir thus reducing damage farther inland; and 4) serve an important role in global cycles of nitrogen and sulfur (Gosselink et al., 1974; Turner, 1977; Thayer et al., 1981; Zimmerman et al., 1984).

Submerged vegetation is found along most of the Gulf coast but is particularly abundant and diverse along the shores of central and southern Florida (Figure 3). The relative abundance and type of submerged vegetation depends mainly on bottom type, turbidity, salinity, water temperature, bottom slope, and tidal range (McNulty et al., 1972). Along the Gulf coast of southern Florida nearly 50 percent of the estuarine bottoms are covered by submerged vegetation. Cover density generally decreases northward, with bays along the panhandle having only 5 percent vegetated bottoms. Reports for isolated study sites indicate that the 5 percent figure would hold for the remainder of the Gulf coast, except for portions of Louisiana where the percentage would be less, and the lower Texas coast where abundance is greater. In their summary of the GMEI, Lindall and Saloman (1977) report 322,593 ha (796,805 acres) of submerged vegetation in estuaries along the Gulf, of which 63 percent are found in Florida and 31 percent are found in the Laguna Madre and Copano-Aransas Bays in Texas (see Section 4.2.2 for additional information on vegetated bottom).

As with emergent vegetation, submerged vegetation is extremely important to fisheries production (see Section 5.0 for species accounts). Seagrass meadows are often populated by diverse and abundant fish faunas (Zieman and Zieman, 1989). The seagrasses and their attendant epiphytic and benthic fauna and flora provide shelter and food to the fishes in several ways and are used by many species as nursery grounds for juveniles. The grass canopy provides shelter for juvenile fish and for small permanent residents. These also can feed on the abundant invertebrate fauna of the seagrass meadows, on the microalgae, on the living seagrasses themselves, or on seagrass detritus. In addition, because of the abundance of smaller fish and large invertebrate predators, such as blue crabs and penaeid shrimp, larger fish in pursuit of prey organisms use the meadows as feeding grounds.

The following state-by-state description of essential estuarine habitat is in two parts: 1) description of the habitat; and 2) EFH alterations of particular concern. The format and much of the summary information are taken from the habitat section of the Council's Draft FMP for Groundfish (GMFMC, 1981a). The Groundfish FMP was written but never implemented. Descriptions are based largely on information published in Phase I, Area Description, of the Cooperative Gulf of Mexico Estuarine Inventory (GMEI) initiated in the mid-1960s by the Gulf States Marine Fisheries Commission and completed in the mid-1970s. The GMEI for Louisiana, Mississippi and Alabama were conducted by state agencies (Perret et al., 1971; Christmas, 1973; Crance, 1971); inventories for Texas and Florida were conducted by NMFS (Diener, 1975; McNulty et al., 1972). Additional information for Texas bay systems was obtained through Texas General Land Office (1996) and Moulton et al. (1997). The GMEI of each state combined original observations with a review of the literature on dimensions, vegetation, geology, stream discharge, oyster and clam beds, artificial fishing reefs, human population, economic development, pollution and dredging. These features are mapped in detail in the GMEI of each state but are too voluminous to include in this amendment. Thus, the GMEI maps are incorporated by reference.

To the extent possible, information was updated by a special Technical Review Panel appointed by the Council to review this amendment. The Panel consisted of habitat experts from each of the Gulf states, plus the NMFS and USFWS. The short time allowed for preparation of this amendment precluded a comprehensive update of information. It is anticipated that more comprehensive updates will follow with future amendments.

4.1.1.1 Texas

Habitat Description

Texas has approximately 612 km (367 mi) of open Gulf shoreline and contains 3,528 km (2,125 mi) of bay-estuary-lagoon shoreline. This is the most biologically rich and ecologically diverse region in the state and supports more than 247,670 ha (611,760 acres) of fresh, brackish, and salt marshes. Henderson (1997) describes the Gulf coast as containing a diversity of salt, brackish, intermediate and fresh wetlands. Of the marshes described, saline and brackish marshes are most widely distributed south of Galveston Bay, while intermediate marshes are the most extensive marsh type east of Galveston Bay. The lower coast has only a narrow band of emergent marsh, but has a system of extensive bays and lagoons.

From the Louisiana border to Galveston, the coastline is comprised of marshy plains and low, narrow beach ridges. From Galveston Bay to the Mexican border, the coastline is characterized by long barrier islands and large shallow lagoons. Within this estuarine environment are found the profuse seagrass beds of the Laguna Madre, a rare hypersaline lagoon, and Padre Island, the longest barrier island in the world (Texas General Land Office, 1996). The Intracoastal Waterway, a maintenance dredged channel, extends from the Lower Laguna Madre to Sabine Lake. Dredging of the channel has created numerous spoil banks on islands adjacent to the channel.

The major bay systems from the lower-to-upper coast are Lower and Upper Laguna Madre, Corpus Christi and Aransas Bays, San Antonio, Matagorda and Galveston Bays, and Sabine Lake. It was estimated that in 1992, these estuaries contained 627,560 ha (1,550,073 acres) of open water (estuarine subtidal areas) and 1,576,823 ha (3,894,753 acres) of wetlands existed along the Texas coast. About 85.3% of the total wetlands was palustrine, 14.5% was estuarine, and 0.1% was marine. There were 711,576 ha (1,757,595 acres) of deepwater rivers (24,356 ha/ 60,159 acres), reservoirs (59,661 ha/ 147,363 acres), and estuarine bays (627,560 ha/ 1,550,073 acres) (Moulton et al., 1997). Climate ranges from semi-arid on the lower coast, where rainfall averages 635 mm, to humid on the upper coast where average annual rainfall is 1,397 mm (Diener, 1975). Detailed information on temperature, salinity, dissolved oxygen, and turbidity collected from Texas estuaries during routine trawl samples from 1983 - 1996 is available from the Texas Parks and Wildlife Department (TPWD, unpublished data).

Laguna Madre

Upper Laguna Madre, including the Baffin Bay system, covers 41,014 ha (101,305 acres) of surface area at mean low water (Diener, 1975). The Baffin Bay system consists of Alazan Bay, Cayo del Infiernello, Laguna Salada, and Cayo del Grillo. Lower Laguna Madre, including the South Bay and La Bahia Grande complex, contains 72,642 ha (179,425 acres) of surface area.

Laguna Madre is separated from the Gulf of Mexico by Padre Island. Water transfer is through Brazos Santiago Pass and Port Mansfield Pass to the south and Aransas Pass adjacent to Aransas and Corpus Christi Bay to the north. The area is bisected imperfectly by the Intracoastal Waterway, which is 38 m wide and 3.7 m deep (Diener, 1975). Many spoil banks are along the route of the waterway. The Upper and Lower Laguna Madre are separated by an area of extensive wind tidal flats but are hydrologically connected by the Intracoastal Waterway in the area known as the “Land Cut”.

Average depth of Upper Laguna Madre is 0.9 m (Diener, 1975). In the Baffin Bay system average depths range from 0.2 to 2.3 m. Lower Laguna Madre averages 1.4 m deep. Bottom sediments consist of mud, silt, sand, and quartzose (sand-small rocks). The only natural oyster reefs in Laguna Madre are in South Bay, the southernmost area of the lagoon. However, in Baffin Bay, large areas of ancient serpulid rock reefs exist, some of which still support live serpulid worms.

Laguna Madre contains 101,150 ha (273,105 acres) of emergent vegetation consisting primarily of shoregrass (*Monanthochloe littoralis*), glasswort (*Salicornia bigelovii*), seacoast bluestem (*Schizachyrium scoparium*), seablite (*Suaeda linearis*), sea oat (*Uniola paniculata*), and gulfdune paspalum (*Paspalum monostachyum*) (Diener, 1975). The total area covered by seagrasses in the Laguna Madre system as of 1988 was 73,088 ha (180,527 acres) (Quammen and Onuf, 1993). In the Lower Laguna Madre, seagrasses cover 47,997 ha (118,552 acres) of area, with the dominant species consisting of turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*).

Shoal grass (*Halodule wrightii*), clover grass (*Halophila*), and widgeon grass (*Ruppia maritima*) also occur. The southern end of the Lower Laguna Madre also has isolated stands of mangroves. In the Upper Laguna Madre, seagrasses cover 25,091 ha (61,975 acres). With the exception of turtle grass (*Thalassia testudinum*), the same species are present, with *Halodule* dominant.

No major rivers drain into the Laguna Madre, and freshwater inflow is minimal. However, the watershed of the lower portion of the Lower Laguna Madre produces freshwater inflow into the Laguna Madre via the Arroyo Colorado. Annual precipitation in the Lower Laguna Madre area (Brownsville) averaged 67.6 cm (26.62 in) from 1961 - 1990 (SRCC, 1997). Average annual salinity in Lower Laguna Madre from 1983 to 1996 was 33 ppt with a range from 31-37 ppt; the average annual salinity in Upper Laguna Madre for the same time period was 39 ppt with a range of 24-50 ppt (TPWD, unpublished data).

<u>Corpus Christi Bay</u>

The Corpus Christi Bay system, comprising Redfish, Corpus Christi, Nueces, and Oso Bays, contains 43,288 ha (106,921 acres) of water area at mean low water. Mustang Island separates the estuary from the Gulf of Mexico. Water transfer is through Aransas Pass via the Corpus Christi Ship Channel. In April 1992, as a result of growing concerns about the health and productivity of Corpus Christi Bay, the Texas Coastal Bend Bays of the Laguna Madre (to Kennedy County including Baffin Bay), Corpus Christi Bay, and Aransas Bay were nominated for inclusion in the National Estuary Program. The Corpus Christi Bay National Estuary Program was established in late 1993 to develop a long-term comprehensive conservation and management plan. The plan is expected to be finalized in the summer of 1998 (CCBNEP, 1998).

Average depths in the system range from 0.5 m in Oso Bay to 3 m in Corpus Christi Bay (Diener, 1975). Bottom sediments consist of mud, sand and silt. Approximately 350 ha (840 acres) of oyster reefs are in the area. Major channels include the Intracoastal Waterway and the Aransas channel, dredged to 3.7 m, and the Corpus Christi Ship Channel leading to Aransas Pass, dredged to 13.7 m.

Diener (1975) lists 10,115 ha (24,984 acres) of emergent vegetation consisting of saltwort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*), glasswort (*Salicornia bigelovii*), smooth cordgrass (*Spartina alterniflora*), coastal dropseed (*Sporobolus virginicus*), seablite *(Suaeda linearis*), sea oats (*Uniola paniculata*), salt marsh bulrush (*Scirpus maritimus*), and seacoast bluestem (*Schizachyrium scoparium*). In the Corpus Christi Bay System shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), clover grass (*Halophila*), and widgeon grass (*Ruppia maritima*) are present. Submerged grasses covered about 9,955 ha (2,359 acres) in 1995 in the Corpus Christi, Nueces, and Redfish Bay System. Although *Halodule* is dominant in Corpus Christi and Nueces Bays, *Thalassia* is mostly dominant in Redfish Bay (Pulich et al., 1997).

Freshwater inflow from the Nueces River averaged 378,000 acre-feet/year from 1983-1993 (Asquith et al., 1997). Annual precipitation in Corpus Christi averaged 76.6 cm (30.14 in) 1961 - 1990

(SRCC, 1997). Average annual salinity in Corpus Christi Bay from 1983 to 1996 was 32 ppt, with a range of 26-37 ppt (TPWD, unpublished data).

Aransas Bay

The Aransas Bay complex, which comprises Aransas, Copano, St. Charles, Dunham, Port, Carlos, Mission, and Mesquite Bays, covers approximately 45,257 ha (111,785 acres) (Diener, 1975). It is separated from the Gulf of Mexico by San Jose Island with major water exchange through Aransas Pass and to a lesser extent through Cedar Bayou Pass. Bottom sediments consist of mud, sand, and shell; approximately 340 ha (840 acres) of oyster reefs are in the area (Diener, 1975). Average depth for the system ranges from 0.6 m in Mission Bay to 2.4 m in Aransas Bay. Major channels include the Intracoastal Waterway dredged to 2.4 and 2.7 m and Lydia Ann and Aransas channels.

Emergent vegetation, consisting primarily of saltwort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*)**,** glasswort (*Salicornia bigelovii*), smooth cordgrass (*Spartina alterniflora*), salt meadow cordgrass (S*partina. patens*), and coastal dropseed (*Sporobolus virginicus*), covers about 18,207 ha (44,971 acres) (Diener, 1975). Submerged grasses cover 3,237 ha (7,995 acres) for the Aransas, St. Charles, and Copano Bay System. In Aransas Bay, the dominant species is shoal grass (*Halodule wrightii*), with minor amounts of turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) occurring. Clover grass (*Halophila*), and widgeon grass (*Ruppia maritima*) are also present (Pulich et al., 1997).

The Aransas Bay receives an average annual freshwater inflow of 634,000 acre-feet/ year which includes sheet flow and an average annual flow of 24.8 m^3/s from the Aransas and Mission Rivers, and Copano Creek (Asquith et al., 1997). Annual precipitation in Corpus Christi averaged 77 cm (30.14 in) from 1961 - 1990 (SRCC, 1997). Average annual salinity in Aransas Bay from 1983 to 1996 was 22 ppt, with a range of 11-30 ppt (TPWD, unpublished data).

San Antonio Bay

The San Antonio Bay system, comprising Espiritu Santo, San Antonio, Guadalupe, Hynes, Mesquite, and Ayers Bays and Mission Lake, covers some 55,123 ha (136,154 acres) at mean low water (Diener, 1975). The system is separated from the Gulf of Mexico by Matagorda Island. Water exchange is through Pass Cavallo (located in Matagorda Bay) and to a lesser extent Cedar Bayou Pass (located in Mesquite Bay).

Average depth of unaltered bay bottom is about 1.1 m and substrates generally consist of mud, sand and shell (Diener, 1975). There are approximately 2,913 ha (7,195 acres) of natural oyster reefs in the area. Two major channels are the Intracoastal Waterway, dredged to 3.7 m, and Victoria Barge Channel, dredged to 2.7 m.

Emergent vegetation, covering about 10,115 ha (24,984 acres), consists primarily of smooth cordgrass (*Spartina alterniflora*), seashore saltgrass (*Distichlis spicata),* shoregrass (*Monanthochloe littoralis*) and salt meadow cordgrass (*Spartina patens*) (Diener, 1975). Common reed (*Phragmites* *communis*) has been reported in the upper portion of the region (Matlock and Weaver, 1979). Pulich (in press) listed 4,289 ha (10,594 acres) of submerged grasses for the San Antonio and Espiritu Santo Bay System in 1989, consisting of shoal grass (*Halodule wrightii*), small amounts of clover grass (*Halophila*) and widgeon grass (*Ruppia maritima*), with *Halodule* being dominant.

Major sources of freshwater are the Guadalupe and San Antonio Rivers that provide most of the average annual inflow of 2,344,140 acre-ft, averaged from 1941 - 1987. Annual precipitation over the drainage area varies from 71 cm (28 in) in the western regions of the Guadalupe and San Antonio river basins to 102 cm (40 in) near the Gulf coast (Longley, 1994). Average salinity in San Antonio Bay from 1983 to 1966 was 18 ppt, with a range of 7-26 ppt (TPWD, unpublished data).

<u>Matagorda Bay</u>

The Matagorda Bay system, comprising East Matagorda, West Matagorda, and Lavaca Bays, encompasses an area of 98,921 ha (244,334 acres) at mean low water (Diener, 1975). The bay is separated from the Gulf of Mexico by the Matagorda Peninsula and water exchange is through Pass Cavallo and Matagorda Pass, a manmade ship channel. The Colorado River, which flowed into the Gulf of Mexico prior to its diversion in 1992, formed a delta that divides the bay into Matagorda Bay proper and east Matagorda Bay. Water exchange with the Gulf of Mexico to the eastern portion is through Mitchell's Cut.

The average depth of the Matagorda system is about 2.1 m, and bottom substrate is sand, shell, silt, and clay (Diener, 1975). There are many oyster reefs in the area, but acreage is unknown. The Intracoastal Waterway, dredged to 3.7 m, the Palicum ship channel, dredged to 4.5 m, and the Matagorda ship channel, dredged to 12.2 m, are the major waterways in the area.

Diener (1975) lists 48,552 ha (119,923 acres) of emergent vegetation consisting of smooth cordgrass *(Spartina alterniflora*), salt meadow cordgrass (*S. patens*), saltwort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*), and coastal dropseed (*Sporobolus virginicus*). Submerged vegetation consisting of shoal grass (*Halodule wrightii*), clover grass (*Halophila*), and widgeon grass (*Ruppia maritima*) covers 1,550 ha (3,828 acres) of the Matagorda and East Matagorda Bay System (Pulich, in press).

Primary freshwater inflow into Matagorda Bay is from the Tres Palacios, Carancahua, Lavaca, and Navidad Rivers and averaged 87 m^3/s/yr (Diener, 1975) before the rediversion of the Colorado River into West Matagorda Bay in the 1980s and creation of Lake Texena, and more recently the installation of a water pipeline from Lake Texena to Corpus Christi. Annual precipitation over the drainage area averaged 101 cm (40 in) from 1951 - 1980 (Longley, 1994). Average salinity in Matagorda Bay from 1983 to 1996 was 24 ppt, with a range of 17-31 ppt (TPWD, unpublished data).

Galveston Bay

Galveston Bay contains 155,403 ha (383,845 acres) of water area and is the largest estuary in Texas (Shipley and Kiesling, 1994). The bay is separated from the Gulf of Mexico by Follets Island, Galveston Island and Bolivar Peninsula. One manmade pass (Rollover Pass in East Bay) and two natural passes (San Louis Pass in West Bay and Bolivar Pass in Galveston Bay) connect the estuary with the Gulf. The Trinity River Delta, located at the northeast end of this bay system, is a growing delta and has the potential for marsh creation.

Average depth of the Galveston Bay system, which includes Galveston, Trinity, East, West, Dickinson, Chocolate, Christmas, Bastrop, Dollar, Drum, and Tabbs Bays and Clear, Moses, and Jones Lakes is 2.1 m or less, except in dredged areas (Diener, 1975). The Houston Ship Channel leading from the Gulf of Mexico into Galveston, Texas City, Baytown, and Houston is a 81 km (51 miles) cut dredged to 12.5 m (Shipley and Kiesling, 1994). The Intracoastal Waterway is dredged to 3.7 m through the lower portion of the system. Bay bottom consists of mud, shell, and clay. There are approximately 3,046 ha (7,524 acres) of oyster reefs in the system, and many spoil banks occur along most dredged channels (Diener, 1975).

Emergent marsh vegetation totals 93,624 ha (231,251 acres), consisting of smooth cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*S. patens*), bulrush (*Scirpus maritimus*), shoregrass (*Monanthochloe littoralis*), rush saltwort (*Batis maritima*), and seashore saltgrass (*Distichlis spicata)* (Diener, 1975). Only 113 ha (279 acres) of submerged seagrasses remain in the Galveston Bay System as of 1989, occurring in Christmas Bay and consisting predominantly of shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*). Very small amounts of clover grass (*Halophila*) and turtle grass (*Thalassia testudinum*) are also present in Christmas Bay (Pulich, in press).

For the period 1941 to 1987, the average fresh water inflow to the Galveston Bay system was 10.1 million acre-ft per year (Shipley and Kiesling, 1994). Average annual rainfall at Houston averaged 128 cm (50.59 in) from 1961-1990 (SRCC, 1997). Average annual salinity in Galveston Bay from 1983 to 1996 was 14 ppt, with a range of 10-21 ppt (TPWD, unpublished data).

The Galveston Bay National Estuary Program was established under the Water Quality Act of 1987 to develop a Comprehensive Conservation Management Plan for Galveston Bay. The Galveston Bay Plan was created in 1994 and approved by the Governor of Texas and the Administrator of EPA in March 1995 (Lane, 1994; GBP, 1995).

Sabine Lake

The Texas-Louisiana border divides Sabine Lake which is 21 km long by 13 km wide and contains 22,605 ha (55,834 acres) of surface area at mean low water. The bay is connected to the Gulf of Mexico by Sabine Pass which is 11 km long. Except in dredge areas, water depths average 3.0 m. The bay bottom consists primarily of mud and silt. A few oyster reefs are found in the southern portion. Two spoil disposal sites along the western shore enclose 2,046 ha (5,053 acres) of the bay bottom (Diener, 1975; Jerry Mambretti, TPWD, personal communication).

An average of 326 m^3/s of fresh water flows into the bay annually, primarily from the Sabine and Neches Rivers (Diener, 1975). Rainfall in the area (Beaumont) averaged 142 cm (55.9 in) from 1961-1990 (SRCC, 1997). Average annual salinity in Sabine Lake from 1983-1996 was 6 ppt, and ranged from 2-10 ppt (TPWD, unpublished data).

Marsh vegetation covers 171,955 ha (424,729 acres) in the Texas portion of Sabine Lake. Dominant species are smooth cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*S. patens*), seashore saltgrass (*Distichlis spicata*), rush (*Juncus roemerianus*), and bulrush (*Scirpus olneyi*) (Diener, 1975). The only submerged seagrass recorded for the bay is widgeon grass (*Ruppia maritima*), and acreage is unknown. The western portion of the bay is heavily industrialized, and most of the marsh vegetation is found on the eastern side.

<u>EFH Alterations of Particular Concern (Texas)</u>

Increasing population pressures and industrialization in Texas and the coastal area in particular have altered the estuaries with dredge and fill operations, changes in amount and timing of freshwater inflow, and agricultural, municipal, and industrial runoff. Many marshes in Texas are subject to rapid deterioration as a result of indirect dredging impacts (e.g., salt water intrusion) and human induced subsidence.

Texas has about 1,770 km (1,062 mi) of navigational channels (Lindall and Saloman, 1977). Spoil disposed from these channels has created 35,200 ha (86,944 acres) of fill in the state, and maintenance generates 36.6 million cubic meters of dredged material per year.

Some reservoir construction has changed the timing of freshwater inflow, such as in Sabine Lake, where there has been a reduction in penaeid shrimp production due to changes in water releases from Toledo Bend Reservoir (White and Perret, 1973). There is concern that estuaries will not be afforded an adequate quantity of fresh water, especially during dry years. In addition, potential future interbasin transfer of fresh water could facilitate a change in quantity and timing of freshwater supply to respective estuaries.

Concern also lies with the general trend in conversion of wetlands to open water and barren flats in deltaic wetlands along the Texas coast. Between the mid-1950s and early 1990s, Texas estuarine wetlands decreased about 9.5 percent with an estimated net loss of 24,130 ha (59,600 acres), making the average annual net loss approximately 647 ha (1,600 acres) (Moulton et al., 1997). Besides reservoir development, the cause of this trend includes human-induced subsidence, natural subsidence, global sea-level rise, channelization, and spoil disposal on natural levees (Duke and Kruczynski, 1992).

See Section 6.0 for additional information on natural and man-made threats to essential fish habitat.

4.1.1.2 Louisiana

Description of the Habitat

Coastal Louisiana is predominately a broad marsh indented by shallow bays containing innumerable valuable nursery areas. Total estuarine area in 1970 encompassed more than 2.9 million ha (7.2 million acres), of which over 1.5 million ha (3.9 million acres) was marsh vegetation and more than 1.3 million ha (3.3 million acres) was surface water area (Perret et al., 1971). These waters are generally shallow with over half between zero and 1.8 m in depth. Sediments consist of mud, sand and silt and are very similar across the coast, ranging from coarse near the Gulf and barrier islands to fine in the upper estuaries (Barrett et al., 1971). By 1990, Louisiana had only 1.53 million ha (3.8 million acres) of coastal wetlands, of which only 1.02 million ha (2.5 million acres) were marsh, and only 0.43 million ha (1.0 million acres) were non-fresh marsh (USGS, 1997).

Perret et al. (1971) calculated estuarine dimensions in the Louisiana GMEI from nine study areas. Area 1 (in the upper part of the Pontchartrain Basin) contains the major water bodies of Lakes Maurepas and Pontchartrain with 23,550 and 159,503 ha (58,191 and 394,127 acres) of surface water, respectively. The major water bodies of Area 2 (in the lower part of the Pontchartrain Basin) are Chandeleur Sound (233,918 ha (578,003 acres)) and Lake Borgne (69,357 ha (171,380 acres)). Breton Sound is the major water body of Area 3 (in the Breton Sound Basin) with 79,050 ha (195,330 acres). Area 4 (the Mississippi River Delta Basin) contains the major water bodies of East Bay (19,504 ha (48,195 acres)), Garden Island Bay (5,465 ha (13,504 acres)), the Mississippi River below the Intracoastal Waterway (14,135 ha (34,982 acres)), and West Bay (7,141 ha (17,646 acres)). The major water bodies of Area 5 (in the Barataria Basin) are Barataria Bay (17,625 ha (43,551 acres)), Caminada Bay (5,730 ha (14,158 acres)) and Little Lake (5,216 ha (12,888 acres)). Area 6 (in approximately the eastern half of the Terrebonne Basin) contains the major water bodies of Lake Barre (8,599 ha (21,247 acres)), Lake Raccouri (7,984 ha (19,278 acres)), Terrebonne Bay (20,392 ha (50,388 acres)) and Timbalier Bay (32,260 ha (79,713 acres)). The major water bodies of Area 7 (in approximately the western half of the Terrebonne Basin) are Caillou Bay (10,961 ha (27,085 acres)), Caillou Lake (3,137 ha (7,752 acres)), Four League Bay (8,257 ha (20,402 acres)), Lake Mechant (3,397 ha (8,395 acres)) and Lake Pelto (9,969 ha (24,633 acres)). Area 8 (in the Teche Vermilion and Atchafalaya Basins) includes the major water bodies of Atchafalaya Bay (54,505 ha (134,679 acres)), East Cote Blanche Bay (33,312 ha (82,314 acres)), Vermilion Bay (49,213 ha (121,604 acres)) and West Cote Blanche Bay (36,383 ha (89,902 acres)). The major water bodies of Area 9 (in the Mermentau and Calcasieu Basins) include Calcasieu Lake (17,318 ha (42,792 acres)), Grand Lake (12,842 ha (31,733 acres)), Sabine Lake (22,606 ha (55, 858 acres)) and White Lake (20,902 ha (51,649 acres)).

In general, the descriptive section of the GMEI for Louisiana does not provide specific, quantitative information (e.g., acreage of vegetation and oyster beds) by water body. Rather, such information is presented statewide by vegetative types (for aquatic vegetation), or by parish (for oyster beds). The following summarizes the major, statewide information contained in the area description of Louisiana's GMEI (Perret et al., 1971).

Emergent marsh amounts to more than 1.58 million ha (3.9 million acres) and is made up of four main types: Saline (349,231 ha (862,973 acres)) consists of oystergrass (Spartina alterniflora), glasswort (*Salicornia sp*.), black needlerush (*Juncus roemerianus*), black mangrove (*Avicennia nitida*), saltgrass (*Distichlis spicata*) and saltwort (*Batis marina*); Brackish (487,174 ha (1,203,790 acres)) is made up of wiregrass (*Spartina patens*), threecorner grass (*Scirpus olneyi*) and coco *(Scirpus robustus*); Intermediate (263,288 ha (650,576 acres)) consists of wiregrass (*Spartina patens*), deer pea (*Vigna repens*), bulltongue (*Sagittaria sp*.), wild millet (*Echinochloa walteri*), bullwhip (*Scirpus californicus*) and sawgrass (*Cladium jamaicense*); and, Fresh (482,939 ha (1,193,325 acres)) consists of maiden cane (*Panicum hemitomon*), pennywort (*Hydrocotyle* sp.), pickerelweed (*Pontederia cordata*), alligator weed (*Alternanthera philoxeroides*), bulltongue (*Sagittaria sp*.), and water hyacinth (*Eichhornia crassipes*).

Submerged vegetation occurs along the coastal areas but no acreage figure is available for its range. The GMEI did not attempt to obtain acreage figures for the submerged vegetation because of the small areas in which it occurs. One exception is along the north shore of Lake Pontchartrain where an estimated 8,094 ha (20,000 acres) of widgeon grass and wild celery exist.

Average annual stream discharge is 19,208 m^3/s (678,736 cfs), with more than 90% from the Mississippi and Atchafalaya Rivers. Peak discharge usually occurs in April and May; low flow occurs typically in September and October. During floods, fresh water is carried into the Gulf and into neighboring estuaries resulting in lower salinities.

Live oyster beds amount to more than 53,825 ha (133,000 acres). More than 46,945 ha are private leases with the largest ones being in St. Bernard (14,949 ha (36,939 acres)), Plaquemines (15,239 ha (37,654 acres)) and Terrebonne (8,234 ha (20,347 acres)) Parishes. Some 486 ha (1,200 acres) are public reefs in Cameron Parish and are opened seasonally. The remaining 6,659 ha (16,453 acres) are in the Seed Ground Reservation managed by the state and are in Jefferson, Plaquemines and Terrebonne Parishes.

More than 1,610 km (1,000 mi) of navigation channels designed and/or maintained by the U.S. Army Corps of Engineers are in the estuarine zone. The longest is the GIWW (486 km (302 mi)) from Lake Borgne to the Sabine River. Navigation channels account for nearly all of the more than 10,522 ha (26,000 acres) of fill.

Barrett et al. (1971) provide abundant data on the hydrological aspects of Louisiana's estuaries. In general, the estuaries and near offshore waters are low in salinity and high in nutrients compared with the other Gulf states. High rainfall and large volume of river discharge account for these characteristics. The Mississippi and Atchafalaya Rivers are the main contributors of nutrients to the estuaries and also are responsible for the large dilutions in salinity within the coastal area. See Barrett et al. (1971) for details on the hydrological aspects of Louisiana's estuaries.

EFH Alterations of Particular Concern (Louisiana)

Marsh loss in Louisiana is of particular concern because the marshes are the most extensive in the nation and are believed to be largely responsible for the high production of estuarine-dependent species in the north-central Gulf of Mexico. Area of land-water interface has been described as more important to fishery production than total wetland acreage (Faller, 1979; Gosselink, 1984;

Zimmerman et al., 1984). Turner (1977) related shrimp yield to total acreage of intertidal vegetation present in adjacent estuaries, acknowledging that assessments of total intertidal area may actually have produced indices of the most valuable habitat: marsh "edge". A study of marshes in three Louisiana coastal basins found a parabolic relationship between land-water interface and marsh disintegration. Aggregated simulation data suggested that interface area was approaching maximum, with a steep decline to follow. A significant positive linear relationship was found between brown shrimp catch and interface length over 28 years. These data suggest declining brown shrimp (and other species) harvest in relation to interface decline, beginning as early as 1995 but possibly not until 10-20 years later (Browder et al., 1989). Losses of marshland are occurring through subsidence, erosion, sediment and freshwater deficits, channelization, and rising mean sea level. Aggravating factors arise from management for agriculture, flood control, and wildlife habitat. Pollution from agricultural, municipal, and industrial (including widespread oil and gas production) activities produces additional habitat degradation.

In the Mississippi River Deltaic Plain, major concerns include loss of salt marsh, salt water intrusion, and maintenance of habitat and water quality. Statewide, a significant change in acreage of coastal wetlands occurred between 1956 and 1978, when about 51% of the state's emergent marsh and 59% of forested wetlands were lost. From 1940 to 1980, an estimated 34% of Louisiana marsh was changed to open water with a net wetland loss of approximately 102 k m^2 (39 mi^2) annually (Duke and Kruczynski, 1992). More recent estimates are that losses peaked at 110 km^2/year (42 mi^2/year) in 1970 and have since decreased to about 66 km^2/year (25 mi^2/year) in 1990 (EPA, 1994a).

See Section 6.0 for additional information on threats to EFH.

4.1.1.3 Mississippi

Description of the Habitat

Unless otherwise noted, the following information on Mississippi estuaries was condensed from Christmas (1973) and Eleuterius (1976 a and b) as summarized in GMFMC (1981a).

Mississippi Sound is a system of estuaries adjoining a lagoon. The Sound, separated from the Gulf of Mexico by a chain of barrier islands, acts as a mixing basin for freshwater discharge from rivers and seawater entering through the barrier island passes. The complexity of the system does not readily lend itself to concise hydrological classification. Both north-south and east-west salinity gradients exist in addition to vertical gradients. Overall, positive salinity gradients exist from the mainland seaward and vertically, surface to bottom. In periods of peak river discharge, the water column may be homogeneous.

Seasonally, salinities are lowest in the early spring, rise sporadically through the summer, and peak in the fall. Temperatures follow expected seasonal trends, with lowest averages in January or February and highest averages in July or August. Levels of dissolved oxygen are usually above lethal limits. Temporary oxygen depletion may occur in deep holes and behind sills in river channels. Anoxia, resulting from excessive biological oxygen demand, occurs periodically in waters near heavily populated areas and in waters subject to industrial outfalls. In some years, the presence of Yucatan Loop waters has been detected near the barrier islands. This water mass characterized by high salinity, below average temperature and extremely low levels of dissolved oxygen, may remain in the area through the late summer months and at times penetrate into Mississippi Sound near the Island passes.

The salinity regime of eastern Mississippi Sound is determined largely by the influx of Gulf waters through Petit Bois, Horn, and Dog Keys Passes and the outflow of waters from Mobile Bay, the Pascagoula River, and Biloxi Bay. Water from Mobile Bay appears to exit entirely through Petit Bois Pass; thus, the west branch of the Pascagoula River becomes the major source of freshwater into the Sound. The outflow from this branch moves westwardly along the shoreline to Belle Fountaine Beach where it turns and eventually exits through Dog Key Pass. During periods of high river flow, waters from the Biloxi Bay drainage area join with the outflow from the West Pascagoula River. The discharge from the East Pascagoula River is directed toward the Gulf by dredge spoil deposited along its channel and this spoil disrupts the westerly flow of water in the eastern Sound. A persistent saltwater wedge remains in this channel extending many miles above the river mouth. These waters exhibit a highly stable density structure, and bottom salinity at the mouth of the river can reach 35.0 ppt. Larvae and postlarvae of commercially important fish and shellfish occur routinely in this channel.

The circulation in central Mississippi Sound is greatly influenced by tidal flux through Dog Keys and Ship Island Passes. The primary source of freshwater is St. Louis Bay; saltwater penetration is close to the mainland in this area.

The western end of Mississippi Sound is heavily influenced by drainage from the Pearl River, the Lake Borgne-Lake Pontchartrain complex, and St. Louis Bay. Depressed surface salinity is a natural occurrence for short periods. During periods of high river flow, Ship Island Pass becomes the main passage for the entrance of saltwater into the Sound. Tides in Mississippi Sound are diurnal, with an average range of 46 cm.

The Pascagoula and Pearl Rivers, Bayou Casotte, and Biloxi Bay are the primary sources of nutrients entering Mississippi Sound. Waters adjacent to industrial areas or subject to effluent discharge and associated BOD loadings exhibit greater variability in nutrient levels. Consequently high levels of phosphorus and nitrogen are found in the Bayou Casotte area where fertilizer manufacturing plants are located. Coastwide, there is a general decline in nutrient concentrations from the mainland to the barrier islands and southward into the Gulf (Fred Deegen, MS Dept. Marine Resources, personal communication).

A periodic event that profoundly influences both the level of nutrients and salinity of Mississippi Sound is the opening of the Bonnet Carré Freshwater Diversion structure west of New Orleans, Louisiana. This flood control structure operated by the U.S. Army Corps of Engineers resulted in a discharge rate as high as 7,000 m^3/s (250,000 cfs) from the Mississippi River into neighboring

Lake Pontchartrain and into the Sound during the 1979 spillway opening. The structure has been opened eight times since its construction in 1931.

The effects of the spillway on fisheries is generally thought to be beneficial in the long term as a result of the nutrient influx that accompanies the diverted waters. Short term impacts such as high turbidity levels, increased concentrations of chlorophyll *a*, increased fecal and total coliform counts, high oyster mortalities and temporary displacement of certain stenohaline species have been noted. The sudden influx of nutrient-laden, cold fresh water into the estuarine environment can also adversely impact any species sensitive to abrupt salinity or temperature changes or the emigration of shrimp postlarvae that may coincide with the spillway opening during the spring months

Spillway waters are first diverted from the Mississippi River through the Bonnet Carré structure into Lake Pontchartrain and from there into Lake Borgne and western Mississippi Sound. The Pearl and Pascagoula Rivers empty directly into the Sound while the Jourdan and Wolf Rivers first drain into the Bay of St. Louis and then into the Sound. Similarly, the Biloxi and Tchoutacabouffa Rivers empty into the Back Bay of Biloxi before discharging into the Sound. The combined drainage of all these stream systems totals approximately 51,000 km^2 (Fred Deegen, MS Dept. Marine Resources, personal communication).

The Pearl River, St. Louis Bay, Biloxi Bay and Pascagoula River estuarine systems empty into Mississippi Sound. Combined drainage area from streams and rivers entering the Mississippi estuarine basin is approximately 50,919 $km^{2.}$ The Pearl River and Pascagoula River drainage areas far exceed those of Biloxi and St. Louis Bays. Pascagoula River has a drainage area of 24,346 km^2 with an average discharge of 430 m^3/s. Pearl River drains 22,533 km^2 and has an average discharge of 365 m^3/s. The combined drainage area for rivers emptying into Biloxi and St. Louis Bays is 3,626 km^2 with an average discharge of 79 m^3/s.

Silty clay is the dominant sediment in Mississippi Sound. Coastal bays receive large volumes of sandy, silty-sandy sediments from the surrounding mainland. In addition, these embayments and the Sound proper receive clay-silt sediments from the rivers. Fine sediments are also carried into the Sound via tidal currents from Lake Pontchartrain and Mobile Bay. The central portion of the Sound is composed of silt and clay muds. In some areas these sediments grade into fine and very fine sands. Medium and coarse sands characterize the barrier islands and are also found along the mainland beach west of the Pascagoula River. Medium to coarse sands extend from Round Island in Mississippi Sound to Horn Island.

The shallowness of the Sound (average depth at mean low water is 2 m), and its sediments and wave action are responsible for the turbidity of the water. In most months, nearshore waters are brown in color due to suspended fine sediment in the water column. In periods of peak river flow, these muddy waters may reach and extend beyond the barrier islands.

There were approximately 26,237 ha (64,805 acres) of mainland marsh identified in south Mississippi in 1968, of which 24,853 ha (61,389 acres) were dominated by *Juncus roemerianus* (black needlerush). *Spartina alterniflora* (oyster grass), *Spartina patens* (wiregrass) and *Scirpus* *olneyi (*threecorner grass*)* comprised the remaining acreage. Tidal marsh is most extensive in the Pascagoula and Pearl River areas, with areas of 5,400 ha (13,340 acres) and 3,522 ha (8,700 acres) respectively. Saltmarsh on the barrier islands covered 860 ha (2,126 acres).

Approximately 49,420 ha of submerged vegetation have been identified in Mississippi Sound. Most of the submerged vegetation is near the barrier islands. Discontinuous beds of *Halodule wrightii* (shoal grass), *Thalassia testudinum* (turtle grass) and *Syringodium filiforme* (manatee grass) lie in a belt north of the islands. Stands of benthic algae occur in the western portion of the Sound north and south of Cat Island. Submerged vegetation near the mainland is dominated by widgeon grass (*Ruppia maritima*). Some tape grass (*Vallisneria americana*) is present. Widgeon grass is also found in low salinity ponds and lagoons on Horn and Cat Islands. Shoal grass has been found in sandy substrates east of Pascagoula (Point-aux-Chenes Bay) and near Bayou Caddy in western Mississippi Sound.

<u>EFH Alterations of Particular Concern (Mississippi)</u>

Because 98 percent of Mississippi's commercial seafood species are estuarine dependent and they occupy a diversity of habitats in Mississippi waters, a major concern is with maintenance of the entire estuarine area in a condition that will allow for continued production. Distribution patterns of shrimp and red drum, very important species managed by the Gulf of Mexico Fishery Management Council, show use of Mississippi Sound and associated bays during various phases of their life history (See Section 5.0).

The Mississippi Coastal Zone has been subject to increased developmental pressures in recent years. Approximately 20,188 ha of mainland marshes have been filled for industrial and residential purposes since 1930, but the passage of the Wetlands Protection Act in 1973 has done much to affect a policy of zero wetlands loss in the state. Still, pressures remain to rezone areas in the Bay St. Louis estuary to permit shoreline development (Fred Deegen, MS Dept. Marine Resources, personal communication).

Water quality may be significantly improved by proposed implementation of regional sewage treatment systems that would eliminate many failing or nonfunctional septic systems. The use of rock-reed filters in certain areas of Jackson County has resulted in improved water quality there (Fred Deegen, MS Dept. Marine Resources, personal communication).

The development of the Grand Bay Savannah National Estuarine Research Reserve in Jackson County and the implementation of a Coastal Preserves program by the Department of Marine Resources will also help to stabilize and minimize encroachment into these sensitive estuarine areas. Located in southeastern Jackson County, the Grand Bay National Estuarine Research Reserve is slated for formal designation and incorporation into the National Estuarine Research Reserve System in December 1998. The reserve encompasses approximately 18,000 acres of shallow-water open bay, estuarine subtidal and intertidal marsh, pine-flatwood maritime forest, pine flatwoods and pine savannah habitats. Of this, approximately 10,000 acres are owned by the state and 6,000 acres by the U.S. Fish and Wildlife Service. Plans are underway to acquire the majority of the remaining acreage (Fred Deegen, MS Dept. Marine Resources, personal communication).

Establishment of the Gulf Islands National Seashore has stabilized habitat alteration on and around the offshore barrier islands of Petit Bois, Horn and Ship.

Present methods of dredge spoil disposal in Mississippi Sound should be carefully studied with particular attention to the alteration of flow patterns and the salinity regime. Dredge spoil along banks of the east branch of the Pascagoula River has already altered the westerly flow of water in the Eastern Sound.

A major concern is a decline in the area covered by seagrass in Mississippi Sound. Seagrass area in 1975 was approximately 60% of that found in 1969, and losses are continuing (Duke and Kruczynski, 1992). The Mississippi Department of Marine Resources has funded several studies to help identify the possible causes of seagrass bed declines in Mississippi Sound. Regulations prohibiting any trawling or other commercial fishing activity within one-mile of the barrier islands of Ship, Horn and Petit Bois are directed at minimizing trawl-related impacts to these seagrass beds (Fred Deegen, MS Dept. Marine Resources, personal communication).

See Section 6.0 for additional information on habitat threats.

4.1.1.4 Alabama

Description of Habitat

Crance (1971) divided the Alabama coastal zone into five estuarine systems: Mississippi Sound, Mobile Bay, Mobile Delta, Perdido Bay and Little Lagoon. Combined, these estuaries contain an open-water surface area of 160,809 ha (397,353 acres) plus 14,008 ha (34,614 acres) of tidal marsh. Total acreage of submerged vegetation is unknown, but an estimated 2,024 ha (5,000 acres) are in Mobile Bay. There are some 2,039 ha (5,038 acres) of live oyster beds, with more than 1,214 ha (3,000 acres) of public beds and nearly 809 ha (2,000 acres) in private leases. More than 850 ha (2,100 acres) of estuarine habitat have been filled for various purposes.

Mean tidal range is small, varying from about 0.3 m at the head of Mobile Bay to about 0.5 m at the entrance. Annual mean discharge of gaged streams in the Mobile River system is 1,659 m^3/s (58,636 cfs). Salinity is highly variable, with oceanic levels sometimes occurring at the Gulf passes while fresh water is often present at the upward end of the estuary.

The following brief summary of the major natural features of each estuarine system is from Crance (1971), unless otherwise noted:

Mississippi Sound

The Alabama portion of Mississippi Sound contains 37,516 ha (92,702 acres) of open water with an average depth of about 3 m. Diurnal tidal range varies from 0.3 to 0.5 m. There are 4,760 ha (11,762 acres) of tidal marsh, mostly in Grand and Portersville Bays. The major species are black needlerush (*Juncus roemerianus*), saltmarsh cordgrass (*Spartina alterniflora*), big cordgrass (*S. cynosuroides*), wiregrass (*S. patens*), and saltgrass (*Distichlis spicata*). Patches of shoal grass (*Halodule wrightii*) are present in the northern portion of Portersville Bay.

Mobile Bay

Mobile Bay and its adjoining subareas comprise 107,031 ha (264,470 acres) of open water with an average depth of 3 m. The diurnal tide range varies from 0.3 to 0.5 m. The area has some 229 km (142 miles) of shoreline and 122 km (75.7 miles) of streams. Tidal marsh amounts to 2,519 ha (6,224 acres), most of which is found in the north end of the bay and along Dog, Deer and Fowl Rivers, and along the shorelines of Weeks, Oyster and Bon Secour Bays and Little Point Clear. Major marsh species in the higher salinity areas are black needlerush (*Juncus roemerianus*), saltmarsh cordgrass (*Spartina alterniflora*), and wiregrass (*S. patens*). In the low salinity areas bordering Battleship Parkway, alligator weed (*Alternanthera philoxeroides*) and *Phragmites communis* are more abundant. The major species of submerged vegetation are southern naiad (*Najas guadalupenis*), wild celery (*Vallisneria spiralis*), horned pondweed (*Zannichellia spiralis*), slender pondweed (*Potamogeton pusillus*), and *Nitella spp*. and are found in the northern end of Mobile Bay.

Mobile Delta

The Mobile Delta estuary consists of a series of rivers, shallow bays and a myriad of interconnecting streams and marshes. It has 8,225 ha (20,323 acres) of open water with an average depth of about 3.3 m. The diurnal tide varies from 0.3 to 0.4 m. There are 6,175 ha (15,257 acres) of tidal marsh, 89 km (55.4 miles) of bay shoreline and 337 km (209.2 miles) of streams in the area. Mean stream discharge is 1,659 m^3/s (58,636 cfs). Major marsh grass species are alligator weed (*Alternanthera philoxeroides*), big cordgrass (*Spartina cynosuroides*), *Phragmites communis*, hardstem bullrush (*Scirpus californicus*), and saw grass (*Cladium jamaicense*). Small, unquantified amounts of submerged vegetation (southern naiad (*Najas guadalupenis*), wild celery (*Vallisneria spiralis*), slender pondweed (*Potamogeton pusillus*)) are present. Some reestablishment of widgeon grass (*Ruppia maritima*) has been noted (Doug Fruge, USFWS, personal communication).

Perdido Bay

The Perdido Bay estuarine area is made up of 6,990 ha (17,271 acres) of open water. Average depth is 2.1 m. Diurnal tidal range is 0.2 m. Bay shoreline is 147 km (91.5 miles) long. Tidal marsh grows along 3.2 km (10.4 miles) of the shore and covers 434 ha (1,072 acres). Major marsh species are black needlerush (*Juncus roemerianus*), saltmarsh cordgrass (*Spartina alterniflora*) and big cordgrass (*S. cynosuroides*). The amount of submerged vegetation is unknown.

Little Lagoon

Little Lagoon has 1,047 ha (2,587 acres) of open water with an estimated average depth of 1.2 m. Shoreline is 30 km (18.7 miles) long with 121 ha (299 acres) of tidal marsh. Major marsh species are black needlerush (*Juncus roemerianus*), saltmarsh cordgrass (*Spartina alterniflora*), big cordgrass (*S. cynosuroides*), *Phragmites communis,* and saw grass (*Cladium jamaicense*). The amount of submerged vegetation is unknown.

EFH Alterations of Particular Concern (Alabama)

The entire Alabama estuarine system is important in sustaining viable fisheries in the Gulf of Mexico. Managed species are found in a variety of habitats, including high and low salinity, small and large bays, tidal marshes and open waters, and channelized and natural waterways. Protection programs for each of these habitats are imperative.

Of primary concern is protection of marsh and seagrass. Emergent marsh habitat in Mobile Bay has declined by more than 4,000 ha (10,000 acres), or 35%, between 1955 and 1979 (Duke and Kruczynski, 1992). Half this loss was from commercial and residential development; the remainder apparently was from erosion and/or subsidence. Earlier surveys show a loss of 50% or more of submerged aquatic vegetation.

Despite considerable effort on a local, state and federal level to protect estuarine habitat, nominal losses will occur. Interstate highway and ship channel construction and maintenance have taken productive estuarine habitats under a “National Security” priority. Even with the best efforts to minimize damage, industrial and residential developments in the coastal area, along with their required services and utilities, will continue to encroach upon the estuarine environment.

See Section 6.0 for additional information on habitat threats.

4.1.1.5 Florida

Description of Habitat

McNulty et al. (1972), in conducting the Florida portion of the GMEI, provided a comprehensive description of the natural and man-made features of the estuaries on the Gulf coast of Florida. The report covers some 40 estuarine areas from Perdido Bay at the Florida/Alabama border to Florida Bay. The following coast wide information is from McNulty et al. (1972) unless otherwise noted.

The total area of Florida west coast estuaries is 1,215,440 ha (3,003,312 acres), including open water, tidal marsh and mangroves. Open water amounts to 824,393 ha (2,081,525 acres). Tidal marshes cover 213,895 ha (528,528 acres) and extend northward the full length of the coast, first as a transition zone between mangroves and freshwater marshes, then as the predominant plant community of the north shore of Tampa Bay. Black needlerush (*Juncus roemerianus*) predominates, but several species are locally abundant, among them saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*), seashore saltgrass (*Distichlis spicata*), *Salicornia perennias,* sea-oxeye (*Borrichia frutescens*), *Batis marina, and Limonium carolinianum.* Mangroves occupy 159,112 ha (393,160 acres). The three common mangroves in their order of abundance and zonation landward are the red (*Rhizophora mangle*), black (*Avicennia germinans*) and button wood (*Conocarpus erectus*). A fourth and less abundant species, the white mangrove (*Laguncularia racemosa*), generally grows landward of the black mangrove.

Submerged vegetation covers 210,618 ha (520,431 acres). Shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*) are abundant intertidally, whereas turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and *Halophila ballonis* and star grass (*H. engelmannii*) are found only below low water levels. In most of Florida's estuaries seagrasses penetrate to about 2.1 m, except where water is exceptionally clear as in parts of Pensacola Bay where penetration is about 3.6 m.

There are nearly 5,666 ha (14,000 acres) of live oyster beds (2,074 ha (5,125 acres) in private leases and public beds comprise 3,529 ha (8,719 acres), most of which are in the panhandle estuaries of Apalachicola Bay and St. George Sound. More than 71,066 ha (170,000 acres) of estuarine bottom is closed to shell fishing because of unacceptable levels of coliform bacteria.

Stream discharge in north Florida estuaries is much greater than that in central and south Florida. Mean stream discharge for the west coast is 1,988 m^3/s (70,251 cfs). More than 70 percent of this runoff is from the Apalachicola, Suwannee, Choctawhatchee and Escambia Rivers. The Apalachicola River alone accounts for about 35 percent and the Suwannee River accounts for nearly 15 percent.

Salinity range in the 40 estuarine areas is from zero near the mouths of river discharge to 36 ppt (the approximate salinity of the Gulf's surface water), except in northern Florida Bay and Ten Thousand Islands where hypersaline conditions are common. The upper extreme is 70 ppt in northern Florida Bay which suffers from a diversion of freshwater flow and recurring drought. In some locations between Anclote Key and Cedar Key, offshore springs depress salinity.

Minimum water temperature varies from 13.3º C (56.0º F) at Key West to 4.4º C (39.9º F) at Pensacola. Maximum water temperatures are about the same at all areas sampled, approximately 33.3ºC (91.9º F).

More than 9,150 ha (23,500 acres) of estuarine area have been filled. Most has occurred in the Tampa Bay vicinity. Emergent spoil banks from navigational dredging account for 459 ha (1,135 acres) and causeways account for 1,609 ha (3,977 acres). The remaining (7,450 ha (18,409 acres)) were filled for housing, industry, and other purposes. Additionally, 10,796 ha (26,676 acres) have been drained for mosquito control.

The 40 estuarine areas described by McNulty et al. (1972) are condensed into following major estuarine systems.

<u>Pensacola Bay System</u>

Much of the following description of the Pensacola Bay estuarine system is based upon descriptions of Gallagher (1971), Olinger et al. (1975), and Little and Quick (1976), as summarized in the habitat section of the Council's Draft Groundfish FMP (GMFMC, 1981a). Information is augmented from McNulty et al. (1972), where noted.

The Pensacola Bay system, consisting of Pensacola Bay, Escambia Bay, East Bay, and Santa Rosa Sound, is formed by drowned stream discharge basins. Depth decreases uniformly from 18 m at the mouth of the Bay to shoal depth at Bay headwaters. Fine to coarse sands sometimes mixed with clays are found in shallows near shorelines, but fine alluvial clays cover most of the bay bottom. Salinity varies from zero near headwaters to 30 ppt near the inlet. Low tidal amplitude and frequency, and relatively low river discharge is responsible for the low flushing rate (one complete turnover every 18 days).

According to McNulty et al. (1972), the Pensacola Bay system consists of 51,005 ha (126,032 acres) of open water. Submerged vegetation covers 2,664 ha (6,583 acres), with nearly 70 percent in Santa Rosa Sound. Tidal marsh totals 3,598 ha (8,891 acres), with over half occurring in Escambia Bay. There are more than 162 ha (400 acres) of live oyster beds in Escambia and East Bays, 56 ha (138 acres) of which are under private leases. More than 121 ha (300 acres) of habitat have been filled, about half for causeways and half for housing, industry and other purposes.

Choctawhatchee Bay

The estuary is about 40 km long and from 5 to 9 km wide. The Bay is relatively shallow, no deeper than 9 m in the center. Goldsmith (1966) described three distinct sedimentary areas. The first is around the Bay's periphery to about 800 m offshore and in water no deeper than two meters. The substrate there is a round, medium-grade, quartzose sand. Seagrasses (*Thalassia*, *Ruppia*, *Halodule*) are found in certain portions of this area. The center of the bay is characterized by very fine, clay-size sediment transported to the Bay through the Choctawhatchee River. The third area is in the western portion of the bay where there is a lack of fine sediment cover over reworked quartzose sand sediment. Salinity varies from zero ppt near the Choctawhatchee River delta to about 30 ppt near Destin East Pass, the only outlet to the Gulf. Ritchie (1961), in a three-day survey of the area, noted extreme salinity stratification in the eastern portion of the Bay.

According to McNulty et al. (1972), surface water area is more than 34,800 ha (86,000 acres) Diurnal tidal range is 0.2 m. Mean stream discharge from the Choctawhatchee River is 200 m^3/s (7,073 cfs). Tidal marsh consists of 1,140 ha (2,816 acres). Submerged vegetation amounts to more than 1,214 ha (3,000 acres). Almost all of the nearly 566 ha (1,400 acres) of oyster beds are under private leases. Some 52 ha (128 acres) of habitat have been filled, nearly all for causeways.

St. Andrew Bay

The St. Andrew Bay system consists of four drowned stream basins. Mean depths of St. Andrew, East, North, and West Bays are 5.2, 2.1, 1.7 and 2.0 m, respectively. Waller (1961) described sediments of this area. Like other north Florida estuaries, nearshore areas are predominantly sand with silts and clays found in the center. The sand bottom supports growth of *Thalassia*, *Ruppia*, *Syringodium*, and *Halodule*. Brusher and Ogden (1976) estimated that there were 3,500 hectares of seagrasses in the bay system. Salinity varies greatly (Ichiye and Jones, 1961), but is generally between 18-33 ppt. Futch and Martina (1967) reported that in one instance following 38.1 cm (15 in) of rain in seven days, surface salinity was zero throughout East Bay and half of St. Andrew Bay. During that sampling, there was also extreme stratification.

According to McNulty et al. (1972), the St. Andrew Bay system contains more than 27.900 ha (69,000 acres) of open water. Submerged vegetation amounts to more than 2,000 ha (5,000 acres), with about half of that in St. Andrew Bay. Tidal marsh totals more than 4,200 ha (10,400 acres), with nearly 1,862 ha (4,600 acres) in East Bay alone. Oyster beds amount to only about 57 ha (140 acres), with the majority in East Bay. About 53 ha (130 acres) of estuarine habitat have been filled for causeways and housing.

Apalachicola Bay System

The Apalachicola Bay System, described in detail in Livingston and Joyce (1977), was formed by emergence of barrier islands about 5,000 years B.C. Bottom types consist chiefly of clays transported by the Apalachicola River. Other portions of the bay consist of hard muds that support large oyster reefs. Sparse patches of marine phanerogams occur around the Bay's periphery. Annual cyclic flows of the Apalachicola River are inversely proportional to salinity in the Bay. Salinity ranges from near zero to about 32 ppt. Livingston and Joyce (1977) stressed the importance of the cyclic flow of the river to primary productivity.

Apalachee Bay to Anclote Key

The estuary system between Apalachicola Bay and Anclote Key (just above Tampa Bay) contrasts sharply with the panhandle estuaries described above. There are no upland hills and valleys creating inland bays and there are no barrier islands to impede stream flow to form drowned valleys. Instead, there is an extremely broad zone of fresh and salt water mixing over the continental shelf with a gentle gradient of about 0.4 m per 12.6 km (1.5 feet per mile) offshore. Bottom sediments usually consist of mud and muddy sand. Seagrasses (*Thalassia, Halodule, Syringodium,* and *Ruppia*) extend far offshore, sometimes in depths to 12 m. Salinity is highly variable, but generally ranges between 10 and 30 ppt.

The estuarine system along this stretch of the coast does not conform to the classic definition of an estuary (i.e., it is not semi-enclosed, nor is it separated from a major water body by barrier islands); nevertheless, the nearshore flora and fauna are characteristically estuarine (Comp and Seaman, 1985). Freshwater discharge to this area is from the St. Marks, Suwannee, Waccasassa, Withlacoochee, Crystal, Chassahowitzka, Homosassa, Weeki Wachee, Pithlachascotee, and Anclote Rivers. According to McNulty et al. (1972), the combined open water area of the many estuaries along this stretch of the coast is more than 102,300 ha (253,000 acres). Submerged vegetation covers about half the area with more than 53,420 ha (132,000 acres). Tidal marsh amounts to nearly 75,000 ha (185,000 acres). Mangroves (primarily black), totaling about 4,047 ha (10,000 acres), make their appearance about midway in this area (near Cedar Key) and become more common farther south. There are some 162 ha (400 acres) of oyster beds, primarily in the Suwannee Sound area. About 25 percent are under private leases. This entire area is relatively undeveloped. Thus, habitat lost to fill is small. The exception is in the southernmost section from Bailey's Bluff to Saddle Key, where some 526 ha (1,300 acres) have been filled, primarily for housing.

Tampa Bay Area

Comp and Seaman (1985) provide a good general description of the Tampa Bay system. Tampa Bay is a large Y-shaped estuary consisting of Old Tampa Bay, Hillsborough and McKay Bays, Tampa Bay proper and Boca Ciega Bay. For convenience, we have included Sarasota Bay to the south and St. Joseph Sound to the north. Major rivers discharging into Tampa Bay are the Little Manatee, Alafia, Manatee, Palm and Hillsborough. Flows from the latter three are artificially controlled. Tampa Bay is about 56 km (35 miles) long and about 16 km (10 miles) wide near the mouth. Widely spaced barrier islands front the Tampa Bay system. A well-defined salinity gradient is established by the free exchange and circulation of Gulf water. Lower Tampa Bay contains some seagrasses and about half its eastern shore is dominated by mangrove forests. Mangroves and salt marshes also are found in portions of Old Tampa Bay while much of the remaining shoreline has been developed (Comp and Seaman, 1985).

The Tampa Bay system, plus Sarasota Bay and St. Joseph Sound, encompasses 137,841 ha (340,600 acres) of surface waters, according to McNulty et al. (1972). Diurnal tidal range varies between 0.7 and 0.9 m. Submerged vegetation amounts to more than 14,970 ha (37,000 acres). St. Joseph Sound contains the most, with more than 3,520 ha (8,700 acres), followed by Tampa Bay proper (3,193 ha (7,890 acres)), Sarasota Bay (3,080 ha (7,610 acres)), Old Tampa Bay (2,756 ha (6,809 acres)), Boca Ciega Bay (2,347 ha (5,800 acres)) and Hillsborough Bay (13 ha (383 acres)). Tidal vegetation is dominated by mangroves (red, black and white) with more than 9,025 ha (22,300 acres). About 40 percent of the mangrove area is in Tampa Bay proper (3,602 ha (8,900 acres)), followed by Old Tampa Bay (2,033 ha (5,024)), Sarasota Bay (1,463 ha (3,616 acres)), Boca Ciega Bay (997 ha (2,464 acres)), St. Joseph Sound (510 ha (1,259 acres)) and Hillsborough Bay (436 ha (1,077 acres)). Tidal marsh encompasses 987 ha (2,440 acres). Less than 608 ha (1,500 acres) of scattered oyster beds exist in the Tampa Bay system. More than 5,340 ha (13,200 acres) of estuarine habitat have been filled, primarily for housing development. This accounts for more than half of all fill in the estuaries on Florida's west coast.

Charlotte Harbor System

For purposes of this amendment, the Charlotte Harbor system is described as consisting of Charlotte Harbor, Pine Island Sound, and the Caloosahatchee River estuary. The Caloosahatchee estuary is fed primarily by the artificially controlled flow of the Caloosahatchee River that traverses some 101 km (63 miles) from Lake Okeechobee. To the north is Charlotte Harbor (including Pine Island

Sound), fed by the Peace and Myakka Rivers which drain some 7,770 km^2 (3,000 mi^2). Charlotte Harbor is fronted by many islands and has more than 322 km (200 miles) of shoreline consisting primarily of mangrove forests and salt marshes. This estuarine system is relatively unperturbed and about 30 percent of the bottom is vegetated by a variety of seagrasses (Comp and Seaman, 1985).

According to McNulty et al. (1972), the surface area of this system is more than 89,400 ha (221,000 acres). Diurnal tidal range varies from 0.3 m in the Caloosahatchee River to 0.8 m in Pine Island Sound. There are more than 20,600 ha (51,000 acres) of submerged vegetation that is about equally shared between Charlotte Harbor and Pine Island Sound. Mangroves encompass 18,252 ha (45,100 acres) and are about 2.5 times more prevalent than tidal marsh (7,366 ha (18,200 acres)). More than 80 percent of the approximately 768 ha (1,900 acres) of oyster beds lie within Charlotte Harbor are under private leases. Some 768 ha (1,900 acres) of estuarine habitat have been filled. Most of the fill in the Caloosahatchee estuary and Charlotte Harbor was for housing, whereas most of that in Pine Island Sound was for causeways and emergent spoil banks.

Ten Thousand Islands and Florida Bay

McNulty et al. (1972) inventoried this southernmost estuarine area of Florida as six different GMEI study areas (Florida Bay, Lake Ingraham, Whitewater Bay, Cape Sable to Lostman's River, Lostman's River to Mormon Key, and Mormon Key to Caxambas Pass). For purposes of this amendment the six areas are treated as a single complex because, as presented in Comp and Seaman (1985), the Ten Thousand Islands and Florida Bay area are dominated by innumerable mangrove islands and mangrove forests fronting expansive marshes on the mainland. The systems are interconnected by extensive series of tidal creeks and natural passes whose freshwater source, at least historically, was primarily from sheet flow across the Everglades.

According to McNulty et al. (1972), the surface water area of this estuarine complex encompasses more than 286,100 ha (707,000 acres), nearly 80 percent of which are in Florida Bay. Diurnal tidal range varies from 0.5 m in Florida Bay to 1.4 m in the Cape Sable to Lostman's River area. Submerged vegetation totals nearly 106,840 ha (264,000 acres), 97 percent of which is in Florida Bay. The amount of emergent vegetation is about equally divided between mangroves (117,970 ha (291,500 acres)) and marsh (107,488 ha (265,600 acres)). Approximately two thirds of the tidal marsh and more than 60 percent of the mangroves are in the area north of Cape Sable. Because most of this complex lies within the boundaries of the Everglades National Park, it has not been subjected to the extensive filling for housing and other purposes that estuarine areas farther to the north have experienced. Nevertheless, about 405 ha (1,000 acres) have been filled, primarily for causeway construction.

EFH Alterations of Particular Concern (Florida)

Owing to Florida's continuously large annual population growth, alteration of all of the State's estuarine systems are of particular concern,. Recent studies have shown the remarkable primary productivity potential of estuarine systems. Recent history has also shown their susceptibility to destruction by human activities, usually in direct proportion to population increases. Promises of attractive economic gain associated with demand for waterfront property was largely responsible for the dredge and fill projects of the 1950s and 1960s resulting in loss of thousands of hectares of productive bay bottom. Prime examples are the losses of productive habitats in Tampa Bay, Sarasota Bay, and Charlotte Harbor. Some 44% of the original wetlands bordering Tampa Bay have been lost; in Sarasota Bay, changes in wetland habitat area from 1944 to 1987 include losses of 35% of its grassbeds, 45% of mangrove swamps and 85% of tidal marshes. Wetland changes in Charlotte Harbor from 1945 to 1982 include losses of 29% of its seagrass beds, 51% of salt marshes, and 39% of oyster reefs (Duke and Kruczynski, 1992).

Changes in the Everglades and Florida Bay ecosystems are prime examples of negative changes to estuarine systems resulting from expanding human population. In this case, most of the negative effects are from altering the natural flow and quality of freshwater. Concern has existed for decades that these and other habitat alterations in south Florida would adversely affect fishery resources (Lindall, 1973). Since 1987 a series of changes in Florida Bay have become evident and have included extensive losses of seagrass habitat, diminished water clarity, micro-algae blooms of increasing intensity and duration, and population reductions in economically significant species such as pink shrimp, sponges, lobster, and gamefish (Interagency Working Group on Florida Bay, 1994).

See Section 6.0 for additional information on habitat threats.

4.2 Habitat Types and Distribution: Marine

The marine EFH boundary is seaward of the coastal barrier islands or other lines of demarcation used after Pearcy (1959). This includes all waters and substrates within the U.S. Exclusive Economic Zone seaward of the estuarine EFH boundary. The habitat types located in the marine environment in the Gulf of Mexico are varied. Thriving coral reefs, seagrass meadows, non-vegetated bottom, drowned reefs related to ancient shorelines, manmade structures, salt diapirs, and large rivers influencing water characteristics on the inner continental shelf all contribute to the diversity of the marine habitat in the Gulf of Mexico. This diversity directly influences the species associated with these varying habitat types.

4.2.1 Water

The Gulf of Mexico is a semi-enclosed, oceanic basin connected to the Atlantic Ocean by the Straits of Florida and to the Caribbean Sea by the Yucatan Channel. Although its surface area is more than 160 million ha (395 million ac), it is a small basin by oceanic standards. Most of the oceanic water entering the Gulf flows through the Yucatan Channel, a narrow (160 km wide) and deep (1,650-1,900 m) channel. Water leaves the Gulf through the Straits of Florida, which is about as wide as the Yucatan Channel, but not nearly as deep (about 800 m). This pattern of water movement produces the most pronounced circulation feature in the Gulf of Mexico basin, known as the Loop Current with its associated meanders and intrusions. After passing through the Straits of Florida, the Loop Current merges with other water masses and becomes the Gulf Stream (see Figure 6 for depiction of Gulf currents).

Runoff from precipitation on almost two-thirds of the land area of the U.S. eventually drains into the Gulf of Mexico via the Mississippi River. The combined discharge of the Mississippi and Atchafalaya Rivers alone accounts for more than half the freshwater flow into the Gulf and is a major influence on salinity levels in coastal waters on the Louisiana/Texas continental shelf. The annual freshwater discharge of the Mississippi/Atchafalaya River system represents approximately 10 percent of the water volume of the entire Louisiana/Texas shelf to a depth of 90 m. The Loop Current and Mississippi/Atchafalaya River system, as well as the semipermanent, anticyclonic gyre in the western Gulf, significantly affect oceanographic conditions throughout the Gulf of Mexico.

4.2.1.1 Temperature

The physical characteristics of the Gulf of Mexico have been extensively mapped. Darnell et al. (1983) mapped physical parameters for the northwestern Gulf of Mexico (the Rio Grande River to the Mississippi River). Bottom temperature was mapped for the coldest and warmest months (January and August). During January, the shallowest waters of the central shelf ranged between 12˚ C (54˚ F) and 14˚ C (57˚ F). The temperature increased with depth, with a broad band of warmer water, between 17˚ C (63˚ F) and 19˚ C (66˚ F), across the middle to deeper shelf. However, on the outer shelf off central Louisiana and south Texas, temperatures dropped below 17˚ C (63˚ F), presumably due to the intrusion of cold deeper waters in both areas.

During August, the shallowest waters of the central shelf reached 29˚ C (84˚ F), and bottom water temperatures decreased almost regularly with depth, attaining lows of around 17˚ C (63˚ F) to 18˚ C (64˚ F) toward the outer shelf. Thus, bottom temperatures showed a seasonal range of 15˚ C (27˚ F) or more, but on the outer shelf the seasonal range was only 2˚ C (3.6˚ F) or less. Clearly, the middle to outer shelf waters could provide a haven for nearshore warm water species during the winter months, and for offshore species it is inhabitable the year round.

Darnell and Kleypas (1987) mapped the eastern Gulf of Mexico (Mississippi River to the Florida Keys), following the same protocol as Darnell et al. (1983) in gathering bottom temperature data during January and August. During the months of January, the coldest shelf water (14˚ C (57˚ F)) appeared just off the Mississippi barrier islands. Water colder than 16˚ C (61˚ F) occupied the nearshore shelf out to the 25-m isobath from the Chandeleur Islands to Cape San Blas, Florida, and below that point it extended to the 20-m isobath to northern Tampa Bay. West of DeSoto Canyon all bottom shelf waters were below 18˚ C (64˚ F). However, east of DeSoto Canyon all outer shelf waters exceeded 18˚ C (64˚ F), and the 18˚ C (64˚ F) and 20˚ C (68˚ F) isotherms passed diagonally shoreward across the isobaths so that all shelf waters from just above Charlotte Harbor to the Florida Keys were 18˚ C (64˚ F) or above. The maximum January temperature (22˚ C (72 ˚ F)) was encountered near the southern tip of the Florida shelf at a depth of 60 m to 70 m.

During August, the temperature of the nearshore bottom water ranged from 26˚ C (79˚ F) near Panama City, Florida, to 30˚ C (86˚ F) around Cedar Keys, Florida. Throughout the eastern Gulf shelf, bottom water temperatures decreased with depth. Near the Mississippi River Delta the outer shelf water was 22˚ C (72˚ F), but temperatures down to 16˚ C (61˚ F) were observed along both the eastern and western rims of DeSoto Canyon and at several localized areas along the outer shelf of Florida. For most of the shelf of the Florida peninsula, bottom isotherms paralleled the isobaths.

Seasonal comparisons reveal that nearshore waters for the entire eastern Gulf shelf were 10˚ C (50˚ F) to 15˚ C (59˚ F) warmer in the summer than in the winter. Near the Mississippi River Delta, the bottom waters of the outer shelf were only about 5˚ C (9˚ F) warmer in the summer than during the winter. However around the rim of DeSoto Canyon and along the shelf of Florida, summer temperatures ranged 1˚ C (1.8˚ F) to 4˚ C (39˚ F) colder in the summer than in the winter. This summer temperature depression is due to the intrusion of colder slope water onto the outer shelf during the summer months.

Surface temperatures for the entire Gulf of Mexico (Figure 5) were reported by NOAA (1985). Surface temperatures were measured in January and July. During January, temperatures ranged from 14˚ C (57 ˚ F) to 24˚ C (75 ˚ F). MMS (1997) found surface temperatures in the Gulf of Mexico in January to range from 25˚ C (77 ˚ F) in the Loop current core to 14˚ C (57 ˚ F) to 15˚ C (59 ˚ F) along the shallow northern coastal estuaries. NOAA (1985) found the coldest water along the Louisiana/Texas border on the upper shelf. The warmest was found off the southwestern tip of Florida. Temperatures gradually increased with distance from shore in the entire Gulf. Temperatures also increased southward on the Florida peninsula with temperatures ranging from 16˚ C (61 ˚ F) to 24˚ C (75 ˚ F) north to south.

Surface temperatures in July ranged from 28˚ C (82 ˚ F) to 30˚ C (86 ˚ F). The coolest water was found off the south Texas coast. The warmest water was found off the Mississippi/Alabama coast, the Big Bend area of Florida, and the southern tip of Florida. Temperatures gradually decreased with distance from shore. Surface temperature reported from SEAMAP cruises during July (Donaldson et al., 1997) ranged from 28˚ C (82 ˚ F) to 31˚ C (88 ˚ F). The warmest water was found around the Florida Keys. The coolest water was found off the Big Bend area of Florida, while most of the Gulf had surface temperatures of 29˚ C (84 ˚ F). These temperatures agree closely with MMS (1997) data showing 29˚ C (84 ˚ F) to 30˚ C (86 ˚ F) water throughout the Gulf during August.

4.2.1.2 Salinity

Surface salinities in the Gulf of Mexico vary seasonally. During months of low freshwater input, surface salinities near the coastline range between 29 and 32 ppt (MMS, 1997). High freshwater input conditions during the spring and summer months results in strong horizontal salinity gradients with salinities less than 20 ppt on the inner shelf. The waters in the open Gulf are characterized by salinities between 36.0 and 36.5 ppt (MMS, 1997).

Bottom salinities were measured by Darnell et al. (1983) for the northwestern Gulf during the freshest and most saline months (May and August). During May, all the nearshore waters showed salinity readings of 30 ppt or less, and for all of Louisiana and Texas to about Galveston Bay, salinity of the nearshore water was less than 24 ppt. Water of full marine salinity (36 ppt) covered most of the shelf deeper than 30 m to 40 m. During August the only water of less than 30 ppt was a very narrow band in the nearshore area off central Louisiana. The 36 ppt bottom water reached shoreward to the 20 m to 30 m depth off Louisiana, but in Texas the entire shelf south of Galveston showed full marine salinity. The shallower shelf bottom waters off Louisiana tend to be fresher than those off Texas during both the freshest and most saline months, but the difference is not great, and brackish water extends no deeper than about 30 m. Bottom waters of the mid to outer shelf remain fully marine throughout the year. Thus, it would appear that the freshening influence of the Mississippi and Atchafalaya Rivers is restricted primarily to the surface layers.

In the eastern Gulf, Darnell and Kleypas (1987) found that during May the bottom salinity of the nearshore water varied locally. From Tampa Bay to the Mississippi River Delta the salinity of the nearshore water was 35 ppt or less with a low value of 33 ppt above Cedar Keys and off the coasts of Alabama and Mississippi. The lowest reading (31.5 ppt) occurred just off the Mississippi barrier islands. Below Tampa Bay all nearshore water was 36 ppt except locally off Charlotte Harbor and the Everglades. Bottom water of about 33 ppt characterized the entire shelf off Mississippi and Alabama, and tongues of fresher water extended from the Mississippi River Delta along the outer shelf. Water of full marine salinity covered the margins and head of DeSoto Canyon, and on the Florida shelf it ran diagonally shoreward to Tampa Bay. The highest salinity (36.5 ppt) appeared at mid-shelf above the outer Keys of south Florida.

The same pattern prevailed in August. From Tampa Bay to the Mississippi River Delta the shore water was 35 ppt or less. A pocket of 32 ppt water appeared near Cedar Key, and off most of

Alabama and Mississippi the water was 34 ppt or less. Below Tampa Bay all nearshore water was 36 ppt or greater except for a small extension of slightly fresher water from Charlotte Harbor. The entire shelf off Mississippi and Alabama had bottom water of less than 36 ppt, and tongues of fresher water protruded eastward from the Mississippi River Delta along the middle and outer shelf. Salinities of 36 ppt and above characterized the area around the rim of DeSoto Canyon and, with undulations, ran diagonally shoreward to Tampa Bay. Salinities in excess of 36 ppt appeared at several areas along the outer half of the Florida shelf, and higher salinity water extended across much of the shelf off the Everglades and above the Keys.

The salinity patterns reflect heavier river outflows in the Louisiana, Mississippi, Alabama area especially during the spring, and lower freshwater outflow from the streams of Florida. The patterns also reflect the movement of open Gulf water over the lower half of the Florida shelf and intrusion of slope water around DeSoto Canyon and along the outer shelf of Florida. Freshwater springs occur at several locations on the Florida shelf.

4.2.1.3 Dissolved Oxygen

Dissolved oxygen values in the Gulf of Mexico average about 6.5 ppm, with values averaging about 5 ppm during the summer months (Barnard and Froelich, 1981). Areas of anoxic bottom water have not been reported from the eastern Gulf continental shelf. However, summer hypoxia of bottom water has been noted for Mobile Bay and Tampa Bay. Areas of excessively low bottom oxygen values (less than 2.0 ppm) have long been known to occur off central Louisiana and Texas during periods of stratification in the warmer months. Oxygen deficient conditions occur primarily from April through October and may cover up to 1.82 million ha (4,495,400 ac) during the midsummer with the location and extent varying annually (Rabalais et al., 1997). Hypoxic bottom waters are found in 5 m to 60 m water depth, 5 km to 60 km offshore Louisiana and Texas and extend up to 20 m above the bottom (Rabalais et al., 1991).

The surface layer in the northern Gulf of Mexico shows an oxygen surplus during February through July (Justic et al., 1993). The oxygen maximum that occurs during April and May coincides with the maximum flow of the Mississippi River. The bottom layer, on the contrary, exhibits an oxygen deficit throughout the year. From January to July the oxygen in bottom waters decreases at an average rate of 0.7 ppm per month, and reaches its lowest value in July (Justic et al., 1993). Bottom hypoxia in the northern Gulf of Mexico is most pronounced when the water column is very stable and does not allow mixing to replenish oxygen to deeper water.

4.2.1.4 Turbidity

Surface turbidity in the marine environment in the Gulf of Mexico is limited to the areas affected by the major river systems. The Mississippi/Atchafalaya river system deposits the most sediment and has the greatest effect on surface turbidity in the Gulf. Scruton and Moore (1953) studied the Mississippi River plume and its effects on sedimentation during October, November, and December. They discovered that during the low water season, the amount of sediment in suspension in the surface layer near a pass mouth was around 0.260 g/l. This value decreased by approximately two-thirds within 8 km off the mouth in the main direction of current flow. Outside of the main stream flow within 8 km of the source, the amount of material in suspension was one-twentieth of the value in the pass mouth. High winds blowing over areas of shallow bottom also greatly influence the turbidity. As much as 0.640 g/l of suspended sediment was measured during a storm period where normal values during calm weather and similar low river discharge were no greater than 0.0064 g/l. These values indicate the amount of suspended material that occur and illustrate the great variation that may be found laterally across the plume and with changes in weather conditions.

The long plumes of sediment that extend seaward from the major passes generally remain connected with their source as long as active seaward dissemination of suspended matter is occurring in a specific direction (Scruton and Moore, 1953). When the direction of sediment dispersal is altered, isolated areas of turbidity may persist for a time in the distal part of the decaying plume because of low particle settling velocity. At the outer extremity, the plumes blend with the adjacent water and no longer can be distinguished.

Close inshore the high turbidity from the Mississippi River commonly extends through the entire water column with turbidity maximum occurring at the surface and toward the bottom. Farther offshore where color and intensity of turbidity indicate the amount and average grain size of material in the surface layer have decreased, the subsurface waters are also somewhat turbid, but the difference between the waters above and below may be more visible than inshore. Still farther offshore, the interface below the surface stratum becomes more diffuse as vertical mixing progresses, until a distinction ceases to exist.

Wind and currents are the agents responsible for the observed direction of turbidity distribution. In the inshore areas, river velocity carries the freshwater over the more saline water beneath. Tidal currents modify these original surface currents and, aided by the wind, deliver the turbid water to offshore areas. Turbidity introduced into the Gulf of Mexico by the Mississippi River can be moved by the wind and tides in plumes that may extend 105 km seaward from the delta (Scruton and Moore, 1953). While Scruton and Moore (1953) only dealt with the Mississippi River Delta, the same type of river, tidal, and wind dispersal of turbidity is thought to occur at the other major rivers whose waters are laden with sediment entering the Gulf.

Another type of turbidity is the layer of turbid water commonly found near the bottom. Called nepheloid layers, these turbid waters occur in the north-central and northwestern Gulf of Mexico when the turbulence of the water is high enough to offset the settling of the sedimentary particles under the influence of gravity. The larger the particles, the more intense the turbulence must be to maintain a suspension. Nepheloid layers are therefore usually composed of silt and clay particles, because only the most energetic flows can maintain a sand suspension.

Along the south Texas continental shelf, Shideler (1981) found that the nepheloid layer thickened offshore to a maximum of 35 m near the shelf break and that the concentration of suspended sediment in the nepheloid layer decreased from a maximum near shore to a minimum at the shelf break. The sediment in the nepheloid layer was dominated by inorganic detrital minerals. Shideler (1981) also found that the nepheloid layer was thinner and of smaller areal extent in the fall than in the spring. He concluded that the nepheloid layer is generated and maintained by resuspension of muddy seafloor sediment as a result of bottom turbulence.

Rezak et al. (1985) studied the nepheloid layer on the Louisiana/Texas shelf from 1979 to 1982. Inshore of the 10-m isobath the water was turbid from top to bottom. Offshore of the 10-m isobath, the top 2 to 3 m of water are turbid with a layer of clear water between the bottom nepheloid layer and the top layer of turbid water. The nepheloid layer at the base of the water column up to 50 km offshore was heavily laden with suspended sediment. The nepheloid layer extends across the shelf in a well-mixed bottom layer 10 to 15 m thick, and spills over onto the continental slope. At the shelf break, the nepheloid layer wells up to more than 25 m in thickness. Rezak et al. (1985) concluded that the sediment in the nepheloid layer is kept in suspension over much of the inner shelf by swift currents and turbulence.

The Mississippi/Alabama shelf is very similar to the Louisiana/Texas shelf in that it receives varying amounts of freshwater and silt and clay and has a well-developed nepheloid layer. The west Florida shelf receives little freshwater runoff and little terrigenous sediment. The absence of silt and clay in the sediment provides much clearer water throughout the water column.

4.2.1.5 Other Important Physical Oceanographic Events

As stated earlier, the Loop Current and the Mississippi/Atchafalaya River system significantly affect oceanographic conditions throughout the Gulf of Mexico. Many tropical species from the Caribbean use the warm, highly saline waters of the Loop Current as a means of dispersal into the Gulf basin and the productivity associated with the Mississippi/Atchafalaya River system benefits the many fish species that use the northern Gulf as a nursery ground.

Part of the Loop Current bends to the east after entering the Gulf through the Yucatan Channel and becomes the Florida Current, after leaving the Gulf through the Straits of Florida. Some water flows farther north into the Gulf and then veers to the east to form a clockwise gyre bounded by two or more smaller counterclockwise gyres off West Florida. Some water also turns to the west and contributes to a series of anticyclonic warm eddies which travel west across the Gulf in a process of decay that typically last 4 to 10 months. The Loop Current has an annual cycle of growth and decay, but the variability in patterns from year to year is significant.

When the Loop Current is north of 27° N latitude, a large anticyclonic eddy about 300 km in diameter usually separates. These warm core eddies originate as pinched off northward penetrations of Loop Current meanders. In the following months the eddy migrates westward at about 4 km/day until it reaches the western Gulf shelf where it slowly disintegrates over a span of months. The boundary of the Loop Current and its associated eddies is a dynamic zone with meanders, strong convergences and divergences, that can concentrate planktonic organisms including fish eggs and larvae.

Richards et al. (1993) collected larvae of 100 different fish families and found that two groups were present in Loop Current boundaries. These were oceanic and continental shelf groups. Within the oceanic group were two subgroups formed by typically mesopelagic families such as the marine hatchetfishes, (sternoptychids), and by ocean but epipelagic families such as the man-of-war fishes (nomeids) and lanternbellies (acropomatids). The shelf group was also divided into two subgroups roughly characterized as the demersals (flounders (bothids), lizardfishes (synodontids), and sea basses (serranids)) plus likely epipelagics (leatherjackets (balistids) and herrings (clupeids)), and the epipelagics (jacks (carangids) and mackerels (scombrids)) along with widely dispersing reef species (wrasses (labrids), parrotfishes (scarids), and scorpionfishes (scorpaenids)). Current boundaries and fronts can concentrate zooplankton and larval fish and are an important habitat for a highly diverse assemblage of fish species (Richards et al., 1991).

The same physical and biological phenomena occur in nutrient rich river plumes that extend into the Gulf. The abundance of larval fish around the Mississippi River plume has been well studied (Grimes and Finucane, 1991; Govini et al., 1989). The plume investigated by Grimes and Finucane (1991) was represented by a shallow lens of water with a salinity less than 34 ppt and temperature less than 29˚ C (84 ˚ F) resting atop warmer but more saline (> 34 ppt) shelf water. They encountered three distinct types of water. These included plume water, northern Gulf of Mexico shelf water, and frontal water, a mixture of the two former types. The frontal zone was about 6 to 8 km wide and contained distinctly visible turbidity fronts that were smaller scale (5 to 100 m). They further reported that individual catches of neustonic ichthyoplankton in frontal water were six times higher on average in frontal than in plume waters, the next highest.

Hydrodynamic convergence associated with frontal waters is a local, but powerful, transport mechanism that could aggregate ichthyoplankton. As surface waters converge, driven by horizontal density gradients and additional factors like tide, wind, and river flow, planktonic organisms move with converging water toward the front. Elevated chlorophyll *a* values associated with frontal waters suggest that primary production is also accentuated there. Presumably, high primary production in frontal waters is due to the mixing of nutrient rich, but turbid, plume water (where photosynthesis is light limited) with clear, but nutrient poor, Gulf of Mexico shelf water (where photosynthesis is nutrient limited), creating good phytoplankton growth conditions.

Grimes and Finucane (1991) found anchovies (engraulids), flyingfishes (exocoetids), drums (sciaenids), and mackerels (scombrids) to be among the most frequently caught families in two of the three water masses. Anchovies were especially common at frontal stations representing nearly one-half of all young fish collected. This concentration of anchovies represents an important food resource for young piscivores like king mackerel, *Scomberomorus cavalla*, and Spanish mackerel, *S. maculatus* (Grimes and Finucane, 1991).

Another area of increased primary production occurs on the west Florida shelf each spring (Gilbes et al., 1996). The chlorophyll plume occurs mainly during spring with high pigment concentrations persisting for one to six weeks. The plume extends along 250 km of the west Florida shelf from Cape San Blas toward the Florida Keys along the shelf break (Gilbes et al., 1996). The cause of the chlorophyll plume is undetermined, but Gilbes et al. (1996) suggest that formation may be associated with one or a combination of the following processes. The first is from the discharge of nutrients from small local rivers along the northwest Florida coast. The next possible cause is the circulation of water from deeper Gulf waters to the surface and then southward along the west Florida shelf. This upwelling of nutrients is associated with Loop Current intrusions. The final possible cause is the discharge of the Mississippi and Mobile Rivers. The significance of the yearly spring plankton bloom is that it coincides with reef fish spawning on the west Florida shelf.

4.2.2 Vegetated Bottom and Other Types of Vegetation

Seagrasses and macroalgae have long been recognized as important primary producers in marine habitats (Mann, 1973). They are also known to provide nursery grounds for recreational and commercial fish species and habitat for many larval and adult invertebrates critical to nearshore food chains. Although often considered continuous around the periphery of the Gulf, a combination of low salinity and high turbidity results in only narrow bands or scattered patches from Louisiana to south Texas (Figure 3).

Five species of seagrass are commonly found in the Gulf. They are turtle grass, *Thalassia testudinum*, shoal grass, *Halodule wrightii*, manatee grass, *Syringodium filiforme*, star grass, *Halophila engelmanni*, and paddle grass, *Halophila decipiens* (Iverson and Bittaker, 1985). Widgeon grass, *Ruppia maritima*, is usually not included in lists of true seagrasses but it has been reported for all Gulf states. Turtle grass is the most abundant in the Gulf, while shoal grass predominates in Mississippi and Alabama, and widgeon grass predominates in Louisiana. Light, salinity, temperature, substrate type, and currents are important local factors that affect distributional patterns.

An estimated 1,475,000 ha (3,700,000 ac) of submerged vegetation exist in the estuaries and shallow coastal waters of the Gulf (MMS, 1983). Most (98.5 %) of the seagrass in the Gulf of Mexico is distributed in the shallow bays and estuaries along the coasts of Texas and Florida (MMS, 1983). Florida is the only state with seagrass in the marine environment. Iverson and Bittaker (1985) estimated that 910,000 ha (2,247,700 ac) of seagrass were on the west Florida continental shelf, contiguous estuaries, and embayments. Of this, 300,000 ha (741,000 ac) were in the Big Bend area and 550,000 ha (1,358,500 ac) comprised seagrass beds in Florida Bay. Seagrasses covered 6,904 ha (17,053 ac) around the Dry Tortugas in 1976 (Davis, 1982).

Iverson and Bittaker (1985), studied the Big Bend and Florida Bay areas in Florida and found all five species of seagrass, along with widgeon grass. Macroalgal species of *Caulerpa*, *Udotea*, *Penicillus*, and *Sargassum* were also common in seagrass beds. Shoal grass occasionally formed both the innermost and outermost monospecific stands in the Big Bend area. Shoal grass, paddle grass, and star grass are considered fringing or pioneer species seen around the edges of the major beds. The Big Bend seagrass beds varied from 11 to 35 km wide between St. Marks and Tarpon Springs, Florida. Shallow water shoal grass, often exposed on shoals at low tide, was typically short (5 to 20 cm blade length) with narrow leaves (0.5 to 1 mm), while deep water shoal grass was generally tall (20 to 40 cm blade length) with wide leaves (1 to 3 cm). Shallow water and deep water forms of shoal grass appear to be morphologically different. Shallow areas not exposed on low tides contained mixtures of turtle grass, manatee grass, and shoal grass. Densest portions of the seagrass beds were dominated by turtle grass and manatee grass in various mixtures. Sponges were observed in the middle and near the outer edges of the seagrass beds while macroalgae, sponges, gorgonians, corals, and bryozoans formed communities outside the bed. Star grass was common in the Big Bend area and was often mixed with turtle grass and manatee grass. Star grass was also abundant outside the major seagrass beds to depths of at least 20 m where it occurred in monotypic stands. Paddle grass occasionally occurred in small monotypic stands or mixed with sparse shoal grass or *Caulerpa* in offshore areas deeper than 5 m. Widgeon grass was primarily restricted to low salinity areas such as river mouths of the Econfina and Suwannee Rivers.

Continental Shelf Associates, Inc. and Martel Laboratories, Inc. (1985) also studied the Florida Big Bend region. They found a nearshore, shallow water association of turtle grass, manatee grass, and shoal grass occurring in water depths less than 9 m. These species formed major, dense seagrass beds. Seaward of this association are large areas characterized by overlapping mixtures of algal, seagrass, and live bottom habitats. Farther offshore, there are large areas covered by beds of fringing seagrasses and algae and were visible to an average depth of 12 m. Paddle grass and star grass are the only vascular plants seen in this offshore association and are seen in large mixed or monotypic stands. Attached macroalgae in these beds include several different forms of *Caulerpa sertularioides*, as well as *C. lanuginosa*, *C. mexicana*, *Udotea* sp., *Penicillus* sp., *Halimeda* sp., and *Sargassum* sp.

Continental Shelf Associates, Inc. (1989) studied the southwest Florida shelf and Florida Bay seagrass beds. The southwest Florida shelf area studied included the inner continental shelf from 25° N latitude to Sanibel Island, Florida. They found that at the peak of its growing season paddle grass is virtually ubiquitous across the southwest Florida shelf from a depth of 6.1 m out to 27.4 m. Paddle grass was seen to a depth of 37.2 m and grew most densely in areas of firmly packed sand and silty sand. In areas of coarser substrate, it grew sparsely, and in areas of protruding hardbottom biotas or where sand thinly covered hardbottom, its growth was not abundant. In these areas macroalgal species made a larger contribution to the observed floral density.

The macroalgal component of the southwest Florida paddle grass and macroalgal continental shelf stands is considerably less than that noted in the Big Bend area. Within the offshore seagrass beds between 10.1 and 20.1 m in the Big Bend area, macroalgae accounted for less than 3 percent of the plant density observed. The algal species growing in association with paddle grass were generally the same in both areas, with *Caulerpa sertularioides* being the most abundant, followed by *C. prolifera* and *C. mexicana*. Around the 24.4-m isobath, a deepwater, thin bladed phenotype of *C. prolifera* began to appear. This growth of *C. prolifera* became more abundant with depth and eventually replaced paddle grass completely in waters below 37.2 m.

The seagrass community in the Lower Keys is dominated by turtle grass and manatee grass, ranging from sparse to dense under specific environmental conditions. In areas showing sparse to medium density seagrass coverage, macroalgae make a considerable contribution to the area coverage. This is due to the greater exposure of bare rock and thinner sediments.

Seagrass meadows are often populated by diverse and abundant fish faunas (Zieman and Zieman, 1989). The seagrasses and their attendant epiphytic and benthic fauna and flora provide shelter and food to the fishes in several ways and are used by many species as nursery grounds for juveniles. In Tampa Bay seagrass beds, 23 species of finfish, crab, and shrimp, of major importance in Gulf of Mexico fisheries, were found as immature forms (Sykes and Finucane, 1966). The grass canopy provides shelter for juvenile fish and for small permanent residents. These also can feed on the abundant invertebrate fauna of the seagrass meadows, on the microalgae, on the living seagrasses themselves, or on seagrass detritus. In addition, because of the abundance of smaller fish and large invertebrate predators, such as blue crabs and penaeid shrimp, larger fish in pursuit of prey organisms use the meadows as feeding grounds.

Seasonal resident fish and invertebrates in the grassbeds are those that spend their juvenile or sub-adult stages or their spawning season there. They include the drums (Sciaenidae), porgies (Sparidae), grunts (Pomadasyidae), snappers (Lutjanidae), and mojarras (Gerreidae). Some of these species are also found in residence throughout the year. The most common are the pinfish, *Lagodon rhomboides*, spot, *Leiostomus xanthurus*, and the silver perch, *Bairdiella chrysoura*. Blue crabs, *Callinectes sapidus*, and penaeid shrimp, *Penaeus* spp., are important fishery resources and utilize seagrass beds as juveniles and adults.

The spotted seatrout, *Cynoscion nebulosus*, is associated with seagrass beds during much of the year. Spotted seatrout also spawn in, or adjacent to seagrass beds. Seagrass beds in selected locales are also recognized as important habitat for juvenile red drum, *Sciaenops ocellatus*. Large roaming predators are not normally present, visiting the grass beds to forage only infrequently. Representatives of this group are the tarpon, *Megalops atlanticus*, and the king mackerel, *Scomberomorus cavalla*. Such transient predatory species represent only a small proportion of the biomass present but may be quite important in determining fish community structure.

In areas where seagrass beds are close to coral reefs or limestone outcroppings, an interaction occurs where several families of coral reef fish feed over grass beds at night. Typically, both juveniles and adults form large heterotypic resting schools over prominent coral heads or find shelter in caves and crevices of the reef. At dusk these fish migrate into adjacent seagrass beds and sand flats where they feed on available invertebrates, returning to the reef at dawn. The major groups that shelter on the reef by day and forage into the seagrass beds at night are members of the grunts (Pomadasyidae), snappers (Lutjanidae), and squirrelfishes (Holocentridae).

The distribution of benthic algae is ubiquitous throughout the Gulf of Mexico from bays and estuaries out to depths of 200 m. It is a significant source of food for fish and invertebrates. The wide gently sloping continental shelf, particularly in the eastern Gulf, provides a vast area where benthic species of algae can become established and drift along the bottom and continue to grow even when detached from the substrate. Benthic algae attach to other organisms, such as coral and seagrasses, in relatively shallow coastal areas. Benthic algae also form large mats that drift along the bottom, while some float at the surface. A total of 157 species of marine algae have been identified from areas on the west Florida shelf (Dawes and Van Breedveld, 1969).

The red algae (Rhodophyta) *Acanthophora*, *Agardhiella*, *Gracilaria*, *Hypnea*, and *Laurencia* and the brown algae (Phaeophyta) *Dictyota* and *Sargassum* are often abundant and conspicuous in shallow turbid waters. Other widespread forms include the green algae (Chlorophyta) *Acetabularia*, *Batophora*, *Caulerpa*, *Cladophoropsis*, *Codium*, *Enteromorpha*, *Halimeda*, *Penicillus*, *Udotea*, and *Ulva*, the brown algae *Ectocarpus* and *Padina*, and the red algae *Ceramium*, *Chondria*, *Gelidium*, *Polysiphonia*, and *Spyridia*.

Among the most important genera of algae are *Halimeda*, *Penicillus*, *Caulerpa*, and *Udotea* which are the primary producers of organic carbon. *Halimeda*, *Udotea*, and *Penicillus* also deposit rigid skeletons of calcium carbonate that become a major component of the sediments upon the death of the plant. Production of lime mud by these algae can be enormous (Zieman, 1982). *Halimeda* tends to break into characteristic sand-sized plates, while *Penicillus* produces fine-grained aragonitic mud. In addition, the combination of *Rhipocephalus*, *Udotea*, and *Acetabularia* generates at least as much mud as *Penicillus* in the same location.

Besides the calcareous algae, several species are present in grass beds as large clumps of detached drift algae. The dominant drift algae is *Laurencia*, but others may also be locally abundant. They are *Acanthophora*, *Hypnea*, *Spyridea*, and *Gracilaria*. Rather than floating at the surface like *Sargassum*, these algae roll along the bottom in clumps or long cylindrical windrows, moved along by tidal currents or wind action. Drift algae may be important habitat for fish and invertebrates and have been found to be critical habitat for newly settled juvenile spiny lobsters, *Panulirus argus*, in south Florida (Marx and Herrnkind, 1985).

The *Sargassum* community is a worldwide circumtropical phenomenon comprising a unique and diverse association of organisms (Dooley, 1972). Shrimp and crabs comprise the bulk of the invertebrates and a major source of food for *Sargassum* associated fish. *Sargassum* acts as a vehicle for dispersal of some its inhabitants and maybe important in the life histories of many species of pelagic, littoral, and benthic fish, providing them with a substratum, protection against predation, and concentration of food in the open Gulf (Dooley, 1972). Dooley (1972) found 54 species of fish associated with the *Sargassum* complex and as many as 100 different animal species can be found in the floating *Sargassum* in the Gulf of Mexico (MMS, 1997). These species include mostly hydroids and copepods, but also contain fish, crabs, gastropods, polychaetes, bryozoans, anemones and sea-spiders. The jacks (carangids) were one of the most numerous and diverse groups associated with *Sargassum*. Very young jacks (< 20 mm) were found within the protection of the weed, while the larger jacks were found progressively further below and away from the weed (Dooley, 1972). Large amberjacks, *Seriola dumerili*, dolphin, *Coryphaena hippurus*, and almaco jacks, *S. rivoliana*, are major predators of the *Sargassum* complex. The gray triggerfish, *Balistes capriscus*, is also associated with *Sargassum* (Dooley, 1972).

4.2.3 Non-vegetated Bottom

The Gulf of Mexico can be divided into two major sediment provinces, carbonate to the east of DeSoto Canyon and southward along the Florida coast, and terrigenous to the west of DeSoto Canyon past Louisiana to the Mexican border (Figure 4). The softbottom sediments of the northwestern Gulf shelf represent a complex array of particle size distribution patterns with much local variation. Darnell et al. (1983) tried to establish the more general sediment patterns as one basis for interpreting the shrimp and fish distributions. They mapped surface sediments in terms of the predominant classes of particle size. Sand and mixed sand were considered coarse sediments. Silt and clay were classified as fine sediments.

Coarse sediments make up the very shallow nearshore bottoms from the Rio Grande River to central Louisiana and comprise the dominant bottom type from shore to deeper water throughout the central third of the shelf. Thus, the fine sediments are limited largely to the eastern third of the shelf (which is under the influence of the Mississippi and Atchafalaya Rivers) and the southwestern third (influenced by the present or ancestral Rio Grande River). Fine sediments are also strongly represented on the outer shelf beyond the 80-m isobath. Surface sediments may affect shrimp and fish distributions directly in terms of feeding and burrowing activities or indirectly through food availability, water column turbidity, and related factors.

The continental shelf of the eastern Gulf of Mexico presents a diverse array of surface substrates (Darnell and Kleypas, 1987). The benthic environments vary greatly on a local scale. West of Mobile Bay, fine-grained organic-rich silts and clays of terrestrial origin are brought to the shelf by distributaries of the Mississippi, Pearl and other rivers. These fine sediments spread eastward from the Louisiana marshes to Mobile Bay, but off the Mississippi barrier islands they are interrupted by a band of coarser quartz sand that extends to a depth of about 40 m. Another tongue of fine sediments runs southwestward from the Everglades, extending the full length of the Florida Keys. Here the surface material is a fine carbonate ooze that in the nearshore sector is mixed with some organic material. A third area of fine sediments lies along the eastern flank of DeSoto Canyon. This outer shelf carbonate deposit is a shallow extension of the fine-grained slope sediments.

Coarser surface deposits include quartz sand, carbonate sand, and mixtures of the two, and the carbonate material itself is rich in the fragmented remains of mollusks, sponges, corals, algae, and foraminifera in various proportions, depending upon the locality. Quartz sand predominates in the nearshore environment to a depth of 10 m to 20 m from the Everglades northward along the coast of Florida. However, from below Apalachicola Bay to Mobile Bay it covers the entire shelf out to at least a depth of 120 m, except the immediate eastern flank of DeSoto Canyon. The outer half to two-thirds of the Florida shelf is covered with a veneer of carbonate sand of detrital origin. Between the offshore carbonate and nearshore quartz there lies a band of mixed quartz/carbonate sand.

Sediment type is a major factor in determining the associated fish community (Hildebrand, 1954; Hildebrand, 1955; Chittenden and McEachran, 1976; Darnell et al., 1983). Shrimp distribution closely matches sediment distribution. White shrimp, *Penaeus setiferus*, and brown shrimp, *P.*

aztecus, occupy the terrigenous muds, while pink shrimp, *P. duorarum*, occur on calcareous sediments (Hildebrand, 1954; Hildebrand, 1955; Pattillo et al., 1997). Shrimp have been shown to actively select substrate type (Williams, 1958). Similar sediment associated distribution also has been observed for many demersal fish (Caldwell, 1955; Hildebrand, 1955; Dawson, 1964; Topp and Hoff, 1972).

The carbonate sediments present east of DeSoto Canyon and southward along the west Florida shelf support a distinct fish community (Chittenden and McEachran, 1976). The pink shrimp predominates on calcareous sediments (Hildebrand, 1955; Darcy and Gutherz, 1984; Pattillo et al., 1997). The dominant fish species of the pink shrimp grounds include Atlantic bumper, *Chloroscombrus chrysurus*, silver jenny, *Eucinostomus gula*, sand perch, *Diplectrum formosum*, leopard searobin, *Prionotus scitulus*, fringed flounder, *Etropus crossotus*, pigfish, *Orthopristis chrysoptera*, and dusky flounder, *Syacium papillosum* (Hildebrand, 1955). The bathymetric distribution of pink shrimp in the Gulf of Mexico extends to about 45 m (Hildebrand, 1955; Pattillo et al., 1997).

The terrigenous sediments are divided into two communities. The brown shrimp grounds and the white shrimp grounds support distinct ichthyofauna (Chittenden and McEachran, 1976). The two communities are separated by different bathymetric ranges (3.5-22 m and 22-91 m) based on the shrimp distributions of Hildebrand (1954). The white shrimp ground (3.5-22 m) fishes have a strong affinity for estuaries, while the brown shrimp ground (22-91 m) fishes are independent of estuaries. Chittenden and McEachran (1976) found Atlantic croaker, *Micropogonias undulatus*, to be the dominant species of the white shrimp grounds. The most dominant family was the drums (Sciaenidae) along with representatives from the snake mackerels (Trichiuridae), threadfins (Polynemidae), sea catfishes (Ariidae), herrings (Clupeidae), jacks (Carangidae), butterfishes (Stromateidae), bluefishes (Pomatomidae), and lefteye flounders (Bothidae). The dominant family of the brown shrimp grounds is the porgies (Sparidae), and the longspine porgy, *Stenotomus caprinus*, is the dominant species. Important supporting fauna includes a variety of species from the drums (Sciaenidae), searobins (Triglidae), sea basses (Serranidae), lefteye flounders (Bothidae), lizardfishes (Synodontidae), snappers (Lutjanidae), jacks (Carangidae), butterfishes (Stromateidae), cusk-eels (Ophidiidae), toadfishes (Batrachoididae), batfishes (Ogcocephalidae), scorpionfishes (Scorpaenidae), goatfishes (Mullidae), and puffers (Tetraodontidae) (Hildebrand, 1954; Chittenden and McEachran, 1976).

4.2.4 Irregular Bottom

4.2.4.1 Live Bottom

Live bottoms are defined as those areas that contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, seagrasses, or corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography favoring the accumulation of turtles and fishes. These communities are scattered across the shallow waters of the west Florida Shelf and within restricted regions of the rest of the Gulf of Mexico. The Florida Middle Ground is probably the best known and most biologically developed of these areas with extensive inhabitation by hermatypic corals and related communities. This area is 160 km west-northwest of Tampa. The faunal assemblages of the eastern Gulf are markedly different from those of the rest of the Gulf. This difference is partially attributed to the calcareous sediments found east of DeSoto Canyon as opposed to the terrigeneous muds and sands of the central and western Gulf and the influence of the upwelling associated with the Loop Current.

It has been estimated by Parker et al. (1983) that 4,772,600 ha (11,788,322 ac) of the Gulf of Mexico can be considered reef habitat, although they did not survey areas in the Gulf deeper than 91 m and they also did not include manmade hard structure in their survey. They sampled waters from 18 to 91 m water depth. The largest area of reef habitat was 4,494,600 ha (11,101,662 ac) and was between Key West and Pensacola, Florida, but only in the Florida Middle Grounds did the relief exceed one meter.

4.2.4.1.1 Coral Reefs

Coral reef communities and solitary specimens exist throughout the Gulf of Mexico. This wide distribution places corals in oceanic habitats of corresponding variability, from nearshore environments to continental slopes and canyons, including the intermediate shelf zones. Corals may dominate a habitat (coral reefs), be a significant component (hardbottom), or be individuals within a community characterized by other fauna (solitary corals).

Geologically and ecologically, the range of coral assemblages and habitat types is equally diverse. The coral reefs of shallow, warm waters are typically built upon coralline rock and support a wide array of hermatypic and ahermatypic corals, finfish, invertebrates, plants and microorganisms. Hardbottoms and hard banks, found on a wider bathymetric and geographic scale, often possess high species diversity but may lack hermatypic corals, the supporting coralline structure, or some of the associated biota. In deeper waters, large elongate mounds called deepwater banks, hundreds of meters in length, often support a rich fauna compared with adjacent areas. Lastly are communities including solitary corals. This category often lacks a topographic relief as its substrate, but may use a sandy bottom instead.

Throughout much of the Gulf of Mexico solitary corals are a minor component of the bottom communities. Although these solitary corals contribute benthic relief and habitat to communities throughout the Gulf of Mexico, they apparently comprise a minor percentage of the total coral stocks in the Gulf of Mexico.

Hardbottoms constitute a group of communities characterized by a thin veneer of live corals and other biota overlying assorted sediment types. Hardbottoms on banks are topographic highs or salt domes created by geologic uplifting. They have vertical relief measured in tens of meters. Hardbottoms are usually of low relief and on the continental shelf. Many are associated with relict reefs where the coral veneer is supported by dead corals.

Ecologically and geologically, hardbottoms and hard banks are two diverse categories. Both habitats include corals but typically not the carbonate structure of a patch or outer bank coral reef nor the lithified rock of lithoherms, a type of deepwater bank. Diverse biotic zonation patterns have evolved in many of these communities because of their geologic structure and geographic location.

The biological categorization of the banks by Rezek et al. (1985) involved first the recognition of a number of distinct benthic biotic zones characteristic of these banks, and second, the depth range of each biotic zone on each bank. Seven characteristic biotic zones were identified and classified within four general categories based on the degree of reef building and primary productivity.

1. Zones of Major Reef Building Activity and Primary Production.

I. *Diploria-Montastrea-Porites* Zone: This zone is characterized by living, high diversity coral reefs with hermatypic corals dominating. The corals include *Diploria strigosa, Montastrea annularis, M. cavernosa, Porites astreoides, P. furcata, Colpophyllia natans, C. amaranthus, Siderastrea siderea, Madracis decactis, Stephanocoenia asperula, Agaricia agaricites, A. fragilis, Helioseris cucullata, Mussa angulosa, Scolymia cubensis, Paracyathus sp.*, and *Millepora alcicornis*. Coralline algae are abundant while leafy algae are limited.

II. *Madracis* and Leafy Algae Zone: The *Madracis* zone is dominated by the small branching coral *Madracis mirabilis*, which produces large amounts of carbonate sediment. In places, large populations of leafy algae dominate the *Madracis* rubble substrate.

III. *Stephanocoenia-Millepora* Zone: This is a zone consisting of living, low diversity coral reefs with hermatypic corals dominating. The species known to occur are *Stephanocoenia michelini, Millepora alcicornis, Agaricia sp., Siderastrea siderea, Porites astreoides, Colpophyllia sp. Diploria strigosa, Montastrea annularis, M. cavernosa, Mussa angulosa, and Scolymia sp.* Coralline algae are abundant and leafy algae are limited.

IV. Algal-Sponge Zone: This is a zone dominated by crustose coralline algae actively producing large quantities of carbonate substrate, including algal nodules. The zone extends downward, past the depth at which algal nodules diminish in abundance, to the greatest depth at which coralline algal crusts are known to cover a substantial portion of the substrate. This is the largest of the reef building zones in terms of area of sea bottom. Corals reported from the Algal-Sponge Zone include *Agaricia agaricites, Helioseris cucullata, Madracis mirabilis, M. formosa, M. myriaster, Montastrea cavernosa, Millepora alcicornis,* and possibly *Agaricia fragilis*. Leafy algae are very abundant.

2. Zone of Minor Reef Building Activity.

V. *Millepora*-Sponge Zone: Crusts of the hydrozoan coral *Millepora* share the tops of siltstone, claystone, or sandstone outcrops with sponges and other epifauna. Isolated scleractinian coral heads may be present, but are rare and coralline algae are rare.

3. Transitional Zones (reef building activity may range from minor to negligible).

VI. Antipatharian Zone: Limited crusts of coralline algae and several species of coral exist within a zone typified by sizeable populations of antipatharian corals (mostly *Cirripathes*). Banks supporting Algal-Sponge Zones generally possess something comparable to an Antipatharian Zone as a transition between the Algal-Sponge Zone and the deeper, turbid-water, Nepheloid Zone of the lower bank.

4. Zone of No Reef Building Activity

VII. Nepheloid Zone: In this zone high turbidity, sedimentation, resuspension of sediments, and resedimentation dominate. Rocks and drowned reefs here are generally covered with veneers of fine sediment. Epifauna are depauperate and variable. Deep water octocorals and solitary stony corals are often conspicuous. This zone occurs in some form on lower parts of all banks below the depths of the Antipatharian Transitional Zones.

The Florida Middle Ground is the best known and most important area on the west coast of Florida in terms of coral communities. This region is a 153,600 ha (379,392 ac) hardbottom area 160 km west-northwest of Tampa, Florida. The Florida Middle Ground is characterized by steep profile limestone escarpments and knolls rising 10 to 13 m above the surrounding sand and sand-shell substrate, with overall depths varying from 26 to 48 m (Smith, 1976).

At present, live corals contribute little to the configuration of the area (Smith, 1976), so that the area has been described as a hardbottom rather than a coral reef. The hydrozoan coral *Millepora alcicornis* forms massive colonies along the rocky margins at about 27 m depth (Hopkins et al., 1977). *Millepora alcicornis* is the major contributor to frame building on the Florida Middle Ground. The dominant scleractinians in the Florida Middle Ground include *Madracis decactis*, *Porites divaricata*, *Dichocoenia stellaris*, *D. stokesii*, and *Scolymia lacera*. Octocorals, a relatively minor component of other Gulf reefs, are prominent on the Florida Middle Ground. Dominant forms of octocorals include *Muricea elongata*, *Muricea laxa*, *Eunicea calyculata*, and *Plexaura flexuosa*.

A species zonation pattern exists on the Florida Middle Ground with overlap between adjacent zones. Grimm and Hopkins (1977) describe a *Muricea-Dichocoenia-Porites* zone at 26 to 28 m. From 28 to 30 m the dominant forms are *Dichocoenia* and *Madracis*. *Millepora* dominates from 30 to 31 m but becomes codominant with *Madracis* from 31 to 36 m.

Coral reefs also exist in areas surrounding the Dry Tortugas, an island group about 117 km west of Key West, Florida. The Dry Tortugas reefs form an elliptical atoll-like structure about 27 km long by 12 km wide. Living coral reefs occupied less than 4 percent (4,831 ha (11,933 ac) of the bottom above the 18-m line at the Dry Tortugas in 1976 (Davis, 1982). The most extensive reef type coral was staghorn coral, *Acropora cervicornis*. It covered a total of 478 ha (1,181 ac), and accounted for 55 percent of the scleractinian coral cover. Nearly half the staghorn reef type was concentrated in a single 220 ha (543 ac) reef. This reef was at depths of 6 to 14 m in an area of strong tidal currents. Coral head buttresses occupied a total 251 ha (620 ac). While they occupied only 1.1 percent of the bottom, they provided shelter for large concentrations of fishes, spiny lobster, *Panulirus argus*, and echinoderms near seagrass and octocoral foraging areas, which made them critical elements of the Dry Tortugas system (Davis, 1982). The bank reef area accounted for 137 ha (338 ac) of the coral reef hardbottom.

On the shallow flats between the outer reefs and the lagoonal grassbeds, a hardbottom community of exposed limestone dominated by octocorals occupied 3,965 ha (9,794 ac) (Davis, 1982). On the shallowest portions of the southeastern sides of the major banks, small algal communities occupied a total of 114 ha (282 ac).

Jaap et al. (1989) studied Bird Key Reef in the Dry Tortugas, recording 45 species of stony corals. They found the shallow reef crest to be formed of coral rubble encrusted with coralline algae. Small eurytopic coral species in this zone included *Millepora alcicornis*, *Porites astreoides*, *Siderastrea radians*, *Favia fragum*, and *Diploria clivosa*. These species occur more frequently as depth increases. From 100 to 250 m seaward, the sea floor is a mosaic of low relief, limestone outcroppings interspersed with carbonate sediments. The limestone outcroppings support a diverse assemblage of sessile reef organisms, and octocorals dominated the inshore portion of the area. *Millepora alcicornis*, *Porites astreoides*, *Siderastrea radians*, *Favia fragum*, and *Diploria clivosa* are common. As depth increases, *Acropora cervicornis, Siderastrea siderea*, and *Montastrea annularis*, all components of the deeper reef habitat, occur frequently. A spur and groove formation begins at approximately 9.4 m.

The East and West Flower Garden Banks are located on the outer edge of the continental shelf, approximately 193 km and 172 km southeast of Galveston, Texas. The banks are topographic prominences of bedrock uplifted by the underlying salt diapirs. The bedrock is capped with a relatively thin layer of calcareous reef building organisms. The Flower Gardens are the two largest of more than 130 calcareous banks charted in the northwest Gulf of Mexico that exhibit topographic elevation above an otherwise smooth continental shelf (Bright et al., 1985).

The East Flower Garden Bank is pear shaped and covers an area of approximately 6,700 ha (16,500 ac) (Rezak et al., 1985). Topographic relief is pronounced on the east and south sides of the bank and gentle on the west and north sides. The shallowest depth on the bank is approximately 20 m and surrounding water depths range from approximately 100 to 120 m.

The West Flower Garden Bank lies 12 km west of the East Flower Garden Bank and is characterized by three main crests separated by grabens that are aligned parallel to the long axis of the underlying diapiric core. The bank covers an area of approximately 13,700 ha. The shallowest depth on the West Flower Garden Bank is approximately 15 m. Surrounding water depths vary from 100 to 150 m.

The Flower Garden Banks are considered near the northern physiological limits for tropical hermatypic corals in the Gulf of Mexico and are the northernmost thriving tropical coral reefs on the North American continental shelf (Rezak et al., 1985). The banks are not considered diverse and only 18 of the 65 western Atlantic hermatypic coral species occur on the Flower Garden Banks (Gittings et al., 1992a). The presence and extent of reef building activity on the Flower Garden Banks is due to favorable conditions of substrate, water depth, temperature, salinity, and water clarity.

Biotic zonation at the Flower Garden Banks is distinct and depth related. The Flower Garden Banks have six of the seven biotic zones described by Rezak et al. (1985). The *Diploria-Montastrea-Porites* Zone extends from 15 to 36 m. This high diversity zone is dominated by scleractinian corals and hydrozoans. This zone is platform-like with broad tops composed of primarily hard substratum formed by hermatypic corals (85%), carbonate sand, and gravel. Coral reefs within this zone are typically made up of closely spaced, massive coral colonies, or heads, up to 3 m in diameter and height. Crustose coralline algae are abundant within this zone, covering approximately 15 to 20 percent of the hard substratum, and contribute substantial calcium carbonate to the reef substratum and sediments. A total of 253 species of reef invertebrates and 103 reef fish were reported by Bright and Pequegnat (1974) from this zone on the West Flower Garden Bank.

The *Stephanocoenia-Millepora* Zone is a narrow and relatively low diversity zone on both banks which ranges from approximately 36 to 46 m, with components to 52 m. This zone comprises 12 species of hermatypic scleractinian corals. Crustose coralline algae cover equals or exceeds that of the corals in this zone, but the basic reef substratum is coral.

Two minor zones, the Leafy Algae Zone and the *Madracis* Zone are located intermittently on the peripheral parts of the East Flower Garden Bank between 28 and 46 m depth. These zones exist on large knolls of thick deposits of skeletal remains of the thin, branching coral *Madracis mirabilis*. These knolls of coral gravel support thriving populations of leafy algae (Leafy Algae Zone) or living *Madracis mirabilis* (*Madracis* Zone). The Leafy Algae Zone has not been documented on West Flower Garden Bank.

Hermatypic coral abundance decreases with increasing depth, leading to virtual dominance by coralline algae. The Algal-Sponge Zone ranges from 46 to 88 m and includes an upper carbonate sand/rubble transition zone and a broad platform covered with sand, rubble, rhodoliths, and partly drowned reef structures. The relict reef structures are predominately covered with living crusts of coralline algae and occasional veneers and heads of several species of hermatypic corals. Deep water octocorals and several species of sponges are abundant. Numerous species of fish, mobile and sessile invertebrates, and plants also commonly occur within the Algal-Sponge Zone.

The Antipatharian Zone constitutes a transition zone between shallow water and deep water assemblages on both banks and ranges from 52 m to more than 90 m in depth within the Algal-Sponge Zone. This zone is characterized by the presence and abundance of white, loosely coiled antipatharians.

In the Nepheloid Zone, sediments change from coarse carbonate sand, mixed with an abundance of nonliving foraminifera tests, to fine silt to clay sized particles that are easily and commonly resuspended in the water column at depths below 88 m. Sponges, deep water octocorals, comatulid crinoids, and ahermatypic scleractinian corals are present. A number of fish species are typically associated with this zone.

A deepwater reef in the Gulf of Mexico was discovered in the 1950s approximately 74 km east of the Mississippi River Delta (Moore and Bullis, 1960). This reef was largely composed of *Lophelia prolifera* in water depths of 420-512 m. The largest portion of the reef is about 55 m thick and over 305 m long. Two smaller portions are over 100 m across and up to 18 m thick. The entire reef is more than 1,200 m in length across the transect sampled by Moore and Bullis (1960).

Corals inhabiting other regions in the Gulf are described in Sections 4.2.4.2.2 - 4.2.4.2.5.

4.2.4.1.2 Artificial Reefs

Two types of artificial reefs exist in the Gulf of Mexico, those structures intentionally placed in the water to serve as artificial reefs and those structures placed in the water to serve another purpose (oil and gas production) but still providing artificial habitat. Artificial reefs have been used to enhance fishing success in the Gulf of Mexico for many years. When the National Fishing Enhancement Act of 1984 was passed, serious attention was given to artificial reefs as fishery habitat enhancements. Currently, Texas, Louisiana, and Florida operate under legislative or agency sanctioned artificial reef plans. Alabama has established criteria for the placement of materials in their large general permit areas, but lacks a comprehensive plan. Mississippi has not yet adopted a state plan.

Florida has more than 587 sites permitted for artificial reefs on their west coast (Figure 7). Florida has several large general permit areas with one permit for 28,500 ha (70,395 ac). The total area permitted for artificial reefs on the west coast of Florida is 153,400 ha (378,898 ac). Historic materials used on Florida artificial reef sites have been ships, concrete rubble, oil platforms, reef modules, barges, tires, bridge spans, boxcars, car bodies, fiberglass boat molds, buses, obsolete military tanks, and airplanes. These materials are in water depths of 2 to 117 m and provide up to 27 m of relief at some sites. The reef sites off Florida vary in distance offshore, with some being near the beach while the furthest is located 87 km offshore.

Alabama was the first state in the nation to organize an artificial reef program. Several reef sites exist in waters off Alabama along with five general permit areas. Over 310,800 ha (768,000 ac) have been approved for the general permitting of artificial reefs in Alabama. Alabama allows fishermen to deploy their own materials in the general permit areas. Past materials used to form artificial reefs off Alabama have been vessels, concrete rubble, boxcars, oil platforms, obsolete military tanks, fire trucks, airplanes, car bodies, barges, oyster shells, and rock. The reef sites are in waters up to 841 m in depth and are located up to 90 km offshore.

Mississippi has 35 sites permitted for artificial reefs in their coastal and offshore waters. Past materials used in the Mississippi artificial reef sites have been Liberty ships, concrete, barges, reef modules, shells, crushed limestone, and tires. Over 4,300 ha (10,700 ac) has been permitted for artificial reefs. The artificial reef sites are in water depths of 1 to 44 m, provide relief up to 9 m, and are located up to 93 km offshore.

Louisiana has 32 sites permitted for artificial reefs in their inshore and offshore waters. The artificial reefs off Louisiana are composed of over 60 oil platforms, oyster shells, and 40 armored personnel carriers. Over 3,400 ha (8,400 ac) have been permitted for artificial reefs in Louisiana. The sites are in water depths of 3 to 105 m of water, provide relief up to 80 m, and are located up to 207 km offshore.

Texas has 30 sites encompassing over 900 ha (2,230 ac) permitted for artificial reefs in inshore and offshore waters. Past reef materials used have been oil platforms, concrete culverts, concrete reef modules, fly ash and granite blocks, car bodies, vessels, and Liberty ships. The sites are in water depths of 10 to 163 m, provide relief of 1.5 to 64 m, and are located 10 to 191 km offshore.

The second type of artificial reef in the Gulf of Mexico is comprised of the structures placed in Gulf waters to serve another purpose and serve secondarily as artificial reefs. Oil and gas structures are the most prominent of this type. More than 4,500 oil and gas structures are in state and federal waters in the Gulf of Mexico (Figure 7b). Most are off the coast of Louisiana.

When petroleum platforms are installed in marine waters, they are rapidly colonized by a diverse array of microorganisms, algae, and sessile invertebrates including shelled forms (barnacles, oysters, and mussels), as well as soft corals (bryozoans, hydroids, sponges, and octocorals) and hard corals (encrusting, colonial forms). The organisms that attach and grow on the structures provide habitat and food for many motile invertebrates and fishes. Collectively, the sessile forms, in conjunction with the dependent motile forms, comprise the biofouling community.

These petroleum platforms provide an increase in the hardbottom area in the north-central Gulf of Mexico. Gallaway (1980) estimated that a major platform in one Texas oil and gas field in 20 m of water provided about 3,800 m^2 of hard substrate. Shinn (1974) estimated that a typical platform in water 30 m deep provides about 8,173 m^2 of hard substrate. If we assume that the average water depth for all structures is 30 m and assume each platform provides 8,173 m^2 of hard substrate, then petroleum platforms provide an increase of approximately 3,700 ha (9,139 ac) of hard substrate. This represents an increase of 1.3 percent of the total reef habitat (278,000 ha (686,660 ac)) calculated by Parker et al. (1983) from Pensacola, Florida to the Mexican border in 18 to 91 m of water.

Gallaway et al. (1981) determined that three distinctive platform faunal groupings were present on offshore platforms. These were coastal, offshore, and bluewater assemblages. The approximate depth boundaries for the assemblages were from the beach to the 30-m depth contour for the coastal assemblage, between the 30- and 60-m depth contours for the offshore assemblage, and beyond the

60-m isobath for the bluewater assemblage. The location and composition of these assemblages are influenced by a number of environmental factors. These are the distribution of turbid water layers, seasonal extremes of temperature, salinity, and dissolved oxygen, primary productivity of the surrounding water column, and the degree and extent that the platforms are exposed to Caribbean water masses.

The coastal platform assemblage is dominated from the surface to about 8 m by the small acorn barnacles *Balanus amphitrite* and *B. improvisus*. The barnacles are covered by a mat of bryozoans, hydroids, macroalgae, and encrusting sponges. The macroalgal component of the mat is restricted to zones near the surface (1-6 m) where growths may be luxuriant or sparse, depending largely upon turbidity and season. Oysters, *Crassostrea virginica*, are usually present but seldom abundant except in the protected areas of the angles and joints of the platforms. Hydroids dominate the near bottom area. Although xanthid crabs and blennies are present, the motile epifauna consists mainly of small crustaceans, particularly amphipods.

The offshore platform assemblage is characterized by a near surface area containing luxuriant growths of red and green algae and the tree oyster, *Isognomon bicolor*, is often present in high densities. The bivalve, *Chama macerophylla*, is also typically biomass dominant to a depth of 20 m. The octocorals (*Telesto* sp.), solitary hard corals (*Astrangia* sp. and *Phyllangia* sp.), and various hydroids and bryozoans also occur. Below 20 m depths, colonial forms such as anemones, ascidians, and encrusting sponges predominate. A marked drop in biomass levels of sessile epifauna occurs between 20 and 30 m depths. Biomass in the upper 20 m of the water column ranges from 8 to 11 kg/m^2, and usually around 2 kg/m^2 below 20 m levels. The sessile epifauna consists of microcrustaceans, arrow crabs, large blennies, oyster drills, sea urchins, and stone crabs are abundant. Bright et al. (1991) reported the occurrence of the hermatypic corals *Diploria* sp., *Porites astreoides*, *Madracis decactis*, *M. asperula*, and *Millepora alcicornis* at various depths on some offshore platforms (Bright et al., 1991).

The biofouling biomass on bluewater platforms is probably low, with a range of 1-5 kg/m^2 (Gallaway and Lewbel, 1982). The bluewater assemblage is distinguished by the dominance of tropical reef forms in the fish community. Creole-fish, *Paranthias furcifer*, creole wrasse, *Clepticus parrai*, and Spanish hogfish, *Bodianus rufus*, are possibly the dominant platform associated fish, while Atlantic spadefish, *Chaetodipterus faber*, and sheepshead, *Archosargus probatocephalus*, are typically absent. Tropical invertebrates, such as spiny lobster, *Panulirus argus*, are also members of the platform associated fauna (Pattillo et al, 1997). The bluewater biofouling assemblage is marked by low biomass. Algae and stalked barnacles are abundant at the surface, and pelecypods are abundant at greater depths. The encrusting mat only sparsely covers the platforms.

Petroleum platforms in the northwestern Gulf of Mexico serve as aggregation points for fish representing many species. The cause of this attraction and the degree of permanence at particular structures vary depending upon the ecological role of the species in question, as well as environmental conditions. The fish can generally be classified as either transient or resident. Within the resident community, two groupings can be made. The first are species directly dependent upon the biofouling community for food or cover, and those that appear attracted to the structures mainly for cover alone, exhibiting little or almost no trophic dependence on the biofouling community. Fish that are trophically independent of platforms are often responsible for most of the fish biomass around production platforms (Gallaway and Lewbel, 1982). Atlantic spadefish, *Chaetodipterus faber*, lookdown, *Selene vomer*, Atlantic moonfish, *Selene setapinnis*, and the creole-fish, *Paranthias furcifer,* all occupy a similar trophically independent niche and comprise high biomass around production platforms.

Resident benthic species around production platforms that also appear mainly trophically independent of the biofouling community include such fish as the red snapper, *Lutjanus campechanus*. Red snapper are extremely habitat faithful, and population levels have been observed as high as 7,000 individuals around major platforms (Gallaway and Martin, 1980). This species is trophically linked to the surrounding soft bottom motile epifauna, preying mainly upon shrimp, swimming crabs, and fish. Red snapper feed at night over soft bottoms away from the platforms, returning to the reef during the day for cover. Other species having a similar trophic mode include large tomtate, *Haemulon aurolineatum,* and some large groupers.

Resident species that appear trophically dependent upon the biofouling community for food or cover include small cryptic forms such as blennies (Blenniidae), as well as large grazers (sheepshead, *Archosargus probatocephalus*) and small grazers (butterflyfishes, Chaetodontidae). Sheepshead are extremely habitat faithful, with population levels proportional to the submerged area of structure. Normal density of sheepshead was estimated to be about 0.3 fish/m^2 of submerged platform substrate (Gallaway and Lewbel, 1982).

With the exception of barracuda, *Sphyraena barracuda*, almaco jack, *Seriola rivoliana*, hammerhead sharks, *Sphryna* spp., and cobia, *Rachycentron canadum*, most of the large predators around petroleum platforms do not appear to be residents, but rather are believed to be highly transient. The above listed, along with the bluefish, *Pomatomus saltatrix*, are either known or expected to feed upon other resident species and probably have a longer resident time at platforms than do the other large predators such as various mackerels (Scombridae), jacks, *Caranx* spp., and the little tunny, *Euthynnus alleteratus*. The latter species come and go to platforms for periods of a few hours to a few days as they follow large schools of prey species. Both the pelagic prey and predator species are attracted to structures, but with different schools constantly moving into and away from the structures. Large variations in the daily number of pelagic species are normal. The results of one study showed as many as 10,000 fish were attracted to small, floating structures one day after they were positioned (Gallaway and Lewbel, 1982).

Zonation of fishes other than cryptic blennies at shallower coastal platforms was not evident (Gallaway and Lewbel, 1982). Dominant species were sheepshead and schools of Atlantic spadefish. Also in schools were bluefish and blue runner, *Caranx crysos*. Individual specimens of lookdown and Atlantic moonfish were also observed. Other reef associated species observed were whitespotted soapfish, *Rypticus maculatus*, gray triggerfish, *Balistes capriscus*, lane snapper, *Lutjanus synagris,* and two species of grouper, *Epinephelus nigritus* and *Mycteroperca rubra*.

Gallaway and Lewbel (1982) found the dominant fishes at an offshore platform to be bluefish, spadefish, and mixed schools of moonfish and lookdowns. Blue runner and other jacks (crevalle jack, *Caranx hippos*, greater amberjack, *Seriola dumerili*, and almaco jack, *Seriola rivoliana*) were common. Sheepshead and gray triggerfish were present but not abundant, and large predators were represented by barracuda, cobia, and a nurse shark, *Ginglymostoma cirratum*. Reef fish encountered included cocoa damselfish, cubbyu, whitespotted soapfish, bigeye, and bermuda chub. The snapper/grouper assemblage was a major component of the ichthyofauna, being represented by large schools of gray snapper and medium to large schools of red and lane snapper. Scamp, *Mycteroperca phenax*, were also abundant.

At bluewater platforms, Gallaway and Lewbel (1982) found the large schools of spadefish, lookdowns, and bluefish were absent, replaced by numerous creole-fish, almaco jacks, and blue runner. Sheepshead were replaced by gray triggerfish and a host of tropical species. In the upper 30 m, mycteropercid groupers and hinds were common to abundant. The vertical members of bluewater platforms are surrounded by swarms of wrasses (particularly the creole wrasse, *Clepticus parrai*, and Spanish hogfish, *Bodianus rufus*) and other tropical species including damselfishes, angelfishes, tangs, rock beauty, red spotted hawkfish, and red hogfish. The most abundant large predators were barracuda and hammerhead sharks.

Another type of unintentional artificial reef are the thousands of underwater obstructions and debris that litter the Gulf of Mexico. These underwater obstructions include sunken boats and barges, equipment purposely dumped or accidently lost overboard from supply vessels and cargo ships, improperly abandoned oil and gas structures and debris, and thousands of miles of abandoned and active pipelines (Rester and Pulsipher, 1997).

Underwater obstructions in the Gulf of Mexico are usually comprised of the same materials used in building intentional artificial reefs. Sunken barges, sunken vessels, 55-gallon drums, pieces of pipe, and assorted oil and gas related debris all provide habitat for fish and hard substrate for invertebrate colonization. More than 10,000 hangs and obstructions are listed by Graham (1996a and 1996b) along the Louisiana and Texas coasts, and there are over 3,500 wrecks and obstructions in the Gulf of Mexico listed by the Automated Wreck and Obstruction Information System (AWOIS) run by the Hydrographic Surveys Division of the National Ocean Service. The number of underwater obstructions in the Gulf could provide a significant amount of habitat to fish. No research has been done on the utilization of underwater obstructions as habitat, but underwater obstructions likely provide the same habitat as artificial reefs. The degree that underwater obstructions function as habitat is dependent on size, durability and stability. While small items may have fish and invertebrates associated with them, if they deteriorate rapidly or move significantly, their habitat function will likely be minimized.

4.2.4.2 Geologic Features

The Gulf of Mexico basin was formed during the Jurassic Period as part of the initial breakup of Pangea as Africa/South America separated from North America. During the middle Jurassic, thick salt was deposited throughout the broad central basin area. The Gulf basin became locked in its current position with respect to North America by early Cretaceous time. Broad carbonate platforms with prominent rimmed margins became established along the edges of the basin. The margins were reefal, made up of algal, coral and rudistic banks. These carbonate shelf margins were exceptionally linear, following a line 129 to 161 km inward of the present Texas-Louisiana coastline, then turning southeast, ultimately determining the position of the Florida Escarpment. A later rise in sea level drowned the outer margins of the carbonate platforms, causing the margins to retreat to more landward positions. This sea level rise was followed by the later partial filling of the basin by large clastic sediments that prograded first from the west and northwest in late Cretaceous-early Cenozoic time and then from the north during the late Cenozoic.

Since the late Cenozoic the Mississippi River has had a profound effect on the north-central Gulf of Mexico. The Mississippi River supplies around 450 million metric tons of sediment annually to the Gulf basin, an order of magnitude greater than all other coastal rivers in the Gulf of Mexico combined. The Mississippi River is responsible for building the vast amounts of wetlands in coastal Louisiana and since the Cenozoic the continental shelf edge has prograded in the Gulf basin as much as 402 km (Woodbury et al., 1973). This accumulation of sediment has reached a thickness of 3,600 m in some areas (Woodbury et al., 1973). This large deposition of sediment on a base of several thousand feet of mobile salt and prodelta clay, has caused the movement of the underlying material to form large salt domes and diapirs near the continental shelf edge in the north-central Gulf of Mexico.

4.2.4.2.1 Continental Shelf Features

The Gulf of Mexico continental shelf varies in width from about 280 km off southern Florida to about 200 km off east Texas and Louisiana. The shelf narrows to 110 km off southwest Texas. The shelf is widest in southern Florida (300 km) and narrowest off the modern Mississippi River Delta (10 km) (Rezak et al., 1985). The shelf is largely composed of muddy or sandy terrigeneous sediments from the Rio Grande River Delta to DeSoto Canyon off Pensacola, Florida. East of DeSoto Canyon, the shelf is mainly dominated by a thick accumulation of southeasterly trending carbonate rocks and evaporite sediments. This area has not been influenced by the massive terrigenous regime that has occurred in other parts of the Gulf.

The continental shelf (0 - 200 m) occupies about 35.2 percent of the surface area of the Gulf, and provides habitats that vary widely from the deeper waters. The shelf and shelf edge of the Gulf of Mexico are characterized by a variety of topographic features. The value of these topographic features as habitat is important in several respects. Some of these features support hardbottom communities of high biomass and high diversity and an abundance of plant and animal species. These features are unique in that they are small, isolated, highly diverse areas within areas of much lower diversity. They support large numbers of commercially and recreationally important fish species by providing either refuge or food.

4.2.4.2.2 West Florida Shelf

The west Florida shelf is composed mainly of carbonate sediments. These sediments are in the form of quartz-shell sand (> 50 percent quartz), shell-quartz sand (< 50 percent quartz), shell sand, and algal sand. The bottom consists of a flat limestone table with localized relief due to relict reef or erosional structures. The benthic habitat types include low relief hardbottom, thick sand bottom, coralline algal nodules, coralline algal pavement, and shell rubble. The west Florida slope forms the edge of a sequence of carbonates intercalated with evaporites more than 5 km thick (Doyle and Holmes, 1985).

The west Florida shelf provides a large area of scattered hard substrates, some emergent, but most covered by a thin veneer of sand, that allow the establishment of a tropical reef biota in a marginally suitable environment. The only high relief features are a series of shelf edge prominences that are themselves the remnants of extensive calcareous algal reef development prior to sea level rise and are now too deep to support active coral communities. In water depths of 70 to 90 m along the southwest Florida shelf, a series of carbonate structures forms a series of steps along the shelf (Holmes, 1981). This area corresponds to the partially buried, 10-km wide reef complex known as Pulley Ridge. The partially buried ridge runs from an area west of the Dry Tortugas, northward for approximately 250 km. The shelf edge is marked by a double reef trend in water depths of 130 and 300 m (Doyle and Holmes, 1985). This reef forms the feature named Howell Hook by Jordan and Stewart (1959). Howell Hook is an arcuate ridge running northward for approximately 105 km. The lower reef crests at about 210 m in the south and 235 m in the north and forms a 40-m high scarp (Holmes, 1981).

Moe (1963) described hundreds of offshore fishing areas along the west Florida coast. Moving northward along the west Florida shelf are areas with substantial relief. In an area south of the Florida Middle Grounds, in water depths of 46 to 63 m, is a ridge formed from limestone rock. Moe (1963) termed this area the Elbow, and it is about 5.4 km at its widest and has a vertical relief of 6.5 to 14 m. South of Panama City are two notable areas with high relief. The Whoopie Grounds are located in 66 to 112 m of water and have rock ledges with 6 to 8 m of relief and are covered with coral and other invertebrate growth (Moe, 1963). The Mud Banks are formed by a ledge that has a steep drop of 5 to 7 m. The ledge extends for approximately 11 to 13 km in 57 to 63 m of water (Moe, 1963). The 3 to 5s are located southwest of Panama City in water depths of 31 to 42 m of water. The ledges are parallel to the 36.5-m isobath and have relief of 5.5 to 9 m (Moe, 1963).

The growth of coralline algae at mid-shelf depths (60 to 80 m), which results in the production of algal nodules and a crustose algal pavement, provides an extensive emergent substrate for the development of deepwater hermatypic corals. The coralline algal nodule and algal pavement/*Agaricia* assemblages represent the closest development of an active reef habitat on the shelf. Whether consisting of exposed or thinly covered hardbottom, the remaining hardbottom areas are scattered across the broad shelf. They are generally colonized by seasonal algae, sponges, and other filter feeders of mixed warm temperature and tropical affinities. The tropical biota consists primarily of the hardier, more tolerant forms, like the hard corals *Siderastrea* sp. and *Solenastrea* sp.

The west Florida shelf has been described by Woodward-Clyde Consultants, Inc. (1984), who grouped the benthic communities based on shared similarities and dissimilarities. The assemblages are:

Inner Shelf Live Bottom Assemblage I - this live bottom biological assemblage consisted of patches of various algae (*Caulerpa* spp., *Halimeda* spp., and *Udotea* spp.), ascidians, hard corals (Siderastrea spp.), large gorgonians (*Eunicea* spp., *Muricea* spp., *Pseudoplexaura* spp., and *Pseudopterogorgia* spp.), hydrozoans, and sponges (*Geodia gibberosa*, *G. neptuni*, *Haliclona* spp., *Ircinia campanal* and *Spheciospongia vesparium*). Individual organisms were generally larger, and the fauna appeared to exhibit a higher biomass per unit area, than in the Inner and Middle Shelf Live Bottom Assemblage II. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 20 to 27 m.

Inner and Middle Shelf Live Bottom Assemblage II - this live bottom biological assemblage consisted of algae (*Cystodictyon pavonium*, *Halimeda* spp., and *Udotea* spp.), ascidians (*Clavelina gigantea*), bryozoans (*Celleporaria* spp. and *Stylopoma spongites*), hard corals (*Cladocora arbuscula*, *Scolymia lacera*, *Siderastrea* spp., and *Solenastrea hyades*), small gorgonians, hydrozoans, and several sponges (*Cinachyra alloclada*, *Geodia gibberosa*, *G. neptuni*, *Ircinia* spp., *Placospongia melobesioides*, and *Spheciospongia vesparium*). This assemblage has a higher number of sponges and a lower biomass per unit area than the Inner Shelf Live Bottom Assemblage I. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 25 to 75 m.

Middle Shelf Algal Nodule Assemblage - this assemblage consisted of coralline algal nodules formed by *Lithophyllum* spp. and *Lithothamnium* spp., combined with sand, silt, and clay particles. Algae (*Halimeda* spp., *Peyssonnelia* spp., and *Udotea* spp.), hard corals and small sponges (*Cinachyra alloclada* and *Ircinia* spp.) were also present. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 62 to 108 m.

Agaricia Coral Plate Assemblage - this biotal assemblage consisted of a dead, hard coral-coralline algae substrate covered with living algae (*Anadyomene menziesii* and *Peyssonnelia* spp.), live hard corals (*Agaricia* spp. and *Madracis* spp.), gorgonians, and sponges. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 64 to 81 m.

Outer Shelf Crinoid Assemblage - this assemblage consisted of large numbers of crinoids (*Comactinia meridionalis*, *Neocomatella pulchella*, and *Leptonemaster venustus*) living on a coarse sand or rock rubble substrate. Small hexactinellid sponges may also be associated with this assemblage. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 118 to 168 m.

Outer Shelf Low Relief Live Bottom Assemblage - this live bottom assemblage consisted of various octocorals (including *Nicella guadalupensis*), the antipatharian corals *Antipathes* spp., *Aphanipathes abietina*, *A. humilis*, occasional hard corals (including *Madrepora carolina*), crinoids, the hydrozoan *Stylaster* sp., and small sponges in the Order Dictyonina. It was found in conjunction with low relief rock surfaces with a thin sand veneer. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 108 to 198 m.

Outer Shelf Prominences Live Bottom Assemblage - this biological assemblage consisted of the gorgonian *Nicella guadalupensis*, the antipatharian corals *Antipathes* spp., *Aphanipathes abietina*, *A. filix*, and *A. humilis*, the hard coral *Madrepora carolina*, crinoids, the hydrozoan *Stylaster* sp., and medium to large hexactinellid sponges in the Order Dictyonina. All of these organisms were found on rock prominences. These prominences generally emerged from a sand-covered bottom and had a vertical relief of up to 2 m. These prominences are most likely dead coral pinnacles. Woodward-Clyde Consultants, Inc. (1984) identified this assemblage in water depths of 136 to 169 m.

The hydrozoan coral *Millepora* sp. is believed to be the main frame builder in the Florida Middle Ground, although populations of hermatypic scleractinians (*Porites*, *Dichocoenia*, *Madracis*) are present at the upper depth ranges (26 to 30 m). Shallow-water alcyonaceans (*Muricea*, *Plexaura*, *Eunicea*) are also present , and the fauna bears a distinct dissimilarity to that of the Flower Garden Banks. Although the Florida Middle Ground provides a high-relief substratum for reef biota, its location is apparently too far northward to allow the establishment of massive hermatypic coral assemblages. Winter water temperatures can reach 15^{o} to 16^{o} C, and hermatypic corals require temperatures of 18^{o} to 30^{o} C for viable existence. Significantly productive areas in the Florida Middle Ground comprise about 12,100 ha (29,900 ac) (Woodward-Clyde Consultants, Inc., 1984).

Another west Florida shelf region with notable coral communities is bounded by the waters of Tampa Bay on the north and Sanibel Island on the south. The area consists of a variety of bottom types. Rocky bottom occurs at the 18 m contour where sponges, alcyonarians, and the scleractinians *Solenastrea hyades* and *Cladocora arbuscula* are especially prominent.

The west Florida shelf has long been recognized as an area that supports commercially important fish and shellfish populations, an importance attributed at least in part to the abundance of scattered rock outcrops and sponge bottoms that provide fish habitat (Darcy and Gutherz, 1984). One hundred seventy species of fish from 56 families have been observed or collected on the Florida Middle Ground. Of these, 97 species are considered primary reef fish and 45 species as secondary reef fish (Hopkins et al., 1977). Commercially important species include striped mullet, *Mugil cephalus*, spotted seatrout, *Cynoscion nebulosus*, Spanish mackerel, *Scomberomorus maculata*, king mackerel, *S. cavalla*, Florida pompano, *Trachinotus carolinus*, snappers, *Lutjanus* spp., and groupers, *Epinephelus* spp. and *Myctoperca* spp., several of which are primarily nearshore/estuarine inhabitants. The most speciose families of demersal fishes on the shelf are the lefteye flounders (Bothidae), sea basses (Serranidae), drums (Sciaenidae), and searobins (Triglidae) (Darcy and Gutherz, 1984).

4.2.4.2.3 Mississippi/Alabama Shelf

The Mississippi/Alabama Shelf is a small area extending from the Mississippi River Delta to DeSoto Canyon. The sediments found here are terrigenous to the west, integrating to carbonate sediments near DeSoto Canyon. The outer shelf is dominated by topographic features, which represent the remains of ancient reef or shoreline structures. Ludwick and Walton (1957) were the first to investigate the bottom irregularities found on the shelf and shelf break off the coasts of Alabama and Mississippi. They termed these low-relief hardbottom features "pinnacles". These pinnacles are made of hard, rigidly-cemented, irregularly-shaped aggregates of calcareous organic structures (Continental Shelf Associates, Inc., 1992). It has been speculated that the pinnacles along the Mississippi-Alabama shelf/slope originated as reefs during lower sea level stands. They are no longer growing but occupy an intermediate position between growth and fossilization.

These calcareous shelf edge and upper slope prominences are present in a wide band (approximately 1.6 km) along the shelf edge from 85˚ to 88˚ W longitude (Ludwick and Walton, 1957). They found the average pinnacle height to be 9 m with some pinnacles exceeding 15 m in relief and the average water depth to the top of the pinnacles to be 99 m. The average water temperature corresponding with this depth was 17.3˚ C (63 ˚ F) and the average salinity was 37 ppt. Pinnacles ranged in water depths from 102 to 179 m and water depths to the top of the pinnacles were found in two zones. In the shallower zone, the depth to the top of the pinnacles ranged from 68 to 84 m and in the deeper zone the depth to the top of the pinnacles ranged from 97 to 101 m. The greatest number of pinnacles were in water depths of 102 to 113 m.

Ludwick and Walton (1957) found the most common organic constituents of their sediment samples within the pinnacle area to be calcareous algae, gastropods, stony corals and bryozoans. All of the calcareous algae collected were red algae (Rhodophyta). Although none of the algae were found alive, the algae did constitute up to 75 percent of the sediments within the pinnacle area. The presence of the algae suggests formation in water depths considerably shallower than those near the pinnacles today.

Continental Shelf Associates, Inc. (1992) also conducted geological and biological investigations of the pinnacle trend area. The biological communities present on the features were antipatharians, ahermatypic hard corals, comatulid crinoids, sponges, alcyonarians, and hydroids. Coralline algae were also present in water depths less than 72 m. They concluded water depth precluded the growth of coralline algae on all but the upper portions of the tallest features. A variety of epifaunal organisms were also found. These included crinoids, urchins, gorgonacephalids, and fireworms. Fishes observed on the pinnacles included vermillion snapper, *Rhomboplites aurorubens*, red porgy, *Pagrus pagrus*, amberjack, *Seriola dumerili*, tattler, *Serranus phoebe*, red snapper, *Lutjanus campechanus*, dolphin, *Coryphaena hippurus*, gag, *Mycteroperca microlepis*, short bigeye, *Pristigenys alta*, Spanish flag, *Gonioplectrus hispanus*, and other small plankton feeders such as anthids.

Brooks (1991) found the areas of high relief to have higher population densities and a higher diversity than the surrounding low relief areas. Brooks (1991) also recognized longitudinal variation in the diversity in the pinnacle trend area. Areas closer to the Mississippi River were lower in diversity than areas farther to the east. He concluded that the Mississippi River plume influences the long term average water quality (salinity and turbidity) over the pinnacle trend area, resulting in diminished developmental potential on features closer to the river delta. Gittings et al. (1992b) reached similar conclusions.

Brooks (1991) identified 70 fish species associated with the topographic high habitats. Thirty-five of these species were taken by bottom trawls during sampling and are listed as soft bottom species. The remaining 35 species seem unique to this habitat.

Brooks (1991) observed that the species composition in the pinnacle trend area is comparable to the Antipatharian Zones and the Nepheloid Zones. Features were also present that represented an Algal-Sponge Zone. Some pinnacles have considerable amounts of crustose coralline algae.

Hardbottoms are also located in several locations on the inner continental shelf adjacent to Florida and Alabama, in depths of 18 to 40 m (Schroeder et al., 1988a). These hardbottom areas lie south of the mouth of Mobile Bay and south of the Alabama/Florida state line. They have a vertical relief of 0.5 to 5 m. Schroeder et al. (1988a) identified these areas as either 1) massive to nodular sideritic sandstones and mudstones, 2) slabby aragonite-cemented coquina and sandstone, 3) dolomitic sandstone occurring in small irregular outcrops and 4) calcite-cemented algal calcirudite occurring in reef-like knobs. Hardbottom formations were aligned parallel to the shoreline, which suggests a connection with paleoshoreline positions (Schroeder et al., 1988a). Brooks (1991) found these shallow water hardbottoms off Mobile Bay to support living algae. These particular shallow water outcrops also serve as spawning areas for certain fish, such as spot, *Leiostomus xanthurus,* and Atlantic croaker, *Micropogonias undulatus*.

The Southeast Banks area lies south-southeast of the mouth of Mobile Bay, approximately 28 km offshore in water depths of 21 to 26.5 m. Southeast Banks consists of a rock rubble field with 4 m of relief on a moderately sloping bottom of shell hash and silty sand (Schroeder et al., 1988a). The Southwest Rock area is located southwest of the mouth of Mobile Bay, approximately 17 km south of Dauphin Island in water depths of 20 to 22 m (Schroeder et al., 1988a). Southwest Rock consists of a rock outcrop 7 to 9 m across that rises 1 to 1.5 m above a smooth bottom of muddy sand. A smaller outcrop, approximately 1.5 to 3.5 m across is located 10 m to the southwest. Epifauna included mostly barnacles, serpulids, and bryozoans (Schroeder et al., 1988a). Near Southwest Rock is a site that encompasses a gently sloping ridge that trends north-northwest to south-southeast and has 1 to 1.5 m of relief (Schroeder et al., 1988a). The 17 Fathom Hole area is located approximately 37 km south of Mobile Bay in water depths of 30 to 32 m. 17 Fathom Hole is a depression consisting of small rock rubble, shell, and coarse sand with relief of 5 m (Schroeder et al., 1988a). The Big Rock/Trysler Grounds area is located approximately 46 km offshore of the Alabama-Florida state line in water depths of 30 to 35 m. Big Rock consists of a large mound feature with 5 m of relief (Schroeder et al., 1988a). The Trysler Grounds consists of small rocks with relief of 2 to 3 m on an irregular bottom (Schroeder et al., 1988a). The 40 Fathom Isobath area is located 24 km northeast of the pinnacles area in water depths of approximately 75 m. This area consists of topographic features with up to 9 m of relief that are either mound-like, pinnacle-like, or ridge-like in form (Schroeder et al., 1988b).

West of the pinnacles area, Sager et al. (1992) examined a multitude of topographic features that can be divided into three classes. The first are reef-like mounds that are widespread in water depths shallower than 120 m and are often clustered. The smallest reef-like mounds are 1 to 2 m in diameter providing 1 to 2 m of relief. Several fields were found by Sager et al. (1992) with high densities of small reef-like mounds (3,500 to 7,000 per km^2), 10 to 15 m across and 2 to 5 m in relief. The largest reef-like mounds are 500 to 1,000 m in diameter with heights of 3 to 18 m. Most reef-like mounds are in water depths of 74 to 82 m in a band that trends from the southwest to the northeast. Many reef-like mounds were found in shallower areas (60 to 70 m) and in deeper waters (87 to 94 m). The reef-like mounds appear to be calcareous bioherms inhabited by crustose coralline algae, *Lithothamnium* and *Peyssonnelia*, serpulid worm tubes, bryzoans, foraminifera, and isolated hermatypic corals, *Stephanocoenia* and *Agaricia* (Sager et al., 1992).

The second type of topographic feature examined by Sager et al. (1992) were ridges that run parallel to the depth contours and have widths of tens to hundreds of meters and lengths of up to about 15 km. Most are within a narrow depth range of 68 to 76 m, sometimes occurring in bands of up to 6 to 8 small ridges. The ridges exhibit low relief with heights of about one meter. The largest ridge examined had a height of 8 m (Sager et al., 1992).

The last type of topographic feature studied by Sager et al. (1992) are the shallow depressions that are generally 10 to 15 m or less in diameter and a meter or less in depth. In the western part of the area surveyed by Sager et al. (1992), large numbers of the depressions are found clustered (1 to 80 per km^2) in several areas.

These areas are also very similar to those described by Shipp and Hopkins (1978) on the northern rim of DeSoto Canyon 25 km offshore near Pensacola, Florida. The rim of DeSoto Canyon consists of continuous ridges of granular limestone outcroppings oriented from east-northeast to west-southwest. The outcroppings were composed of one to three ridges, and each was bordered by sandy flats. The ridges were approximately 20 m wide. The relief of the ridges varied from barely detectable along the northeast segment to nearly 10 m along the southwestern extremity of the canyon. Further to the southwest, the ridges become discontinuous but form numerous ledges of 10 to 15 m relief.

The invertebrate faunal observations by Shipp and Hopkins (1978) included two distinct areas that support low diversity communities of an apparently mixed tropical and temperate nature. The first was the sand-shell-coralline-algae slope immediately above and below the block ridges of limestone and the block substrate of the ridges. Two forms of attached pennatulaceid coelenterates, decapod crustaceans and asteroid echinoderms were encountered at the sand-shell-coralline-algae slope. There was also evidence of bioturbation by worms and molluscs that were not directly observed.

The rocky ridges were colonized by sponges, scleractinians, octocorals, solitary antipatharians, and some hydroids. Majid crabs, hermit crabs, whelks, and sea cucumbers were also present.

The fish fauna of the DeSoto Canyon rim, recorded by Shipp and Hopkins (1978), were dominated by families characteristic of Caribbean reefs. Sea basses (Serranidae) and damselfishes (Pomacentridae) comprised the most visibly abundant components. Also present in large numbers were the cardinal fishes (Apogonidae), butterflyfishes (Chaetodontidae), bigeyes (Priacanthidae), drums (Sciaenidae), squirrelfishes (Holocentridae), and snappers (Lutjanidae). Grunts (Pomadasyidae) and porgies (Sparidae) were represented but the sightings were sporadic.

Based on the findings of Brooks (1991), the most significant aspect of the hardbottoms and topographic features of the Mississippi-Alabama shelf lies in the fact that they form part of a chain of such features lying at comparable water depths around the entire rim of the Gulf of Mexico supporting similar biological communities. Located in a central position, the topographic features possibly facilitate genetic exchange between the faunas of such communities both to the east and west (Brooks, 1991). Lying directly in the path of Loop Current intrusions, these are likely the first hardbottom communities to be encountered by species transported from the Caribbean. Thus, they may at times serve as centers of dispersal for successful colonizers from the tropics. The presence of the Mississippi-Alabama hard banks may serve the function of "island hopping" for important reef species and may present the key habitat link between the reef fauna of the northwestern and northeastern Gulf of Mexico. In these respects the hardbottoms and topographic features are important in terms of the larger Gulf of Mexico ecosystem as a whole.

Vertical relief of individual hardbottom features is the single most significant factor influencing live bottom community development. All of the major live bottom studies conducted in the northeastern Gulf have demonstrated higher frequencies of occurrence and higher numbers of species with increasing vertical relief (Shipp and Hopkins, 1978; Schroeder et al., 1988a; Brooks, 1991; Continental Shelf Associates, Inc., 1992; Gittings et al., 1992b).

4.2.4.2.4 Louisiana/Texas Shelf

The Louisiana/Texas Shelf is dominated by muddy or sandy, terrigenous sediments deposited by the Mississippi River. These terrigenous sediments cover over 3,000 m of rock salt (Louann Salt) that has been deposited since the formation of the Gulf of Mexico basin. Nearly 15 km of sediment cover the Louann salt deposit south of the Louisiana/Texas state line. This huge sediment load has caused the deposits of salt to flow and form diapirs which now dot the inner shelf and adjacent coastal plain. Many large isolated salt stacks interconnected by intricate networks of growth faults characterize the middle shelf and lower Mississippi River delta region. More than 130 calcareous banks exist as a result of active diapirism in the northwest Gulf of Mexico (MMS, 1983).

Vertical relief of the banks on the Louisiana-Texas Shelf varies from less than one meter to over 150 m. These banks exist in water depths of 22 to 300 m. Some shallow water banks have been described by Putt et al. (1986). They examined six shallow water (<35 m) hardbottom sites off the coast of central Louisiana. These were areas of low relief from one to three meters. These hardbottom areas were generally enveloped in a dense nepheloid layer. The associated sessile epibiota included hydroids, bryozoans, ascidians, encrusting sponges, and some ahermatypic stony corals. Common fish species included Atlantic spadefish, *Chaetodipterus faber*, red snapper, *Lutjanus campechanus*, sheepshead, *Archosargus probatocephalus*, gray triggerfish, *Balistes capriscus*, blue runner, *Caranx crysos*, vermillion snapper, *Rhomboplites aurorubens*, rock hind, *Epinephelus adscensionis*, grouper, *Mycteroperca sp.*, and tomtate, *Haemulon aurolineatum*.

These sites differed in their relief and the area covered by each outcropping. The smallest outcropping had an area of approximately 20 m^2. The largest outcropping had an area of several hundred square meters, and some were in the form of a low relief, narrow (< 3 m wide) ridge of rock outcrops running in an east-west direction for a distance of at least 76 m.

Three deepwater hardbottom areas in water depths of 43 to 58 m were also examined by Putt et al. (1986). The relief of these features extended above the nepheloid layer and are colonized by more tropical assemblages of invertebrates and fishes. The peak of one feature was within 18 m of the surface. Rock outcrops in the forms of ridges and hummocks were observed atop the feature, with reliefs ranging from 3 to 5 m.

The epibiota of these areas included bryozoans, hard corals, octocorals, fire corals, sponges, sea whips, gastropods, hydroids, sea urchins, and spiny lobsters. Over 47 species of fish were identified with the major species being greater amberjack, *Seriola dumerili*, vermillion snapper, *Rhomboplites aurorubens*, bigeye, *Priacanthus furcifer*, blue runner, *Caranx crysos*, blue angelfish, *Holacanthus bermudensis*, French angelfish, *Pomacanthus paru*, queen angelfish *Holacanthus ciliaris*, spotfin butterflyfish, *Chaetodon ocellatus*, and yellowtail reeffish, *Chromis enchrysurus*. Large schools, often including hundreds of individuals, of amberjack, tomtate, blue runner, and vermillion snapper were observed above the peak of one hardbottom feature.

Rezak et al. (1985) conducted extensive research on the banks and reefs of the northern Gulf of Mexico. They grouped the banks into two categories. The first are the mid-shelf banks, defined as those that rise from depths of 80 m or less and have a relief of 4 to 50 m. They are similar to one another in that all are associated with salt diapirs and are outcrops of relatively bare, bedded Tertiary limestones, sandstones, claystones, and siltstones. Some of the named mid-shelf banks are Sonnier Bank, Fishnet Bank, Claypile Bank, 32 Fathom Bank, Coffee Lump, Stetson Bank, Phleger Bank, and 29 Fathom Bank.

The biotic assemblages that occupy the North Texas-Louisiana mid-shelf banks are distinct and compose a *Millepora*-Sponge Zone dominated by hydrozoan fire corals and various sponges (Rezak et al., 1985). Rezak et al. (1985) found numerous species of fish at the mid-shelf banks. These included yellowtail reef fish, *Chromis enchrysurus*, bluehead, *Thalassoma bifasciatum*, hogfishes, *Bodianus* spp., creole-fishes, *Paranthias furcifer*, rock hind, *Epinephelus adscensionis*, groupers, *Mycteroperca* spp., and others typical of submerged reefs and banks in the northwestern Gulf. Large schools of vermillion snapper, *Rhomboplites aurorubens*, were seen above 35 m depth, and schools of red snapper, *Lutjanus campechanus*, were encountered near the base of most banks. Dennis and Bright (1988) found the reef fish community on mid-shelf banks to be quite diverse with 76 species observed with 51 being primary reef species.

The other category of banks is the shelf-edge carbonate banks and reefs located on complex diapiric structures. They are carbonate caps that have grown over outcrops of a variety of Tertiary and Cretaceous bedrock and salt dome caprock. Although all of the shelf-edge banks have well-developed carbonate caps, local areas of bare bedrock have been exposed by recent faulting on some banks. Relief on shelf-edge banks ranges from 35 to 150 m. Some of the named shelf-edge banks are East Flower Garden Bank, West Flower Garden Bank, Geyer Bank, Rankin Bank, Elvers Bank, MacNeil Bank, Appelbaum Bank, Bright Bank, McGrail Bank, Alderdice Bank, Rezak Bank, Sidner Bank, Ewing Bank, Jakkula Bank, Bouma Bank, Parker Bank, Sackett Bank, Diaphus Bank, and Sweet Bank.

The Algal-Sponge Zone assemblage is the most important clear water community on shelf edge banks (Rezak et al., 1985). This assemblage is indicative of year round tropical/subtropical oceanic conditions. Although, a high diversity assemblage (*Diploria-Montastrea-Porites* Zone) limited to depths of 36 m and a comparatively low diversity assemblage (*Stephanocoenia-Millepora* Zone) between 36 and 52 m exists on the East and West Flower Garden Banks. The coral reef assemblages of the East and West Flower Garden Banks was covered in Section 4.2.4.1.1.

The fish associated with the shelf-edge banks is extremely diverse. Excluding the Flower Garden banks, ninety-five species of reef fish were observed on the shelf-edge banks by Dennis and Bright (1988) with 69 species being classified as primary reef species. Dennis and Bright (1988) found several species that were found exclusively on the shelf-edge banks.

4.2.4.2.5 South Texas Shelf

The continental shelf south of Matagorda Bay, Texas contains an area of drowned reefs on a relict carbonate shelf (Rezak et al., 1985). These carbonate structures, the remains of relict reefs, currently only support minor encrusting populations of coralline algae. The banks vary in relief from 1 to 22 m. The sides of these reefs are immersed in a nepheloid layer that varies in thickness from 15 to 20 m (Rezak et al., 1985). The sediments around the reef consist of three main components, including clay, silt, and coarse carbonate detritus. These banks are composed of carbonate substrata overlain by a veneer of fine-grained sediment around the base that reaches an approximate thickness of 20 cm. These fine-grained sediments decrease to a trace on the crests. Carbonate rubble is the predominant sediment on the terrace and peaks of the banks.

Several shallow water reefs also occur on the south Texas shelf. These reefs are East Bank, Sebree Bank, Steamer Bank, Little Mitch Bank, Four Leaf Clover, 9 Fathom Rock, and Seven and One-half Fathom Reef. These reefs are located south of Corpus Christi down to Brownsville in water depths of 14 to 40 m and provide relief of up to 5 m. These reefs are thought to have different origins from the other banks located farther offshore on the south Texas shelf.

Southern Bank is a typical example of the relict reefs found on the south Texas shelf. It is circular in view with a diameter of approximately 1,300 m, and rises from a depth of 80 m to a crest of 60 m (Rezak et al., 1985). Approximately fourteen banks are on the south Texas shelf in water depths ranging from 60 to 90 m. The named south Texas banks are Big Dunn Bank, Small Dunn Bank, Blackfish Ridge, Mysterious Bank, Baker Bank, Aransas Bank, Southern Bank, North Hospital Bank, Hospital Bank, South Baker Bank, Sebree Bank, Big Adam Bank, Small Adam Bank, and Dream Bank.

The epifaunal communities surrounding these banks are diverse, and they are typical of the Antipatharian Zone. These banks are similar in biotic composition to the banks located off north Texas and Louisiana in similar depths. *Cirripathes* is the most conspicuous epifaunal organism on the south Texas mid-shelf banks. Another conspicuous macrobenthic organism is the sponge *Ircinia campana*. Comatulid crinoids are abundant everywhere on the upper portions of the banks. Large, white sea fans, *Thesea*, are also seen frequently along with other deepwater alcyonarians, mostly paramuriceids. The only stony corals are agariciid colonies near the top of banks that are in relatively clear water. Coralline algae is sparse, but occurs at the crest of the banks. It forms on isolated patches on the carbonate blocks and also encrusts the tops of pieces of rubble between blocks on the sediment covered bottom. Leafy algae is also present at some banks. Large mobile benthic invertebrates such as arrow crabs, hermit crabs, black urchins, sea cucumbers and fireworms are also present.

Groundfish populations at the south Texas banks are similar in composition and magnitude to those of the northwestern Gulf (Rezak et al., 1985). The most common fish discovered by Rezak et al. (1985) were the yellowtail reeffish, *Chromis enchrysurus*, roughtongue bass, *Holanthias martinicensis*, spotfin hogfish, *Bodianus pulchellus*, reef butterflyfish, *Chaetodon sedentarius*, wrasse bass, *Liopropoma eukrines*, bigeye, *Priacanthus sp.*, tattler, *Serranus phoebe*, hovering goby, *Ioglossus calliurus*, and the blue angel fish, *Holocanthus bermudensis*. Few large groupers of the genus *Mycteroperca* or hinds of the genus *Epinephelus* were observed on the south Texas mid-shelf banks. Larger migratory fish were also observed. These included schools of red snapper, *Lutjanus campechanus*, and vermillion snapper, *Rhomboplites aurorubens*. Also present were the greater amberjack, *Seriola dumerili*, the great barracuda, *Sphyraena barracuda*, small carcharhinid sharks, and cobia, *Rachycentron canadum*. Dennis and Bright (1988) observed 66 species of fish on the south Texas banks with 42 species being primary reef species.

Because of their relatively low relief above the surrounding mud bottom, the southernmost mid-shelf carbonate banks on the south Texas shelf apparently suffer from chronic high turbidity and sedimentation from crest to base, and all rocks are heavily laden with fine sediment (Rezak et al., 1985). Consequently, the epibenthic communities on these banks are severely limited in diversity and abundance.

5.0 <u>ESSENTIAL FISH HABITAT OF MANAGED SPECIES</u>

This section provides maps, tables and pertinent environmental information for selected species or species complexes under management in the seven fishery management plans (FMPs) of the Gulf of Mexico Fishery Management Council. Much of the basic text was extracted from the existing habitat sections of the respective FMPs. Species maps are NOS/SEA Division products (i.e., NOAA's National Ocean Service, Strategic Environmental Assessments Division). Habitat association tables were formulated by NMFS Southeast Fisheries Science Center especially for this amendment.

The maps and tables are the basis for defining the gulfwide EFH (estuarine and marine) presented in Section 4.0. The maps, particularly those showing seasonal distribution of juveniles in estuaries, are especially useful in defining EFH. They provide relative abundance information based on a combination of catch per unit effort (CPUE) data and information from published literature and expert review for areas for which data are not available. "*Highly abundant*" denotes the top 90-100 percentile of catch; "*abundant*"denotes 50-90 percentile; "*common*" denotes 10-50 percentile; "*rare*" denotes >0-10 percentile; and, "*not present*" indicates no catch. Estuarine EFH for each of the species consists of those areas mapped as "common", "abundant" and "highly abundant." The offshore EFH maps were made by NOS from the Gulf of Mexico Data Atlas (NOAA, 1985). EFH in the offshore areas are those depicted as adult areas, spawning areas and nursery areas.

It is important to note that NOS produced numerous maps and tables in its efforts to assist the Council in developing this EFH amendment, but not all of them were used. All maps and tables are available in a "source document" (i.e., NOAA's EFH Work Plan and associated products), but only those deemed necessary to adequately identify and define EFH of the selected species were used in this amendment. The "source document" can be accessed on the Internet Web Site address:

http://christensenmac.nos.noaa.gov/gom-efh.

A hard copy of the "source document" also is on file at the Gulf Council office.

The selected species account for about a third of the species under management by the Gulf of Mexico Fishery Management Council. Nevertheless, they are the more important species in terms of commercial and recreational harvest. They were selected because they are considered to be ecologically representative of the remaining species within their respective FMUs. Their selection was further supported because sufficient information was available in most cases to document and map their habitat associations and use. Collectively, these selected species commonly occur throughout all of the marine and estuarine waters of the Gulf of Mexico. Thus, even if maps and tables of additional species were available, they would not encompass any habitat that is not already included and identified as EFH for one or more of the selected species. EFH for the remaining managed species, as well as additional refinement of the available information on the representative species, will be addressed in future FMP amendments, as NMFS gathers the requisite information and provides it to the Council.

5.1 Amendment to the FMP for the Shrimp Fishery

5.1.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for the Shrimp Fishery of the Gulf of Mexico United States Waters to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C. et seq.). This amendment contains the following actions:

- Defines and describes EFH based on known distribution of the various life stages of brown shrimp (*Penaeus aztecus),* white shrimp (*Penaeus setiferus*)*,* pink shrimp (*Penaeus duorarum*) and royal red shrimp (*Pleoticus robustus*).
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.1.2 Distribution and Summary of Habitats Used by Shrimp

Figures 8 through 13 depict the areas of common occurrence (and thus the EFH) of brown, white and pink shrimp in the Gulf of Mexico. EFH in the estuaries are those areas depicted on the maps as "common", "abundant" and "highly abundant". EFH in the offshore areas are those depicted as adult areas, spawning areas and nursery areas. Brown shrimp are found within the estuaries to offshore depths of 110 m throughout the Gulf; white shrimp inhabit estuaries and to depths of about 40 m offshore in the coastal area extending from Florida's Big Bend area through Texas; pink shrimp inhabit the Gulf coastal area from estuaries to depths of about 65 m offshore and is the dominant species off southern Florida. Brown and white shrimp are generally more abundant in the central and western Gulf, whereas pink shrimp are generally more abundant in the eastern Gulf.

Brown, white, and pink shrimp use a variety of habitats as they grow from planktonic larvae to spawning adults (GMFMC, 1981c). Habitat associations for the three species by life stage are summarized in Tables 1, 2 and 3. A brief discussion of the EFH of each species follows:

Brown Shrimp - Brown shrimp eggs are demersal and occur offshore (Table 1). The larvae occur offshore and begin to migrate to estuaries as postlarvae. Postlarvae migrate through passes on flood tides at night mainly from February - April with a minor peak in the fall. Postlarvae and juveniles are common to highly abundant in all U.S. estuaries from Apalachicola Bay in the Florida panhandle to the Mexican border (Figure 8). In estuaries, brown shrimp postlarvae and juveniles are associated with shallow vegetated habitats but also are found over silty sand and non-vegetated mud bottoms.

Postlarvae and juveniles have been collected in salinity ranging from zero to 70 ppt. The density of late postlarvae and juveniles is highest in marsh edge habitat and submerged vegetation, followed by tidal creeks, inner marsh, shallow open water and oyster reefs; in unvegetated areas muddy substrates seem to be preferred. Juveniles and sub-adults of brown shrimp occur from secondary estuarine channels out to the continental shelf but prefer shallow estuarine areas, particularly the soft, muddy areas associated with plant-water interfaces. Sub-adults migrate from estuaries at night on ebb tide on new and full moon. Abundance offshore correlates positively with turbidity and negatively with hypoxia. Adult brown shrimp occur in neritic Gulf waters (i.e., marine waters extending from mean low tide to the edge of the continental shelf) (Figure 9) and are associated with silt, muddy sand, and sandy substrates. More detailed discussion on habitat associations of brown shrimp is provided in Nelson (1992) and Pattillo et al. (1997).

White Shrimp - White shrimp are offshore and estuarine dwellers and are pelagic or demersal, depending on life stage (Table 2). The eggs are demersal and larval stages are planktonic; both occur in nearshore marine waters. Postlarvae migrate through passes mainly from May-November with peaks in June and September. Migration is in the upper two meters of the water column at night and at mid depths during the day. Postlarval white shrimp become benthic upon reaching the nursery areas of estuaries, where they seek shallow water with muddy-sand bottoms high in organic detritus or abundant marsh, and develop into juveniles. Juveniles are common to highly abundant in all Gulf estuaries from Texas to about the Suwannee River in Florida (Figure 10). Postlarvae and juveniles inhabit mostly mud or peat bottoms with large quantities of decaying organic matter or vegetative cover. Densities are usually highest in marsh edge and submerged aquatic vegetation, followed by marsh ponds and channels, inner marsh, and oyster reefs. Juveniles prefer lower salinity waters (less than 10 ppt), and frequently are found in tidal rivers and tributaries throughout their range. As juvenile white shrimp approach adulthood, they move from the estuaries to coastal areas where they mature and spawn. Migration from estuaries occurs in late August and September and appears to be related to size and environmental conditions (e.g., sharp temperature drops in fall and winter). Adult white shrimp are demersal and generally inhabit nearshore Gulf waters (Figure 11) to depths less than 30 m on bottoms of soft mud or silt. See Nelson (1992) and Pattillo et al. (1997) for more detailed information on habitat associations of white shrimp.

Pink Shrimp - Pink shrimp occupy a variety of habitats, depending on their life stage (Table 3). Eggs and early planktonic larval stages occur in marine waters. Eggs are demersal, whereas larvae are planktonic until the postlarval stage when they become demersal. Postlarvae and juveniles of pink shrimp occur in estuarine waters of wide-ranging salinity (0 to >30 ppt) . Recruitment into estuaries occurs in spring and fall at night, primarily on flood tides, through passes or open shoreline. Juveniles inhabit almost every U.S. estuary in the Gulf but are most abundant in Florida (Figure 12). Juveniles are commonly found in estuarine areas with seagrass where they burrow into the substrate by day and emerge at night. Postlarvae, juvenile, and subadult may prefer coarse sand/shell/mud mixtures. Densities are highest in or near seagrasses, low in mangroves, and near zero or absent in marshes. Adults inhabit offshore marine waters (Figure 13) with the highest concentrations in depths of 9 to 44 m. Preferred substrate of adults is coarse sand and shell with a mixture of less than 1% organic material. More detailed discussion of habitat associations of pink shrimp is provided in Nelson (1992) and Pattillo et al. (1997).

As indicated above, the three major species of shrimp in the Gulf (i.e., the brown, white and pink) are estuarine dependent. The estuaries along the Gulf coast formed during the past 5,000 years, when alluvial sediment supplied to the coast exceeded that removed through erosion and subsidence. The general physiography of the Gulf coast favored extensive wetland formation. Some 60 percent of the coastal wetland area of the conterminous U.S. occurs along the Gulf coast. Tidal marsh, mangroves, and submerged aquatic vegetation that comprise this area amount to some 6.2 million acres. An additional 8.4 million acres are classified as unvegetated estuarine open water (Crance, 1971; Perret et al., 1971; Chabreck, 1972; McNulty et al., 1972; Christmas, 1973; Diener, 1975). A state-by-state description of essential estuarine habitat is provided in Section 4.1.

Royal Red Shrimp - Royal red shrimp also are in the management unit of the shrimp FMP, but little is known of the species habitat requirements (GMFMC, 1996). The species is known to occur from Martha's Vineyard (Massachusetts) through the Gulf of Mexico and the Caribbean Sea to French Guiana where they live on the upper continental shelf at depths between about 180 and 730 m. Royal reds are scarce in less than 250 m and not abundant at depths greater than 500 m. The highest concentrations have been reported in the northeastern part of the Gulf of Mexico at depths between 250 and 475 m. The larvae are unknown. Commercial concentrations of royal red shrimp have been reported on the following types of bottoms: blue-black terrigenous silt and silty sand off the Mississippi River Delta; whitish, gritty, calcareous mud off the Dry Tortugas (GMFMC, 1996). A habitat association table and distribution map are not available for royal red shrimp but will be provided in a future amendment when NMFS provides the requisite information.

While the quantitative relationships between the various estuarine habitats and shrimp production are not known, information is available on the kind of environment necessary for shrimp survival (Idyll et al., 1967). Tidal marsh, particularly smooth cordgrass (*Spartina alterniflora*), provides important habitat for juvenile brown shrimp (Zimmerman et al., 1984). Submerged vegetation likewise is important shrimp habitat. Costello et al., (1986) found early juvenile pink shrimp in Florida Bay to be most abundant in shoal grass (*Halodule wrightii*) beds and less abundant in turtle grass (*Thalassia testudinum*). Turner (1977) observed that the yield of shrimp in Louisiana's estuaries is directly related to the acreage of marsh, while that from the northeastern Gulf of Mexico is directly related to the acreage of marsh and submerged grassbeds. He found no relationship between yields and estuarine water surface, average water depth, or volume. His findings concur with the observations of Barrett and Gillespie (1973) that annual brown shrimp production in Louisiana is correlated with the acreage of marsh with water above 10 ppt salinity, but not with acres of estuarine water above 10 ppt salinity. These findings suggest that the brown, white, and pink shrimp yields in the U.S. Gulf of Mexico depend on the survival of the estuarine marshes and grassbeds in their natural state. These areas not only provide postlarval, juvenile, and subadult shrimp with food and protection from predation, but they help to maintain an essential gradient between fresh and salt water.

The above focus on estuaries as essential habitat for shrimp does not imply that offshore (i.e., marine) habitat is any less important. The estuaries are emphasized because (1) they are more vulnerable to degradation from a wider variety of human activities than is the marine environment (see Section 6.0), and (2) the estuarine phase of growth is considered the weakest link in the life cycle of shrimp.

Marine habitat also is critically important to the survival and reproduction of shrimp. Adult shrimp occur throughout the Gulf's marine habitat. White shrimp occur to depths of about 40 m, pink shrimp to about 65 m and browns to about 110 m. Species association generally occurs with bottom type. Within the Gulf there are three general offshore bottom type regions extending to the 200 m isobath. One occurs from the Texas-Mexico border to just west of the Texas-Louisiana border. Here the offshore zone consists mainly of sand and finer grain sediments. Occasional pockets of sand and shell are found from the 20 m to 200 m isobath. The second zone extends eastward to a point approximately even with Pascagoula Bay, Mississippi, and is mainly a complex of fine grain sediments with occasional surface deposits of sand and shell. The dominance of muddy bottoms in this zone is attributed to the deposition by the Mississippi River. The third region encompasses the remaining area offshore Alabama and Florida, which is almost exclusively comprised of sand, shell, and coral. Coral becomes more prevalent along the central and southern Florida coast.

The first two zones are primarily associated with brown and white shrimp, while the third zone is primarily associated with pink shrimp. These zones are all essential habitat for shrimp. More detailed description of these zones and other essential marine habitat components is found in Section 4.2.

5.1.3 <u>Prey Dependence</u>

Larvae of shrimp feed on phytoplankton and zooplankton. Postlarvae feed on epiphytes, phytoplankton, and detritus. Juveniles and adults prey on polychaetes, amphipods, and chironomid larvae but also on detritus and algae (Pattillo et al., 1997). The habitat of these prey is essentially the same as that required by shrimp (i.e., the estuarine and marine habitats described in Section 4.0).

5.1.4 <u>Review and Update of Amendment</u>

The Council and NMFS will review and update the EFH component of the shrimp FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on habitat of all shrimp species in the management unit as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the shrimp FMP.

5.2 Amendment to the FMP for the Red Drum Fishery of the Gulf of Mexico

5.2.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for the Red Drum Fishery of the Gulf of Mexico to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C. et seq.). This amendment contains the following actions:

- Defines and describes EFH based on known distribution of the various life stages of red drum (*Sciaenops ocellatus)*.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.2.2 Distribution and Summary of Habitats Used by Red Drum

Figures 14 and 15 depict the areas of common occurrence (and thus the EFH) of red drum (*Sciaenops ocellatus)* in the Gulf of Mexico. EFH in the estuaries are those areas depicted on the maps as “common”, “abundant” and highly abundant”. EFH in the offshore areas are those depicted as adult areas, spawning areas and nursery areas. Table 4 summarizes the habitat associations of the various life stages.

Red drum are distributed over a geographical range from Massachusetts on the Atlantic coast to Tuxpan, Mexico (Simmons and Breuer, 1962). In the Gulf of Mexico red drum occur in a variety of habitats, ranging from depths of about 40 m offshore to very shallow estuarine waters. They commonly occur in virtually all of the Gulf’s estuaries (Figure 14) where they are found over a variety of substrates including sand, mud and oyster reefs. Red drum can tolerate salinities ranging from freshwater to highly saline, but optimum salinities for the various life stages have not been determined. Types of habitat occupied depend upon the life stage of the fish. Spawning occurs in deeper water near the mouths of bays and inlets, and on the Gulf side of the barrier islands (Pearson, 1929; Simmons and Breuer, 1962; Perret et al., 1980). The eggs hatch mainly in the Gulf, and larvae are transported into the estuary where the fish mature before moving back to the Gulf (Perret et al. 1980; Pattillo et al., 1997). Adult red drum use estuaries, but tend to spend more time offshore as they age (Figure 15). Schools of large red drum are common in deep Gulf waters.

Estuarine wetlands are especially important to larval, juvenile and subadult red drum. Yokel (1966) concluded that abundance of red drum varied directly with the estuarine area (habitat). He also reported that, in general, landings within a state varied with the amount of that state's suitable habitat. Davis (1980) also discussed red drum occurrence in the Everglades National Park, and suggested that recorded changes in species and size distribution resulted from increased salinities from drainage control. An abundance of juvenile red drum has been reported around the perimeter of marshes in estuaries (Perret et al., 1980). Young fish are found in quiet, shallow, protected waters with grassy or slightly muddy bottoms (Simmons and Breuer, 1962). Shallow bay bottoms or oyster reef substrates are especially preferred by subadult and adult red drum (Miles, 1950). Based largely on such observations, the Fish and Wildlife Service (FWS) developed a habitat suitability index model for larval and juvenile red drum (Buckley, 1984). The model indicates that shallow water (1.5 to 2.5 m deep) with 50 to 75 percent submerged vegetation growing on mud bottoms and fringed with emergent vegetation provides optimum red drum habitat. The model, however, needs to be further refined, and estuaries in the Gulf need to be surveyed for habitat and optimum environmental conditions available for red drum production.

Given the widespread distribution of red drum in the Gulf's estuarine waters (Figure 14), all of the estuaries described in Section 4.1 are considered essential habitat for red drum. Likewise, all marine habitat of the Gulf where red drum are known to occur is essential (Figure 15). Description of essential marine habitat is found in Section 4.2.

5.2.3 Prey Dependence

Estuaries are important habitat for the prey species of red drum. This is especially true for the larvae, juvenile and early adults of red drum as they spend virtually all of their time in estuarine habitat. Larval red drum feed almost exclusively on mysids, amphipods, and shrimp, whereas larger juveniles feed more on crabs and fish (Peters and McMichael, 1987). Overall, crustaceans (crabs and shrimp) and fishes are most important in the diet of red drum; primary food items are blue crabs, striped mullet, spot, pinfish and pigfish. As they grow larger, red drum eat proportionately more crabs, with fish diminishing in importance as food for the largest red drum (Mercer, 1984). Protection of estuaries is especially important not only to maintenance of essential habitat for red drum but also because so many of the prey species of red drum are estuarine dependent (e.g., shrimp, blue crab, striped mullet and pinfish).

5.2.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the red drum FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on red drum habitat as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the red drum FMP.

5.3 Amendment to the FMP for the Reef Fish Fishery of the Gulf of Mexico

5.3.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for the Reef Fish Fishery of the Gulf of Mexico to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C. et seq.). This amendment contains the following actions:

- Defines and describes EFH based on known distribution of the various life stages of selected reef fish.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.3.2 Distribution and Summary of Habitats Used by Reef Fish

Figures 16 through 30 depict areas of common occurrence (and thus EFH) of 11 selected species of reef fish (red grouper, *Epinephelus morio*; gag grouper, *Mycteroperca microlepis;* scamp grouper, *Mycteroperca phenax*; red snapper, *Lutjanus campechanus;* gray snapper, *Lutjanus griseus;* yellowtail snapper, *Ocyurus chrysurus;* lane snapper, *Lutjanus synagris*; greater amberjack, *Seriola dumerili;* lesser amberjack, *Seriola fasciata;* tilefish, *Lopholatilus chamaeleonticeps;* and gray triggerfish, *Balistes capriscus*) in the Gulf of Mexico. EFH in the estuaries are those areas depicted on the maps as "common", "abundant" and "highly abundant". EFH in the offshore areas are those depicted as "adult areas", "spawning areas" and "nursery areas". These species were selected because they are considered to be ecologically representative of the other species in the FMU and also because it was reasonably certain that maps of their distribution, as well as habitat association tables, could be completed during the time frame allowed for the preparation of this amendment.

Collectively, the EFH of the selected species ranges from the estuaries to depths of more than 500 m offshore. Juveniles of four of the 11 species (i.e., gag grouper, gray, yellowtail and lane snappers) occupy estuaries to some extent. Tables 5 through 15 show habitat associations for the various life stages of the selected species. As maps and habitat tables of other species, or more sophisticated maps (i.e., GIS-based) become available, they will be included in future amendments.

In general, reef fish are widely distributed in the Gulf of Mexico, occupying both pelagic and benthic habitats during their life cycle. A planktonic larval stage lives in the water column and feeds on zooplankton and phytoplankton. Juvenile and adult reef fish are typically demersal and usually associated with bottom topographies on the continental shelf (<100m) which have high relief, i.e., coral reefs, artificial reefs, rocky hard-bottom substrates, ledges and caves, sloping soft-bottom areas, and limestone outcroppings. However, several species are found over sand and soft-bottom substrates. For example, juvenile red snapper are common on mud bottoms in the northern Gulf, particularly off Texas through Alabama. Also, some juvenile snapper and grouper such as mutton, gray, red, dog, lane, and yellowtail snappers, jewfish, and red, gag, and yellowfin groupers have been documented in inshore seagrass beds, mangrove estuaries, lagoons, and larger bay systems (GMFMC, 1981b). More detail on hardbottom substrate and coral can be found in the Fishery Management Plan (FMP) for Corals and Coral Reefs (GMFMC and SAFMC, 1982; also, see Sections 4.1 and 4.2 of this amendment for identification and description of the essential estuarine and marine habitat). The following briefly summarizes EFH for each species, by life stage, where known.

Red Grouper - The red grouper is demersal and occurs throughout the Gulf of Mexico at depths from 3 to about 200 m, preferring 30 to 120 m depths (Figure 16). It is particularly abundant off west Florida and the Yucatan coasts. Habitat associations are summarized in Table 5. Spawning occurs at depths of approximately 25 to 90 m on the Florida Banks with peaks during April and May. Eggs are pelagic and planktonic, and require at least 32 ppt salinity for buoyancy. Larvae leave the planktonic stage to become benthic at about 20 mm standard length. Late juveniles select inshore hardbottom to depths of about 50 m, seeking shelter in crevices and other hiding places. Favored nursery areas for juveniles are grass beds, rock formations, and shallow reefs. Juveniles remain in the nursery areas until mature before moving to deeper Gulf waters (NOAA, 1985). Adults select rocky outcrops, wrecks, reefs, ledges, crevices and caverns of rock bottom, as well as “live bottom” areas, in depths of 3 to 190 m. Spawners occur in offshore coastal waters in depths of 20 to 100 m.

Black Grouper - The black grouper is found along the eastern Gulf of Mexico and Yucatan Peninsula, but is considered rare in the western half of the Gulf. The species is demersal and is found from shore to depths of 150 m. Adults occur over wrecks and rocky coral reefs. Spawning occurs during spring and summer throughout all adult areas. Juveniles venture into estuaries occasionally (NOAA, 1985). A habitat table and distribution map are not available for black grouper but will be added in a future amendment when NMFS provides the requisite information.

Gag Grouper - The gag is demersal and is most common in the eastern Gulf, especially the west Florida shelf (Figures 17 and 18). Habitat associations are summarized in Table 6. Eggs are pelagic, occurring in December - April, with areas of greatest abundance offshore on the west Florida shelf. Larvae are pelagic and are most abundant in the early spring. Postlarvae and pelagic juveniles move through inlets into coastal lagoons and high salinity estuaries in April - May where they become benthic and settle into grass flats and oyster beds. Late juveniles move offshore in the fall to shallow reef habitat in depths of one to 50 m. Adults occupy 10 to 100 m depths (large adults occur in greater depths), selecting hardbottoms, offshore reefs and wrecks, coral, and live bottom. Spawning adults form aggregations in depths of 50 to 120 m. Spawning occurs December - April with a peak in the early spring (March - April) on the west Florida shelf.

Scamp - Scamp are demersal and widely distributed on shelf areas of the Gulf, especially off Florida (Figure 19). Habitat associations are summarized in Table 7. As with many of the reef species, information on habitat relationships is sparse. Eggs and larvae are pelagic, occurring offshore in the spring. Early and late juveniles occur on inshore hardbottoms and reefs in depths of 12-33 m. Adults occupy ledges and high relief hardbottoms in depths of 12-189 m, but most are captured at 40-80 m depths. Spawning adults have been taken at depths of 60-100 m. Spawning occurs from late February to early June in aggregations.

Red Snapper - Red snapper occur throughout the Gulf of Mexico shelf (Figure 20). They are particularly abundant on the Campeche Banks and in the northern Gulf. The relatively high abundance once known on the shelf areas of west Florida is now significantly reduced (GMFMC, 1981b). Habitat associations are summarized in Table 8. The species is demersal and is found over sandy and rocky bottoms, around reefs, and underwater objects at depths between 0 to 200 m, possibly even beyond 1200 m. Adults favor deeper water in the northern Gulf. Spawning occurs in offshore waters from May to October at depths of 18 to 37 m over fine sand bottom away from reefs. Eggs are found offshore in summer and fall. Larvae, postlarvae and early juveniles are found July through November in shelf waters ranging in depth of 17 to 183 m. Early and late juveniles are often associated with structures, objects or small burrows, but also are abundant over barren sand and mud bottom. Late juveniles are taken year round at depths of 20 to 46 m. Adults are concentrated off Yucatan, Texas, and Louisiana at depths of 7 to 146 m and are most abundant at depths of 40 to 110 m. They commonly occur in submarine gullies and depressions, and over coral reefs, rock outcroppings, and gravel bottoms.

Vermilion Snapper - Vermilion snapper are found throughout the shelf areas of the Gulf of Mexico. The species is demersal, occurring over reefs and rocky bottom from depths of 20 to 200 m. Spawning occurs from April to September in offshore waters. Juveniles occupy reefs, underwater structures and hard bottom habitats in 20 to 200 m depths (NOAA, 1985).
A habitat association table and distribution map are not available for vermilion snapper but will be added in a future amendment when NMFS provides the requisite information..

Gray Snapper - The gray snapper occurs on the shelf waters of the Gulf and is particularly abundant off south and southwest Florida (Figures 21 and 22). Gray snapper occur in almost all of the Gulf's estuaries but are most common in Florida. Habitat associations are summarized in Table 9. Considered to be one of the more abundant snappers inshore, the gray snapper inhabits waters to depths of about 180 m. Adults are demersal and mid-water dwellers, occurring in marine, estuarine, and riverine habitats. They occur up to 32 km offshore and inshore as far as coastal plain freshwater creeks and rivers. They are found among mangroves, sandy grassbeds, and coral reefs and over sandy, muddy and rocky bottoms. Spawning occurs offshore around reefs and shoals from June to August. Eggs are pelagic and are present June through September after the summer spawn , occurring in offshore shelf waters and near coral reefs. Larvae are planktonic, occurring in peak abundance June through August in offshore shelf waters and near coral reefs from Florida through Texas. Postlarvae move into estuarine habitat and are found especially over dense grass beds of *Halodule* and *Syringodium*. Juveniles also are marine, estuarine, and riverine dwellers, often found in estuaries, channels, bayous, ponds, grassbeds, marshes, mangrove swamps, and freshwater creeks. They appear to prefer *Thalassia* grass flats, marl bottoms, seagrass meadows, and mangrove roots. More detailed information on habitat associations of gray snapper is provided in Nelson (1992) and Pattillo et al. (1997).

Yellowtail Snapper - Yellowtail snapper are distributed throughout the shelf area of the Gulf of Mexico, but are more concentrated off central and southern Florida (Figures 23 and 24). Habitat associations are summarized in Table 10. The species is demersal, occurring over hard irregular bottoms, such as coral reefs and near the edge of shelves and banks. Spawning occurs February through October (peaks in February - April and September - October) in offshore areas. Information on eggs, larvae, and postlarvae is sparse and represents an area of needed research. Juveniles are found in nearshore nursery areas over vegetated sandy substrate and in muddy shallow bays (NOAA, 1985). *Thalassia* beds and mangrove roots are apparent preferred habitat for early juveniles. Late juveniles apparently select shallow reef areas as primary habitat. Adults are found from shallow waters to depths of 183 m but generally are taken in less than 50 m depths. Adults are considered to be semi-pelagic wanderers over reef habitat.

Lane Snapper - The lane snapper occurs throughout the shelf area of the Gulf in depths ranging from zero to 130 m (Figures 25 and 26). Habitat associations are summarized in Table 11. The species is demersal, occurring over all bottom types, but is most common in coral reef areas and sandy bottoms. Spawning occurs in offshore waters from March through September (peak July-August). Information on habitat preferences of larvae and postlarvae is non-existent and is in need of research.. Nursery areas include the mangrove and grassy estuarine areas in the southern Texas and Florida and shallow areas with sandy and muddy bottoms off all Gulf states. Early and late juveniles appear to favor grass flats, reefs, and soft bottom areas to offshore depths of 20 m (NOAA, 1985). Adults occur offshore at depths of 4 to 132 m on sand bottom, natural channels, banks, and man-made reefs and structures.

Greater Amberjack - The greater amberjack occurs throughout the Gulf coast to depths of 400 m (Figure 27). Habitat associations are summarized in Table 12. Information is sparse on habitat associations for all life stages of amberjack. Adults are pelagic and epibenthic, occurring over reefs and wrecks and around buoys. Very little information exists on spawning adults, but in the northern Gulf spawning occurs from May to July and may be as early as April based on histology. Spawning occurs offshore year- round. Juveniles also are pelagic and often attracted to floating plants and debris in the nursery areas that also are offshore (NOAA, 1985).

Lesser Amberjack - Distribution of the lesser amberjack is shown in Figure 28. Habitat associations of life stages are summarized in Table 13. Information is sparse, particularly for the early life stages (i.e., eggs, larvae and postlarvae). Juveniles occur offshore in the late summer and fall in the northern Gulf. Small juveniles are associated with floating *Sargassum*. Adults are found offshore year round in the northern Gulf where they are associated with oil and gas rigs and irregular bottom. Spawning occurs offshore September-December and February-March, probably in association with oil and gas structures and irregular bottom.

Tilefish - Tilefish occur throughout the deeper waters of the Gulf of Mexico (Figure 29). Habitat associations are summarized in Table 14. The species is demersal, occurring at depths from 80 to 450 m, but is most common between depths of 250 to 350 m. Preferred habitat is rough bottom and steep slopes. Spawning occurs in the months of March to November throughout the species range. Eggs and larvae are pelagic; early juveniles are pelagic-to-benthic. Nursery areas are throughout the species range (NOAA, 1985). Late juveniles burrow and occupy shafts in the substrate. Adults also dig and occupy burrows along the outer continental shelf and on flanks of submarine canyons.

Gray Triggerfish - Occurrence of the gray triggerfish in the Gulf is shown in Figure 30. Habitat associations of life stages are summarized in Table 15. Information is sparse, particularly for the early life stages (i.e., eggs, larvae and postlarvae). Eggs occur in late spring and summer in nests prepared in sand near natural and artificial reefs. Eggs are guarded by the female and/or male. Larvae and postlarvae are pelagic, occurring in the upper water column, usually associated with *Sargassum* and other flotsam. Early and late juveniles also are associated with *Sargassum* and other flotsam and may be found in mangrove estuaries. Adults are found offshore in waters greater than 10 m where they are associated with natural and artificial reefs. Spawning adults occur in late spring and summer around natural and artificial reefs in water depth greater than 10 m.

5.3.3 Prey Dependence

With 44 species of reef fish in the management unit, the prey of this species complex is rich and varied (GMFMC, 1981b). Many species of snapper and grouper occupy inshore areas during their juvenile stages (e.g., mutton, dog, lane, gray and yellowtail snapper; and jewfish, red, gag, and yellowfin groupers) where they feed on estuarine dependent prey (e.g., shrimp, small fish and crabs). As they mature and move offshore, the diets in many cases change more to fish, but estuarine-dependent species (e.g., shrimp, crabs) can still constitute an important dietary component. The gray snapper is a good example of a species with widely diverse habitat and feeding regimens. This species is classified as an opportunistic carnivore at all life stages (Pattillo et al. 1997). During the juvenile stage in the estuarine environment, the gray snapper feeds on small shrimp, copepods, amphipods and larval fish; at offshore reefs adults feed primarily on fish and secondarily on crustaceans; larger fish eat proportionately more fish. Likewise, the red snapper is basically carnivorous, feeding mainly on fish and squid. Juvenile red snapper often feed on shrimp but become more piscivorous after age one. Of the vertebrates consumed, most are not obligate reef dwellers, indicating that red snapper feed away from reefs (GMFMC, 1981b). In general, groupers are considered to be unspecialized, opportunistic feeders, feeding on a variety of fishes and crustaceans (Jory and Iversen, 1989).

For more information on specific feeding habits of other reef fish species see GMFMC (1981b).
Habitat important to the prey of reef fish species ranges from the estuaries to the offshore reefs and adjacent sand and mud bottom areas. Thus, the habitat of the prey is no different than the essential reef fish habitat, both estuarine and marine, as described in Sections 4.1 and 4.2.

5.3.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the reef fish FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on habitat of all reef fish species in the management unit as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the reef fish FMP.

5.4 Amendment to the FMP for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic.

5.4.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for the Coastal Migratory Pelagic Resources in the Gulf of Mexico and South Atlantic to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C et seq.). This amendment contains the following actions within the geographical area of responsibility of the Gulf of Mexico Fishery Management Council. The South Atlantic Fishery Management Council is responsible for similar actions for the EFH within its geographical area of responsibility.

- Defines and describes EFH based on known distribution of the various life stages of selected coastal migratory pelagic species.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.4.2 Distribution and Summary of Habitats Used by Coastal Migratory Pelagic Species

Figures 31 through 35 depict the areas of common occurrence (and thus the EFH) for four of the six managed species of coastal migratory pelagics (king mackerel, *Scomberomorus cavalla;* Spanish mackerel, *Scomberomorus maculatus;* cobia, *Rachycentron canadum;* and dolphin, *Coryphaena hippurus*) in the Gulf of Mexico. Collectively, these species are commonly distributed from the estuaries (cobia and Spanish mackerel) throughout the marine waters of the entire Gulf of Mexico (i.e., dolphin). Tables 16 through 19 show the habitat associations of the various life stages of king and Spanish mackerel, cobia and dolphin. EFH in the estuaries are those areas depicted on the maps as “common,” “abundant” and “highly abundant”. EFH in the offshore areas are those depicted as “adult areas,” “spawning areas” and “nursery areas”.

The occurrence of these four species of coastal migratory pelagics is governed by temperature and salinity (GMFMC and SAFMC, 1985). All four are seldom found in water temperatures less than 20º C. Salinity preference varies, but is generally for high salinity. Dolphin are seldom found in waters with salinity less than 36 ppt. The scombrids prefer high salinities, but less than 36 ppt. Salinity preference of cobia is not well defined. King mackerel seldom venture into brackish waters, although juveniles occasionally use estuaries. Spanish mackerel tolerate brackish to oceanic waters and often inhabit estuaries, which, along with coastal waters, offer year round nursery habitat. The larval habitat of all species in the coastal pelagic management unit is the water column. Within the spawning area, eggs and larvae are concentrated in the surface waters. These areas are identified for each species in Section 5.1 of Amendment 1 to the FMP (GMFMC and SAFMC, 1985). The following briefly summarizes EFH for each species, by life stage, where known.

King Mackerel - The king mackerel is found throughout the Gulf of Mexico from shore to 200 m depths (Figure 31). Habitat associations are summarized in Table 16. The species is a marine pelagic, so it seldom moves into brackish water. Spawning occurs throughout the range from May to October. Eggs are pelagic over depths of 30 to 180 m. Nursery areas are located in marine waters throughout the range. Juveniles use estuaries occasionally.

Spanish Mackerel - Spanish mackerel are pelagic, occurring over depths to 75 m throughout the coastal zone of the Gulf of Mexico (Figures 32 and 33). Habitat associations are summarized in Table 17. Adults usually are found in neritic waters and along coastal areas. They will inhabit estuarine areas, especially the higher salinity areas, during seasonal migrations, but are considered rare and infrequent in many Gulf estuaries. Spawning grounds are offshore where spawning occurs from May to October. Nursery areas are in estuaries and coastal waters year-round. Larvae are most frequent offshore over the inner continental shelf in marine waters, most frequently in water depths from 9 to about 84 m but are most common in less than 50 m. Juveniles are found offshore and in beach surf, and sometimes in estuarine habitat. Relative abundance among the Gulf's estuaries is shown in Figure 32. Although they occur in waters of varying salinity, juveniles appear to prefer marine salinity and generally are not considered estuarine dependent. Clean sand appears to be the substrate preference of juveniles; preferences of other life stages are unknown. More detailed information on habitat associations are provided in Nelson (1992) and Pattillo et al. (1997).

Cobia - Cobia are found throughout the coastal waters of the Gulf (Figure 34). Habitat associations are summarized in Table 18. The species is large, pelagic, and epibenthic and is often found near wrecks, reefs, pilings, buoys and floating objects. They occasionally enter estuaries. Greatest abundance is in the coastal areas from shore to 20 m depths in the eastern Gulf, 40 m in the northern Gulf and to 100 m in the southern Gulf. Adults occur year round throughout the Gulf, but display seasonal migrations, occurring more abundantly March-October in the northern Gulf and November-March in the southern Gulf. Spawning adults occur April-September in nearshore and shelf waters of the northern Gulf. Spawning occurs in spring and summer in the northern Gulf throughout all adult areas, except in estuaries (NOAA, 1985). Eggs are pelagic, usually found in the top meter of the water column in the summer. Larvae are found from May to September in estuarine and offshore shelf waters of the northern Gulf from the surface to depths of 300 m. Pre- and early juveniles occur in April-July in coastal waters and the offshore shelf in the northern Gulf. Late juveniles are found May-October in coastal waters and the offshore shelf. Nursery areas are the same as the adult areas and include coastal areas, bays, and river mouths (NOAA, 1985).

Dolphin - Dolphin are distributed throughout the Gulf of Mexico, as shown in Figure 35. Table 19 summarizes habitat associations by life stage. The dolphin is primarily an oceanic species, although it occasionally enters coastal waters that have oceanic strength salinity. It is common in coastal waters of the northern Gulf mainly during summer months. It is an epipelagic species known for aggregating below or near floating objects, especially *Sargassum*. Spawning occurs throughout the adult areas of the open Gulf year-round with peaks in spring and early fall. Larvae are usually found over depths of greater than 50 m and are most abundant over 180 m. Adults occur over depths out to 1,800 m, but are most common over the 40 to 200 meter depth range. Nursery areas are year-round in the oceanic and coastal waters where salinity is high (NOAA, 1985).

Bluefish - Bluefish are a pelagic species found in many Gulf estuaries and on the continental shelf to depths of 200 m. In the Gulf bluefish are most common along the coasts of Louisiana, Mississippi, Alabama and Florida, although they are more abundant along the Atlantic seaboard. Spawning grounds are generally along the outer half of the continental shelf. Spawning occurs from April to November in the northern Gulf. Nursery areas are inshore along beaches and in estuaries, inlets and rivers (NOAA, 1985). A habitat association table and EFH distribution map for bluefish are not available but will be included in a future amendment when NMFS provides the requisite information.

LittleTunny - Little tunny are distributed throughout the Gulf of Mexico, usually occupying depths less than 200 m but occasionally up to 1,000 m. The species is pelagic and is most common in coastal areas with swift currents, near shoals. Spawning occurs throughout the species' range from March to November. Nursery areas include most coastal pelagic waters throughout the range (NOAA, 1985). A habitat association table and EFH distribution map are not available for little tunny but will be included in a future amendment when NMFS provides the requisite information.

5.4.3 Prey Dependence

Estuaries are important habitats for most of the major prey species of coastal pelagics (GMFMC and SAFMC, 1985 and 1990). For this reason estuarine habitats and factors which affect them should be considered as a part of the coastal pelagic management unit. All the coastal pelagic species, except the dolphin, move from one area to another and seek as prey whatever local resources happen to be abundant. The coastal pelagics feed throughout the water column on a variety of fishes, especially herrings. Squid, shrimp, and other crustaceans also are eaten. Many of the prey species of the coastal pelagics are estuarine-dependent in that they spend all or a portion of their lives in estuaries. Accordingly, the coastal pelagic species, by virtue of their food source, are to some degree also dependent upon estuaries and, therefore, can be expected to be detrimentally affected if the productive capabilities of estuaries are greatly degraded.

5.4.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the coastal migratory pelagics FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on the habitat of all managed species of coastal migratory pelagics as it is developed and advise when there is sufficient new information to warrant an amendment. The

Council will determine whether the amendment should be generic (as with the present amendment) or only for the coastal migratory pelagics FMP.

5.5 Amendment to the FMP for the Stone Crab Fishery of the Gulf of Mexico

5.5.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for the Stone Crab Fishery of the Gulf of Mexico to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C et seq.). This amendment contains the following actions:

- Defines and describes EFH based on known distribution of the various life stages of the stone crab, *Menippe mercenaria*.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.5.2 Distribution and Summary of Habitats Used by Stone Crabs

Figure 36 depicts the areas of common occurrence (and thus the EFH) of the stone crab, *Menippe mercenaria,* in Gulf of Mexico estuaries. Figure 37 depicts offshore occurrence of *Menippe spp*. Figure 37 is labeled *Menippe spp.* because it includes *M. mercenaria* and *M. adina*. West of about Cedar Key, Florida, however, the species is likely *M. adina*, or a *M. mercenaria* x *adina* cross. Table 19 shows habitat associations of the various life stages of *M. mercenaria*. This amendment discusses EFH only for *M. mercenaria* since the fishery is virtually all for that species. EFH in the estuaries are those areas depicted on the maps as “common”, “abundant” and “highly abundant”. EFH in the offshore areas are those depicted as “adult areas,” “spawning areas” and “nursery areas.”

Unless noted otherwise, the following discussion is from Amendment 5 to the Stone Crab FMP (GMFMC, 1994).

Adult stone crabs burrow under rock ledges, coral heads, dead shell, or grass clumps. In seagrass flats (primarily *Thalassia testudinum*) and along the sides of tidal channels they inhabit burrows which may extend 127 cm (50 in.) into the substrate. They occasionally inhabit oyster bars and rock jetties.

Juveniles (less than 30 mm carapace width, CW) do not dig burrows; they use readily available hiding places that offer close proximity to food items. Juveniles have been reported to be abundant on shell bottom, sponges, and *Sargassum* mats as well as in channels and deep grass flats. After reaching a width of about one-half inch (12.5 mm), the crabs live among oyster shells and rocks in shallow parts of estuaries. There are numerous reports of large juveniles - small adults (up to 60 mm CW) being abundant on oyster reefs.

Unlike the benthic dwelling adults and juveniles, stone crab larvae are planktonic (drifting with water currents). Although they are capable of feeble swimming, they are essentially at the mercy of water currents. Adults and juveniles appear to be hardy: they tolerate most environmental extremes within their distributional range and are capable of surviving salinities considerably higher or lower than 33 ppt. However, stone crab larvae require warm water 30^o C (86^o
F) and high salinity (30-35 ppt) for most rapid growth. Larval survival and growth rates decline rapidly below 25^o C (77^o F) and 25 ppt. Thus in certain broad areas of shallow water where salinity and temperature can dramatically fluctuate, such as upper Florida Bay, larvae may have high mortality rates due to these factors alone.

The most productive habitat by far is found in the Everglades - Florida Bay area. Stone crabs are sought in shallow Florida Bay and offshore from Cape Sable to Cape Romano out to a water depth of 15 to 18 m. The shoreline in this area is characterized by a broad maze of mangrove swamp, with extensive oyster reef development in the Ten Thousand Islands area. Extensive turtle grass flats occur from Cape Sable northward to Cape Romano Shoals. However, in the area of Cape Romano Shoals, the bottom is characterized by "flocculent sand" and mud and is not commercially fished. Offshore of the turtle grass habitat (along the west coast of Florida turtle grass is found to a maximum depth of 6 to 9 m, hard packed sand with scattered shell and patches of hardbottom with attached soft coral and sponge communities typifies stone crab habitat.

According to Dr. T. Burt, Research Scientist, Florida Marine Research Institute, there are three known recruitment grounds for small juveniles (post settlement) (personal communication 3/31/98). These include the nearshore waters off the Ten Thousand Islands north of Cape Sable, the Cedar Key area, and the Tampa Bay area. These small juveniles are rare or absent from Florida Bay, upper Tampa Bay or estuaries north of Cedar Key. Dr. Burt also reports that larger juveniles are found in the nearshore waters of west Florida and they, too, are most abundant on the recruitment grounds. They are not found in Florida Bay and are rare in upper Tampa Bay and upper Charlotte Harbor.

5.5.3 <u>Prey Dependence</u>

The food and feeding habits of the stone crab are summarized in Pattillo et al. (1997). Basically, the stone crab is a high trophic level predator and is primarily carnivorous at all life stages. Juveniles feed on small molluscs, polychaetes and crustaceans. Adults crush all types of molluscs and are known to feed on oysters and mussels. They also consume carrion and vegetable matter such as seagrass.

The stone crab population is basically dependent upon the prey produced in the estuaries and seagrass beds that abound along the Florida west coast (GMFMC, 1994). Nutrient rich, freshwater runoff flowing into the estuaries fertilizes the seawater, resulting in high seagrass and phytoplankton productivity. Lower salinity (which can often exclude predators) and plentiful phytoplankton are ideal for oysters, worms, and other organisms. These provide abundant food and shelter for juveniles and adult stone crabs. Seagrasses and mangrove forests, often the dominant features in nearshore and estuarine environments, and the epiphytic algae on them are generally considered to be the major producers of organic matter in coastal ecosystems. They provide protective covering and, along with the phytoplankton in the surrounding water, support the food items of the stone crab.

5.5.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the stone crab FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on stone crab habitat as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the stone crab FMP.

5.6 Amendment to the FMP for Spiny Lobster in the Gulf of Mexico and South Atlantic

5.6.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C et seq.). This amendment contains the following actions within the geographical area of responsibility of the Gulf of Mexico Fishery Management Council (note: the South Atlantic Fishery Management Council is responsible for similar actions for the EFH within its geographical area of responsibility):

- Defines and describes EFH based on known distribution of the various life stages of spiny lobster.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.6.2 Distribution and Summary of Habitats Used by Spiny Lobster

Figures 38 and 39 depict the areas of common occurrence (and thus the EFH) of spiny lobster in the Gulf of Mexico. EFH in the estuaries are those areas depicted on the maps as "common," "abundant" and "highly abundant." EFH in the offshore areas are those depicted as "adult areas," "spawning areas" and "nursery areas." The species inhabits areas from shore to depths of 80 m or more. Table 21 shows habitat associations of the various life stages.

The principal habitat used by spiny lobster is offshore coral reefs and seagrasses (GMFMC and SAFMC, 1989). The Florida Platform is fronted by shelf-edge reef complexes of the Cretaceous Era. It is characterized by three regional structures but only the Southwest Florida Reef Tract is of prime importance to spiny lobster. The bottom is composed of sand and shell inshore and coral-sponge farther offshore. Salinity and temperature are high throughout most of the year and are generally higher than in the area north of Tampa. Bottom topographies on the continental shelf have high relief; i.e., coral reefs, artificial reefs, rocky hardbottom substrates, ledges and caves, sloping softbottom areas, and limestone outcroppings. More detail on these habitat types is found in the fishery management plan for coral and coral reefs (GMFMC and SAFMC, 1982) and in Section 4.2 of this amendment.

The spiny lobster spawns in offshore waters along the deeper reef fringes (Lyons et al., 1981). Although adult males and females sometimes inhabit bays, lagoons, estuaries, and shallow banks, none are known to spawn there (Marx and Herrnkind, 1986). Requirements of offshore spawning habitat are high shelter quality, suitable water conditions (stable temperature and salinity, low surge, and turbidity), and adequate larval transport by oceanic currents (Kanciruk and Herrnkind, 1976 in Marx and Herrnkind, 1986).

The following excerpt from Marx and Herrnkind (1986) detail habitat requirements for the various spiny lobster life stages:

> "Phyllosoma larvae inhabit the epipelagic zones of the open ocean, which are characterized by relatively constant temperature and salinity, low levels of suspended sediments, and few pollutants. Relatively stable, natural conditions are apparently required for optimum survival. Ingle and Whitham (1968) noted that 'spiny lobster larvae are extremely delicate, physically, and inordinately fastidious, physiologically.' Larvae are particularly sensitive to silt particles, which can, in extreme instances, lodge on their setae, weigh them down, and cause death (Crawford and De Smidt, 1922). Because nutritional requirements change throughout the life of the larvae (Provenzano, 1968; Phillips and Sastry, 1980), enhanced growth and survival require a diverse, productive oceanic plankton community. Positive correlations between plankton biomass and density of late-stage phyllosomes were reported by Ritz (1972). Although pueruli settle on isolated oceanic banks where the minimum depth exceeds 10 m (Munro, 1974), productive fisheries apparently require well-vegetated shallow habitat for juvenile development. Biscayne Bay and Florida Bay are critical nurseries for Florida lobsters (Davis and Dodrill, 1980). These bays are characterized by extensive meadows of benthic vegetation, primarily turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), and various algae (Tabb et al., 1962; Hudson et al., 1970; Eldred et al., 1972). Macroalgal communities interspersed among these areas apparently are important for the earliest benthic stages. Red algae, *Laurencia* spp., are abundant in waters supporting concentrations of young juveniles (Eldred et al., 1972; Andree, 1981; Marx, 1983). Intricate algal branching provides young lobsters with cryptic shelter and supports a diverse assemblage of small gastropods, crustaceans, and other prey.
>
> "Juveniles larger than 20 mm CL take refuge in both biotic (sponges, small coral heads, sea urchins) and abiotic (ledges, solution holes) structures. The importance of shelter availability on population distribution is magnified because, unlike clawed lobster, spiny lobsters can modify but not construct dens (Kanciruk, 1980). Substantial addition of artificial shelters in Biscayne Bay caused population redistribution but did not increase the numbers of lobsters in the area (Davis, 1979). The south Florida juvenile lobster population may be limited by recruitment, emigration, food, and perhaps other factors (Davis, 1979).
>
> "Adults inhabit coral reef crevices or overhangs, rocky outcroppings, ledges, and other discontinuities in hard substrate. Residential patterns of habitation are apparent in large, permanent dwellings near extensive feeding grounds (Herrnkind et al., 1975). Soft-substrate shelters, like grass-bed ledges, are occupied primarily during nomadic movements. Muddy, turbidity-prone substrates are usually avoided (Herrnkind et al., 1975; Kanciruk, 1980).

> "Throughout benthic life spiny lobsters use other habitats besides those providing shelter. Lobsters concentrated during the day in localized dens disperse at night to forage over adjacent grass beds, sand flats, and algal plains (Herrnkind et al., 1975). Interactions between population density of spiny lobster and food availability have not been studied in south Florida. Extreme variation in growth rates, both among individuals and by habitat, suggests that food abundance is a critical factor, as demonstrated in spiny lobster species elsewhere (Chittleborough, 1976)."

In southeast Florida, lobsters are distributed in accord with the habitats serving each life stage. Reproductively active adults are mainly found along the oceanic (eastward) and gulfward (west) reef and hard substrate fringes of the Keys and Florida Bay. However, some of these individuals transit back and forth to the bay during non-reproductive periods. Juveniles above 20 mm CL are abundant but scattered throughout middle and lower Florida Bay wherever benthic conditions provide refuge. The larger juveniles wander over all intervening habitats and feed extensively in vegetated substrates; they make up the bulk of animals captured in traps within the bay. The distribution and abundance of young juveniles between settlement and 20 mm CL are yet to be quantitatively estimated. Based on recent ecological studies (Marx and Herrnkind, 1985, Herrnkind and Butler, 1986, Herrnkind et al., 1988), it is likely that settlement occurs wherever swimming postlarvae are brought into contact with inshore stands of benthic algae and other fouling assemblages. Slightly older individuals can be reliably found in mixed substrates within and adjacent to such areas. Upon outgrowing the algal habitat, the young juveniles take on an increasingly nomadic lifestyle as they gain locomotory proficiency.

Maintaining healthy settlement and early juvenile habitat is crucial both because it is essential for regional lobster recruitment and because it is so vulnerable to human and natural impacts. Nearshore and shallow water vegetated habitats are especially subject to degradation by pollution, physical disturbance (e.g., prop damage, dredging, burial), turbidity, etc., (see below), as well as natural cold chill, vegetation die-off, and salinity flux. Each hectare (10,000 m^2) of red algal meadow is calculated to nurture 1,000 juvenile lobsters annually as new settlers continually recruit monthly, then grow and emigrate to other habitats after several months (Marx, 1986).

5.6.3 <u>Prey Dependence</u>

The feeding and food items of spiny lobster are summarized in Pattillo et al. (1997). Spiny lobster phyllosomes presumably feed on plankton. Benthic postlarvae are opportunistic feeders, consuming a large variety of organisms including small gastropods, bivalves and crustaceans. Young juveniles feed on molluscs, crustaceans and other fauna that exist on the algal clumps in which they reside. Large juveniles and adults are higher carnivores, feeding on algae, foraminifera, sponge spicules, polychaetes, bivalves, conchs, hermit crabs, and other crustaceans. Habitat of the prey species is essentially the same as habitat required by spiny lobster.

5.6.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the spiny lobster FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on spiny lobster habitat as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the spiny lobster FMP.

5.7 Amendment to the FMP for Coral and Coral Reefs of the Gulf of Mexico

5.7.1 List of Actions

This subsection, when paired with Sections 3.0, 4.0, 6.0, 7.0 and 8.0, amends the Fishery Management Plan for Coral and Coral Reefs in the Gulf of Mexico to comply with the essential fish habitat (EFH) requirements of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C et seq.). This amendment contains the following actions within the geographical area of responsibility of the Gulf of Mexico Fishery Management Council:

- Defines and describes EFH based on known distribution of coral and coral reefs.
- Identifies adverse impacts to EFH from fishing and non-fishing activities.
- Provides recommendations to minimize impacts to EFH from identified threats from non-fishing activities.
- Identifies for consideration in subsequent FMP amendments some potential threats to EFH from fishing-related activities.
- Identifies needed research to better identify and describe EFH

5.7.2 Distribution and Summary of Habitats Used by Coral

Figure 40 depicts the distribution (and thus the EFH) of coral reefs in the Gulf of Mexico. Coral reef communities or solitary specimens exist throughout the geographical areas of authority of both the Gulf of Mexico and the South Atlantic Fishery Management Councils. This wide distribution places corals in oceanic habitats of corresponding variability, from nearshore environments to continental slopes and canyons, including the intermediate shelf zones. For a description of coral habitat throughout the southeastern U.S., see GMFMC and SAFMC (1982).

The three primary areas in the Gulf of Mexico where corals are concentrated are the East and West Flower Garden Banks, the Florida Middle Grounds and the extreme southwestern tip of the Florida Reef Tract. Only the Flower Gardens and the Florida Middle Grounds are described here. Description of the Florida Reef Tract can be found in the South Atlantic's Council's EFH amendment for coral since virtually all of the Florida Reef Tract is located in the South Atlantic Council's jurisdiction. Also, see Section 4.2.4.2 of this amendment for discussion on the relationship of coral to live bottom habitat.

East and West Flower Garden Banks

The two separate banks at the Flower Gardens are distinct geologic structures located about 25 km apart and over 200 km from the coasts of Texas and Louisiana. Located on the edge of the continental shelf, the East Bank's midpoint is located at about 27˚ 55' 07.44" N and 93˚ 36' 08.49" W. The West Bank center point is at 27˚ 52' 14.21" N and 93˚ 48' 54.79" W. The salt dome infrastructure of the Banks projects up through the overlying rock strata and forms two distinct hills rising several hundred m above the sea floor to less than 50 m (165 ft) of the sea surface. The habitat area of particular concern (HAPC) is limited to the portions of each bank above the 50-fathom isobath.

East Flower Garden Bank is a tear-shaped dome roughly 5 km in diameter rising to within 20 m (66 ft) of the sea surface (Bright and Rezak, 1976, 1978). The total area of coral reef atop the bank is 0.3 km² (75 acres) (Office of Coastal Zone Management, 1979). The corals and associated species occur in seven distinct zones from the cap at 16 m (52 ft) to the base of the bank (i.e., onset of soft bottom community) at 110 to 120 m (360 to 393 ft): 1) leafy algae; 2) *Madracis*; 3) *Diploria, Montastrea,* and *Porites*; 4) algae-sponge; 5) deepwater corals; 6) antipatharians and drowned reefs; and 7) soft bottom (Bright, 1977). The *Madracis* zone is occupied almost entirely by populations of the small branching coral *M. mirabilis*. Principal species, including corals, within each of the zones have been elucidated by submersible transects and listed by Bright and Rezak (1976, 1978).

West Flower Garden Bank is oblong, shaped roughly 11 km by 8 km, trending northeast to southwest. The live reef atop the dome occupies 0.4 km² (100 acres) (Office of Coastal Zone Management, 1979), including a peak rising to within 20 m (66 ft) of the surface (Rezak, 1977). Biotic zonation at West Flower Garden is characterized by assemblages similar to those observed at the East Flower Garden Bank. From its peak at about 20 m (66 ft) depth to the dome base at 136 m (450 ft), four zones exist: 1) *Diploria*, *Montastrea, Porites*; 2) algae-sponge; 3) deepwater corals; and 4) soft bottom (Bright and Pequegnat, 1974). No leafy algae or *Madracis* zones were described (Bright, 1977). Antipatharians have been observed amidst the soft bottom zone. Corals at West Bank have been classified and published by Tresslar (1974); Bright and Pequegnat (1974) describe a substantial number of the associated species.

Coral assemblages and habitat at East and West Flower Garden Banks comprise a unique resource. The coral reefs on those banks are the northwestern most reefs in the Gulf of Mexico. Hence the biota they support are stressed climatologically, at least partially isolated from the gene pool, and susceptible to collapse should existing populations be destroyed. As the northwestern most coral reefs, they are of particular research interest. The biotic zonation at the Flower Gardens has been described as one of the most extensive of all Gulf of Mexico banks (Bright, 1977).

<u>Florida Middle Grounds</u>

The Florida Middle Grounds is a live hardbottom area located on the outer edge of the continental shelf in the eastern Gulf of Mexico. It is approximately 160 km (99 miles) west-northwest of Tampa and 140 km (87 miles) south-southeast of Cape San Blas, Florida.

The Florida Middle Grounds is the best known and most important area in terms of coral in the northeastern Gulf of Mexico. The dominant stony corals include *Madracis decactis, Porites divaricata*, *Dichocoenia stellaris* ,and *Dichocoenia stokesii*. Octocorals, a relatively minor component of other Gulf reefs, are prominent on the Middle Grounds. Dominant forms include

Muricea elongata (orange *Muricea*), *Muricea laxa* (delicate *Muricea*), *Eunicea calyculata* (warty *Eunicea*) and *Plexaura flexuosa* (sea rod), Hopkins et al. (1977).

The boundary of the area identified as a habitat area of particular concern contains the major area of high relief bottom . The Florida Middle Grounds were nominated as a marine sanctuary but no further action has yet been taken. The MMS has identified areas in the northern portion of this HAPC as "no activity areas" for oil and gas exploration and development.

See Section 4.2.4.1.1 for a more detailed description of coral habitat in the Gulf.

5.7.3 Prey Dependence

Coral are suspension feeders for the most part, using nematocysts to capture prey. As such, their prey are the various planktonic organisms carried in the water column. Much of the prey are found in reef sediments during the day and enter the water column at night. Thus, the water column as well as reef sediments represent the habitat of the prey of coral.

5.7.4 Review and Update of Amendment

The Council and NMFS will review and update the EFH component of the Coral FMP at least every five years and amend it as appropriate. The decision to amend will be a joint decision between the Council and NMFS. NMFS will continually provide the Council with new information on coral habitat as it is developed and advise when there is sufficient new information to warrant an amendment. The Council will determine whether the amendment should be generic (as with the present amendment) or only for the coral FMP.

6.0 THREATS TO ESSENTIAL FISH HABITAT

This section discusses what is known, or what is reasonable to assume, about the general impacts of threats to essential fish habitat (EFH) and does not attempt to discusses any other aspects of the activities contained herein. As discussed in previous sections of this Amendment, and published on December 19, 1997 in the Federal Register (62 FR 66531) Magnuson Act Provisions; EFH, Interim Final Rule, the definition of EFH states:

***Essential Fish Habitat* means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: *waters* include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include areas historically used by fish where appropriate; *substrate* includes sediment, hard bottom, structures underlying the waters, and associated biological communities; *necessary* means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.**

The role of habitat in supporting the productivity of organisms has been thoroughly documented in the ecological literature, and the linkage between habitat and fishery productivity has been clearly established for several fishery species. Because habitat is an essential element for sustaining the production of a species, the goals of FMPs cannot be achieved if the managed species do not have a sufficient quantity of suitable habitat.

From the broadest perspective, fish habitat is the geographic area where the species occurs at any time during its life. This area can be described in terms of ecological characteristics, location, and time. Ecologically, essential habitat includes structure or substrate that focus distribution (e.g., coal reefs, topographic highs, pinnacle trends, artificial reefs, marshes, or submerged aquatic vegetation) and other characteristics that are less distinct (e.g., turbidity zones, salinity gradients, or anoxic areas). Spatially, habitat use may shift over time due to climatic change, human uses and impacts, or other factors.

Fishery species use habitat for spawning, breeding, migration, feeding and growth, and for shelter to increase survival. EFH utilized by a species can change with life history stage, abundance of the species, competition from other species, and environmental variability in time and space. The type of habitat available, its attributes, and its functions are important to species productivity, diversity and survival and societal benefits.

The coastal areas of the southeast are highly sought after as places for human habitation. The amenities of the coast and the water-related activities and climate that people enjoy produce the highest growth rates in the nation. Growth rates of over four times the national average have been observed (Chambers, 1992). The population along the Gulf of Mexico is expected to increase by as much as 46 percent between 1980 and 2010 (Chambers, 1992). As the population increases so does urbanization. People require places to live as well as related services such as roads, schools, water and sewer facilities, power, etc. These needs often are met at the expense of EFH and may adversely impact the very values that brought people to the coast. Wetlands and adjacent contiguous lands have been filled for housing and infrastructure. Further, the demand for shoreline modifications (docks, seawalls, etc.) and navigation amenities has further modified the coast.

Every reasonable effort has been made to identify the principal non-fishing and fishing-related threats to EFH, and to provide examples and information concerning the relationship between threat-related activities and EFH. Other information sources and examples undoubtedly exist, and many new studies are underway or in various stages of publication. Accordingly, the following discussion is only a starting point in the identification of threats to EFH and is intended to meet the strict time limitations imposed by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). It is hoped this will lead to further discussions and information development that can be used to update and improve future versions of this document.

The quantitative relationships between fishery production and habitat are very complex and no reliable models currently exist. Accordingly, the degree that habitat alterations have affected fishery production is unknown. Turner and Boesch (1987) assembled and examined the accumulating evidence of the relationship between the extent of wetland habitats and the yield of fishery species dependent on coastal bays and estuaries. They discussed evidence of stock losses following wetland losses and stock gains following wetland gains. While most of the studies were related to shrimp production, other fisheries likely follow similar trends. Accordingly, a significant threat facing fishery production is the loss of habitat by natural and human-related causes.

6.1 Fishing Activities That May Adversely Affect EFH

It should be noted that regarding the guidelines requirement to identify threats to EFH from fishing activities and the inclusion of management measures to minimize these adverse threats, the GMFMC has addressed these issues since the first FMP was published in the late 1970's. Discussions of fishing activities that could adversely affect EFH is presented in current FMPs, including current management measures that are implemented to minimize effects on EFH from fishing. The conservation and management measures implemented by the Council, to date, include actions that eliminate or minimize physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species, and their habitat, and other components of the ecosystem. It is the GMFMC's view that they currently prevent, mitigate for, and/or minimize most adverse effects associated with Gulf of Mexico fishery activities. The GMFMC currently employs many of the options recommended in the guidelines for managing adverse effects from fishing. This includes fishing gear restrictions; seasonal and area restrictions on the use of specified gear including use of transponders to monitor vessels involved in certain fishing activities; gear modifications to allow escapement of particular species or particular life stages (e.g., juveniles); harvest limits; prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; prohibitions on fishing activities that cause significant physical damage in EFH; time/area closures including closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as habitat areas of particular concern. See Section 6.1.1. for a complete description.

However, the actual physical effects to EFH from the use, or cumulative use, of a specific piece of fishing gear in a specified area at a specified time has not been generally well studied in the Gulf of Mexico. To date, the effects of fishing has been the subject of numerous, mostly site specific and fishery specific, investigations that have focused largely on economic and social factors. Most fisheries management efforts today deal with increased yields, gear use requirements or restrictions, and identifying and locating new target species and markets. With the current world wide decline of many fish stocks, emphasis has shifted to stock management and recovery. This change in management emphasis has gradually led to realization that reductions in the size and quality of fishery habitats have reached critical levels. It has also furthered the view that, in certain situations, fishing itself may be profoundly changing the physical and biological character of fish harvest and life requisite areas (sic EFH). An example is "faunal winnowing" and "species replacement", incumbent with intensive fishing. Habitat includes not only the physical and hydrological context, but also the living biological context of a species. Continuous fishing pressure not only affects the physical part of the habitat, but also the biological context within which a species lives. Major, and sometimes irreversible, faunal shifts can occur when the same commercial or sport species are continuously removed from the environment. For example, continuous removal of bottom feeding red drum might result in filling of the niche by hardhead catfish. Additionally, the crash of cod populations in the North Atlantic has been offset by increased numbers of spiny dogfish. Filling the environment with a different suite of dominant species can drastically alter or eliminate EFH for desirable species.

Bottom trawling and other fishing activities that involve direct contact between fishing gear and the bottom environment in the bays, estuaries, and Gulf of Mexico can alter the structural character and function of fish habitats. When the change is sufficient enough to preclude or limit use by fishery directed or target species, declines in catch abundance and individual fish size may occur. Although a clear cause and effect relationship is evident, determination of the level of effect induced by physical change may be complex. Relevant factors, in addition to the magnitude of the direct physical change, may include disturbance frequency and duration, seasonality, and other environmental, ecological, and physiological processes that control recovery and recruitment of requisite species of the community. As noted by Auster and Langton (1998) "... mobile fishing gear reduced habitat complexity by (1) directly removing epifauna or damaging epifauna leading to mortality, (2) smoothing sedimentary bedforms and reducing bottom roughness, and (3) removing taxa which produce structure (i.e., taxa which produce burrows and pits)." Other major methods of fishing in Gulf waters that supposedly do not disturb bottom habitat but still impact EFH are fish, crab and lobster traps, bottom long-lines, and diver harvesting of "live rock" coral.

As difficult and complex as restoring habitats and controlling fish harvest has proven to be, success in these efforts still may not yield satisfactory results. Environmental changes brought about by physical alteration of substrates and changes in species composition may create conditions that cannot sustain preexisting plant and animal assemblages or abundances. As noted by Auster and Langton (1998), population response (and successful fishery management) may be linked to parameters that are closely correlated to...ecological relationships (and) population response may be the result of : 1) independent single-species (intraspecific) responses to fishing and natural variation; 2) interspecific interactions such that, as specific populations are reduced by fishing, non-harvested populations experience a competitive release; 3) interspecific interactions such that as non-harvested species increase from some external process, their population inhibits the population growth rate of the harvested species; and 4) habitat mediation of the carrying capacity for each species, such that gear induced habitat changes alter the carrying capacity of the area. As further implied by Auster and Langton (1998), the magnitude of environmental or ecological change needed to affect a fishery may not need to be monumental from a physical perspective. After all, significant reductions in benthic diatoms and microalgae can affect higher trophic levels.

In their conclusion, Auster and Langton (1998) state: "Much of the research described herein is not at a scale that is directly applicable to fishery management decisions. What the research on trawling impacts does offer is an indication of the types of changes one might expect in benthic communities over large spatial scales as well as confirmation that benthic communities are dynamic and will ultimately compensate for perturbations. However, as observations show, shifts in communities are not necessarily beneficial to the harvested species. The scale of fishing is a confounding factor in management because systems are being fished to the point where recovery is delayed so long that the economic consequences are devastating. We are seeing that now in many U.S. fisheries. Because our knowledge of ecosystem dynamics is still rather rudimentary, managers bear the responsibility of adopting a precautionary approach when considering the environmental consequences of fishing rather than assuming that the extraction of fish has no ecological price and therefore no feedback loop to our non-ecologically based economic system.

This review has revealed that primary information is lacking for us to strategically manage fishing impacts on EFH without invoking the precautionary measures discussed above. A number of areas where primary data are lacking, which allow better monitoring and improved experimentation, ultimately leading to improved predictive capabilities, are:

1. The spatial extent of fishing induced disturbance . While many observer programs collect data at the scale of single tows or sets, the fisheries reporting systems often lack this level of spatial resolution. The available data make it difficult to assess the effects of fishing effort on habitat, community, and ecosystem processes.

2. The effects of specific gear types, along with a gradient of effort on specific habitat types. These data are the first order needs to allow an assessment of how much effort produces a measurable level of change in structural habitat components and the associated communities. Second order data should assess the effects of fishing disturbance in a gradient of type 1 and type 2 disturbance treatments.

3. The role of sea floor habitats on the population dynamics of harvested demersal species. While there is often good time series data on late juvenile and adult populations, and larval abundance, there is a general lack of empirical information (except in coral reef, kelp bed, and for SAV fishes) on linkages between EFH and survival, which would allow modeling and experimentation to predict outcomes of various levels of disturbance."

4. Because information regarding the effects of fishing is lacking in most cases, the Council will make examination of the use of research closure areas a top research priority to detect effects of fishing on EFH by comparison with fished areas.

Auster and Langton (1998) further state that, "Recovery of benthic communities, especially for sessile invertebrates, is dependent upon recruitment at the larval stages. Two aspects of this process that are necessary for success are 1) proximity of reproductively mature adults, and 2) an undisturbed site for settlement and growth to maturity. If the intensity of fishing is too great, then the possibility of a type II disturbance, where a small patch of reproductive animals is isolated by large expanses of sea floor, exists. The frequency of disturbance is equally important because newly settled juveniles may be damaged or destroyed if their settlement surface is perturbed at a critical time in their life cycle. Fishing should therefore be conducted at an intensity that does not create isolated benthic communities that are then expected to recolonize an area if the objective is a sustainable level of harvest. Similarly, the habitat requirements of the harvested species have to be taken into account, as suggested in terms of 1 and 3 above, to insure that the habitat itself is not disturbed anymore frequently than is required to maintain the integrity of the benthic community that supports the fishery."

6.1.1 Current Management Measures Protecting Fishery Habitat

Table 22 and the following text show and describe the current, specific types of fishing gear used in each managed fishery under the appropriate Fishery Management Plan, along with a description of current measures in use to protect fishery habitat. Each of the States also have implemented management measures for their waters (e.g., closed areas and specific gear restrictions) that protect fishery habitat. Contact the individual States for specifics.

Current management measures implemented by the Gulf Council that protect fishery habitat are listed as follows:

Reef Fish FMP

The Reef Fish Fishery Management Plan, implemented in 1984, established a "stressed area" within which the use of fish traps, roller trawls, and powerheads for the harvest of reef fish are prohibited.

Reef Fish Amendment 1, implemented in 1990, expanded the stressed area to the nearshore waters of the entire Gulf of Mexico and added a longline boundary and buoy gear within which the use of longlines and buoy gear for the directed harvest of reef fish was prohibited within the prohibited area across the entire Gulf of Mexico.

Reef Fish Amendment 5, implemented in February 1994, established a seasonal closure of Riley's Hump (near Dry Tortugas) to all fishing during May and June to protect mutton snapper spawning aggregations. The Amendment also established a special management zone (SMZ) with gear restrictions in a portion of Alabama's general permit area for artificial reefs, and created a framework procedure for establishing future SMZs.

Reef Fish Amendment 14, implemented in March 1997, prohibited the use of fish traps in the EEZ west of Cape San Blas, Florida.

Shrimp FMP

The Shrimp Fishery Management Plan, implemented in May 1981, established: (1) a cooperative Tortugas Shrimp Sanctuary with the state of Florida to close an area to shrimp trawling where small pink shrimp comprise the majority of the population most of the time; (2) a cooperative 45-day seasonal closure (from the shoreline of Texas out 200 miles) with the state of Texas to protect small brown shrimp emigrating from state bay nursery areas; and (3) seasonal zoning of an area of Florida Bay for either shrimp or stone crab fishing to avoid gear conflict. Shrimp Amendment 1, approved later that year, established a procedure to adjust by regulatory amendment the size of the Tortugas Sanctuary or the extent of the Texas closure, or to eliminate either closure for one year.

Corals and Coral Reef FMP

The Corals and Coral Reefs Fishery Management Plan, implemented in August 1984, identified portions of the East and West Flower Garden Banks off Texas, the Florida Middle Grounds, and

Oculina Bank (in the SAFMC area) as habitat areas of particular concern (HAPC), and within these areas prohibited the use of bottom longlines, traps and pots, and bottom trawls to prevent damage to corals. An additional proposed measure to prohibit anchoring within the East and West Flower Garden Banks HAPC, except for vessels less than 100 feet in length, was disapproved by NOAA as being beyond the authority provided by the MSFCMA. Detailed discussion of HAPCs is found at Section 7.3.

Coral Amendment 2, implemented December 1994, closed the Gulf of Mexico EEZ to live rock harvest except for the area from the Florida-Alabama state line to the Monroe-Collier County line in Florida, prohibited chipping of live rock north and west of the Pasco-Hernando County Line, and prohibited all harvest of wild live rock after 1996.

Coral Amendment 3, implemented 1995, reduced the area for allowable live rock harvest to the EEZ from Collier County through Levy County, Florida.

6.1.2 Fisheries of the Gulf of Mexico

A complete discussion of the commercial and recreational fisheries in the Gulf of Mexico is found in the existing FMPs and will not be repeated here. What is important is to describe the economic value of the Gulf fisheries to the individuals involved in the fishery, the local governments and states, and the nation.

According to the NMFS report, "Status of Fishery Resources off the Southeastern United States for 1991, " marine fisheries in the Southeastern U.S. continue a downward slide (USDOC, 1992b). This report documents a decline in the yield of both recreational and commercial fisheries from 1989 to 1990 in the region. In the Gulf of Mexico, commercial yield dropped by 9.2 percent, from 811,600 metric tons (894,600 tons) to 737,000 metric tons (812,174 tons) between 1989 and 1990. Recreational yield declined by 51 percent from 104.3 million fish to 50.3 million fish. Within the recreational fisheries where estimates were presented, declines were noted for groupers (-81 percent), snappers (-35 percent), sharks (-68 percent), and tuna (-41 percent). Increases were reported for king mackerel (31 percent) and Spanish mackerel (2 percent). It should be noted that decreased landings may also be influenced by increased regulations and catch limits imposed on fisheries or a reduction in fishing effort (USEPA, 1994d).

6.1.2.1 Trawl fishery review

The commercial shrimp industry is the most important fishery in the Southeastern U.S. In 1990, over 125.6 million kg (277 million pounds) of shrimp valued at $454 million were landed in the Gulf and South Atlantic regions (USDOC, 1991). With the exception of localized harvesting techniques, most wild-caught shrimp are produced using bottom trawls—nets towed along the sea floor, held apart with very large and heavy "doors", bottom sled devices made of wood or steel. Shrimp trawls are inherently nonselective harvesting gear; that is, nontarget species (bycatch) are caught along with the species being sought (USEPA, 1994d). Shrimp fishermen must sort through this bycatch in order to separate shrimp and other marketable species from the catch. The component of the catch which is not marketable is returned overboard. While red snapper bycatch in the shrimping industry was a major focus during 1990, bycatch of other species has become a significant issue (Seidel and Watson, 1990). The magnitude of this bycatch, the fact that most of it is dead when returned to the sea, and the fact that some species in the bycatch are experiencing severe population declines, make this an important issue in the Gulf of Mexico (USEPA, 1994d).

A large component of the trawl fishery is the bait trawl fishery, which is composed of many small vessels that pull small bottom trawls in Gulf bays to supply bait-houses with live shrimp and small finfish for recreational fishermen. This bait trawl fishery also supplies fresh seafood for the general public at bait-houses and other outlets.

In addition to the nonselective nature of bottom trawls, research indicates that they can be potentially damaging to the bottom community (Gaston, 1990). Recent studies on the effects of bottom trawling emphasized the impacts on communities of bottom dwelling invertebrates. The seafloor is covered by thousands of organisms, including shrimp that live on the sediment surface and sometimes burrow beneath it. Crustaceans and worms build tubes that protrude above the bottom, stabilizing the sediments, and allowing the organisms access to oxygenated water. Shrimp graze the bottom, scavenging among the tube dwelling species. Trawls pulled over the bottom disrupt this community, destroying tubes, eliminating organisms on the sediment surface, and increasing the turbidity of the water (USEPA, 1994d). Videos taken of a bottom community off the coast of Florida showed trawling scars along the seafloor, damage to sponge communities and reefs, and disruption of other bottom fauna (Gaston, 1990).

6.1.2.2 Recreational fishery review

Almost all recreational finfish fishing involves hook and line fishing gear, however, recreational fisheries also include other methods such as crab traps, shrimp trawls, and gill nets. Small throw nets are used for capturing bait fish. A very small number of fish are taken by scuba divers. EFH is impacted by the loss of fishing gear, which is a major part of what is commonly called "ghost fishing", and the physical impacts generated by millions of fishermen using tens of thousands of small, medium, and large fishing boats and their associated pollutants throughout the coastal zone of the Gulf of Mexico each year.

As stated in USEPA (1994d), marine recreational fishing participation grew through the 1970s and 1980s in spite of declining abundance of many target species and increasing competition with the commercial fishing sector (Schmied, 1993). The NMFS Marine Recreational Fisheries Statistics Survey for the Gulf and Atlantic Coasts (USDOC, 1990) and a special report by Schmied and Burgess (1987) indicate there are about four million resident participants in marine recreational fishing and over two million tourists who fish for Gulf marine species. According to NMFS, over 40 percent of the nation's marine recreational fishing comes from the Gulf of Mexico, and marine anglers in the Gulf made over 13 million fishing trips in 1989, exclusive of Texas (USDOC, 1990). Texas marine anglers, using private boats, expended over seven million man-hours to land almost three million saltwater fish during the 1986-1987 fishing years (Osburn et al., 1988). High recreational fishing participation is partially explained by strong regional population growth, the tourism-based economies of many of the coastal communities, and the region's abundant sport fishing infrastructure (e.g., boat ramps, marinas, piers, charter boats, head boats, bait camps, and tackle shops) (Schmied, 1993).

Marine recreational fishing in the Gulf region is a major industry important to these state's economies. The marine recreational fishing industry accounts for an estimated $769 million in sales (equipment, transportation, food, lodging, insurance, and services) and employment of over 15,000 people, earning more than $158 million annually in the central and western Gulf of Mexico region (USDOC, 1992d).

Together, population increases, environmental degradation, and the increasing demand for fish have led to population declines in many marine species. Consequently, over the past ten years, there has been a rapid increase in state and federal fishing regulations to reduce fishing pressure, rebuild fish stocks, and minimize conflicts between resource users (Schmied, 1993).

6.1.2.3 Trap fishery review

Throughout the Gulf coast states commercial trap fishing is utilized for the capture of reef fish, and commercial and recreational trap fishing is utilized for the capture of spiny lobster, stone crab, and blue crab. Reef fish trap fishing in the EEZ is regulated under the Gulf of Mexico Fishery Management Council's Reef Fish FMP. Spiny lobster trap fishing is regulated under the Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic Fishery Management Councils' joint FMP. Stone crab trap fishing is regulated under the Gulf of Mexico Fishery Management Council's Stone Crab FMP. Blue crab is a state regulated trap fishery.

Reef fish traps are primarily constructed of vinyl-covered wire mesh, and include a tapered funnel where the fish can enter but not escape. The reef fish traps are placed at the beginning of the trip by throwing the traps overboard. According to Amendment 5 of the Reef Fish Fishery Management Plan, traps are to be buoyed and returned to shore at the end of each fishing trip.

Fish traps are inherently non-selective. Studies have shown that up to 50% of the reef fish present in the traps are non-targeted species (bycatch) (Taylor and McMichael, 1983; Sutherland and Harper, 1983). When the fish traps are hauled to the surface, the reef fish are sorted and the bycatch is dumped back overboard.

Spiny lobster and stone crab traps are generally slatted boxes constructed of wood, which is considered self-deteriorating. Some non-deteriorating traps, constructed of metal or plastic, are utilized in conjunction with a self-destruct panel to minimize potential ghost fishing by lost traps. The traps are weighted with cement to assure that they will reach the bottom. The wooden traps are sometimes reinforced with wire mesh to minimize damage from sea turtles. This, in essence, allows these traps to function as wire-mesh fish traps, with the same bycatch issues as discussed above.

Fishers string numerous lobster and stone crab traps along a trap line, with each end of the trap line marked by a buoy. Lobster traps are generally allowed to "soak" for up to 5 days after deployment, at which time they are hauled onto the boats. Stone crab traps generally "soak" longer, up to 21 days. The catch is removed from the lobster or stone crab trap, the traps are rebaited, and then thrown overboard.

Traps, like trawls, can potentially damage the bottom community, depending on where they are placed. If they are deployed and retrieved from coral reefs or live hardbottom, they can damage the corals and other invertebrates on the reef. Seagrasses can also be broken or killed by placement and retrieval of traps. It is not unusual for strings of unbuoyed traps to be retrieved by dragging 40-pound grapnels and chains across the bottom until the trap string is hooked by the grapnel, thereby adversely affecting the bottom community.

6.2 Identification of Non-Fishing Related Activities That May Adversely Affect EFH

The detailed discussion of Essential Fish Habitat (EFH) types and distribution is found in Section 4.0 and will not be repeated here. Physical alterations to EFH occur from man's activities and natural environmental events of nature. Potential activities that adversely impact EFH can range from minor (possible recovery of the EFH to 100 percent functionality in months to years) to major (possible recovery of partial EFH functionality in years to decades) to catastrophic (loss of all EFH functionality to the foreseeable future)

The purpose of this section is to document non-fishing activities that have the potential to adversely impact EFH, in order to support recommendations for actions to prevent the degradation or loss of such habitat. It is not intended to target or burden any individual or group. This analysis will also provide the public with information necessary to design projects that only minimally impact EFH. Identifying adverse effects to EFH is expected to lead to those activities being located away from EFH, especially habitat areas of particular concern, and toward less sensitive areas, or to minimize the impacts of the activities on EFH.

6.2.1 Physical Alterations

Broad categories of activities which can adversely affect EFH include, but are not limited to, dredging (ship channels, waterways, and canals), fill, excavation, fossil shellfish dredging, mining, impoundment, discharge, water diversions, thermal additions, actions that contribute to non-point source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH.

Wetlands are highly productive habitats that are of great value to society and the environment. Wetlands are defined as: "Those areas which are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Federal Interagency Committee for Wetland Delineation, 1989). Coastal wetlands of the Gulf of Mexico are of special interest because of their recognized importance in maintaining the production of the rich Gulf fisheries resources.

The 1992 Gulf-wide wetland inventory, prepared by NOAA, is based on FWS National Wetland Inventory maps prepared from 1972 to 1984 photographs. The NOAA report summarizes acreage of coastal wetland types by counties and by selected estuarine drainage areas. Because recent national trends indicate that the amounts of most wetland types are still declining, the acreage presented in the NOAA report may be greater than the actual current acreage of coastal wetlands. Seagrass habitat was not included in the NOAA survey. Of the five major coastal wetland habitats included, 66 percent of the acreage was salt marsh, 17 percent forested scrub-shrub, 13 percent tidal flats, 3 percent tidal fresh marsh, and 1 percent forested. The distribution of these habitats is not equal across the Gulf states. Louisiana contains most of the Gulf's salt marshes with 69 percent, followed by Texas (17 percent), Florida (10 percent), Mississippi (2 percent), and Alabama (1 percent). Texas contains 54 percent of the tidal flats and Florida has 97 percent of the estuarine forested scrub-shrub habitats (mostly mangroves) (USEPA, 1992).

Other surveys have estimated acreage of seagrass meadows. There are an estimated 323,887 ha (800,000 ac) of seagrasses within Gulf estuaries, and 95 percent of these are found in Florida and Texas. Large meadows of seagrass are located near shore along the west coast of Florida; 5,500 ha (13,585 ac) of beds are located within the boundaries of the Everglades National Park in Florida Bay. Seagrass meadows support diverse flora and fauna and are important nursery areas which provide both cover and food for many species of fish which are harvested commercially and recreationally. Unfortunately, human activities have resulted in extensive, historic, direct losses of seagrasses. Also, suspended particulate materials from dredging and other activities can block sunlight from seagrasses, and interfere with their growth and reproduction (USEPA, 1992).

Mangrove forests occur mainly along Florida's coasts. Estimates of the total area of mangroves in Florida range for 174,000 to 263,000 ha (430,000 to 650,000 ac). Mangrove forests provide important habitats for young fish and other species and their elimination can result in a loss in recruitment of juveniles. Several human activities, including ditching or impounding for mosquito control, reduction of fresh-water input, and clearing and filling, have degraded the quantity and quality of mangrove habitats (USEPA, 1992).

Inquiline habitat consists of scallops and related invertebrates that provide essential juvenile habitat for several commercial fishes. Other important estuarine fish habitats are oyster bars and reefs, and inquiline habitat in nearshore waters. Destruction of oyster reefs associated with coastal dredging, and other activities along the Gulf coast exert heavy impacts on juvenile fish habitat.

Wetlands and other coastal communities are important habitats for many threatened or endangered plants and animals. Marine turtles such as Kemp's Ridley, Hawksbill, Leatherback, Green, and Loggerhead, as well as other species of endangered or threatened vertebrates, are found along the Gulf coast. Gulf habitats also provide important sites for bird rookeries. Gulf habitats offer one of the most important wintering areas in North America for significant numbers of the continent's duck and goose populations, and are a haven to a host of wildlife species including shorebirds, wading birds, raptors, songbirds, fur animals, alligators and other reptiles, and various amphibians.

Miscellaneous factors that impact coastal wetlands include marsh burning, marsh buggy traffic, onshore oil and gas activities, and well-site construction (USDOI MMS, 1996). Bahr and Wascom (1984) report major marsh burns have resulted in permanent wetland loss. However, properly timed and managed marsh burns have the potential to enhance accretion rates (i.e., marsh build up) and decrease probabilities of catastrophic marsh fires. Marsh burns also increase plant diversity and production, and are necessary to prevent succession into non-grassland vegetative stages (Barry Wilson, Gulf Coast Joint Venture, personal communication). Sikora et al. (1983) reported that in one 16 km^2 wetland area in coastal Louisiana, 18.5 percent of the area was covered with marsh-buggy tracks. Marsh buggy tracks have been found to open new channels of water flow through an unbroken marsh, thereby inducing and accelerating erosion and sediment transport. Marsh buggy tracks are known to persist for anywhere up to 10 to 15 years in Louisiana marshes. Well-site construction activities include board roads and ring levees. Ring levees are approximately 1.6 ha impoundments constructed around a well site (USDOI MMS, 1996). In oil and gas fields, access canal spoil banks impound large areas of wetlands. With 41,000 onshore coastal wells drilled in Louisiana as of 1984, the total acreage of impounded, dredged, and filled wetlands is substantial and would amount to 32,800 ha if there were two wells per ring levee in 1984 (USDOI MMS, 1996).

6.2.1.1 Navigation projects, ports, marinas, and maintenance dredging

Potential navigation-related threats to EFH located within estuarine waters can be separated into two categories: navigation support activities and vessel operations. Navigation support activities include, but are not limited to, excavation and maintenance of channels (includes disposal of excavated materials); construction and operation of ports, mooring, and cargo handling facilities; construction and operation of ship repair facilities; and construction of channel stabilization structures such as jetties and revetments. Potentially harmful vessel operations activities include, but are not limited to, discharge or spillage of fuel, oil, grease, paints, solvents, trash, and cargo; grounding/sinking/prop scaring in ecologically/environmentally sensitive locations; exacerbation of shoreline erosion due to wakes; and transfer and introduction of exotic and harmful organisms through ballast water discharge or attachment to hulls.

The most conspicuous navigation-related activity in many estuarine waters is the construction and maintenance of navigation channels and the related disposal of dredged materials. The amount of subtidal and intertidal area affected by new dredging and maintenance dredging is unknown, but undoubtedly great. These activities have adversely affected and continue to adversely affect EFH by modifying intertidal and subtidal habitats, filling EFH for dredged material disposal and construction of facilities, and in some cases adversely affecting EFH by releasing contaminants and suspending fine sediments. For more extensive dredged features and related disposal sites, hydrology and waterflow patterns also have been modified. While the channel excavation itself is usually visible only while the dredge or other equipment is in the area, the need to dispose of excavated materials has left its mark in the form of confined and unconfined disposal sites, including those that have undergone human occupation and development. Chronic and individually small discharges and disturbances routinely affect water and substrate and may be significant from a cumulative or synergistic perspective. EFH effects generally observed include direct removal/burial of organisms as a result of dredging and placement of dredged material; turbidity/siltation effects, including increased light attenuation from turbidity; contaminant release and uptake, including nutrients, metals, and organics; release of oxygen consuming substances; noise disturbance to aquatic and terrestrial organisms; and alteration to hydrodynamic regimes and physical habitat. The relocation of salinity transition zones due to channel deepening may be responsible for significant environmental and ecological change.

The expansion of ports and marinas has become an almost continuous process due to economic growth, competition between ports, and increased tourism. Elimination or degradation of aquatic and upland habitats are commonplace since port and marina expansion almost always require the use of open water, submerged bottoms, and riparian zones. Ancillary related activities and development often utilize even larger areas, many of which provide water quality and other functions needed to sustain living marine resources. Vessel repair facilities use highly toxic cleaners, paints, and lubricants that can contaminate waters and sediments. Modern pollution containment and abatement systems and procedures can prevent or minimize toxic substance releases; however, constant and diligent pollution control efforts must be implemented. The operation of these facilities also poses an inherent threat to EFH by adversely affecting water quality in and around these facilities. The extent of the impact usually depends on factors such as flushing characteristics, size, location, depth, and configuration. For marinas as an example, it is common for any nearby shellfish beds to be closed up to some distance away. It is now a common practice to consider safe zones for siting these facilities near EFH or aquatic resources that may be threatened.

Cargo arriving and departing through ports and traveling through the Gulf Intracoastal Water Way (GIWW) on barges serve as the primary route for needed goods, supplies, and energy. The cargo may be diverse and ranges from highly toxic and hazardous chemicals and petroleum products to relatively benign materials. Spills (major and minor), and other discharges of hazardous materials are not uncommon, and are of constant concern since large and significant areas of wetlands and submerged aquatic vegetation (SAV) habitat are at risk. Any expansion of these facilities occurs at the expense of EFH, and operation and maintenance impact EFH to varying degrees.

Maintenance and dredged material disposal to maintain navigable depths for vessels is a major issue at all port facilities and for many marinas. In many cases, dredged materials are contaminated and disposal locations for these sediments are not readily available. Often offshore disposal for clean and contaminated sediments is proposed and for some of the major ports, dredged material disposal sites have been used offshore. Still, contaminated sediments remains an issue as does the effects of these materials on offshore systems.

The operation of vessels, both commercial and recreational, also threaten EFH. The USEPA (1993) identified a suite of possible adverse environmental impacts and pollutants discharged from boats; pollutants generated from boat maintenance activities on land and in the water; exacerbation of existing poor water quality conditions; pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces; and the physical alteration or destruction of wetlands and shellfish and other bottom communities during the construction of marinas, ramps, and related facilities.

The chronic effects of vessel grounding, prop scarring, and anchor damage are generally more problematic in conjunction with recreational vessels. While grounding of ships and barges is less frequent, individual incidents can have significant localized effects. Propeller damage to submerged bottoms occurs everywhere vessels ply shallow waters. Direct damage affects multiple life stages of associated organisms, including eggs, larvae, juveniles, and indirectly through water column de-stratification (temperature and density), resuspending sediments, and increasing turbidity (Stolpe, 1997). This damage is particularly troublesome where SAV is found.

Anchor scarring is probably less important than other physical disturbances associated with vessel operation. On coral reefs and other sensitive hard bottoms, however, damage caused by anchoring may be significant (Davis, 1977). Dragging or pulling anchors and anchor chains through coral reefs breaks and crushes the coral, destroying the coral formation.

The effects of vessel induced wave damage have not been quantified, but may be extensive. The most damaging aspect relates to the erosion of intertidal and SAV wetlands adjacent to marinas, navigation channels, and boating access points such as docks, piers, and boat ramps. The wake erosion in places along the GIWW and elsewhere is readily observable and undoubtedly converts a substantial area of wetlands to less important habitat (e.g., marsh to submerged bottom). In heavily trafficked submerged areas, bottom stability is constantly in flux, and bottom communities may be weakened as a result. Indirect effects may include the resuspension of sediments and contaminates that can modify EFH. Where sediments flow back into existing channels, the need for maintenance dredging with its attendant impacts may be increased.

Marinas and other sites where vessels are moored or operate often are plagued by accumulation of anti-fouling paints in bottom sediments, fuel spillage, and overboard disposal of trash, sewage, and wastewater. However, in areas where vessels are dispersed and dilution factors are adequate, the water quality impacts of boating are likely mitigated. This is especially troubling in areas where house boats have proliferated without authorization. Boating and operations at these facilities (e.g., fish waste disposal) may lead to lowered dissolved oxygen, increased temperature, bioaccumulation of pollutants by organisms, water contamination, sediment contamination, resuspension of sediments, loss of SAV and estuarine vegetation, change in photosynthesis activity, change in the nature and type of sediment, loss of benthic organisms, eutrophication, change in circulation patterns, shoaling, and shoreline erosion. Pollutants that result from marinas include nutrients, metals, petroleum hydrocarbons, sewage, and polychlorinated biphenyls (USEPA, 1993).

Marina personnel and boat owners use a variety of boat cleaners, such as teak cleaners, fiberglass polish, and detergents. Cleaning boats over the water, or on adjacent upland, creates a high probability that some cleaners and other chemicals will enter the water (USEPA, 1993). Copper-based antifouling paint is released into marina waters when boat bottoms are cleaned in the water (USEPA, 1993). Tributyl-tin, which was a major environmental concern, has been largely banned except for use on military vessels. Fuel and oil are often released into waters during fueling operations and through bilge pumping. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA, 1993).

One of the more conspicuous byproducts of commercial and recreational boating activities in coastal environments is the discharge of marine debris, trash, and organic wastes into coastal waters, beaches, intertidal flats, and vegetated wetlands. The debris ranges in size from microscopic plastic particles (Carpenter et al., 1972), to mile-long pieces of drift net, discarded plastic bottles, bags, aluminum cans, etc. In laboratory studies, Hoss and Settle (1990) demonstrated that larval fishes consume polystyrene microspheres. Investigations have also found plastic debris in the guts of adult fish (Manooch, 1973, Manooch and Mason, 1983). Based on the review of scientific literature on the ingestion of plastics by marine fish, Hoss and Settle (1990) conclude that the problem is pervasive. Most media attention given to marine debris and sea life has focused on threatened and endangered marine mammals and turtles, and on birds. In these cases, the animals become entangled in netting or fishing line, or ingest plastic bags or other materials.

6.2.1.2 Canals, ditches, levees and embankments

Canals have been dredged in coastal Louisiana wetlands since the 1930s for oil and gas exploration and extraction. Most waterways are abandoned after mineral extraction is completed. Today, thousands of miles of canals crisscross these wetlands. These canals are typically dredged to 2.5 m depth and are 20 to 40 m wide. Canal lengths vary from hundreds to thousands of meters in length in the case of Outer Continental Shelf (OCS) pipeline canals (Turner et al., 1994).

Studies have linked dredged canals, dead-end canals, and mosquito control canals to a number of undesirable effects on the wetland environment including alterations in salinity, flooding and drainage patterns, indirect loss of marsh by conversion to open water by the erosion “edge effect” of wave action, and increases in marsh erosion rates. These effects have led state and federal agencies charged with managing the wetland resource to look for methods of mitigating canal impacts. One possible method of dealing with spoil banks after the abandonment of a drilling site is to return spoil material from the spoil banks to the canal with the hope that marsh vegetation will be reestablished on the old spoil banks and in the canal. The movement of former spoil bank material back into the canal is referred to as “backfilling” (Turner et al., 1994).

Canals potentially account for as much as 50-90 percent of the coastal wetland loss in Louisiana (Turner et al., 1982), with indirect impacts of canals being significantly more important than direct impacts (USDOI, 1994). Where canal densities are near zero, wetland loss also tends to be near zero (Mendelssohn et al., 1983).

6.2.1.3 Tidal water control structures

Structural marsh management has been practiced for many decades throughout the coastal Gulf of Mexico states, particularly in Louisiana. In fact, it is estimated that approximately 460,000 acres of Louisiana’s coastal marshes are under some type of water control (Hartman et al., 1993). This does not include over 100,000 ac in the Cameron-Creole watershed, thousands of acres managed on state and Federal refuges, or areas placed under management prior to FWPCA/CWA enactment. Water control structures and levees have been constructed for a variety of reasons, such as improving waterfowl habitat, slowing marsh loss, and mosquito control. Studies on a variety of structurally managed tidal marshes have consistently shown significant decreases in production of most economically important marine fishery species (Gilmore et al., 1982; Knudsen et al., 1985;

Wenner et al., 1985; Rogers et al., 1987; Clark, 1989; Konikoff and Hoese, 1989; Pittman and Piehler, 1989; Rogers, 1989; Serpas, 1989; Calhoon and Groat, 1990; McGovern and Wenner, 1990; and Rogers et al., 1992 a,b). The most thorough study of marsh management effects on fisheries to date evaluated the impacts of a fixed crest weir set 12 inches below marsh level in the Chenier plain of Louisiana. Average annual reductions in production greater than 70 percent were reported for Gulf menhaden, brown and white shrimp, spotted and sand seatrout, and red and black drum (summarized in Herke et al.. 1987 a,b,c; Herke et al., 1992; and Knudsen et al., 1989). A study in Louisiana by Rogers et al. (1987) found that an experimental management area controlled by a slotted weir still had 80 percent fewer Gulf menhaden, 48 percent less white shrimp and 71 percent fewer brown shrimp than in an unmanaged control pond.

Structural marsh management and tidal water control also have the potential to accelerate marsh loss and affect overall plant community health. Semi-impoundments have been reported to increase average water depths, duration of inundation and drying events (Chabreck et al., 1979; and Swenson and Turner, 1987). Studies by Calhoon and Groat (1990), Reed and McKee (1991) and Reed (1992) have documented significantly lower rates of sediment deposition and accretion in managed as compared to unmanaged marshes. Calhoon and Groat (1990) also reported that in management situations where water levels were unable to be lowered 8-12 inches below the soil surface, above ground primary production, soil redox potential, and plant health were adversely affected. Several studies have reported greater marsh loss rates in structurally managed marshes as compared to control marshes (Calhoon and Groat, 1990; Nyman et al., 1990; and Coastal Environments Incorporated, 1989).

An assessment by Boesch et al. (1994) perhaps best sums up the status of the science regarding tidal water control:

> "Impoundments of wetlands for reclamation of agricultural development and control of wetland water level largely to promote waterfowl utilization have had significant local effects on wetland loss that are difficult or impossible to reverse. On the other hand, some would argue that impoundment water-level-control in some instances reduced wetlands loss rates that would have occurred in their absence. Scientific evidence has not been conclusive on the effectiveness of water-level-controls, generally referred to as marsh management, for controlling wetland loss. In fact, many studies have demonstrated undesirable impacts are common, such as loss of wetlands, reduction of sedimentation and inhibition of access by migratory fishes and crustaceans."

6.2.1.4 Pipeline crossings and rights-of-way

Pipeline and navigation canals have the potential to change the natural hydrology of coastal marshes by (1) facilitating rapid drainage of interior marshes during low tides or low precipitation, (2) reducing or interrupting fresh water inflow and associated littoral sediments, and (3) allowing salt water to move farther inland during periods of high tide (Chabreck, 1972), reducing or altering sheet flow, and unintentional ponding. Salt water encroachment (intrusion) into fresh marsh often causes loss of salt-intolerant emergent and submerged-aquatic plants (Chabreck, 1981, Pezeshki et al., 1987), erosion, and net loss of soil organic matter (Craig et al., 1979). Because vegetated coastal wetlands provide forage and protection to commercially important invertebrates and fishes, marsh degradation due to plant mortality, soil erosion, or submergence will eventually decrease productivity. Vegetation loss and reduced soil elevation within pipeline construction corridors should be expected with the continued use of current double-ditching techniques (Polasek, 1997).

Pipeline landfall sites on barrier islands potentially cause accelerated beach erosion and island breaching. A Minerals Management Service (MMS) study and other studies (Wicker et al., 1989; LeBlanc, 1985; Mendelssohn and Hester, 1988) have investigated the geological, hydrological, and botanical impacts of pipeline emplacement on barrier land forms in the Gulf. In general, the impacts of existing pipeline landfalls were minor to nonexistent. In most cases, due to new installation methods, no evidence of accelerated erosion was noted in the vicinity of the canal crossings if no shore protection for the pipeline was installed on the beach (USDOI MMS, 1996). Wicker et al. (1989) warn, however, that the potential for future breaching of the shoreline remains at the sites of flotation canal crossings where island width is small or diminishing because of Gulf and bay erosion or the sediments beneath the sand-shell plugs are unconsolidated and susceptible to erosion.

Numerous pipelines have been installed on the bay side of barrier islands and parallel to the barrier beach. With overwash and Gulf shoreline retreat, many of these pipeline canals serve as sediment sinks, resulting in narrowing and lowering of barrier islands and their dunes and beaches. Such islands and beaches are more susceptible to breaching and overwash. This type of pipeline placement was quite common in Louisiana, but has been discontinued (USDOI MMS, 1996).

Inland, pipelines cross open water, wetlands, levied-land, and upland habitats. The number, type and length of pipelines that cross open water and wetlands are unknown at this time, but are estimated to be in the tens of thousands, from 1.0 in to 40 in diameter, and from thousands of feet to hundreds of miles in length, throughout the Gulf Coast. New pipeline canals through wetlands are typically 3 m wide, which is necessary for the push-ditch method of pipeline construction (Turner and Cahoon, 1988). Since 1970, backfilling newly dredged pipeline canals has been required by permitting agencies. Typically, installation of a new pipeline through wetlands disturbs a 30.5-m wide path through the vegetation. After being backfilled, the right-of-way may revegetate or remain as shallow open water, a result of ditching and use of marsh buggies (Wicker et al., 1989). This remaining impact is estimated to be a water channel 1.5-m wide in wetland areas (USDOI MMS, 1996).

In the Eastern Gulf, there are currently no offshore oil and gas pipelines because no oil and gas leases have begun production. A proposed pipeline system is being considered by industry for gas transport from the Destin Dome Area. Approximately 700 km of new trunk lines (one oil line and one gas line) and 104 km of gathering lines are projected to be constructed to support future oil and gas activities off Florida's northwest coast (as well as in support of activities in the Central Gulf Area east of the Mississippi River). It is anticipated that these pipelines will make a landfall in Jackson County, Mississippi, and Mobile County, Alabama (USDOI MMS, 1996).

6.2.1.5 Impoundments and alteration of freshwater inflow

Estuaries are by definition bodies of water that receive freshwater inflows. Estuaries function as transition zones between the freshwater of a river and the saline environment of the sea. The estuaries of the Gulf of Mexico are highly productive ecosystems that support wildlife and fisheries and contribute substantially to the economy of coastal areas (USEPA, 1994a). Estuarine-dependent species comprise more than 95 percent of the commercial fishery harvests from the Gulf of Mexico, and many important recreational fishery species also depend on estuaries during some part of their life cycle. The ability of an estuary to function as a nursery depends upon the quantity, timing, and input-location of freshwater inflows (USEPA, 1994a). Estuarine ecosystems are vulnerable to disturbances by man, primarily decreases in seasonal inflow caused by upstream withdrawals of riverine freshwater for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges and agricultural runoff carrying pesticides, herbicides and other toxic pollutants, and eutrophication caused by excessive nutrient inputs from a variety of nonpoint and point sources.

The functional role of freshwater inflow. Freshwater inflow affects estuaries at all basic levels of interaction; that is, with physical, chemical, and biological effects (Longley, 1994). The functional role of freshwater inflow in the ecology of estuarine environments has been scientifically reviewed (Snedaker et.al., 1977; Hackney, 1978; Texas Department of Water Resources, 1982; Skreslet, 1986), and the effects on these living coastal systems were found to include but may not be limited to:

1. Dilution of seawater to brackish conditions;

2. Dilution and transport of harmful materials and contaminants;

3. Creation and maintenance of low salinity nursery habitats which provide food and cover to juvenile fish, shrimp, crabs, oysters, and other biota;

4. Moderation of bay water temperatures;

5. Reduction of metabolic stresses and the energy required for osmoregulation (regulation of internal body salts) in estuarine-dependent organisms;

6. Provision of a medium for the transport of beneficial sediments and nutrients, the biogeochemical cycling of essential primary nutrients (carbon, phosphorus, and nitrogen), and the removal of metabolic waste products from living organisms;

7. Modification of concentration-dependent chemical reactions, ion-exchange, and flocculation (coagulation and precipitation) of particles in the saltwater environment;

8. Creation of a resource partitioning mechanism among estuarine plants and animals as a result of the combined effects of inflow on salinity, temperature, and turbidity of bay waters;

9. Distribution (horizontal displacement) and vertical movement of organisms in the water column related to the stimulation (release) of a positive phototaxic or negative geotaxic behavioral response;

10. Creation of a cutting and filling mechanism that affects both erosion and deposition in the bays and estuaries;

11. Creation of a salt-wedge and mixing zone in concert with tidal action from the ocean;

12. Transportation of allochthonous (external) nutritive materials (organic detritus from decaying plant and animal tissues) into bays and estuaries as a function of land surface topography, amount of rainfall, and size of the drainage area;

13. Migration (timing of arrivals and departures) and orientation (direction of movement) of migratory organisms like the penaeid shrimps and many marine fishes; and

14. Stimulation of some plants and animals that may be considered less desirable or even a nuisance to man such as the plant-like red tide organism, the Eurasian water milfoil, the South American water hyacinth, and the Chinese grass carp (Longley, 1994).

Effects of reduced freshwater inflows. The major effects associated with loss of inflow due to droughts, dams, or diversions of freshwater have been observed to include, but may not be limited to:

1. Increased salinity of bay, estuary, and neritic (nearshore) marine waters;

2. Reduced mixing due to salinity differences and stratification of the water column;

3. Penetration of the salt-wedge farther upstream allowing greater intrusion of marine predators, parasites, and diseases;

4. Saltwater intrusion into coastal ground and surface water resources used by man;

5. Diminished supply of essential nutrients to the estuary from inland or local terrestrial origins;

6. Increased frequency of benthic (bottom) sediments becoming anaerobic (without oxygen), liberation of toxic heavy metals into the water column that had been sequestered in the benthic substrates, and sulphur cycle domination;

7. Reduced inputs of particulates and soluble organic matter with flocculation and deposition of the particles locally rather than being more widely dispersed throughout the estuarine ecosystem;

8. Loss of economically important seafood harvests from coastal fisheries' species for a variety of reasons related to high salinity conditions, reduced food supply, and loss of nursery habitats for the young;

9. Loss of characteristic dominance of euryhaline (widely salt-tolerant) species in the bays and estuaries to stenohaline (narrowly salt-tolerant) species as natural selection occurs for species more fully adapted to marine conditions in general;

10. Deterioration of salt marshes, mangrove stands, and seagrass beds if under constantly elevated salinities;

11. Loss of sand/silt renourishment of banks and shoals resulting in erosion;

12. Alteration of littoral drift and nearshore circulation patterns; and

13. Aggravation of all negative effects during low-flow (drought) periods with increasing severity as the frequency of occurrence increases (Odum, 1970; Snedaker et. al., 1977; Hackney, 1978; Texas Department of Water Resources, 1982; Skreslet, 1986).

6.2.1.5.1 Salinity characteristics of Gulf of Mexico estuaries

Salinity is an important environmental factor affected by alterations in freshwater inflow. A change to the salinity structure of an estuary may cause impacts throughout the system, at scales many times larger than the impacts of wetland loss or pollutant discharge. To a great extent, distributions of organisms in an estuary are determined by salinity, which in turn is determined by a complex suite of interacting factors including rainfall, river discharge, tides, wind, and basin configuration. Human alteration of river flow can significantly affect the salinity regime of an estuary, and thereby change its biota (USEPA, 1994a).

Salinity is a fundamental environmental factor because all organisms are 80 to 90 percent water, and internal salt concentrations must be maintained within a certain range in each species. Each species or life stage within a species is adapted to a particular external environment. Most estuarine organisms can tolerate a wider range of external salinities than oceanic species; however, even estuarine species have tolerance limits. Few estuarine species can function optimally within the entire salinity range from fresh to sea water. Most organisms are associated with either the higher end of the salinity range (25-36 ppt) or the middle range (10-25 ppt), but not both. Few estuarine organisms will tolerate salinity fluctuations greater than 15 or 20 ppt (USEPA, 1994a).

Shifts in salinity distributions caused by changes in freshwater inflows can shut species out of formerly ideal refuges, feeding areas, and nursery grounds. Alterations in freshwater inflow can dramatically change the distribution of salinities across an estuary. For example, changes in freshwater inflow can shift the boundary between fresh and salt water (usually considered the one part per thousand isohaline) several miles up or down stream. The result may be a drastic area reduction of bottom types that are suitable for a given species. Although many organisms are mobile, movement does not benefit them if no suitable areas with favorable salinities are available or if such areas have become so small that crowding occurs. Because of the effect on salinity patterns alone, changes in freshwater inflow can reduce the overall carrying capacity of an estuary (USEPA , 1994a).

6.2.1.5.2 Other factors affected by freshwater inflow

Changes in nutrient and sediment loads associated with altered freshwater inflow can also disrupt the nursery function of an estuary by affecting food and habitat availability. Various studies have shown that changes in phytoplankton, zooplankton, and benthos, as well as fish and invertebrates, are associated with alterations in freshwater inflow. Freshwater inflow changes can affect such water quality parameters as suspended sediments, dissolved oxygen (DO), water temperature, and pH, which in turn affect biota (USEPA ,1994a).

Suspended sediments are usually deposited in estuaries, as the flow velocity of the river widens and slows. This natural process helps offset settling of deposited soils, erosion, and other processes removing solids. Suspended sediments are also commonly associated with nutrients, and can also carry bacterial populations (USEPA, 1994a).

The DO level in water is one of the primary factors determining the populations which can survive in those waters. As DO drops from 2 parts per million (ppm) to 0 ppm, the number of species surviving tends to shift rapidly to favor anaerobic bacterial populations. The primary cause of DO depletion is metabolism of nutrient loads, mostly by bacteria. The primary sources of DO are surface mixing and photosynthesis of phytoplankton populations (USEPA, 1994a).

Water temperature determines not only which species are present in a population, but also much of the timing of their life cycles. Species demanding high DO are commonly associated with lower water temperatures since low temperatures allow more oxygen to be dissolved. The metabolic rate of most aquatic species is directly determined by the water temperature in a relationship where a change in water temperature of 10°C causes a doubling of the metabolic rate. Thus, higher water temperatures stimulate rapid growth, but can reduce the DO available to support it (USEPA, 1994a).

Water pH in the range of five to nine is usually regarded as acceptable for most species, with a pH around eight being preferred. Outside this range, pH becomes first a stress, then lethal. In natural waters, a low pH is commonly associated with outflow from watersheds rich in digestible carbon, such as forests and bogs. These produce tannic acids, as well as the carbonic acid formed by metabolism. High pH can be associated with high phytoplankton loads in poorly buffered waters, with pH rising as carbonic acid is removed through photosynthesis (USEPA, 1994a).

Freshwater inflow is also important for the process of circulation and flushing in estuaries. In some estuaries, such as Tampa Bay, horizontal density gradients established by freshwater inflows combine with winds and tides to drive circulation in the estuary. The resulting currents and related flushing rates not only influence water quality, but are also instrumental in transporting planktonic organisms throughout the estuary. Freshwater inflows also flush planktonic organisms and detritus into the Gulf of Mexico, providing food for those organisms that do not enter the estuaries (USEPA, 1994a).

As people continue to move to the coastal cities, competition between municipal and commercial water user demands and the freshwater inflow needs of the bays and estuaries will only escalate. Municipal water use will grow exponentially while freshwater inflows (releases from upstream dams) will be cut back by local and state water managers. Cities may offer to build return flow systems with discharge points upriver of the bay or estuary, but little if any action is ever taken due to ongoing problems with funding and local politics. When droughts occur, water managers initiate drought release programs, and within a short time all freshwater inflows are stopped and salinity levels begin to rise, with associated impacts on the living marine resources in the estuary and bay.

6.2.1.6 Industrial/commercial development and operations

Potential threats from industrial and commercial development and operations include conversion of wetlands to industrial and appurtenant sites such as roads, parking, and administrative and distribution centers; point and non-point-source discharge of fill, nutrients, chemicals, toxic metals, hot water resulting from cooling operations, air emissions, and surface and ground waters into streams, rivers, estuaries and ocean waters; hydrological modification to include ditches, dikes, water and waste lagoons; intake and discharge systems; hydropower facilities; and cumulative and synergistic effects caused by association of these and other industrial and non-industrial related activities.

Industrial and commercial development and operations affect EFH in a number of ways. The most inexpensive land is usually sought for development near major shipping lanes such as rivers or ports. These lands usually contain wetlands and these wetlands are generally filled for plant siting, parking, storage and shipping, and treatment or storage of wastes or by-products. At locations near EFH these facilities are often a major source of non-point-source contaminants because of an abundance of hard impervious surfaces. Many industries are heavy water users. Water often is a vital component of the manufacturing process, serves as a cooling mechanism, and is used to dilute and to flush wastes or other by-products, which often lead to highly contaminated estuarine and bay bottom sediments. Many heavy industries also produce airborne emissions that often include contaminants.

Commercial development and operations along the Gulf coast has been extensive. Few coastal areas or barrier islands exist that have not been subject to some form of commercial development, targeting mainly the tourist trade. Past development practices have been especially abusive where, before adequate regulation, it was not uncommon for extensive nearshore modifications to take place for hotel and resort construction. This has now abated largely because better information and regulations have explained the damage to natural resources caused by this practice. However, it remains a fact that dry land or uplands are a decreasing commodity along the coast and that filling of wetlands is viewed as a less expensive alternative. Accordingly, there will continue to be proposals aimed at altering wetlands for commercial development and related infrastructure and these must be carefully assessed to minimize their impact on remaining EFH.

The overall amount of EFH lost to or affected by commercial and industrial development, however, are likely to be at least as important as those from urban and suburban development. In some situations, especially for industries that produce hazardous materials, non-point source discharges can be a traumatic event, especially if there are accidental releases of chemicals. An added concern with industrial operations are contaminants that are emitted into the atmosphere. The types and levels of airborne contaminants reaching Gulf surface waters is unknown, but may have a marginal effect because of dispersal by winds.

6.2.1.7 Housing developments

The coastal areas of the Gulf are highly sought after as places to live. The amenities of the coast and the water-related activities and climate that people enjoy lead to high human population growth rates. As the population increases so does urbanization. People require places to live as well as related services such as roads, schools, water and sewer facilities, power, etc. These needs often are met at the expense of EFH and may adversely impact the very values that brought people to the coast. Wetlands and adjacent contiguous lands have been filled for housing and infrastructure. Further, the demand for shoreline modifications (docks, seawalls, etc.) and navigation amenities have further modified the coast. Chemicals produced and used by people also find their way into the waters as non-point-source runoff. An example is the oil from roads, parking lots, etc. This has lowered water quality in waters and wetlands adjacent to urban developments. As a result, the quality of EFH is often much reduced.

Potential threats include: 1) conversion of wetlands to sites for residential and related purposes such as roads, bridges, parking lots, commercial facilities, reservoirs, hydropower generation facilities, and utility corridors; 2) bulkheading of the coastal land/water interface; 3) direct and/or non-point-source discharges of fill, nutrients, chemicals, hot water resulting from cooling operations, and surface waters into ground water, streams, rivers and estuaries; 4) reliance on septic tanks for onsite waste disposal; 5) hydrological modification to include ditches, dikes, flood control, and other similar structures; 6) damage to wetlands and submerged bottoms; and 7) cumulative and synergistic effects caused by association of these and other developmental and non-developmental related activities.

Wetlands and other important coastal habitats continue to be adversely and irreversibly altered for urban and suburban development. One of the most serious of the adverse effects is filling for houses, roads, septic tank systems, etc. This directly removes EFH and degrades EFH that lies next to developed areas. While the total affected area is unknown, it has been extensive in much of the Gulf coast and its footprint is readily observable.

Another major threat posed by housing development is that of non-point-source discharges of the chemicals used in day to day activities associated with operating and maintaining homes, septic tanks used for onsite human waste disposal, for maintaining roads, for fueling vehicles, etc. In addition to chemical input, changes that affect the volume, rate, location, frequency, and duration of surface water runoff into coastal rivers and tidal waters are likely to be determinants in the distribution, species composition, abundance, and health of Gulf of Mexico fishery resources and their habitat. In the long-term, impacts of chemical pollution (e.g., petroleum hydrocarbons, halogenated hydrocarbons, metals, etc.) are likely to adversely impact fish populations (Schaaf et al., 1987). Despite current pollution control measures and stricter environmental laws, toxic organic and inorganic chemicals continue to be introduced into marine and estuarine environments.

6.2.1.8 Oil and gas operations in the Gulf of Mexico

Structures placed or anchored on the Outer Continental Shelf (OCS) to facilitate oil and gas exploration, development, and production include drilling ships (jack-ups, semi-submersibles, and drill ships), production platforms, and pipelines. Such structure placement disturbs some area of the bottom directly beneath the structure. If anchors are deployed, the bottom habitat (immediately under the anchors and about one-third of the anchor chain) is directly impacted. Jack-up rigs and semi-submersibles are generally used to drill in water depths less than 400 m and disturb about 1.5 ha (3.7 ac) each. In water depths greater than 400 m, dynamically-positioned drill ships disturb little bottom area (except the very small area right where the well is drilled). Conventional, fixed platforms installed in water depths less than 400 m disturb about 2 ha. Tension leg platforms, installed by tethers in water depths greater than 400 m, disturb about 5 ha. Placement of pipelines disturb an average of 0.32 ha per kilometer of pipeline (USDOI MMS, 1996).

Each exploration rig, platform, and pipeline placement on the OCS disturbs some surrounding area or areas where anchors and chains are set to hold the rig, structure, or support vessel in place. Exploration rigs, platforms, and pipelaying barges use an array of eight 9,000-kg anchors and very heavy chain to both position a rig and barge, and to move a barge along the pipeline route. These anchors and chains are continually moved as a pipelaying operation proceeds. The area actually affected by anchors and chains depend on water depth, wind, currents, chain length, and the size of the anchor and chain (USDOI MMS, 1996).

Conventional, fixed multileg platforms, which are anchored into the seafloor by steel pilings, predominate in water depths less than 400 m. During structure removal, explosives are used to sever conductors and pilings because of the strongly over built condition of these structures that must withstand probable hurricane conditions over an average 20-year life span. Upon removal the MMS requires severing at 5 m below the seafloor to ensure that no part of the structure will ever be exposed to and interfere with commercial fishing. Possible injury to biota from explosive use extends outward 900 m from the detonation source and upward to the surface. Based on MMS data, it is assumed that approximately 70 percent of removals of conventional, fixed platforms in the Gulf of Mexico in water less than 400 m deep will be performed with explosives (USDOI MMS, 1996).

Alternative methodologies such as mechanical cutting and inside burning that might be used to sever pilings of multileg structures are often ineffective and are always hazardous to underwater workers.

Bottom debris is herein defined as material resting on the seabed (such as cable, tools, pipe, drums, and structural parts of platforms, as well as objects made of plastic, aluminum, wood, etc.) that is accidentally lost or thrown overboard by workers from fixed structures, jack-up barges, drilling ships, and pipeline placement operations. Varying quantities of ferromagnetic bottom debris may be lost or thrown overboard per operation. The maximum quantity of bottom debris per operation is assumed to be several tons. Extensive analysis of remote-sensing surveys within developed blocks indicates that the majority of ferromagnetic bottom debris falls within a 450 m radius of a site. Current federal regulations require all bottom debris to be cleared from a defined radius around a site after its abandonment unless it is an artificial reef site.

Improperly balanced well pressures that result in sudden, uncontrolled release of petroleum hydrocarbons are called blowouts. Blowouts have caused the greatest number of fires, explosions, deaths, injuries, property damage, or loss of rigs (Danenberger, 1980; Fleury, 1983).

Blowouts can occur during any phase of development: exploratory drilling, development drilling, production, or work over operations. Historically, 23 percent of all blowouts result in oil spills, 8 percent result in oil spills greater than 50 barrels (bbl), and only 4 percent result in oil spills greater than or equal to 1,000 bbl. In subsurface blowouts, sediment of all available sizes resuspend and the bottom disturbance is within a 300 m radius. Sands settle within 400 m, but finer sediments remain in suspension for periods of 30 days or longer. Fine sediments are distributed over large distances (USDOI MMS, 1996).

6.2.1.9 Agriculture and silviculture practices

The Clean Water Act exempts from the Section 404 program discharges associated with normal farming, ranching and forestry activities such as plowing, cultivating, minor drainage, and harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices [Section 404(f)(1)(A)]. To be exempt, these activities must be part of an established, ongoing operation. For example, if a farmer has been plowing, planting, and harvesting in wetlands, he can continue to do so without the need for a Section 404 permit, so long as he does not convert the wetlands to dry land. Activities which convert a wetland, which has not been used for farming or forestry, into such uses are not considered part of an established operation, and are not exempt. For example, the conversion of a bottom land hardwood wetland to crop production is not exempt. Indirect effects and EFH threats associated with these activities include direct and non-point source discharge of fill, nutrients, chemicals, and surface and ground waters into streams, rivers, and coastal waters; hydrological modification including ditches, dikes, farm ponds and other similar structures and water control devices; and cumulative and synergistic effects caused by association of these and other related activities.

6.2.1.10 Faulting induced by water and oil/gas extraction

Subsurface and deep well water and oil/gas extraction along the Gulf coastal zone has been directly related to coastal subsidence in areas of Texas and Louisiana. This has led to the loss of large areas of coastal habitat in these subsidence districts, with a concomitant loss of EFH. Coastal subsidence is a permanent geological action and when it happens, it is unalterable. Once the coastal marsh and grass beds are drowned by the rising seawater, marsh creation in a shallow water zone area is a method used to replace what was lost, but the success rate of this action has so far been less than 100 percent effective in survival of new plantings. Questions also remain unanswered in regards to the productive potential of the man-made marsh in relation to a natural marsh. So far, man made marshes are significantly less productive than a natural marsh, even after 10 or more years of observation and measurement. As restoration techniques improve, so should success rates.

6.2.1.11 Loss of barrier islands and shorelines

Coastal barriers consist of relatively low land masses that can be divided into several interrelated environments. The beach consists of the foreshore and back shore. The nonvegetated foreshore slopes up from the ocean to the beach berm-crest. The back shore is found between the beach berm-crest and the dunes and may be sparsely vegetated. The back shore may occasionally be absent due to storm activity. The dune zone or a barrier landform can consist of a single dune ridge, several parallel dune ridges, or a number of curving dune lines that are stabilized by vegetation. These elongated, narrow land forms are composed of sand and other unconsolidated, predominantly coarse sediments that have been transported and deposited by waves, currents, storm surges, and winds (USDOI MMS, 1996).

These habitats provide a variety of niches that support many avian, terrestrial, aquatic and amphibian species, some of which are endangered or threatened. Habitat stability is primarily dependent upon rates of geodynamic change in each coastal vicinity. Changes to barrier land forms are primarily due to storms, subsidence, delta abandonment, deltaic sedimentation, and human activity. Barrier landform configurations continually adjust in response to prevailing or changing environmental conditions (USDOI MMS, 1996). Man-made obstructions to long shore sediment transport include jetties, groins, breakwaters, and bulkheads.

From east to west, headlands found on the barrier coasts of the Western and Central Gulf include Baldwin County Headland in Alabama, the barrier islands of Mississippi Sound, the Chandeleur Islands, the Modern Mississippi River Delta and its developing barrier islands, the Bayou Lafourche Headland and accompanying barrier islands, Isles Dernieres, the Chenier Plain of Louisiana and Texas, Trinity River Delta, Brazos-Colorado River Delta and its accompanying barrier islands, barrier islands of Espiritu Santo Bay and Laguna Madre, and the Rio Grande Delta (USDOI MMS, 1996).

Coastal barriers are eroding very rapidly in Louisiana as a result of alterations of the sediment dynamics of the Mississippi River deltaic system, limited sources of sand-sized sediment, high coastal subsidence rates, and storm erosion. Effort to stabilize the Gulf shoreline have adversely impacted barrier landscapes. Greater application of stabilization techniques has been mainly along the Louisiana coast. Undoubtedly, effort to stabilize the beach with seawalls, groins, and jetties have contributed to coastal erosion by depriving downdrift beaches of sediments, thereby accelerating erosion (Morton, 1982). Over the last 15 years, dune and beach stabilization have been accomplished more successfully by using more natural applications such as sand dunes, beach nourishment, and vegetative plantings (USDOI MMS, 1996).

6.2.1.12 Impacts of recreational water craft

Recreational water craft impacts are predominantly focused on marsh edge and submerged aquatic vegetation (SAV) caused by boat wakes and propeller scarring. Secondary impacts are caused by anchoring impacts, groundings, and trash. South Florida and the Everglades are particularly vulnerable to prop scarring, and thousands of acres of SAV have been severely impacted over the last 20-30 years (Sargent et al., 1995). With the continuous increase in the use of water craft, the impacts can only become more severe and numerous.

"Seagrasses are completely submerged, grass-like plants that occur mostly in shallow marine and estuarine waters. Seagrasses form small, patchy beds if their seedlings have recently colonized bare sediments or if sediment movement or other disturbances disrupt typical growth patterns. Where disturbances are minimal and conditions promote rapid growth, large continuous beds—known as meadows—may develop when patchy seagrass beds coalesce. Seagrass meadows may require many decades to form. In shallower waters of good quality, seagrass meadows may be lush and have a high leaf density, but in deeper waters, they may be sparse, or species composition may shift to a less robust species." (Sargent et al., 1995)

"The numerous plants and animals that live and grow among seagrasses form a complex, fragile community. Marine and estuarine animals—especially larval and juvenile fish—benefit from seagrasses, which provide critical shelter and sustenance. Seagrasses form some of the most productive communities in the world (Zieman and Zieman, 1989) and are aesthetically and economically valuable to humans. Seagrasses are a principal contributor to the marine food web and ultimately provide humankind with much of its seafood (Thayer et al., 1975). In addition, seagrasses improve water quality by stabilizing mobile sediments and by incorporating some pollutants into plant biomass and into the stabilized sediments." (Sargent et al., 1995)

As the population grows in the coastal counties of the Gulf Coast state's, and especially in Florida, threats to seagrass communities increase (Livingston, 1987). The cumulative effects of anthropogenic threats (e.g., water pollution, docks, dredging and filling) are increasing in their complexity and severity. One threat that is becoming more acute—as people increasingly use boats and other watercraft for work and recreation—is scarring of seagrasses. Scarring can refer to either the activity of scarring or to a group of scars in a seagrass bed. Boat propellers scar seagrasses more often than do other sources.

"Most scarring of seagrasses is caused by small-boat propellers; however, larger craft, which are usually confined to deeper waters, may have much larger individual effects when they run aground, especially near shipping channels and ports. Propeller scarring of seagrasses was commented on in the scientific literature as early as the late 1950s (Woodburn et al., 1957; Phillips, 1960). Concern has occasionally been voiced since then (e.g., U.S. Dept. of the Interior, 1973; Chmura and Ross, 1978). Eleuterius (1987) noted that scarring in Louisiana seagrasses was common and in deeper water was caused by shrimp boats, which also ripped up the margins of the beds with their trawls. Shrimper-related scarring and seagrass damage was also recognized by Woodburn et al. (1957)." (Sargent et al., 1995).

Propeller scarring of seagrasses occurs when boaters motor through water that is shallower than the drafts of their boats. The propellers tear and cut up seagrass leaves, roots, stems, and sediments, creating unvegetated, light-colored, narrow furrows called prop scars. In the Florida Keys, as waterfront and recreational development has increased since the 1970s, so has the number, size, and power of vessels in this region—resulting in widespread, and in some cases severe, scarring of shallow seagrass communities (Sargent et al., 1995).

6.2.1.13 Sand, gravel and shell extraction

Offshore dredging for sand, gravel, and shell locally destroys bottom habitat which may eventually recover. Large scale removal of coarse materials would eliminate protective cover and change the nature of the bottom habitat. Dredging near shores could remove protective barriers and result in greater erosion of the beach. In addition to extraction of substrate, addition of substrate, such as "beach replenishment" and "beach nourishment" can also be highly disruptive and destructive to shoal fish habitat in the adjacent nearshore areas, especially if this substrate addition results in burial or sediment overlay of live/hardbottom, coral, and/or seagrasses. Extraction of chemicals from seawater is not known to cause significant environmental damage except for loss of coastal habitat where the extraction plant is located. If solar evaporation of seawater is involved, extensive land areas may be utilized as evaporation pans (Darnell et al., 1976).

6.2.2. Water Quality Issues

Major activities affecting Gulf coastal water quality include those associated with the petrochemical industry; hazardous and oil-field wastes disposal sites; agricultural and livestock farming; power plants; pulp and paper plants; fish processing; commercial and recreational fisheries; municipal waste water treatment; mosquito control activities, maritime shipping; and land modifications for flood control and river development, and for harbors, docks, navigation channels, and pipelines. The petrochemical industry along the Gulf Coast is the largest in the United States. It includes extensive onshore and offshore oil and gas development operations, tanker and barge transport of both imported and domestic petroleum into the Gulf region, and petrochemical refining and manufacturing operations (USDOI MMS, 1996).

As described above, Gulf estuary water quality problems are multifaceted. In many cases, the problems are not completely understood. Many Gulf estuaries are not routinely monitored for water quality parameters. Understanding of the natural dynamics at work in these waterbodies is in many cases limited. As a result of these problems, decision makers lack a general picture of estuary management, particularly with regard to water quality (Larry Goldman, USFWS, personal communication).

Monitoring - Some states do not monitor coastal bays and estuaries for many key parameters (e.g. Mississippi does not, it monitors only for coliform bacteria). Therefore, there is no record of estuarine conditions which prohibits assessment of either current estuarine health or consideration of assimilative capacity of the estuary to handle wastes without loss of important functions. In some cases, only spotty site and temporal measurements are available, some of which indicate potential problems. Even in states that do monitor estuary water quality, sampling is in many cases only a monthly frequency (Larry Goldman, USFWS, personal communication).

Water Quality Standards - In many states, estuarine water quality standards are based on standards prepared for freshwater rivers and streams. This approach fails to deal with natural processes unique to estuaries such as tides and seasonal stratification. These processes can drastically affect estuary water quality (e.g. dissolved oxygen in Mobile Bay). Many states assess water quality conditions based upon measurements taken at the surface, or at 5 foot depths or mid-depth, whichever is less. This approach does not deal with conditions and processes in the deeper estuarine areas. These areas are coincidentally where stratification in warmer months can inhibit oxygen concentrations. Sediment oxygen demand can also be a factor in decreasing dissolved oxygen concentrations. As a result, warm water hypoxic conditions are found in areas like Mobile Bay, Mississippi Sound, St. Louis Bay and Biloxi Bay. The disconnect between standards and environmental conditions necessary for fishery production becomes more severe as greater amounts of waste are added to the system from point and non-point sources. Hypoxia conditions (as above) are of greater severity and geographic extent (Larry Goldman, USFWS, personal communication).

Loss of Human Uses - Some human uses are affected by certain types of pollution while others may at the same time continue. The most prevalent example in Gulf estuaries is coliform bacteria contamination that is used as an indicator of shellfish suitability for human consumption. Elevated coliform bacteria counts in estuaries lead to prohibitions on shellfish harvest. Theses conditions can be temporal or permanent, depending on the situation. Many Gulf estuaries have oyster beds permanently closed to harvest that are otherwise biologically productive. A major part of the problem is the lack of meaningful septic tank regulations or the lack of enforcement of otherwise adequate regulations. In a worst case situation, other human uses such as water contact (recreation) activities might be affected (Larry Goldman, USFWS, personal communication).

One of the most prevalent examples of total loss of human uses in the Gulf is the mercury poisoning of part of Lavaca Bay in Texas. See Section 6.2.2.1 for a complete discussion. Part of Lavaca Bay is permanently closed to all human uses, including fishing and swimming, because of mercury contamination of bottom sediments and one spoil island. The closed area has been declared a

Superfund Site and it is not anticipated that this large area of Lavaca Bay can ever be "cleansed" of the mercury contamination and brought back into use by people. The recreational and commercial finfish industry has been particularly hit hard and will continue to suffer from this permanent prohibition on possession of any and all finfish and shellfish from this area. This includes such economically valuable species as red drum, spotted seatrout, southern flounder, and blue crab. White and brown shrimp and oysters do not seem to be affected from the mercury poisoning.

Holistic Estuary Water Management Problems - Two major management shortfalls contribute to a lack of consideration of overall estuarine health. Watershed destruction, including non-point source pollution, has been identified as the greatest source of water pollution nationwide. Gulf of Mexico estuaries and bays are experiencing this phenomenon. National Estuary Programs for Gulf areas like Mobile Bay, Barataria-Terrebonne basin, and Galveston Bay have all identified this problem as a major contributor to degraded estuary conditions. The second and related major problem is the lack of planning for managing the ability of estuaries to assimilate wastes and at the same time sustain the historical human uses of the waterbodies. Pollution impacts from all sources, plus in-bay activities like dredge material disposal, when combined with a lack of basic in-bay water quality data and no assimilative capacity assessment, add up to a major shortfall in basic planning and use accommodations. The major use that suffers the consequences of inadequate estuary water planning is use of fish and shellfish resources. All of these problems need to be fully considered and accommodated for coastal fisheries production to be sustained into the future (Larry Goldman, USFWS, personal communication).

In summary of all of the above, standards, parameters, and regulations for pollutant discharges and similar activities that tend to degrade EFH water quality are either unavailable or inadequate to maintain healthy fish habitat. Pursuant to the Clean Water Act, states are required to establish Total Maximum Daily Loads (TMDLs) for all state waters. This concept holds great promise for the protection of water quality. However, states have been slow in implementing these requirements. The Council encourages implementation of this approach as a means of restoring and protecting EFH.

6.2.2.1 Point-source discharges

Point-source discharges from commercial and industrial development and operations follow the same risks imposed for urban and suburban development, and the discussions under "Housing Developments" (Section 6.2.1.7.) apply. Industrial point-source-discharges are of greater concern because of their quantity and content. They can alter the diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness of ecosystems and the communities at the discharge points and further downstream (Carins, 1980). Growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites of finfish, shellfish, and related organisms also may be altered. In addition to direct effects on plant and animal physiology, pollution effects may be related to changes in water flow, PH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities (Carins, 1980). Some industries, such as paper mills, are major water users and the effluent dominates the conditions of the rivers where they are located. Usually, parameters such as dissolved oxygen, PH, nutrients, temperature changes, and suspended materials are the factors that have the greatest affect on EFH. The direct and synergistic effects of other discharge components such as heavy metals and various chemical compounds are not well understood, but preliminary results of research is showing that these constituents will be a major concern for the future. More subtle factors such as endocrine disruption in aquatic organisms and reduced ability to reproduce or compete for food are being observed (Scott et al., 1997). Mercury was found to be high in Matagorda Bay, Texas, which was probably related to a major discharge of this element in the area in the 1970's (USDOC NOAA, 1992c). There were also some temporal trends that were apparent in the data.

A report by NOAA's National Status and Trends Program (NST) examines data from six different electronic information systems maintained by USEPA and NOAA and evaluates the spatial distribution of sediment contamination (Daskalakis and O'Connor, 1994). The report's conclusion that the Gulf of Mexico has more areas with high concentrations than other United States coasts contradicts the conclusions presented above that are based only on the NOAA Status and Trends dataset. Although the report does not explain this discrepancy, it does state that most of the six databases provide chemical concentrations that were measured near effluent discharge sites while the NOAA database provides chemical concentrations that were measured at randomly selected points along the Gulf Coast. Given that the Gulf of Mexico has the greatest number of waste discharge point sources, it is not surprising that the Gulf of Mexico would show a larger number of sites with 'high' levels of contamination than do other regions (USDOI MMS, 1996).

The cumulative effect of many types of discharges on various aquatic systems also is not well understood, but attempts to mediate their effects are reflected in various water quality standards and programs in each state and within the various water systems. Industrial wastewater effluent is regulated by the EPA through the NPDES permitting program. This program provides for issuance of waste discharge permits as a means of identifying, defining, and controlling virtually all point-source-discharges. The complexity and the magnitude of effort required to administer the NPDES permit program limit overview of the program, and federal agencies such as the NMFS and the FWS generally do not provide comments on NPDES permit notices. For these same reasons, it is not possible to presently estimate the singular, combined, and synergistic effects of industrial (and domestic) discharges on aquatic ecosystems. The use of toxic chemicals such as Malathion, an organo-phosphate, for coastal mosquito control spraying, is administered by EPA under the Federal Insecticide, Fungicide, Rodenticide Act, Amended 1988. In Texas, EPA has delegated the oversight authority to the state of Texas, through the Texas Natural Resource Conservation Commission, for the setting of application rates and amounts. Although, after most major coastal spraying events public notification is received complaining of mortality events involving finfish, shellfish and other estuarine organisms, Texas has no program to respond to these reports or to test the estuaries for potential cumulative toxic impacts from the continued use of Malathion on EFH.

An illustration of the extremely toxic effects of industrial discharges of heavy metals into bays and estuaries is the current mercury pollution of approximately one-third of Lavaca Bay in Texas. The Alcoa Point Comfort Operations began as an Aluminum Smelter in 1949 (Alcoa, 1995). Originally, raw alumina was shipped, via shallow draft barge, to Point Comfort where it was smelted to produce aluminum ingots. In 1959, bauxite refining was added to the Point Comfort Operations (PCO) to produce alumina from the raw bauxite. Alumina extraction occurred using the Bayer process, which utilizes large amounts of sodium hydroxide. As such, a denora cell chlor-alkali facility was installed at PCO to supply the sodium hydroxide for the aluminum refining process. Mercury, used as a cathode in the chlor-alkali process area (CAPA), was ultimately discharged into Lavaca Bay as wastewater from the production of the sodium hydroxide. Peak operation of the CAPA facility occurred between 1966 and 1970. After 1970, Alcoa purchased sodium hydroxide from an outside vendor and shut down the CAPA facility. During the four year period Alcoa operated the CAPA facility, it is estimated that approximately a minimum of 700,000 pounds of mercury may have been discharged into Lavaca Bay and the Dredge Island. All mercury originally discharged into the Bay occurred as elemental mercury. In 1980, Alcoa shut down all smelter operations at PCO; bauxite refining, however, still occurs today.

In July 1970, the Texas State Department of Health (TDH) closed part of Lavaca Bay due to elevated mercury levels in oysters. In 1971, Lavaca Bay was reopened to oyster harvesting. In 1988, TDH closed the area around PCO to the taking of finfish and crabs due to elevated tissue mercury concentrations. On February 23, 1994, the Alcoa PCO site was placed on the National Priority List (Superfund) with an effective listing date of March 25, 1994. In late 1995, Alcoa began the Remedial Investigation phase of the study which included the collection and analysis of over 10,000 environmental samples from surface waters, sediments and biological organisms (Alcoa, 1996, 1997a, and 1997b) near the facility.

The results of the remedial investigation show that, in most areas, historical mercury contamination is being buried by sedimentation (both naturally and man made through active dredging of the nearby ship channels). Areas containing elevated surface mercury concentrations are limited to the areas directly offshore of the Plant where the main source of the discharge occurred, and other small areas where sediment hydrodynamics have inhibited active sedimentation. Mercury tissue concentrations in fish and blue crabs within the TDH closed area average > 1 ppm total mercury, thus the continued closure of the area for public health reasons.

Mercury is considered to be one of the more readily bioaccumulated metals. It is volatile and is readily transformed into methyl mercury by marine bacteria (Belliveau and Tevors, 1989; Bartlett and Craig, 1981). There is also evidence of abiotic methylation of mercury in marine sediments (Belliveau and Tevors, 1989; Moore and Ramamoorthy, 1984). Biological membranes tend to discriminate against the absorption of ionic and inorganic mercury, but they allow relatively free passage of methyl mercury and dissolved mercury vapor (Boudou et al., 1991; Eisler, 1987). Evans and Engel (1994) suggest that the most important mechanisms for mercury accumulation in a marine food web are via the consumption of sedimentary detritus and benthic invertebrates.

Mercury is toxic to all biota, including birds, mammals, and aquatic organisms. Mercury causes lethal and sublethal effects on the central nervous, cardiovascular, immunologic, reproductive, and excretory systems of mammals (ATSDR, 1993). Low doses of metallic mercury vapors have been associated with adverse effects on the kidney and central nervous system of mammals. In birds, mercury can adversely affect growth, development, reproduction, blood and tissue chemistry, and behavior (Eisler, 1987). In aquatic organisms, mercury can produce impairment, growth reduction, osmoregulatory disturbances, developmental effects, or death.

Since methylation does take place in aquatic environments and bioaccumulates/bioconcentrates, it can be found in higher trophic level predators in substantially elevated levels in areas such as the Lavaca Bay closed area where significant mercury contamination has occurred. Also, since mercury accumulation in fish and other aquatic organisms takes place in many organs, including muscle tissue, contaminated fish can serve as a pathway to the human population eating seafood from contaminated areas.

6.2.2.2 Hydromodifications

Hydromodification, which includes channelization, wetland dredge and fill modifications, natural subsidence and apparent sea level rise, is strongly altering the Gulf's coastal water quality. These activities result in sediment deficit and saltwater intrusion, particularly in the Louisiana coastal area. Saltwater intrusion is defined as the inland movement of offshore saline waters into more brackish and fresh waters. About 9-10 million cubic meters (m^3) of material are estimated to be dredged every year to support oil and gas projects in Louisiana. Dredged material disposal results in temporarily increased turbidity and resuspension of released sediment contaminants into coastal waters (USDOI MMS, 1996).

6.2.2.3 Non-point source runoff

Despite the significance of point source contamination, non-point source runoff has had the greatest impact on coastal water quality. Non-point pollutant sources include agriculture, forestry, urban runoff, septic tanks, marinas and recreational boating, and hydromodification. Waterways draining into the Gulf transport wastes from 75 percent of U.S. farms and ranches, 80 percent of U.S. cropland, hundreds of cities, and thousands of industries not located in the Gulf's coastal zone. Urban and agricultural runoff and septic tanks contribute large quantities of pesticides, nutrients, and fecal coliform bacteria (USDOI MMS, 1996).

Over 10 million pounds of pesticides were applied within the Gulf of Mexico coastal area in 1987, making it the top user of pesticides in the country (USDOC NOAA, 1992a). The Gulf of Mexico ranked highest in the use of herbicides (6.6 million pounds) and fungicides, and a close second in the use of insecticides. The Atchafalaya/Vermilion Bays, the Lower Laguna Madre, and Matagorda Bay ranked in the top 10 estuarine drainage areas in the U.S. for carrying pesticides to coastal waters. Although ranking high based on inputs, when NOAA normalized pesticide use for risk to estuarine organisms (USDOC NOAA, 1992a), the Gulf fared better; Tampa Bay and the Lower Laguna Madre were the only two drainage basins in the top 10 (USDOI MMS, 1996).

An excess of nutrients, primarily found in river runoff, is one of the greatest sources of contamination to Gulf coastal waters. Nutrient over-enrichment can lead to noxious algal blooms, decreased seagrasses, fish kills, and oxygen-depletion events. Nitrogen and phosphorus loadings in the Mississippi River and Gulf coastal waters have risen dramatically over the last three decades (Rabalais, 1992). The Nutrient Enrichment Subcommittee of the Gulf of Mexico Program estimated that more than 379,000 pounds of phosphorus and over 1.87 million pounds of Kjeldahl nitrogen are discharged into the Gulf on an average day, with 90 percent of both elements coming from the Mississippi River system (Lovejoy, 1992). Nutrient over-enrichment has been a particular problem for the Lower and Upper Laguna Madre in Texas; Lake Pontchartrain, the Mississippi River, and Barataria Bay in Louisiana; Mississippi Sound, Pascagoula Bay, and Biloxi Bay in Mississippi; and Perdido, Pensacola, Choctawhatchee, and St. Andrews Bays in Florida (Rabalais, 1992).

A good indicator of coastal and estuarine water quality is the frequency of fish kill events and closures of commercial oyster harvesting. Of the 10 most extensive fish kills reported in the United States between 1980 and 1989, five occurred in Texas (3 in Galveston County, 1 in Harris County, and 1 in Chambers County) (USDOC NOAA, 1992a). Because oysters are bottom-dwelling filter feeders, they concentrate pollutants and pathogens. The oyster industry is a good indicator of impacts from septic tank runoff pollution. About one-half of the harvestable shellfish beds in Louisiana are closed annually because of *E. coli* bacteria contamination. Most of the productive oyster reefs in Gulf estuaries are in conditionally approved areas or areas where shellfish harvesting is affected by predictable levels of pollution (USDOC MMS, 1996).

Since 1984, the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends Program (NST) has monitored the concentrations of synthetic chlorinated compounds such as DDT, chlordane, polychlorinated biphenyls (PCBs), tributyltin, polynuclear aromatic hydrocarbons (PAH's), and trace metals in bottom-feeding fish, shellfish, and sediments at coastal and estuarine sites along the Gulf of Mexico (USDOC NOAA ,1992c). Sites were randomly selected to represent general conditions of estuaries and nearshore waters away from waste discharge points. Eighty-nine sites were sampled along the Gulf Coast and compared with more than 300 sites located throughout the U.S. coastal areas. Chemical concentrations exceeding natural levels are considered contamination. NOAA defines "high" levels of a compound class as when the logarithmic value is more than the mean plus one standard deviation of the logarithm. The following summarizes NOAA's findings for both sediments and shellfish (USDOI MMS, 1996).

Oysters were sampled for five years as part of NOAA's (NST) National Mussel Watch Program. Examining the entire U.S. coastal area, the highest chemical contamination consistently occurred near urban areas. Fewer sites along the Gulf were contaminated than along other coastlines. Of the six U.S. urbanized areas showing highest levels of organic compound contamination in shellfish, Mobile, Alabama, was the only Gulf Coast site in this group. Sites located along the Gulf having oysters containing at least three compounds with "high" concentrations included Panama City and Choctawhatchee Bay, Florida; Mobile Bay, Alabama; Lake Borgne, Louisiana; and Galveston Bay, Brazos River, Corpus Christi, and the Lower Laguna Madre, Texas (O'Connor, 1992). Moderately elevated concentrations of pesticides and PCBs appeared along the central Louisiana coastline and at isolated stations in Texas (Matagorda and Galveston Bays) (Texas A&M University, 1988). Within Gulf samples, the highest concentrations of chlorinated hydrocarbons were observed along the Mississippi to northern Florida coast and at stations in Tampa Bay. High cadmium concentrations in oysters occurred at some sites for some years, but the reasons for the changes in cadmium levels could not be explained. The DDT concentrations in oysters showed significant decreases over the five years sampled, primarily since DDT use is no longer allowed. In Terrebonne Bay, Louisiana, arsenic showed consistent decreases while zinc increased each year (USDOI MMS, 1996).

Sediment data were also collected and examined (O'Connor, 1992). As in benthic samples, higher levels of sediment contamination were associated with highly populated areas, and, in general, sites in the Gulf of Mexico had lower concentrations of toxic contaminants than the rest of the country (sampling period from 1984 to 1988). Again, the likely reason for this finding was that sampling sites in the Gulf of Mexico coastal area were away from urban areas, which are characterized as having large numbers of point-source discharges. The distribution of organochlorine loadings in sediment followed those observed in oysters (Texas A&M University, 1988). The number of sites in each state having concentrations among the top 20 nationally for selected classes of contaminant compounds in sediments was provided (USDOC NOAA , 1992c). Florida had 17 of the sites; Mississippi and Texas each had 1 site; and Alabama and Louisiana had none. Florida was also identified as having sites in the top 20 nationally for all selected contaminants. Florida was one of four states that have contaminant concentrations in the top 20 nationally for all selected toxics; Mississippi's site ranked high only for PAHs; and the Texas site had high DDTs. Sediments with chemical concentrations exceeding high levels were identified in Tampa Bay, Panama City, St. Andrew Bay, and Choctawhatchee Bay, Florida; Biloxi Bay, Mississippi; and Galveston Bay, Texas (USDOI MMS, 1996).

Also, as part of NOAA's NST Program, petroleum hydrocarbons were measured in Gulf of Mexico oyster and sediment samples. The results showed (1) total hydrocarbon concentrations were lower than hydrocarbon concentrations at east and west U.S. coast locations, probably because the sites in the Gulf are farther removed from large point sources, such as large cities and industrial areas; (2) chronic petroleum contamination is taking place, possibly from oil and gas operations along the Gulf of Mexico coastline, but also due to contamination of the discharge from the Mississippi River; and (3) water quality degradation from oil and gas operations is not taking place to such an extent to show marked increases over U.S. coastal areas that do not have as many oil operations (USDOI MMS, 1996).

6.2.2.4 <u>Hypoxia "dead zones"</u>

Hypoxia (commonly referred to as "dead zones") or oxygen depletion, occurs in some areas of the open Gulf (Rabalais et al., 1995). A zone of hypoxia affecting up to 16,500 km^2 of bottom waters on the inner continental shelf from the Mississippi River delta to the upper Texas coast has been identified during mid-summer months. Researchers have expressed concern that this zone may be increasing in frequency and intensity. Although the causes of this hypoxic zone have yet to be conclusively determined, high summer temperatures combined with freshwater runoff carrying excess nutrients from the Mississippi River have been implicated. Benthic fauna studied within the area exhibited a reduction in species richness, abundance, and biomass that was much more severe than has been documented in other hypoxia-affected areas (Rabalais et al., 1995). At dissolved oxygen (DO) levels less than 2.0 ppm, a variety of physiological responses and behaviors occur among organisms. Motile fishes, cephalopods, and crustaceans leave the area. Responses of non-motile benthic organisms range from pronounced stress behavior to death. At 0.0 ppm DO there is no sign of aerobic life. In areas affected by hypoxia annually, complete recovery of a climax community may not occur (Harper and Rabalais, 1997). Although the Mississippi/Alabama inner shelf has the potential for bottom-water hypoxia, and low oxygen concentrations have been documented, such events are not considered frequent or widespread (Rabalais, 1992).

Coastal Louisiana shrimp catch data show a negative relationship between catch and percent area of hypoxic waters in shrimp catch sampling cells (Zimmerman et al., 1997). Decreased catches of epibenthic and demersal fisheries species have been shown, through fisheries-independent sampling, to occur in areas of lower oxygen. Other potential fisheries impacts may include: concentration of fishing effort, leading to increased harvest and localized overfishing; low catch rates in directed fisheries; and changes in recruitment due to impacts on zooplankton. However, Zimmerman et al. (1997) confuse the issue later in their paper when they state that the inverse relationship between catch and percent hypoxia in statistical cells is most likely a reflection of the characteristics of the Louisiana shrimp fishery; not a habitat-related phenomenon. Changes in distribution and abundance of fish species could result in loss of commercial and recreational fishing opportunities (Hanifen et al., 1997). Diaz (1997), in reviewing hypoxic areas worldwide, found reduced or stressed fisheries populations to be common in areas where hypoxia occurs.

The White House has launched an 18-month study to assess the causes of the hypoxia zone and propose management strategies. The White House Council of the Environment and Natural Resources has formed a multi-disciplinary "Hypoxia Assessment Work Group" to conduct the study. The work group includes members of academia, tribal leaders, and Federal and state agencies with an interest in the Mississippi River and the Gulf of Mexico, and will develop the following six interrelated reports:

1. Distribution, dynamics, and characterization of hypoxia causes;
2. Ecological and economic consequences of hypoxia;
3. Sources and loads of nutrients transported by the Mississippi River to the Gulf of Mexico;
4. Effects of reducing nutrient loads to surface waters within the basin and the Gulf of Mexico;
5. Evaluation of methods to reduce nutrient loads to surface water, ground water, and the Gulf of Mexico; and
6. Evaluation of social and economic costs and benefits of methods for reducing nutrient loads.

See Section 7.1.4.2 for a further discussion.

6.2.2.5 Entrainment, impingement, and thermal cooling water discharges

The thermal effluent cooling water discharges from coastal power plants have a pronounced effect on bay and estuary organisms and nearshore open Gulf habitat. Hot, thermal effluent discharges in the hot summer months usually lead to very high mortality levels for eggs, larvae, and sub-adult marine organisms, while the same high, thermal effluent discharges in the cold winter months are usually beneficial to living marine organisms. A secondary, and major effect, is the entrainment and impingement of juvenile and adult species on power plant filter screens at the water intake points, which lead to very high mortality levels, especially in the spawning seasons for the various marine organisms.

6.2.2.6 Hazardous waste management

Government and industry use several methods to reduce or store hazardous waste. Management methods include land filling, land farming, incineration, chemical treatment, discharging, deep-well injection, and recycling. Many hazardous wastes can be treated to render them nonhazardous, as through neutralization, or can be recycled to recover usable constituents, as through solvent recovery or metal reclamation (NOAA, 1996).

Remediation of existing and pre-existing toxic chemical sites and proper management of toxic chemical wastes -- including reducing the total production of such wastes -- will lessen the potential for environmental degradation to bays, estuaries, wetlands, and other coastal natural resources. Current efforts to improve waste management are expected to continue. These efforts are particularly essential within the coastal zone where the chemical and petrochemical manufacturing capacity is concentrated (NOAA, 1996).

6.2.2.7 Petroleum products and operations

As of January 1, 1993, approximately 30,000 oil and gas wells had been drilled, and almost 5,000 platforms were producing on the OCS. In 1993, approximately 300 million barrels (bbl) of crude oil and 4.6 trillion cubic feet (tcf) of gas were produced and shipped to shore by pipeline. Although such activity seems extensive, the maritime industry’s use of Gulf waters is even greater. Approximately 1.5 billion barrels of crude oil were imported through Gulf waters by tanker in 1993, about 5 times the volume piped from domestic production. In addition, about 236 million bbl of petroleum products were imported in Gulf waters and 175 million bbl were exported. Although petroleum, both crude oil and petroleum products, is the most common commodity shipped through Gulf waters, vessel traffic associated with other commodities is extensive; the Gulf has four of the top 10 busiest ports in the United States. All of these offshore activities discharge some form of treated waste waters into the Gulf and have resulted in accidental spills of both oil and other chemicals (USDOI MMS, 1996).

The major operational wastes of concern generated in the largest quantities by offshore oil and gas exploration and development include drilling fluids and cuttings, and produced waters. Other major wastes generated include the following; from drilling--waste chemicals, fracturing and acidifying fluids, and well completion and work over fluids: from production--produced sand, deck drainage, and miscellaneous well fluids (cement, BOP fluid); and from other sources--sanitary and domestic wastes, gas and oil processing wastes, ballast water, storage displacement water, and miscellaneous minor discharges (USDOI MMS, 1996).

Major contaminants or chemical properties of concern in oil and gas operational wastes can include high salinity, low pH, high biological and chemical oxygen demand, suspended solids, heavy metals, crude oil compounds, organic acids, priority pollutants, and radionuclides. New restrictions on these waste streams were recently implemented by the USEPA (USDOI MMS, 1996). Any and all of these contaminants and properties can lead to direct loss and/or harmful effects on managed species, including prey species, and the associated inshore, nearshore and offshore EFH.

Accidental discharge of oil in coastal and offshore EFH can occur during almost any stage of exploration, development, or production on the OCS. Oil spills occur as a result of many causes, e.g., equipment malfunction, ship collisions, pipeline failures, platform (or well) blowouts, human error, or severe storms. Many oil spills are not directly attributable to the oil extraction process but are indirectly related to the support activities necessary for recovery and transportation of the resource. In addition to crude oil spills, chemical, diesel, and other oil-product spills can occur in association with OCS activities. Of the various potential OCS-related spill sources, the great majority of the spills have resulted from transportation activities (USDOI MMS, 1996).

6.2.2.8 Chemical contaminant spills

Chemical contaminant spills occur predominantly in the Gulf Intracoastal Waterway (GIWW) and ship channels caused by barges carrying chemicals being rammed by a ship transiting a ship channel, suffering a major fracture due to weather related accidents or being rammed by another barge in the GIWW. The chemical spill impact on the immediate and surrounding habitat is generally dictated by the type of chemical, time of day, weather conditions, and geographic location. Most barge spills in the GIWW are extremely damaging to the marshes and estuaries due to the narrow confines of the GIWW itself and the usually isolated and hard to get to geographic location of the spill. This usually necessitates a long response time before clean-up crews can first get to the spill site, thus allowing a very large area to subsequently be impacted. This also leads to a long clean-up time period with subsequent further impact to the environment from the clean-up operation itself. This clean-up operation impact is usually unavoidable.

Chemical spills kill fish, crabs, shrimp, benthic animals, birds, mammals, and most of the marsh plants. The degree of mortality is based on the chemical itself and its interaction with water and air, depth of water, time of year, time of day and local weather conditions. Recovery of the impacted area is usually measured in months or years.

6.2.2.9 Atmospheric deposition

Atmospheric deposition results when nitrogen and sulfur compounds or other substances, such as heavy metals and toxic organic compounds, are transformed by complex chemical processes and deposited on the earth away from the original sources. The transformed chemicals return to the earth in either a wet or dry form. Wet forms may be rain, snow, or fog; dry forms may exist as gases or particulates. Once these transformed substances reach earth, they can pollute surface waters, including rivers, lakes, and estuaries (USEPA, 1994b).

The Clean Air Act established the National Ambient Air Quality Standards (NAAQS); the primary standard to protect public health and a secondary standard to protect public welfare. The Clean Air Act Amendments of 1990 established classification designations based on regional monitored levels of ambient air quality. These designations impose mandated time tables 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 (USDOI MMS, 1996).

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 that are defined in the Clean Air Act Amendments (1990).

Ambient air quality is a function of the size, distribution, and activities directly related to 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. The impacts to EFH are unknown at this time due to a lack of scientific research. Although detailed scientific studies have been done on the severe, and often catastrophic impact to the Northeast and Canadian interior watersheds due to “acid rain”, theoretically caused by acids from the smoke plums of coal-fired electric generating plants in the southwestern United States combining with rain and falling to the earth, no research has been done on possible coastal habitat impacts from large petrochemical complexes and coal-fired electric generating plants.

6.2.2.10 Ocean dumping

No legal ocean dumping of industrial and commercial waste material occurs in the Gulf of Mexico. The Gulf-wide artificial reef building program instituted by the Gulf states is not considered ocean dumping. Ocean dumping is inherently destructive to EFH as denoted by the ocean dump sites off New York City and San Francisco.

6.2.2.10.1 Dredged material

Under the Marine Protection Research and Sanctuaries Act (MPRSA), the U.S. Environmental Protection Agency (EPA) and the Corp of Engineers (COE) share a number of responsibilities with regard to the ocean disposal of dredged material. This involves 1) designating ocean sites for disposal for dredged material; 2) issuing permits for the transportation and disposal of the dredged material; 3) regulating times, rates, and methods of disposal and the quantity and type of dredged material that may be disposed of; 4) developing and implementing effective monitoring programs for the sites; and 5) evaluating the effect of dredged material at the sites.

The principal authority and responsibility for designating ocean sites for the disposal of dredged material is vested with the Regional Administrators of the EPA Regions in which the sites are located. The Regions are responsible for developing and publishing Environmental Impact Statements (EIS) and the rulemaking paperwork associated with ocean disposal site designations. The COE Districts provide the EPA Region with the necessary information to prepare the EIS and identify any significant issues which should be addressed in the site designation process, generally through a scoping process.

Ocean dumping cannot occur unless a permit is issued under the MPRSA. The decision to issue a permit for dredged material is made by the COE, using EPA’s environmental criteria and subject to EPA’s concurrence. EPA’s environmental criteria under the MPRSA basically provide that no ocean dumping will be allowed if the dumping would cause significant harmful effects, or the material proposed to be dumped is not adequately characterized (there is not enough information to make the above determination).

6.2.3 Biologic Alterations

6.2.3.1 Blooms (toxic and nontoxic)

Brown tide first appeared in the Texas upper Laguna Madre (ULM) in the early 1990's. This chrysophyte has been identified as part of the blue-green algae family as possibly *Aureoumbra lagunensis* and has now persisted for over 8 years. Brown tide reduces light available for seagrass photosynthesis and has caused significant seagrass losses in the ULM (McEachron, et. al., 1998).

Over the past few years, the bloom has apparently run its course and has disappeared from the ULM-Baffin Bay System (McEachron, et. al., 1998). The disappearance may have been aided by the more than 25 inches of rain that fell in 4 days during October 1996. This lowered the salinities (from ›50 ppt) to ‹10 ppt in some areas. The brown tide organism is still present but not in bloom proportions demonstrated by latest counts from researchers (50-100 cells/ml versus previous 500,000 cells/ml). Researchers report high densities of the larval dwarf surf clam, a major grazer of the brown tide organism. While there has been some reduction of seagrass beds, only 7 percent remain unvegetated. These are deeper areas and are expected to take longer to recover.

Red tides are a natural phenomenon in the Gulf, primarily off Florida, Texas, and Mexico. Red tides are blooms of a dinoflagellate that produces potent toxins harmful to marine organisms and humans.

They can result in severe economic and public health problems and are associated with fish kills and invertebrate mortalities.

Red tide began off the Texas Coast on September 18, 1997 near Pass Cavallo and Sargent's beach (McEachron, et. al., 1998). The bloom progressed southward into Mexico during October, with the majority of the bloom occurring in the Gulf waters off of Padre Island. The duration of the offshore bloom was September 18 through November 23, 1997. On November 21, 1997, red tide was reported inside bay waters near Corpus Christi and Port Aransas, Texas. The duration of this bloom lasted from November 21 through December 10, 1997, with areas of high cell counts lasting through January 19, 1998. A minimum estimate of mortality was 21.8 million aquatic organisms (16.5 million occurring in the surf and 5.3 million in the bays). The species killed included (in the millions) were anchovies (5.5), menhaden (4.6), Atlantic bumper (3.9), ghost shrimp (1.8), scaled sardines (1.7) and mullet (1.2) (McEachron, et. al., 1998). There are ongoing studies to determine whether human activity that increases nutrient loadings to Gulf waters contributes to the intensity of red tides (USDOI MMS, 1996).

In 1991, persistent and widespread blooms of cyanobacteria were reported in Florida Bay over hundreds of square kilometers (Butler et al., 1995). Blooms occurred again each year from 1992 through 1995. The cyanobacteria blooms caused widespread sponge mortality in central Florida Bay where the blooms occurred. Sponges in Florida Bay provide shelter for numerous animals including stone crabs (*Menippe mercenaria*), octopus (Octopus spp.), spider crabs (*Mithrax* spp.), and juvenile spiny lobster (*Panulirus argus*). These sponges are valuable habitat for spiny lobster which depend on them for shelter during their early life history (Butler et al., 1995). The exact cause of the blooms is presently unknown.

6.2.3.2 <u>Introduction of exotic species</u>

The introduction of non-native species into an environment, including coastal and marine habitats, can have a variety of impacts ranging from rather benign to causing serious disruptions of biological communities. Some of these impacts may include: competition with, predation on, or displacement of native species; habitat disruption; introduction of diseases; and disruption of food webs. The National Research Council in 1995, reviewing the most critical threats to marine biodiversity, stated that invasion of exotic species was among the top five issues facing coastal ecosystems (Carlton, 1997). Exotic species can actually be viewed as a form of biological pollution; however, unlike chemical contaminants, exotic species may continue to proliferate long after they are introduced (GMP, 1997). Some species may experience explosive population expansion since they may be unaffected by predators, parasites, or competitors in their new environment.

Some "exotic" species may enter new environments through natural range expansion. However, usually of most concern environmentally are those introductions that are facilitated by human actions, either intentionally or unintentionally. It should be noted that humans are not just speeding up nature by spreading species into new areas, since some species are transported from very distant locations to areas where they would probably never occur without human intervention. (GMP, 1997). Common mechanisms by which exotic species are introduced into coastal and marine environments include: vessel or other structural transport (i.e., on or within hulls or as ballast); aquaculture activities; fisheries stocking releases; research activities; and canals (Carlton, 1997).

To date there have been no formal investigations of exotic species introductions into the Gulf of Mexico and its coastal habitats. However, there are suspected to be at least 75 species in Gulf of Mexico and coastal waters that were not native to the region before transoceanic voyages by humans from distant lands became common. There may also be hundreds of other species that we think of as being native, but which were actually introduced to the Gulf of Mexico prior to the 19th Century, when most comprehensive faunal records in North America began (Carlton, 1997). Some of the species that may be important with regard to EFH are described below. Although this discussion could have been greatly expanded by including species found predominantly in coastal freshwater habitats, only those that may be found in or may significantly affect brackish and saltwater habitats are considered here.

6.2.3.2.1 Viruses and other disease organisms

Four exotic viruses of penaeid shrimp are of concern in the Gulf of Mexico. These are the Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV), Yellow Head Virus (YHV), White Spot Syndrome Virus (WSSV) and Taura Syndrome Virus (TSV) (JSA 1997). While none of these have been identified in wild shrimp populations in the Gulf, they have caused serious problems with shrimp mariculture operations around the world, as well as in the United States, and they have been identified on mariculture facilities in Gulf coastal areas. The viruses are believed to have been introduced through the processing of imported diseased shrimp or the importation of diseased shrimp for mariculture. It is believed the viruses can be further spread through discharge of wastes from processing plants and shrimp farms, home discards, bait shrimp distribution, as well as through ballast water, research facilities and fishing vessels. Some of these viruses can also infect other crustaceans besides shrimp. The viruses have a potential to cause major impacts to Gulf fisheries if wild populations become infected (GMP, 1997).

During Summer 1991, a strain of cholera bacteria (*Vibrio cholera*) was detected in oysters taken from Mobile Bay. Subsequent investigations indicated that the organisms were a strain of cholera responsible for an epidemic earlier that year in Peru, and that identical bacteria were found in ship ballast water in Mobile Harbor. It was concluded that the bacteria were probably introduced to Mobile Bay through ballast water. (GMP, 1997).

An eel swimbladder nematode (*Anguillicola crassus*) was found in European eels (*Anguilla anguilla*) in a Texas aquaculture facility. Eels escaped the facility, and may have entered the Gulf, so it is possible the nematode may occur in the Gulf off the Texas coast, since it is known to survive in both fresh and salt water (FCSC, 1997). However, no wild American eels (*Anguilla rostrata*) have been found infected off Texas, though infections have occurred in that species off South Carolina (Overstreet, 1997).

The myxosporean parasite (*Myxobolus episquamalis*) causes easily discernible pseudocysts on scales of striped mullet (*Mugil cephalus*). Although common in Japan and the Mediterranean, the parasite was unknown in North America until infected mullet were found in Mississippi estuaries in 1997 (Overstreet, 1997).

The Asian tapeworm (*Bothriocephalus acheilognathi*), which causes serious impacts in aquaculture facilities in Europe and Asia was introduced into the United States around 1975. It has been found infecting mosquitofish (*Gambusia affinis*) in coastal Mississippi (Overstreet, 1997).

A lungworm (*Angiostrongylus cantonensis*), known to infect humans, was introduced from the South Pacific to the New Orleans area sometime after 1981 by shipboard rats, a reservoir host. A land snail intermediate host spread the parasite to zoo primates in New Orleans, producing a fatal epidemic. The organism can also be transmitted by shellfish or finfish in fresh or low salinity water to rats or primates, including humans. (Overstreet, 1997).

Massive fish kills involving sea “hardhead” catfishes (*Arius felis*) since 1993 all across the Gulf coast are known to have been caused by a virus that also appears to be responsible for similar fish kills in South America and western Africa. Such fish kills involving only that species were previously unknown in the Gulf of Mexico (Overstreet, 1997).

Although not traditionally considered a pathogen, the algae responsible for the chronic brown tide on the Texas coast may or may not be an introduced species (McKinney, 1997).

6.2.3.2.2 Zebra mussel

Zebra mussels (*Dreissena polymorpha*), native to eastern Europe and central Asia, are believed to have been introduced into the Great Lakes through ballast water from an ocean-going vessel in the mid-1980s. The species eventually spread into the upper Mississippi River, and in 1991 it had been found in some portions of the Tennessee River system. In Summer 1992 zebra mussels were discovered in the lower Mississippi River at Greenville, Mississippi (Forester et al., 1993). By Fall 1994 they had spread to the mouth of the Mississippi River, as well as the Atchafalaya Basin. Although, it was originally predicted that this species would not become established south of Arkansas due to the hot summer water temperatures, zebra mussel populations seem to be well established in the lower Mississippi River. Their anticipated expansion into coastal habitats has not occurred, although in other regions they have shown an ability to tolerate low salinity waters. They have also not expanded eastward or westward from the Mississippi River through the Gulf Intracoastal Waterway.

Zebra mussels attach in great numbers to just about any hard substrate by means of byssal threads, and can have a variety of impacts through bio-fouling. Major concerns are clogging of water intake pipes and effects on boat hull performance and efficiency. There have also been serious bio-fouling impacts on native mussels documented in some areas, such as the Ohio River and the Great Lakes. The mussels also are extremely proficient at filter feeding, and are believed to be partly responsible for improved water clarity in some areas of the Great Lakes. Although effects on fish production due to potential reductions in phytoplankton populations have been the subject of speculation, and no such impacts have yet been definitely proven, it is suspected to have been a factor in recent fish population declines in the Great Lakes. Zebra mussels are believed to spread primarily through the movement of barges and other boats in waterways, but some downstream spread through larval transport may also occur. The adult mussels can also survive for a time out of water, and mussels attached to small watercraft that may be moved from one water body to another is another potential mechanism for range expansion.

6.2.3.2.3 Edible brown mussel

The edible brown mussel (*Perna perna*) is native to Africa and South America and is similar to the zebra mussel in its habit of fouling hard substrates, including native molluscs. Unlike the zebra mussel, however, it is a marine/estuarine organism, and may have been introduced attached to the hulls of ocean-going vessels. The brown mussel was discovered on the Texas coast in 1990 at Port Aransas and since that time has spread southward to Veracruz, Mexico and north/east to the Freeport, Texas area. Range expansion southward has been more rapid and extensive than northward. This is believed to have been due to the prevailing east to west long shore surface currents on the Texas coast, and possibly due to temperature effects during the winter seasons (CCFRO, 1997).

Potential impacts of the brown mussel are similar to those of the zebra mussel in that it may clog water intakes of industrial and municipal facilities. It can also possibly affect the stability of offshore navigational structures and oil/gas structures, as well as foul the hulls of watercraft. Although the potential impacts on native oysters, which comprise a major fishery of the northern Gulf of Mexico, is unknown, there are concerns. The species has not yet invaded the major oyster production areas of the Texas coast, which are in Galveston Bay and eastward. Another aspect of the brown mussel that is different from the zebra mussel is that it is, indeed, edible, and there is evidence that harvest is already beginning to take place on the Texas coast. Such harvest may have contributed to the disappearance of some established colonies (CCFRO, 1997). There is also recent indication that established populations may actually be in decline.

6.2.3.2.4 Mammals

Nutria (*Myocaster coypus*) are rodents native to South America. They were introduced into Louisiana in 1937 as a small captive population held at Avery Island, Louisiana. These individuals escaped during a hurricane in 1940, and rapidly established a thriving wild population. Nutria were also later introduced to other Gulf coastal states in attempts to control aquatic plants. (Linscombe and Kinler, 1997a).

Nutria eat the lower stems and roots of plants, and cause severe damage to sugarcane and rice crops, as well as marsh vegetation. Although nutria sometimes inhabit salt marsh, brackish marsh is very much affected by nutria grazing, particularly because of the synergistic effects of tidal action.

Because of this, nutria are contributing to the critical problem of coastal erosion in Louisiana. (GMP, 1997).

When a market for nutria fur developed in the late 1950s through the 1970s, nutria impacts declined due to population control through trapping. However, with changes in the fur market that took place in the 1980s, habitat damage caused by nutria has returned to serious levels, because harvest has stayed below 300,000 animals since 1989. High nutria populations have produced widespread reports of damage to marshes since 1987. Quantitative statewide analyses have not been made, but aerial surveys in 1996 in the Barataria and Terrebonne basins found impacts from nutria herbivory to 8,357 ha (20,642 acres). Estimates of total damage to these basins range from 25,100 to 33,600 ha (62,000 to 83,000 acres).

Damaged sites were found in fresh (44%), intermediate (27%), and brackish (29%) marshes. Size of damaged areas ranged from 1 to 1.243 ha (2 - 3,070 acres), with 67% of damaged sites classified as showing moderate to severe vegetative damage. Only 15 of 97 sites identified in earlier (1993, 1995) surveys showed signs of recovery (Linscombe and Kinler, 1997b).

6.2.3.2.5 Fishes and other vertebrates

Several species of tilapia have been introduced across the Gulf into freshwater systems through aquaculture and aquarium escapes. In some areas these have established reproducing populations. Three species in particular are significant with regard to coastal habitats in south Florida. The blue tilapia (*Oreochromis aureus*) has had the most impact on Florida coastal waters. It tolerates high salinities and cool water, and has become a popular recreational and commercial species in both fresh and salt water. The Mozambique tilapia (*Oreochromis mozambicus*) are present in numerous places, and are common in southeast Florida coastal canals and in Tampa Bay. The blackchin tilapia (*Sarotherodon melanotheron*) was the first tilapia to establish reproducing populations in Florida; however on the Gulf coast it is present only in Tampa Bay, from which it has not significantly extended its range for 30 years. (Roberts 1997)

The Mayan cichlid (*Cichlasoma urophthalmus*) is common in south Florida south of the Tamiami Trail, and supports a limited sport fishery. It is found in mangrove areas, and may contribute to the forage base for tarpon and snook, and may prey on smaller individuals of those species as well. (Roberts, 1997)

The grass carp (*Ctenopharyngodon idella*) is native to the Pacific slope of Asia from the Amur River of China and Siberia south to southern China and Thailand. It was introduced to the United States in the 1960s for aquatic weed control, and has been recorded from all of the southeastern states. (FCSC, 1997). Although reproducing populations have been established in several freshwater systems, only in Galveston Bay, Texas, have they been identified as a significant problem in a coastal area. It has been identified as the primary culprit in the failure of numerous marsh revegetation projects in the upper reaches of that system. The species has also been reported in several other Texas coastal bays. There is increased pressure to use this species to control vegetation in lakes and reservoirs as an alternative to chemical treatments, which increases the potential for additional introductions.

Two Indo-Pacific marine fish species have been found in the Gulf of Mexico as single specimens. These are the humpbacked rock cod (*Cromileptes altivelis*), found in the Tampa Bay area in 1984, and the scat (*Scatophagus argus*), found near Ceder Key, Florida in 1992. The latter was probably an aquarium escapee. (FCSC, 1997)

The Asian swamp eel [*Monopterus albus* (Zuiew 1793)], with common names of ricefield eel, belut, rice paddy eel, and ta-unagi, has been found in Florida (since mid-1990's) and Georgia (since 1989). Its native range is fresh or brackish waters of Asia, including Burma, Thailand, Sumatra, Borneo, Java, northern and southern China, Japan, and Okinawa (Merrick and Schmida, 1984; Roberts, 1989). In Georgia, the eel has been reported from and apparently established in a small, spring-fed pond at the Chattahoochee Nature Center in Roswell since 1989 (D. Bryant, Georgia Game and Fish, personal communication). In Florida, two populations are known to be established. One is in the Miami/Ft. Lauderdale area and the other is in the Tampa area. The population in the Miami/Ft. Lauderdale area most likely originated from an aquarium release, whereas the one in the Tampa area most likely represents an escape from a tropical fish farm (USGS press release). This eel is a voracious piscivore capable of living out of water for a considerable length of time (Day, 1958) and can move across land. This gives it the potential to spread rapidly and makes it difficult if not impossible to control. It can survive in both hot and cold climates. Thus, it has the potential to spread from south Florida to the southern half of the country. It is very secretive, active primarily at night, and hides during the day. This allows it to reach high population numbers without detection. It eats a variety of animals including crayfish, crabs, worms, frogs, and many species of commercially and recreationally valuable fishes. It can grow to 1 to 1.5 m in length and up to 10-15 pounds in weight.

6.2.3.2.6 Other invertebrates

Several hydroid species are known to have been introduced to the Gulf of Mexico. These include *Obeila* spp., *Cordylophora caspia* and *Garveia franciscana*. All of these may cause fouling problems on marine surfaces. Another potential fouling organism that has been introduced is the sea anemone (*Diadumene lineata*). (Carlton, 1997)

Two polychaete worms introduced to the Gulf of Mexico (*Hydroides elegans* and *Ficopomatus enigmaticus*) that are known to cause fouling problems (Carlton, 1997).

Some crustacean species are very tiny, and the introduction of a new species may go unnoticed for years. One of these is an Atlantic copepod (*Centropages typicus*) that was found in Texas in the 1980s, probably introduced by ballast water. Three exotic barnacles (*Balanus amphitrite*, *B. reticulatus* and *B. trigonus*) are now abundant in the Gulf. Four exotic isopods, two native to the Indian Ocean, are *Sphaeroma walkeri*, *S. terebrans*, *Limnoria* spp. and *Ligia exotica*. *Sphaeroma terebrans* is known to be having impacts on mangrove development in some areas. (Carlton, 1997)

The river crab (or saber crab) (*Platychirograpsus spectabilis*), found in eastern Mexico and west Africa, has established a small population in the Hillsborough River, Florida with minimal apparent impacts on the biological community. Although primarily freshwater, part of its life cycle may be estuarine (Roberts, 1997).

Although not yet in the Gulf, a population of the commercial marine crab *(Charybdis helleri*) apparently exists in the Indian River Lagoon on Florida's east coast. This crab, native to the Indo-Pacific region, is aggressive and is known to migrate extensively, so it is likely to appear in the Gulf at some point in the future (Roberts, 1997).

A single specimen of the Chinese mitten crab (*Eriocheir sinensis*) was found near the mouth of the Mississippi River in 1987, probably a ballast water introduction (FCSC, 1997).

Specimens of the Pacific white shrimp (*Penaeus vannamei*) have been found in waters off south Texas, probably due to escape from shrimp farms in the area (FCSC, 1997).

A single specimen of Benedict's Wharf Crab (*Armases benedicti*), native to Brazil, Guyana, and Surinam, was reportedly collected only once at Key West, Florida, in 1918 (McCann et al., 1996).

Wood-boring bivalve molluscs of the genus *Lyrodus* (shipworms) were likely introduced to the Gulf from the Indo-Pacific region during the days of wooden-hulled ships. An eastern Atlantic limpet-like snail (*Siphonaria pectinata*) was probably introduced with ballast rocks during the 19th Century (Carlton, 1997). Also, specimens of the West Indian topsnail or trochid (*Cittarium pica*) have been found in the Florida Keys, though it is possible these may have become established through natural recruitment, since their larvae are planktonic. Also found in the Keys were a few individuals of an eastern Pacific marine nudibranch (*Glossodoris sedna*) (Roberts, 1997).

6.2.3.2.7 Wetland and aquatic plants

The melaleuca (*Melaleuca quinquenervia*) (also called paperbark, cajeput, punk, or white bottlebrush tree) is currently Florida's most destructive terrestrial plant. It was introduced from Australia in the early 1900s for use as a lumber tree and as a means of drying out the Everglades, at that time considered useless. Melaleuca trees consume as much as 2,200 gallons of water per hour per acre, a rate of consumption so high that they are now considered a threat to the Biscayne Aquifer, the source of most of South Florida's drinking water. This tree is not limited to swamps, but has also been found in native South Florida habitats such as pinelands (FCSC, 1997).

Despite expensive and massive eradication efforts, the melaleuca tree is thriving. It has no known native pests and tolerates droughts, floods, and fires. Each tree reproduces prolifically and when chopped down, burned or otherwise stressed releases millions of seeds. By the late 1980s the melaleuca had infested more than 3 million acres of Everglades. More than 50,000 acres now contain melaleuca stands so dense that people and animals are unable to penetrate them. The Florida Department of Natural Resources estimates that the tree is spreading at a rate of 5,300 acres per year, half of which (2,650 acres) are wetlands. For comparison, the Florida Department of Environmental Regulation estimates that only about 860 acres of wetlands are lost to development each year

(FCSC, 1997). Because of its high rate of water consumption, the melaleuca may be contributing to problems of freshwater inflow through the Everglades to the Florida Bay ecosystem.

The Brazilian pepper bush (*Schimus terebinthifolius*), native to Brazil and Paraguay, was introduced into the United States in the 1890s as an ornamental landscaping shrub. It poses a significant economic and environmental threat to the state of Florida. Sometimes called Florida Holly, Brazilian pepper is abundant in moist to transitional zones in fresh and saltwater habitats (LES, 1995), and may be found in upper mangrove communities (FCSC, 1997). It tends to dominate native vegetation due to its rapid growth, shading and chemical inhibition. It provides less habitat value than native species, and its fruit may be toxic (LES, 1995).

Asiatic colubrina (*Colubrina asiatica*), common names colubrina and leatherleaf, was introduced into the Caribbean Islands from Asia where it escaped from cultivation, and then dispersed to coastal Florida. Its natural habitat is coastal beach and dune vegetation and coastal hammocks where it is a rambling, twining shrub. It has floating seeds that are transported by seawater. It is most often found growing in the uplands-submerged lands interface; the seeds reach the uplands during spring and storm tides. Asiatic colubrina can form dense walls which are virtually impenetrable. Its climbing growth habit allow it to grow over the native vegetation canopy and can often effectively shade out native flora. It has been known to replace native communities of buttonwood, mangrove and mangrove fringe communities.

The seaside heliotrope (*Heliotropium curassavicum*), a native of tropical America, is found in brackish to saline marshes, shores and flats along the entire Gulf of Mexico coastline (FCSC, 1997). Another species, the French tamarisk or saltcedar (*Tamarix gallica*) is found in the salt marshes of the Barataria Basin, Louisiana and Texas. It is a native of Eurasia. (FCSC, 1997)

A submerged aquatic plant, Eurasian water-milfoil (*Myriophyllum spicatum*), is found in shallow fresh to brackish waters of bays and creeks in the Mississippi and Mobile River deltas. It is often spread by attachment to boat propellers (FCSC, 1997). Eurasian water-milfoil competes aggressively to displace and reduce the diversity of native aquatic plants. It quickly grows to the surface to form dense canopies that overtop and shade the surrounding vegetation. Canopy formation and light reduction are significant factors in the decline of native plant abundance and diversity observed when Eurasian water-milfoil invades healthy plant communities. Although fish may temporarily experience a favorable edge effect, the characteristics of Eurasian water-milfoil's overabundant growth negate any short-term benefits to fish in healthy waters. At high densities, its foliage supports a lower abundance and diversity of invertebrates. The dense cover allows high survival rates of young fish. However, larger predator fish lose foraging space and are less efficient at obtaining their prey. Its rank growth and senescence may also degrade water quality and deplete dissolved oxygen levels. Typical dense beds and matted canopies restrict swimming, fishing and boating, clog water intakes and result in unsightly decaying mats that foul shores and beaches.

The Chinese tallow tree (*Sapium sebiferum*), common name: popcorn tree, chicken tree, was first introduced to South Carolina in the late 1700s. In the early 1900s, the Foreign Plant Introduction Division of the U.S. Department of Agriculture promoted tallow planting in Gulf Coast states to establish a local soap industry. But Chinese tallow is yet another example of a species brought intentionally to North America with unforeseen and unwelcome consequences. Chinese tallow has flourished in its new home, spreading from South Carolina to all of the Gulf coast states.. Capable of flowering and fruiting at only three years of age and three feet in height, the plant produces an abundant seed crop that is dispersed by birds and moving waters. It can thrive not only in developed and degraded areas near human habitation, but also in more natural wet prairies and bottomland forests. Able to grow in both full sunlight and shade, the tree is also more tolerant of salinity than many native competitors. Chinese tallow wields a hidden weapon against competitors: the leaves it sheds contain toxins that alter soil chemistry and make it difficult for native vegetation to become established.

This tree has displaced native species and changed natural community structures in the lands it has invaded. Formerly natural coastal habitats are becoming infested with stands of Chinese tallow. Large parts of the Texas Gulf coastal prairie have been transformed from native grassland or abandoned cropland into Chinese tallow woodland. Although the plant is a serious and growing threat to the native plants and habitats of the Southeast, it is still in demand from nurseries there, many of which continue to stock it as an ornamental. Educating both plant consumers and nursery owners could help control the spread of such invasive exotics as Chinese tallow, which should no longer be used for landscaping (http:/www.consci.tnc.org/tallow.html).

6.3 Cumulative Impact Analysis

This section analyzes "cumulative" impacts, defined as the impacts on the environment from the incremental impact of actions on wetlands and EFH when added to other past, present, and reasonably foreseeable future actions. The effect of human activity coupled with natural forces has been substantial for those wetlands and habitats that are readily accessible and can be economically modified. Dahl (1990) reports that in the 1780s Florida had 20.3 million acres of wetlands, Alabama had 7.6 million acres, Mississippi had 9.9 million acres, Louisiana had 16.2 million acres, and Texas had 16.0 million acres. By the 1980s Florida's wetlands had been reduced to 11.0 million acres, Alabama's to 3.8 million acres, Mississippi's to 4.1 million acres, Louisiana's to 8.8 million acres, and Texas' to 7.6 million acres. Region wide this amounted to a 50.4 percent loss of wetlands: 46 percent for Florida, 50 percent for Alabama, 59 percent for Mississippi, 46 percent for Louisiana, and 52 percent for Texas. Besides direct alteration or destruction of substrate habitat types (i.e., wetlands), substantial impacts have occurred and continue to occur because of water quality degradation from point and non-point source pollution. There is a substantial linkage between watershed health and estuarine water quality that should be recognized and taken into consideration in assessments of estuarine habitat quality.

Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time. Most of these impacts can be controlled by various state and Federal regulatory processes as shown in Table K. Between 1981 and 1996 more than 50,485 individual development proposals were received by the NMFS for review from the five coastal states bordering the Gulf of Mexico. A subsample of 7,848 of these development proposals involved over 925,181 acres of various habitats. Unfortunately, current Federal regulatory agencies are not funded or staffed to conduct follow up studies, so it cannot be documented with any certainty the overall effects of these programs. However, there is some indication that once permits or licenses are granted, applicants generally complete their projects as specified in public notices or other advertisements. Mager and Thayer (1986) reported on a limited monitoring effort where 580 permitted projects were surveyed. About 80 percent of these projects were in compliance with associated permits. Most of the differences observed related primarily to design of structures and not the area of habitat affected.

6.3.1 EFH Loss Rates and Trends

6.3.1.1 Texas

According to a recent study (Moulton et al., 1997), wetlands in coastal Texas are being lost through conversion to open water, uplands and palustrine emergents at an estimated annual rate of 1,600 acres, or about 59,618 acres from 1955 to 1992. A primary cause of this loss has been associated with the submergence (drowning) and erosion of wetlands most likely due to faulting and land subsidence resulting from the withdrawal of underground water and oil and gas (White and Tremblay, 1995). The conversion of intertidal wetlands and shallow estuarine subtidal bottoms to uplands and palustrine emergents is primarily the result of ship channel construction and maintenance.

Direct EFH losses have resulted from dredging and filling associated with residential and commercial development, and oil and gas development. Man-induced impacts to Texas coastal wetlands have been documented for over 15 years through a computerized habitat logger system maintained by the NMFS Southeast Region Habitat Conservation Division (Table TX). Between 1981 and 1996, the NMFS received and reviewed 10,030 development proposals in Texas. Project impacts generally range from a few hundred square feet to several acres; however, the cumulative effects are evident by the 48,615 acres involved in only 1,342 of the total number of projects reviewed by the NMFS. Direct loss of EFH from residential and commercial projects can be mitigated by avoidance and minimization. This is often accomplished by relocating or redesigning the project. Unavoidable impacts are often compensated through on site and off site restoration and creation of wetlands. Although projects involving compensation of smooth cordgrass (*Spartina alterniflora*) marshes have been relatively successful, seagrass and mangrove mitigation has had limited success.

There have been numerous accidental spills of oil and toxic and hazardous chemicals on the Texas coast. Because of the large number of petrochemical industries located along the coast, Texas is vulnerable to future catastrophic spills which could have very serious and immediate detrimental impacts to EFH. Most of the coast is highly urbanized and industrialized, therefore the bays and estuaries are at risk of deliberate and illegal dumping.

Propscarring of seagrasses, particularly in the southernmost bays, from recreational fishermen has been documented. Boat registration increases annually, which will increase the threat of propscarring and groundings. This could lead to significant seagrass loss in the near future. The use of bottom trawls by the commercial and recreational shrimp fishery alters the substrate of Texas bays. This could effect the distribution and abundance of benthic organisms. Trawls also stir up large amounts of mud and add significant amounts of turbidity to the bays. Additional, man-made turbidity could effect EFH primary production.

The timing, volume, and quality of fresh water inflows have direct effects on the overall health of an estuary and its living marine resource habitats. Fresh water inflows to Texas bays have been drastically reduced through the construction of large dammed reservoirs. For example, Nueces Bay, once had a white shrimp fishery, often goes hypersaline. Hypersaline conditions have been attributed to reduced fresh water in the drainage from the construction of the Choke Canyon Reservoir. Continued population growth will place more demand on the state's limited fresh water supply. Reduced inflows will significantly alter salinity gradients, circulation patterns and nutrient levels within the bays and can effect habitat such as wetlands and oyster reefs. These alterations can also alter the distribution and abundance of fish and shellfish species that inhabit the bays.

6.3.1.2 Louisiana

Louisiana leads the nation in rate of coastal land loss, with some 80 percent of national losses. Wetland loss peaked during the 1970s at over 100 km^2/yr (Penland et al., 1990), and continued at a rate of about 90 km^2/yr for the period 1978-1990 (USGS, 1997). Between the 1930s and 1990, over 3,950 km^2 of wetlands were lost (Britsch and Dunbar, 1993). A major underlying cause of wetland loss in Louisiana is subsidence, or submergence of the land surface. Subsidence is the result of geologic faulting, crustal down warping, and sediment compaction (Gagliano and Van Beek, 1970; Coleman, 1981; Suhayda, 1987). When combined with increases in mean sea-level (Coleman, 1988), these effects are producing rates of relative sea-level rise in Louisiana coastal areas of over 1 cm/yr (Penland and Ramsey, 1990). Reduced net sediment supply to coastal marshes contributes to the current high rates of loss (Baumann et al., 1984). Numerous studies have indicated the suspended sediment load of the Mississippi River has decreased substantially since the early 1960s. This change stems from the damming of many Mississippi River tributaries, improved soil conservation practices which lessened rates of erosion, the mining of sand deposits along the river for industrial use, and the dredging and on-land disposal of river sediments (Reid and Trexler, 1991).

Compounding this problem, artificial levees have confined the Mississippi along practically its entire length from Cairo, Illinois southward, and various control structures have blocked or restricted river flow in natural distributary delta channels. As a result, less sediment is available for deltaic sedimentation and barrier island nourishment while valuable delta-building sediments are being funneled out onto the slopes of the outer continental shelf. Coupled with subsidence and the sediment deficit, shoreline erosion has resulted in the loss of some 10 percent of the coastal wetlands, and such activities as dredging channels and land "reclamation" have also damaged wetlands area directly (Reid and Trexler, 1991). Direct losses from canal dredging account for 12,000 ha (16 percent of total loss) between 1955 and 1988. Canals contribute indirectly to additional marsh loss by allowing increased erosive energy, salinity intrusion, and disruption of flow effects, producing areas of excessive sediment drying as well as areas of waterlogging. Thus, the total contribution to marsh loss from canal building is postulated to be from 30 to 59 percent (Turner and Cahoon, 1988).

The NMFS also has data on the cumulative effects of individual development proposals in Louisiana. Between 1981 and 1996, the NMFS received and reviewed 15,502 development proposals for review (Table LA). The largest number of projects received relate to oil and gas development, while the largest acreage are involved in proposals for hydrological manipulations. Project impacts generally range greatly in size; however, the cumulative effects are evident by the 836,201 acres involved in only 1,947 of the total number of projects reviewed by the NMFS.

6.3.1.3 Mississippi

Two of the most significant issues in Mississippi involving loss of wetlands and EFH concern casinos and port development. The casino industry has caused significant and rapid growth to coastal Mississippi. Two of the three coastal counties allow casinos, and due to the state law that requires specific gaming facilities to be in navigable waters, the involvement of estuarine resources is necessary. The evolution of casinos has led to a great demand for on-site facilities consisting of hotels, parking lots, theaters, marinas, and restaurants. The secondary impact issue from casino development is significant. Residential and commercial developments within the watersheds are having a cumulative adverse impact to estuarine resources.

Coastal Mississippi has major ports at Pascagoula and Gulfport, and both involve major estuarine resource issues for maintenance and expansion. Maintenance issues involve open water and diked disposal, and expansion issues involve impact to bottom land hardwoods, Mississippi Sound bottoms, and wetland fringe areas.

Between 1981 and 1996, the NMFS received and reviewed 1,653 proposals that could potentially affect EFH in Mississippi, which has a small coastal area relative to the rest of the state (Table MS). A subsample of 185 of the projects reviewed by the NMFS involved 2,193 acres of various wetland habitat types. Most of the acreage associated with projects received for review involved various industrial developments. The greatest number of projects reviewed involved various shoreline modifications; mainly bulkheading and backfilling . Maintenance dredging, mainly for Federally maintained navigation channels also involves a substantial amount of acreage. A related and dominant maintenance dredging feature involves a technique called thin- layer disposal. This involves spreading a thin layer of material over a larger area, rather than placing the sediment in smaller mounds. Thin-layer disposal is proposed for material dredged from the channel to Gulfport Harbor. At the request of the NMFS and other resource agencies, the Corps of Engineers initiated a demonstration project to assess the impacts of thin-layer disposal of dredged material on fishery resources. This process continues and will likely be a dominant activity in Mississippi for many years.

6.3.1.4 Alabama

Data from Watzin et al. (in preparation) reveal that, between the 1940s and 1979, emergent marsh habitat in Alabama's Mobile Bay declined by more than 4,047 ha (10,000 acres), to 35 percent. Also, a probable loss of 50 percent or more of the submerged aquatic vegetation occurred during the same time period. In addition, the hydrology of the bay has been markedly altered by a profusion of spoil areas in open water and by excavation of a deep channel through the center of the bay (USEPA, 1994c). According to Stout (1979), historically, the most significant human impacts noted in the bay were the direct and indirect effects of dredged material disposal.

Habitat loss due to erosion along the shoreline of the Mississippi Sound in Alabama, including adjacent islands, was about 8.5 ha/year (21 ac/yr), or a total of 255 ha (630 acres) from 1955 to 1985. Much of this loss was marshland (Smith, 1989). Continued loss is expected under the prevailing natural system, primarily due to the action of natural forces (wind-generated waves, tides, currents, and the predicted drowning effect of sea level rise) (USEPA, 1994c).

Between 1981 and 1996, the NMFS received and reviewed 2,522 proposals that could potentially effect EFH in Alabama, which, like Mississippi, has a small coastal area relative to the rest of the state (Table AL). A subsample of 371 of the projects reviewed by the NMFS involved 24,315 acres of various wetland habitat types. The largest number of activities received for review involved shoreline modifications such as bulkheading and backfilling. The largest acreage involved maintenance dredging for Federally maintained navigation channels. Only 22 of the maintenance dredging projects involved over 22,000 acres of mainly subtidal areas.

6.3.1.5 Florida

Cumulative impacts to Florida wetlands and EFH are occurring at an increasing rate as the state's population increases. Increasing population growth is resulting in increased needs associated with residences and new infrastructure. Between 1981 and 1996, the NMFS received and reviewed 20,778 proposals that could potentially effect EFH in Florida (Table FL). A subsample of 3,996 of the projects reviewed by the NMFS involved 13,823 acres of various wetland habitat types. The largest number of projects received involved various shoreline modifications and housing-related development was second. The largest impact areas were related to housing developments followed by navigation projects. The latter is attributed to the state's large recreational boating population. Another dominant activity involves beach nourishment along the extensive barrier island system in Florida. Only 24 of these projects in Florida involved over 2,078 acres of nearshore habitat. Proposals frequently involve dredging to obtain fill and covering of nearshore hardbottom habitats to expand shorelines. The highly important tourism industry largely drives this process, and the issue remains problematic because the related environmental impacts warrant further explication.

Residential, commercial, and industrial developments are directly impacting essential fish habitats by dredging and filling coastal resources or by affecting the watersheds. The Corps of Engineers handled about 8,000 permit actions in 1996, mostly within coastal counties. As evidenced in Table FL, cumulatively, each proposal potentially contributes to reduced quantity or quality of fishery habitat to some degree. Compensatory mitigation is requested when impacts are unavoidable. For adjacent, upstream, and isolated wetlands, mitigation by wetland enhancement, preservation, and utilizing mitigation banks are generally allowed. This process is evolving and will be a dominant feature in Florida's regulatory processes in the coming years. In reference to mitigation, it should be emphasized that the concept sounds attractive, but often does not work due to our lack of understanding of EFH requirements of specific species. For example, local populations of the spotted sea trout spawn year after year at the same locations. Loss of a spawning site due to coastal development cannot easily be mitigated. We do not know why sea trout choose a given site, and consequently we do no know how to duplicate such a site, i.e., mitigate the loss. Consequently, eliminating the spawning site usually means total loss of the local population (USDOI, USFWS, 1998).

Point source discharges from industry, wastewater treatment plants, and power plants, combined with septic tanks leachates, stormwater runoff, and oil and chemical spills contribute to lower water quality and a reduced fishery habitat. Discharge from the Buckeye Florida paper mill in Taylor County, has resulted in significant seagrass loss (presently over 9 square miles) in Apalachee Bay and also the elimination of the Fenholloway River as a fishery habitat. Efforts are underway to improve the discharge. Every coastal power plant that obtains cooling water from an open waterbody has entrainment and impingement as well as thermal discharge impacts. In any developed area, stormwater runoff often carries significant sediments, nutrients, and pollutants into an estuary. Also, as Florida's population increases, freshwater consumption and wastewater discharges increase. Many wastewater treatment facilities are designed to be ungradable when expansion is needed.

In the bay and estuary seagrass beds, propscarring from thousands of recreational power boats and small commercial fishing boats cause immense impacts throughout the state. According to Sargent et al. (1995), propeller scarring has impacted approximately 16,702 ha (41,270 acres) of seagrass habitat in Monroe and Dade Counties alone. Boat registration increases annually, and therefore the threat to seagrasses will continue to grow.

Losses of seagrasses in Florida Bay have been substantial. The specific reasons remain unknown, however, many federal and state agencies are investigating problems in the Everglades and certain steps to improve the water quality and quantity to Florida Bay are being pursued.

Public and private dredging projects in the Lake Worth Lagoon ecosystem are a major threat to dynamic seagrass species such as *Halophila decipiens* and *H. johnsonii*. Navigation channels and boat basins create landscape barriers and fragment the benthic habitat that interrupts the distribution of *Halophila* seeds. Fragmentation of the habitat will reduce long term seagrass coverage, thus reducing EFH. Many consultants involved in the permitting of private navigation channels argue that they have successfully avoided impacts to seagrass by aligning these channels outside of existing seagrass beds, but in fact, they have not. To date, there have been no satisfactory compensatory mitigation projects proposed that can offset these impacts.

Destruction of living coral reefs as a result of beach re-nourishment activities is a threat to EFH. The most damaging activity is associated with removing sand from borrow areas between living reef formations. Physical destruction, sedimentation and increased turbidity are the major identifiable threats. The current attempts to minimize these impacts has been to provide the dredging contractor better navigation and positioning equipment, mark borrow area boundaries with buoys and provide buffer zones between the borrow area and the living reef. These measures have met with limited success.

6.3.2 Assessment of Effects of Multiple Threats

6.3.2.1 Marine bioinvasions

Marine bioinvasions, causing the alteration of marine ecosystems by nonindigenous species has been occurring in the continental United States for hundreds of years. Only recently, in the last 30 to 40 years, has the bioinvasion of our coastal habitats become critical to the survival of our indigenous marine species. Introductions of nonindigenous marine organisms by human activities are not new. Beginning with wooden hulled ships with rock and metal ballast and progressing to steel hulled ships with water ballast, the nonindigenous species invasion continues to this day.

These marine bioinvasions impact marine ecosystem functions by altering the energy flow, the species interactions, and virtually all other aspects of community structure. Cumulative and synergistic effects of each of the specific invasions in the Gulf Coast should focus key questions on the ecology, biogeography, prevention, and control of exotic species. A critical need exists to begin to elucidate patterns, if such exist, on how many, where, when, and why invasions have been relatively successful and unsuccessful, through comparisons of different marine provinces. An important focus will be to look at the resistance or susceptibility to invasions in distinct communities within and between provinces (Carlton, 1997).

6.3.2.2 Natural factors

6.3.2.2.1 Weather events

Coastal processes may be dramatically altered by unpredictable natural events. These include shorter term forces such as storms, hurricanes, floods, etc., and longer-term events such as global warming and sea level rise. The latter may also be considered as a result of human activity. Effects vary from potentially positive to catastrophic. For example, a moderate storm may provide badly needed fresh water, flush stagnant systems, and provide a supply of nutrients from upland and high marsh surfaces. Severe events can lead to erosion, destruction of wetlands, subsidence, and severe short-term and possibly long range reduction in the ability of EFH to support fishery production. The eventual result of global changes is difficult to predict. However, it is evident that the coast and related wetland systems will change and that the ability of humans to affect this change will largely frame the outcome. With extensive development along the coastlines, sea level rise can have serious consequences for humans, EFH, and the fishery resources that rely on coastal habitats.

6.3.2.2.2 Climate-based environmental shifts

Climate-based environmental shifts are usually global in nature and occur over very long time scales. There is much disagreement within the scientific community as to causes and effects, and even on the ability to accurately measure the sum of all the events over time. Two of these major shifts are global warming and the cyclic climate phenomenon known as El Niño. The effects of these phenomena on the EFH of the Gulf of Mexico and coastal states are under investigation and debate.

6.3.2.2.2.1 Global warming effects

Global warming (GW) refers to observed and predicted increases in average world temperatures over time. The earth's climate is dynamic, has gone through warming phases in the very distant past over vast geological time scales, and this appears to be occurring again. Recent surface and satellite-based temperature measurements indicate an increasing trend in global average surface air temperatures. Also, trends in a number of other climate indicators are consistent with what is expected to result from GW (USEPA, 1998). The Intergovernmental Panel on Climate Change has determined that recent climatological trends are attributable to a combination of natural climate variations and human factors, the leading one being the "greenhouse effect" (GE) (NASA, 1997). The GE is so named because the earth's atmosphere acts like a greenhouse allowing the sun's shortwave (light) radiation to enter but prohibiting longwave (heat) radiation from exiting, thus warming the air. Without the natural GE, almost all radiation would be returned to space and the earth's average temperature would be around 0°C. Atmospheric gases that trap heat are primarily water vapor, carbon dioxide (CO_2) and methane (NASA, 1997). Of most concern is CO_2, which humans have been adding to the atmosphere for a long time, mostly through burning fossil fuel (USEPA, 1998). Atmospheric levels of CO_2 remained fairly constant at around 280 parts per million (ppm) for thousands of years, until around 1800 when levels began to increase. This increase has accelerated exponentially over the last two centuries to today's level of around 350 ppm. Through several lines of evidence, scientists have concluded that this sharp rise in CO_2 is attributable to fossil fuel combustion (GCRIO, 1998).

It is expected that the earth's average temperature will rise by several degrees in the next century (USEPA, 1998). While most of the United States is expected to warm, and there is likely to be an overall trend toward increased precipitation and evaporation, more intense rainstorms and drier soils, scientists are not sure which parts of the United States will become wetter or drier (USEPA, 1998). Some of the potential impacts of GW include stronger and more frequent tropical storms, changes in rainfall patterns that may affect agriculture, spreading of tropical diseases, melting of glaciers and land based ice caps causing sea level rise, and increases in pollution levels. (NASA, 1997).

6.3.2.2.2.2 El Niño and La Niña effects

The term El Niño was coined by South American fisherman to characterize the periodic arrival of unusually warm water in the eastern Pacific ocean around Christmas time. El Niño means "The

Little Boy" or "Christ child" in Spanish. It is a periodic phenomenon that is caused by changes in surface trade wind patterns. The tropical trade winds normally blow east to west piling up water in the western Pacific and causing upwelling of cooler water along the South American coast. El Niño occurs when this "normal" wind pattern is disrupted. While this disruption tends to occur to some extent annually, an El Niño is an exaggeration of what is usually a brief disruption in the normal pattern. (NOAA, 1998).

During an El Niño year the thermocline along Pacific South America is depressed, and surface waters warm. The climate in South and Central America becomes wetter, while the climate in the western Pacific becomes drier. Fish production along the South American coast, which is sustained by the upwelling of deep nutrient-rich waters, declines. The phenomenon also affects climate in other regions of the world far removed from the Pacific South American coast. Although normally cyclic over a number of years, El Niño's occurred in rapid succession during 1990-1994. The El Niño of 1997-98 was a particularly strong one, the strongest one since 1982-83, which was the greatest ocean-atmosphere disturbance ever recorded. El Niño generally produces cooler and wetter weather in the southern United States and warmer than normal weather in the north. The Gulf Coast states experienced heavy rains and flooding causing $1.2 billion in property and agricultural losses between December 1982 and May 1983. There seem to be fewer, but no less severe tropical storms during and after El Niño years, but major increases in tropical storms and hurricanes 2 to 4 years following El Niño. (NOAA, 1998).

La Niña means "The Little Girl", and is sometimes called El Viejo (Old Man), anti-El Niño, or simply "a cold event" or "a cold episode." La Niña is characterized by unusually cold ocean temperatures in the eastern equatorial Pacific, as compared to El Niño, which is characterized by unusually warm ocean temperatures in the Equatorial Pacific.

La Niña tends to bring nearly opposite effects of El Niño to the United States — wetter than normal conditions across the Pacific Northwest and dryer and warmer than normal conditions across much of the southern tier. The impacts of El Niño and La Niña at these latitudes are most clearly seen in wintertime. In the continental U.S., during a La Niña year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. Direct effects to the Gulf of Mexico can be very dry and hot conditions throughout the region and the possibility of more than the average number of tropical storms, and possibly hurricanes, occurring in the Gulf from June through October. Long term environmental effects are not well documented or known at this time.

6.3.2.2.2.3 Loss of coastal wetlands

It has been estimated that along the Gulf and Atlantic coasts, a one-foot sea level rise is likely by 2050 and possible by 2025. By the end of the next century a two-foot rise is likely, but a four-foot rise is possible. Sea level will probably continue to rise for several centuries, even if global temperatures stop rising within a few decades (EPA ,1998).

How well coastal wetlands survive sea level rise depends upon the rates of relative sea level rise and marsh accretion. Relative sea level rise is a function of both land submergence and real water level rise. Since both processes lower land surface relative to water levels, it is often difficult to separate the relative magnitudes of each. Global estimates of sea level rise made in the 1980s do not recognize a significant variation in relative sea level change found in various regions of the United States, ranging from over 10 mm per year decline in the sea surface along the coast of southeastern Alaska to a 10 mm per year rise along the northeastern Maine and Louisiana coasts (Stevenson et al., 1986).

In the face of rising relative sea level, coastal marshes may keep pace if vertical marsh accretion increases sufficiently. At historic rates of sea level rise, most coastal wetlands of the East and Gulf Coasts of the U.S. have kept pace with sea level rise (Stevenson et al., 1986). Out of 18 U.S. wetlands for which sufficient data on accretion rates and relative sea level rise are available, only four sites (encompassing the Mississippi River Delta and Blackwater Marsh in the Chesapeake Bay) have not accrued sediment fast enough to keep pace with relative sea level rise. In general, wetlands in regions with relatively small tidal ranges have lower rates of vertical accretion because less sediment is transported by tidal action (Stevenson et al., 1986). By the same token, coastal areas with higher tidal ranges are less vulnerable to sea level rise (Reid and Trexler, 1991). It is estimated that a two-foot rise in sea level could eliminate 17-43 percent of all U.S. wetlands, with more than half of this loss occurring in Louisiana (EPA, 1998).

As wetlands become inundated by sea level rise, estuarine marsh productivity may temporarily increase because of edge effect as marsh begins converting to open water, and estuarine dependent organisms have greater access to the marsh. However, as sea level continues to rise, eventually most or all of the wetlands may be replaced by open water, with catastrophic decreases in production for these species. (EPA, 1998).

A synergistic effect of sea level rise and coastal development is that coastal beaches and shorelines that are bulkheaded and developed are less able to accrete sediment for new wetland creation. (EPA, 1998).

6.3.2.2.2.4 Loss of or impacts to coral reefs

Both sea level rise and changing water temperatures will influence U.S. coral reefs located in southern Florida, on small isolated banks in the Gulf of Mexico off Louisiana and Texas, and off Puerto Rico and Hawaii. At current rates, sea level rise (1 to 2 mm/yr) does not inhibit coal reefs' upward growth, estimated to be roughly 10 mm/yr (Grigg and Epp, 1989). But sea level rise under scenarios of GW is likely to equal or exceed these limits (Reid and Trexler, 1991).

Coral bleaching, the loss of the mutualistic algae living with the coral, is believed to stem from such stresses as sedimentation, pollution, or unusually cold or warm water temperatures. During bleaching events, coral lack the primary energy needed to grow, and if bleaching is frequent or protracted, the coral ultimately dies (Goreau, 1990a).

Coral bleaching has been observed sporadically around the world for decades, but all such cases involved such locally confined stresses as muddy river water plumes or high temperatures caused by poor water circulation. In the past decade, however, coral bleaching has taken place on an unprecedented scale. Major bleaching episodes at sites around the world have taken place in 1980, 1983, 1987-88, and 1990 (Goreau, 1990a; William and Williams, 1990; Williams, 1990). In many cases, the corals died as a result. In the Caribbean, all of the major bleaching episodes in the 1980s have been associated with above-normal water temperatures (Goreau, 1990b).

At any latitude, a water temperature rise of 2° to 3°C above normal can cause bleaching. If water temperatures increase slowly over a number of years, corals will probably adapt physiologically to the new environmental conditions. But a rapid elevation in sea temperature -- a rise like that predicted to accompany global warming -- may cause a coral die-off. Unfortunately, the pattern of the 1980s suggests that such a situation may already be upon us (Reid and Trexler, 1991).

6.3.2.2.2.5 Impacts on water quality

Although global warming will likely cause more severe rainstorm events during winter and spring, it may also cause less rainfall and more evaporation during summer, which overall may result in decreased river flows. This, coupled with higher temperatures, could reduce water quality in bays and coastal habitats. In areas where river flows decrease, pollution concentrations will rise because there will be less water to dilute the pollutants. Increased frequency of severe rainstorms could also increase the quantity of pollutants running off of farms, lawns, chemical/industrial sites, city streets and shopping mall parking lots, and newly created large suburban areas into the nations rivers, lakes, and bays. (EPA, 1998).

Rising sea level tends to increase salinity of surface and ground water. Higher estuarine salinity has been cited as one of several causes of declining oyster harvests in Chesapeake and Delaware Bays, and a cause for wetland loss in Louisiana, Florida, and Maryland. Oysters may be affected by improving habitat conditions for oyster predators and parasites, such as “dermo” (*Perkinsus marinsus*), a protozoan parasite, and the oyster drill *(Thais haemosoma)*, which require salty water. (EPA, 1998).

Warmer water temperatures may also cause estuaries to become inhospitable for some species. In Apalachicola Bay (Florida), for example, a 4˚ C (7˚ F) warming could result in several species leaving bay waters on hot days for cooler Gulf of Mexico waters, possibly increasing predation on these species. Also, immobile species, such as clams and oysters, would not be able to leave such unfavorable conditions. Lower dissolved oxygen due to warmer water could also lead to fish kills in some estuaries (EPA, 1998).

Because El Niño tends to produce above average rainfall and generally cooler spring temperatures in Gulf coastal areas, it may result in below average production of shrimp and other estuarine-dependent fisheries species.

6.3.2.2.2.6 Impacts to open water habitats

Coastal fisheries include estuarine dependent species and several fishes that primarily utilize nearshore continental shelf habitats. Species such as bluefish, tuna, mackerel, and other migratory species would probably be able to migrate northward as ocean temperatures rise. In the Gulf of Mexico, spiny lobster and other species off south Florida may expand their range northward to Alabama, Mississippi, and the Florida Panhandle. However, fish in the Gulf of Mexico may be limited by lower salinity waters of the northern Gulf, and the coastline itself would present a barrier to northward movement. Higher water temperatures in the Gulf may also exacerbate the anoxic conditions found off the Louisiana coast during summer. (EPA, 1998).

Fish that primarily utilize open ocean habitats may be less affected by GW than coastal species. Annual fluctuations in ocean conditions are probably greater than that expected from GW over the next century. However, there is a possibility that GW could affect El Niño, and other global ocean phenomena, with unpredictable effects. Warmer temperatures may enhance general oceanic biological productivity since more food may be available, fish may grow faster, and reproduce at younger ages. However, this effect may be negated if upwelling of cooler nutrient-rich water is inhibited. (EPA, 1998).

7.0 <u>CONSERVATION AND ENHANCEMENT MEASURES FOR ESSENTIAL FISH HABITAT</u>

7.1 Management Options To Minimize Identified Threats From Fishing-Related Activities

As discussed in Sections 6.1 and 8.0, the limited or lack of scientific, verifiable information concerning fishing-related impacts on essential fish habitat in the Gulf of Mexico precludes the Council from proposing any new management options for consideration and implementation at this time. However, the Council is fully cognizant of all the options open to it to protect, conserve, and enhance essential fish habitat. The Council intends to take each option discussed below into consideration and, when necessary and justified by the best scientific information available, implement those regulations necessary to protect fisheries and associated essential habitat.

7.1.1 <u>Options for Managing Adverse Effects From Fishing</u>

The Interim Final Rule states that fishery management options may include, but are not limited to the following:

7.1.1.1 <u>Fishing equipment restrictions</u>

These options may include, but are not limited to: seasonal and area restrictions on the use of specified equipment; equipment modifications to allow escapement of particular species or particular life stages (e.g., juveniles); prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; and prohibitions on fishing activities that cause significant physical damage in EFH.

See Sections 6.1 and 6.1.1 for a list of fishery management units already covered by equipment restrictions.

7.1.1.2 <u>Time/area closures</u>

These actions may include, but are not limited to: closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as habitat areas of particular concern.

See Sections 6.1 and .6.1.2.1. for a discussion of fishery management units already covered by time/area closures.

7.1.1.3 <u>Harvest limits</u>

These actions may include, but are not limited to, limits on the take of species that provide structural habitat for other species assemblages or communities, and limits on the take of prey species.

See Section 6.1 for a discussion of fishery management units already covered by harvest limits.

7.2 Recommendations To Minimize Impacts Of Identified Threats From Non-Fishing Activities

The Gulf Council recognizes that managed species are dependent on the quantity and quality of their essential habitats, and it is therefore a policy of the Council to conserve, protect, restore and develop (create) habitats upon which fisheries depend; to increase the extent of their distribution and abundance; and to improve their productive capacity for the benefit of present and future generations.

7.2.1 Conservation Recommendations

These guidelines are recommendations and are not intended to replace or modify any state regulation or guideline in any way. The Council intends these guidelines (recommendations) to be used solely in their deliberations and reviews of EFH documents, and has no objection to any state resource and/or permitting agency adopting for their use these guidelines (recommendations). The Council recognizes that habitat conservation requirements vary from site to site and determinations and recommendations provided by the Council and NMFS may vary from those that are prescribed in this document

The following guidelines were developed and implemented as recommendations in the early 1990's by an interagency team of Federal and state resource and permitting agencies in Texas, consisting of the EPA, USCOE, NMFS, USFWS, TPWD, TXGLO, and TNRCC. The guidelines (recommendations) were established to expedite the wetlands permitting process in Texas and to give permit applicants early and consistent recommendations. The guidelines (recommendations) are given to each permit applicant before they draw up their plans, and the process has and continues to work in a remarkable manner, alleviating much confusion and questions on the part of permit applicants. The guidelines (recommendations) are constantly reviewed by the interagency team and are revised at the request of any team member. In assessing the potential impacts of proposed projects, the following general factors should be considered:

- The extent to which the activity would directly and indirectly affect the occurrence, abundance, health, and continued existence of fishery resources;
- The extent to which a net gain of tidal wetlands would be attained;
- The extent to which an unacceptable precedent may be established or potential for a significant cumulative impact exists;
- The extent to which adverse impacts can be avoided through project modification or other safeguards;
- The availability of alternative sites and actions that would reduce project impacts;

.• The extent to which the activity is water dependent if loss or degradation of EFH is involved;

.• The extent to which mitigation may be used to offset unavoidable loss of wetland habitat functions and values.

7.2.1.1 Specific recommendations by project type

In many cases, states have specific guidelines and regulations that relate to project types. These recommendations do not supersede or alter any state guidelines or regulation.

7.2.1.1.1 Docks and piers

Docks and piers, whether built over or floating on the water, are generally acceptable methods of gaining access to deep water and are generally more preferable methods than dredging. General considerations include:

a. Docks and piers should be aligned to avoid existing oyster reefs, marsh grasses, and seagrass beds when possible. In addition, pier walkways should generally be no wider than four feet.

b. Terminal structures should be located in sufficiently deep waters to avoid propwashing of bay bottoms.

c. In areas where either submergent or emergent vegetation cannot be avoided, terminal structures should be limited to 6 feet in width and 20 feet in length to minimize shading impacts to the vegetation. If vegetation is in the project area, additional appurtenances on terminal structures or walkways are not recommended.

d. In non-vegetated areas shallower than 4 feet at mean high water (MHW), terminal structures should be limited to a maximum width of 8 feet and length of 20 feet. In non-vegetated waters deeper than -4 feet MHW, terminal structures should be limited to a maximum width of 10 feet and length of 30 feet.

e. No boathouses should be constructed in waters less than -4 feet MHW. Boathouses should be designed without walls to allow sunlight to penetrate the water (this may be required in areas with seagrasses). Boathouses should be limited to a maximum width of 16 feet. Generally, only one boathouse per pier is recommended for single family residences. Community or group boathouses are preferred.

f. Deck board spacing should be at least one inch to allow sunlight penetration to the water.

g. If oyster reefs, seagrasses, or emergent marshes occur along the shoreline at the project site, parallel structures should not be built along the shoreline. These structures should be built in deeper offshore waters to avoid these resources. A walkway no wider than 4 feet should be utilized to access the deeper water structure.

h. Decks parallel to the shoreline are generally not recommended.

I. Piers should not be constructed within 50 feet of an existing oyster reef. Oyster reefs should be temporarily marked to help avoid impacts during construction.

j. When possible, pilings should be jetted in by hand and the pier should be built out from land using the pier itself as a work platform or using small boats with small outboard motors while exercising extreme care to assure that no propwashing occurs.

k. Support structures in contact with the water should be constructed of non-toxic material.

7.2.1.1.2 Boat ramps

Boat ramps are necessary for public use of the Gulf of Mexico, bays, and rivers. However, they should be designed to minimize direct and secondary impacts to aquatic resources. General recommendations include:

a. Sites should be located in the least environmentally sensitive areas along shorelines that do not support wetland vegetation or seagrasses and where adjacent waters have adequate navigational depths to avoid propwashing. Acceptable sites may include existing marinas, bridge approaches and causeways (with highway agency approval) where construction access channels already exist, and natural and previously created deep water habitats.

b. Sites should be restricted to areas that do not require dredging to gain access to navigable waters. When located close to grassbeds and oyster reefs, adequate navigation channels must exist and should be clearly marked and maintained to avoid damage to these areas.

c. Sites should contain adequate upland area for parking and for boat launching/removal. Catchment basins for collecting runoff should be included as components of the site development plan.

d. Adequate waste collection facilities should be required at public boat launching facilities.

e. Clearing of brush, trees and riparian vegetation for construction of any component of the project should be avoided

7.2.1.1.3 Marinas

All marinas have potential to adversely affect aquatic habitats. These effects can be minimized through proper location and design. In addition to guidelines for boat ramps, bulkheads and seawalls, sewage treatment, housing developments, and disposal of dredged material, the following apply:

a. Marinas are best created from excavated uplands that are designed so that water quality degradation does not occur. Applicants should consider basin flushing characteristics and other design features such as surface and waste water collection and treatment facilities. Catchment basins for collecting and storing runoff should be included as components of the site development plan.

b. Marinas should be located in areas where suitable physical conditions exist. For example, potential sites should be located in areas with suitable navigable depths to avoid dredging or propwashing and away from environmentally sensitive areas such as wetlands, seagrasses, ~~and~~ shellfish beds, mud flats, and sandy beach areas.

c. To protect water quality and to provide adequate flushing, turning basins and access channels should not create sumps or other slack-water areas and depths must not exceed those of the connecting waterbody.

d. Consideration should be given to aligning access channels and configuring marinas to take full advantage of circulation from prevailing winds, with emphasis on the hottest months of the year.

e. Permanent dredged material disposal sites (for use in initial and maintenance dredging) that do not impact wetland areas should be acquired. Suitable disposal alternatives include placing dredged material on uplands and using dredged material to create/restore wetlands. Projects that lack permanent disposal sites will likely not be authorized if maintenance dredging is needed and disposal sites/options are not available.

f. Catchment basins for collecting and storing surface runoff should be included as components of the site development plan. Repair and support facilities should be equipped with hazardous material containment facilities so that biocides such as marine paints, oil and grease, solvents and related materials are not directly or indirectly discharged into the marina.

g. Marinas should be sited in areas with adequate upland area to provide parking and other support facilities.

h. Marinas with fueling facilities should be designed to include measures for reducing oil and gas spillage into the aquatic environment. Spill control plans are required when marina facilities hold more than 55 gallons of petrochemicals per The Oil Spill Prevention and Recovery Act of 1990.

i. Facilities for the collection of trash are required. Where vessels with marine toilets will be moored, pump out facilities and notices regarding prohibition of sewage and other discharges are required.

7.2.1.1.4 <u>Bulkheads and seawalls</u>

Bulkheads and other shoreline stabilization structures are used to protect adjacent shorelines from wave and current action and to enhance water access. These projects may adversely impact wetlands through direct filling, isolation, and increase of wave scour. Adverse impacts may be reduced by applying the following criteria:

a. Vegetation plantings, sloping (3:1) riprap or gabions are generally considered to be environmentally compatible as shoreline stabilization methods over vertical seawalls since they provide shoreline protection and also provide good quality fish and wildlife habitat. Riprap material should be clean and free of toxic substances.

b. In areas where marsh exists along the shoreline, vertical structures are not recommended.

c. Where vertical structures are proposed, they should be aligned at or landward of the mean high tide line and above wetland vegetation. Vertical structures should be constructed so that reflective wave energy does not scour or otherwise adversely affect adjacent essential fish habitat or adjacent shorelines.

d. Submerged riprap material should be placed at the toe of bulkheads to protect the integrity of the bulkhead, reduce reflective wave energy, and provide hard substrate for aquatic organisms.

e. Breakwaters should have openings that allow for fish ingress and egress and water circulation.

f. Breakwaters constructed of riprap material with a minimum 3:1 slope are preferred in most cases in lieu of vertical wall structures.

7.2.1.1.5 Cables, pipelines, and transmission lines

Excavation of wetlands or submerged lands is sometimes required for installing submerged cables, pipelines, and transmission lines. Construction may also require temporary or permanent wetlands filling. The following guidelines apply:

a. Crossings should be aligned along the least environmentally damaging route. Environmentally critical habitats such as submerged aquatic vegetation, oyster reefs, emergent marsh, sand and mud flats, and endangered species habitats should be avoided.

b. Directional drilling, a technique that allows horizontal, subsurface placement of pipelines, is recommended for crossing sensitive wetland habitats, beaches, dunes, or navigation channels.

c. Construction of permanent access channels should be avoided since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion. Construction equipment should be limited to the minimum size necessary to complete the work. Shallow draft equipment should be employed so as to minimize impacts and eliminate the necessity of temporary access channels for construction equipment. The size of the pipeline trench proper should also be minimized. The push-ditch method, in which the trench is immediately backfilled, reduces the impact duration.

d. Where possible, excavated materials should be stored and contained on uplands. If storage in wetlands or waters cannot be avoided, alternating stockpiles should be used to allow continuation of sheet flow. Stockpiled materials should be stored on construction cloth rather than bare marsh surfaces, seagrasses, or reefs.

e. Excavated wetlands should be backfilled with either the same material as removed or a comparable material that is capable of supporting similar wetland vegetation. Original marsh elevations should be restored. Topsoil and organic surface material such as root mats should be stockpiled separately and returned to the surface of the restored site. Adequate material should be used so that following settling and compaction of the material the proper preproject elevation is attained. If excavated materials are insufficient to accomplish this, similar grain size material should be used to restore the trench to the required elevation. After backfilling, erosion protection measures should be implemented where needed to prevent essential fish habitat degradation and loss.

f. Following backfilling of the trench, planting of the disturbed area may be required in those areas previously supporting marsh or seagrass vegetation. Additional off-site mitigative actions may be required to offset unavoidable project impacts.

g. Use of existing rights-of-way is generally preferred to lessen overall encroachment and disturbance of wetlands.

h. Pipelines and submerged cables should be buried and maintained below the water bottom.

i. Inactive pipelines and submerged cables are generally required to be removed unless they are located in environmentally sensitive areas (e.g. marsh, reef, seagrasses, etc.) or when they are located in the Gulf of Mexico and can be shown to present no safety hazard. If allowed to remain in place, pipelines should be properly pigged, purged, filled with seawater, and capped prior to abandonment in place.

j. If seagrasses or oyster reefs occur at or near the project site, silt curtains or other type barriers should be used to reduce turbidity and sedimentation. These silt barriers should extend at least 100 feet beyond the limits of the seagrass beds or oyster reefs. If seagrasses and oyster reefs can not be avoided, pre- and post-construction surveys should be completed to determine project impacts and mitigation needs.

k. Equipment access should be limited to the immediate project area. Tracked vehicles are preferred over wheeled vehicles. Consideration should be given to the use of mats and boards to avoid sensitive areas. Equipment operators should be informed to avoid environmentally sensitive areas.

l. Environmentally sensitive areas should be clearly marked to ensure that they are not traversed by equipment operators.

m. Propwashing is not a recommended backfilling method.

7.2.1.1.6 Transportation

State and Federal highway agencies generally have the capability of conducting advanced planning in association with road, causeway, bridge, and airport runway construction. To the extent possible, NMFS Branch Office personnel should participate in early planning efforts. Since highway and airport projects are generally considered to be in the public interest and frequently require wetland crossings, identification of mitigation needs, and development of suitable mitigation plans should be undertaken early in the planning process. The following criteria should be considered:

a. Pre-application meetings and site visits should be held before securing and committing resources to a preferred right-of-way.

b. Roadways, railways, and airports should avoid wetlands. Where wetland crossings cannot be avoided, bridging should be used rather than filling, and the least environmentally damaging route, preferably along cleared, existing rights-of-way and road beds should be followed. Suitable erosion control and vegetation restoration methods should be used on bridge approaches. Span bridges are preferred over culverts because they do not disrupt flow.

c. Structures should be designed and maintained to prevent shoaling and alteration of natural water circulation. Suitable erosion control and vegetation restoration should be implemented at wetland crossings.

d. Construction of road improvement projects should follow the existing alignments. Existing causeway and fill areas should be used wherever possible. Clearing of riparian vegetation occurring along rivers, streams, and creeks, as well as brush and trees on the project site, should be avoided.

e. Transportation facilities should be designed to accommodate other public utilities, thus avoiding the need for additional wetland alteration. An example would be using bridges to support transmission lines and pipelines.

f. When possible, temporary board roads are encouraged in sensitive areas in lieu of fill roadways.

g. Transportation facilities should be designed to direct runoff into detention ponds.

h. Other guidelines for housing developments, drainage canals and ditches, and disposal of dredged material may be applicable.

7.2.1.1.7 Navigation channels and boat access canals

Construction and maintenance of navigation channels and boat access canals may cause severe environmental harm. In addition to direct habitat losses associated with wetland and deepwater excavation and filling, these activities may significantly modify salinity and water circulation patterns. These changes could greatly modify the distribution and abundance of living marine resources. The following criteria should be followed:

a. Alignments of channels and access canals should utilize existing channels, canals, and other deep water areas to minimize initial and maintenance dredging requirements. All canals and channels should be clearly marked to avoid damage to adjacent bottoms from propwashing.

b. Alignments should avoid sensitive habitats such as oyster reefs and areas of submerged or emergent vegetation. In addition, canals and channels should not cut through barrier beaches, barrier islands, or other Gulf shoreline protection features.

c. Access channels and canals should be designed to ensure adequate flushing so as not to create low-dissolved oxygen conditions or sumps for heavy metals and other contaminants. Widths of access channels in open water should be minimized to avoid impacts to aquatic bottoms. In canal subdivisions, channels and canals within the development should be no deeper than the parent body of water and should be of a uniform depth or become gradually shallower inland. Residential canals and navigation channels should be aligned with prevailing summer winds to take advantage of wind driven circulation. Dredge depths should be no greater than necessary for navigation but should not exceed -6 feet MLW unless it can be clearly demonstrated that deeper draft vessels would be utilizing the channel or canal.

d. Permanent dredged material disposal sites should be located in upland areas. Where long-term maintenance is anticipated, upland disposal sites should be acquired and maintained for the entire project life.

e. Construction techniques (e.g. silt curtains) must minimize turbidity and dispersal of dredged materials into sensitive wetland areas (i.e. submerged grasses and shellfish beds).

f. Channels and access canals should not be constructed in areas known to have high sediment contamination levels. If construction must occur in these areas, specific techniques, including the use of silt curtains, will be needed to contain suspended contaminants.

g. Propwashing is not a recommended dredging method.

h. To ensure adequate circulation, confined and dead-end canals should be avoided by utilizing bridges or culverting that ensures exchange of the entire water column. In general, depths should be minimized, widths maximized and canals oriented towards the prevailing summer winds to enhance water exchange.

i. Consideration should be given to the use of locks in navigation channels and access canals which connect more saline areas to fresher areas.

j. To the maximum extent practicable, all navigation channels and access canals should be backfilled upon abandonment and restored to as near pre-project condition as possible. Plugs, weirs, or other water control structures may also be necessary as determined on a case-by-case basis.

k. To the maximum extent possible, the timing of navigation channel maintenance should be confined to seasons when impact on larval and juvenile fishes will be minimal. This period of time will vary among geographical areas and based on species life histories.

7.2.1.1.8 Disposal of dredged material

Disposal of dredged material can adversely affect wetlands and water quality if disposal sites are not properly sited and managed. Recognizing that most navigation channels and access canals require periodic maintenance dredging, it is important that long-range maintenance plans be developed and that they provide adequate storage capacity for the life of the channel or marina. Implementing the following guidelines should minimize adverse impacts associated with most dredged material disposal activities.

a. Uncontaminated dredged material should be viewed as a potentially reusable resource and beneficial uses of these materials are encouraged. Materials that are suitable for beach nourishment, marsh construction, or other beneficial purposes should be utilized for these purposes. Deposition of sand for beach renourishment should avoid burying or impacting hard bottom, seagrass, or other nearshore EFH areas.

b. If disposal sites must be located near wetlands, they should be confined with levees and stabilized using vegetation, native hay mulch or other means to eliminate possible wind or water erosion or encroachment onto those wetlands.

c. If no beneficial uses are identified, dredged material should be placed in contained upland sites. The capacity of these disposal areas should be used to the fullest extent possible. This may necessitate dewatering of the material or increasing the elevation of embankments to augment the holding capacity of the site. Techniques could be applied that render dredged material suitable for export or for use in re-establishing wetland vegetation.

d. Where possible, disposal area outfalls should be positioned so that they discharge into the dredged area or other sites with reduced biological/ecological significance and are not near public water supply intakes. When evaluating potential upland disposal sites, the possibility of saltwater intrusion into ground water and surrounding freshwater habitats should be assessed by the state water quality agency. Groundwater contamination could necessitate redesign of disposal practices.

e. Toxic and highly organic materials should be placed in impervious containment basins on uplands. Effluent should be monitored to ensure compliance with state and federal water quality criteria and measures should be incorporated to ensure that surface runoff and leachate from dredged material disposal sites do not enter aquatic ecosystems.

f. In general, public disposal areas should not be used for disposal of dredged material generated from private projects.

g. Potential disposal sites should not contain trees and brush. The clearing of woody or native vegetation should be avoided when possible.

h. Pipes used in the hydraulic dredging process should be placed and moved so as not to damage or destroy sensitive habitats such as emergent marshes, endangered species habitats, etc. Where temporary impacts are unavoidable, the impact site should be restored to pre-project conditions as soon as possible.

7.2.1.1.9 Impoundments and other water-level controls

Thousands of wetland acres are impounded each year in the southeastern United States for purposes such as waterfowl habitat creation, protection or management, mariculture, agriculture, flood control, hurricane protection, mosquito control, and control of marsh subsidence and erosion. Projects range in size from minor, such as repair of existing embankments, to large-scale marsh management projects where constructing dikes and water control structures may affect thousands of wetland acres.

A. Wetland impoundments:

Proposals to impound or control marsh water levels should contain water management plans with sufficient detail to determine the accessibility of impounded areas to marine organisms and the degree to which detrital and nutrient export to adjacent estuarine areas will be affected. Significant adverse impacts can be avoided or minimized with implementation of the following recommendations:

a. Proposals to impound or reimpound wetlands are unacceptable unless designed to accommodate (1) access and wetland use by marine fish and invertebrates and (2) continuation of beneficial biological interaction, such as nutrient exchange, and other similarly important physical and chemical interactions; and

b. Proposals to repair or replace water control structures and/or restore historical conditions will be assessed on a case-by-case basis.

B. Watershed impoundments:

Water-development agencies sometimes propose impounding rivers, bayous, and tributaries for such purposes as flood control or creation of industrial, municipal, and agricultural water supplies. Activities of this type are usually unacceptable because associated alteration of the quality, quantity, and timing of freshwater flow into estuaries may cause large-scale adverse modification or elimination of estuarine and marine habitats. Such actions also may block fish and invertebrate migrations.

Significant adverse impacts can be avoided or minimized with implementation of the following guidelines:

a. Proposals to impound previously unimpounded tidal wetlands, or to convert one wetland type to another, would not be recommended but should be carefully reviewed on a case by case basis and overall. Special consideration should be given to the need for such projects to address adverse wetland impacts resulting from previous manmade hydrologic changes, such as canal induced saltwater intrusion into fresh or low salinity marshes.

b. Proposals to repair or replace water control structures and/or restore historical conditions should be assessed on a case-by-case basis.

c. Impoundment levees should only be constructed in wetland areas as part of approved water or marsh management plans or to prevent the release of pollutants. Water or marsh management plans should result in the overall benefit to all forms of fish and wildlife resources currently utilizing the area. Management plans that benefit a certain resource type while adversely impacting another type are not recommended.

d. New water control structures will be assessed separately based on their individual merits and impacts and in relation to the overall water or marsh management plan of which they are a part. In coastal marshes, new water control structures should be designed to ensure adequate ingress and egress of migratory marine organisms.

e. Impoundments of rivers, bayous, and tributaries are not recommended if they adversely affect the quality, quantity, and timing of freshwater flows into estuaries or block migration of fishery and wildlife resources.

f. Levees should be planned and sited to avoid isolation or segmentation of wetland areas and systems to the maximum extent practicable.

g. Hurricane and flood protection levees should be located in uplands to the maximum extent practicable. They should be designed, operated, and maintained to minimize disruptions of existing hydrologic patterns, and to maximize the interchange of water, beneficial nutrients, and aquatic organisms between the enclosed wetlands and those outside the levee system. Borrow material for levee construction should not be taken from wetlands or other sensitive habitats.

h. A monitoring plan for impoundments should be designed to ensure that the objectives of the management area are met and that non-target resources are not unacceptably impacted (e.g. fisheries, wildlife, vegetation, water quality, etc.). Without monitoring, measurement of positive and negative impacts, recommendations for plan revisions, or plan abandonment cannot be properly evaluated.

7.2.1.1.10   Drainage canals and ditches

Drainage canals may be important components of upland development. Their potential to shunt polluted stormwater runoff and fresh water directly into tidal waters requires intermediate connection to retention ponds or wetlands. This allows natural filtration and assimilation of pollutants and dampening for freshwater surges prior to discharge into tidal waters. Other guidelines for housing developments and/or transportation projects may apply. Guidelines for drainage canals and ditches include:

a. Canals that drain wetlands, special aquatic sites, or cause other adverse impacts are not recommended.

b. Constructing upland retention ponds and other water management features such as sheet-flow diffusers is encouraged. A retention pond or other pollution elimination/assimilation structure may be required in uplands to intercept any effluent-containing materials that are toxic to marsh vegetation or other aquatic life.

c. Excavated materials resulting from canal and retention pond construction should be placed and contained on uplands or, when possible, used beneficially, such as in approved wetlands restoration or beach restoration projects.

d. Proposed plans should be prepared in accordance with comprehensive flood plain management plan(s) and other plans such as wastewater management, drainage, etc. Applicants are encouraged to consult with the Environmental Protection Agency, Federal Emergency Management Agency, and appropriate state agencies to ensure that federal and state water quality standards are met.

e. Runoff and erosion from agricultural lands should be minimized through the use of best management practices.

f. Allowing natural vegetation to line drainage canals and ditches is encouraged. Vegetation is preferred to concrete lined ditches because it slows flood waters, binds sediments, prevents erosion, and provides fish and wildlife habitats.

g. The clearing of brush, trees, and riparian vegetation for equipment access and/or project design should be avoided.

h. Locating mosquito control ditches in wetlands should be discouraged. If built, they should be designed so that they do not drain coastal wetlands and should not allow for salt water to encroach into lower salinity wetlands. They also should be designed to avoid water stagnation, and they should provide access for aquatic organisms that feed on mosquito larvae; and

i. Use of innovative techniques such as rotary ditching, spray dispersal of dredged materials, and open-water marsh management should be encouraged.

7.2.1.1.11 Oil and gas exploration and production

Exploration and production of oil and gas resources in wetlands usually have adverse impacts since excavation and filling are generally required to accommodate access and production needs. In open marine waters, dredging and filling is usually not necessary, but special stipulations are required to minimize adverse impacts to living marine resources. In addition to the above recommendations for navigation channels, access canals, and pipeline installation, the following apply:

General recommendations

a. 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. Air boats should be used instead of marsh buggies whenever possible.

b. 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.

c. 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.

d. Exploration/production activities and facilities should be designed and maintained in a manner that will maintain natural water flow regimes, avoid blocking surface drainage, and avoid erosion.

Activities in coastal marsh

a. Activities should avoid wetlands. Drilling should be conducted from uplands, existing drill sites, canals, bayous, or deep bay waters (greater than six feet), wherever possible, rather than dredging canals or constructing board roads. When wetland use is unavoidable, work in previously disturbed wetlands is preferable to work in high quality or undisturbed wetlands.

b. If (a) is not possible, temporary roads (preferably board roads) to provide access are more desirable than dredging canals because roads generally impact less acreage and are easier to restore than canals. The following apply to the establishment of the well site:

1. Proposed road alignments and well pads should utilize upland or already disturbed marsh areas and should be no larger than necessary to conduct exploration/production activities. All borrow material for the ring levees should come from within the leveed areas.

2. Borrow pits for fill material, if necessary, should be dredged adjacent to and on alternate sides of the roads and should be no more than 500 feet long. Continuous borrow pits are to be avoided.

3. Culverts or similar structures should be installed under the road at sufficient intervals to prevent blockage of surface drainage, tidal flow, and sheet flow (at least every 500 feet), with all culverts maintained open for the life of the roadway. Where possible, flowlines should be installed in the roadbed.

4. All streams, bayous, etc., should be bridged or culverted to prevent alteration to the natural drainage patterns.

5. If the well is a producer, the drill pad should be reduced to the minimum size necessary to conduct production activities and the disturbed area should be restored to pre-project conditions.

c. Upon completion or abandonment of wells in wetlands, all unnecessary equipment should be removed and the area restored to pre-project elevations. The well site, various pits, levees, roads, and other work areas should be graded to pre-project marsh elevations and then restored with indigenous wetland vegetation. Abandoned canals frequently need plugging and capping with erosion-resistant material at their origin to minimize bank erosion and to prevent saltwater intrusion. In addition, abandoned canals will frequently need to be backfilled to maximize fish and wildlife production in the area and to restore natural sheet flows. Spoil banks containing uncontaminated materials should be backfilled into borrow areas or breached at regular intervals to re-establish hydrological connections.

<u>Activities in the open bay</u>

a. Maximum use should be made of existing navigable waters already having sufficient width and depth for access to the drill sites.

b. Environmentally sensitive areas such as oyster reefs and seagrass beds should be avoided when siting extraction facilities.

c. Over-water storage facilities and structures are generally not recommended.

d. All unnecessary equipment and structures should be immediately removed upon cessation of drilling or production.

e. Oyster reefs and seagrass beds should be marked to assure that they are not traversed. All equipment access should be limited to the immediate project area. Equipment operators should be closely supervised to avoid damaging environmentally sensitive areas.

f. Propwashing should be strictly avoided. No access channels or floatation canals should be constructed in areas containing seagrasses or oyster reefs if practical alternatives exist.
g. An oil spill response plan should be developed and coordinated with federal and state resource agencies.

Activities on the continental shelf

Activities are conducted under Federal Regulations found in: The Outer Continental Shelf Lands Act; The Marine Mammal Protection Act; The Magnuson-Stevens Fishery Conservation and Management Act of 1976; The Endangered Species Act; The National Fishing Enhancement Act; The Marine Protection, Research and Sanctuaries Act; The Oil Pollution Act; The Clean Water Act; The Clean Air Act; The Resource Conservation and Recovery Act; The Marine Plastic Pollution Research and Control Act; and the Coastal Zone Management Act. The DOI MMS is responsible for regulating and monitoring the oil and gas operations on the Federal OCS. Regulations provide for the MMS to regulate all operations conducted under a lease, right of use and easement, or DOI pipeline right-of-way; to promote orderly exploration, development, and production of mineral resources, and to prevent harm or damage to, or waste of, any natural resource, any life or property, or the marine, coastal, or human environment (DOI MMS 1996). Examples of some of the requirements placed on permitees follow:

a. Drill cuttings should be shunted through a conduit and discharged near the sea floor, or transported ashore;

b. Drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef;

c. All pipelines placed in waters less than 200 feet-deep should be buried to a minimum of three feet beneath the sea floor, where possible. Where this is not possible and in deeper waters where user-conflicts are likely, pipelines should be marked by lighted buoys and/or lighted ranges on platforms to reduce the risk of damage to fishing gear and the pipelines. 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.

d. All abandoned structures must be cut off at least 15 feet below the mud line. If explosives are to be used, the National Marine Fisheries Service should be contacted to coordinate marine mammal and endangered species concerns.

e. All natural reefs and banks, as well as artificial reef areas, should be avoided. Consult local fish and game agencies or the Gulf States Marine Fisheries Commission for a list of artificial reefs in State waters.

7.2.1.1.12 Other mineral mining/extraction

a. Proposals for mining mineral resources (sand, gravel, shell, phosphate, etc.) from or within 1,500 feet of exposed shell reefs and vegetated wetlands, and within 1,500 feet of shorelines should be carefully analyzed in relation to possible environmental impact to these habitats;
b. Borrow sites should be chosen which are downcurrent of important coral resources, live hard bottom and seagrasses; and

c. All other proposals should be considered on a case-by-case basis.

7.2.1.1.13 Sewage treatment and disposal

Urbanization and high density development of coastal areas has resulted in a substantial increase in proposals to construct sewage treatment and discharge facilities in coastal wetlands. Since many of these facilities utilize gravity flow systems for movement of waste water and materials, wetlands and other low-lying areas are often targeted as sites for placement of treatment facilities. Since treatment facilities are not water dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. The guidance provided for cables, pipelines and transmission lines also applies to sewage collector and discharge pipelines. Additional guidelines for housing developments, marinas, and water intakes/discharges may also apply. The following guidance should be considered in association with other aspects of sewage treatment and discharge:

a. Sewage treatment facilities should be constructed entirely in uplands.

b. Discharges should be treated to meet State Water Quality Standards. Implementation of up-to-date methodologies for reducing discharges of biocides (e.g. chlorine) and other toxic substances is encouraged.

c. Use of land treatment and upland disposal/storage techniques of solid waste should be implemented where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large scale wastewater discharges should be limited to those instances where wetlands have been specifically created for this purpose and the overall environmental and ecological suitability of such an action has been demonstrated.

d. Discharging into open ocean waters is generally preferable to discharging into estuarine waters since discharging into estuarine waters has a higher potential to result in living marine resources contamination and nutrient overloading. Discharge points in coastal waters should be located away from critical habitats such as oyster reefs, marshes, sand and mud flats, seagrass beds, endangered species habitats, and other sensitive habitats. Proposals to locate outfalls in coastal waters must be accompanied by hydrographic studies that demonstrate year round dispersal characteristics and provide proof that effluents will not reach or affect fragile and productive habitats.

e. Sewage outfalls should not be located near a public recreational facility.

7.2.1.1.14 <u>Steam-electric plants and other facilities requiring water for cooling or heating</u>

Facilities that require substantial intake and discharge of water, especially heated and chemically-treated discharge water, are generally not suited for construction and operation in estuarine and near-shore marine environments. Major adverse impacts may be caused by impingement of organisms on intake screens; entrainment of organisms in heat-exchange systems or discharge plumes; and through the discharge of toxic materials in discharge waters. NMFS and USFWS personnel should be notified of such projects early in the planning process since the operation of steam-electric plants can affect endangered species such as sturgeon and West Indian manatee. The Council recommends that a species and site specific approach to identifying threats and proposing recommendations be utilized, especially with regard to cooling water intake structures.

Projects that must be sited in the coastal zone and utilize estuarine and marine waters are subject to the following recommendations:

a. **"**Once-through**"** cooling systems should not be located in areas such as estuaries, inlets, or small coastal embayments where fishery organisms are concentrated. Discharge points should be located in areas that have low concentrations of living marine resources, or they should consider incorporating cooling towers that employ sufficient safeguards to ensure against release of blow-down pollutants into the aquatic environment;

b. Intakes should be designed to minimize impingement. Velocity caps that produce horizontal intake/discharge currents should be employed and intake velocities across the intake screen should be determined that cause the least acceptable amount of mortality to marine organisms on a case by case basis;

c. Discharge temperatures (both heated and cooled effluent) should not exceed the thermal tolerance of the majority of the plant and animal species in the receiving body of water;

d. The use of construction materials that may release toxic substances into receiving waters should be prohibited. The use of biocides (e.g., chlorine) to prevent fouling should be avoided where possible and least damaging antifouling alternatives should be implemented; and

e. Intake screen mesh should be sized to avoid entrainment of most larval and post-larval marine fishery organisms. Acceptable mesh size is generally in the range of 0.5 to 0.7 mm and rarely exceeds 1.0 mm in estuarine waters or waters that support anadromous fish eggs and larvae.

7.2.1.1.15 <u>Mariculture/processing</u>

Recognizing that mariculture presents both potential benefits as well as potential negative impacts, it is the policy of the Gulf of Mexico Fishery Management Council (Council) to encourage environmentally responsible mariculture. The Council encourages consideration of the following guidelines:

a. Exotics:

The Council recommends that native species receive priority as candidate culture species. Exotics should be used only after thorough investigation has demonstrated no detrimental impacts on native species. The Council opposes use of non-native species in Mariculture systems unless demonstrated it has no detrimental impacts on native species.

The sale of exotic shrimp as bait should be prohibited and an outreach program developed to educate sport fishers and shrimp retailers about the risks of spreading shrimp viruses and encourage retailers to label shrimp as to their point of origin.

b. Habitat:

To ensure that mariculture activities are environmental responsible, the following considerations should be made with respect to habitat in that:

1. existing shoreline, bottom, and open-water habitats should be protected from physical alterations or degradation;

2. ingress and egress of native wild organisms in natural and public waters should not be impeded by physical or water quality barriers; and

3. navigation in natural or public waters should not be impeded.

c. Research and monitoring:

The Council recommends the mariculture industry demonstrate, in part, its stewardship of Gulf waters by:

1. actively educating its member institutions about the necessary regulations and permits;

2. actively participating in cooperative research and monitoring to improve the understanding of mariculture's relationship to coastal and marine ecosystems; and

3. participation in cooperative research to enhance knowledge of cultured species.

d. Location, design, and operation:

Mariculture operations should be located, designed, and operated to reduce, prevent, or eliminate adverse impacts to estuaries and marine habitats and native fishery stocks. These impacts that cannot be eliminated must be fully mitigated in-kind.

Conditions should be maintained to sustain healthy, diverse, native biological communities without the production of nuisance, toxic or oxygen-demanding conditions.

Standard operating procedures should contain methods to prevent escapement, accidental transport or release of cultured organisms.

e. Water quality:

Mariculture facilities should be operated in such a manner that minimizes impacts to the local environment by utilizing water conservation practices and discharging effluent that protects existing designated use of receiving water.

Mariculture facilities are responsible for developing, implementing, and monitoring best management practices to conserve water and improve effluent water quality.

f. Disease control:

Mariculture activities should have procedures established that: prevent the importation or spread of pathogens or parasites; minimize impacts of disease outbreaks if they occur; and eliminate disease problems wherever possible.

On-farm disease control programs should include the following minimum requirements: exclusive use of certified "specific pathogen free" shrimp, a multi-screen system to block escape sites; regular disease monitoring, and cessation of farm discharges when signs of disease are observed.

A system similar to a Hazard Analysis Critical Control Point system should be developed and implemented by shrimp processing facilities, with the goal of preventing the spread of exotic shrimp viruses to wild and farmed shrimp.

7.2.1.1.16 Water intakes and discharges

Facilities that require substantial intake and discharge of water, especially heated and chemically-treated discharge water, are generally not suited for construction and operation in estuarine and near-shore marine environments. Major adverse impacts may be caused by impingement of organisms on intake screens, entrainment of organisms in heat-exchange systems or discharge plumes, and through the discharge of toxic materials in discharge waters. Additional guidelines for sewage treatment and disposal, and aquaculture/agriculture may also apply. Projects that must be sited in the coastal zone and utilize estuarine and marine waters are subject to the following guidelines:

a. “Once-through” cooling systems should not be designed for areas such as estuaries, inlets or small coastal embayments.

b. Intakes should be designed to minimize impingement. Velocity caps that reduce horizontal intake/discharge currents should be employed. Past studies have shown that intake velocities that do not exceed 0.5 feet per second across intake screens allow adequate protection for fishery resources. Because of this, some resource agencies have recommended this velocity restriction be incorporated into the Corps of Engineers permit conditions on past permit applications.

c. Discharge temperatures (both heated and cooled effluent) should not exceed state water quality standards for the receiving water body.

d. The use of construction materials that may release toxic substances into receiving waters should be avoided. The use of biocides (e.g. chlorine) to prevent fouling should be avoided where possible and least damaging antifouling alternatives should be implemented.

e. Intake screen mesh should be sized to minimize entrainment of most larval and post-larval marine fishery organisms. Past studies have shown that 0.5 mm screens across intakes allow adequate protection for fishery resources. Because of this, some resource agencies have recommended this mesh size be incorporated into the Corps of Engineers permit conditions on past permit applications.

f. To prevent scouring at the discharge point, discharge velocities should not exceed 0.5 feet per second. Discharge sites should be located to avoid adverse impacts to sensitive areas such as emergent marshes and seagrasses.

7.2.1.1.17 Housing developments

Housing developments sited along the waterfront have a great potential for adverse impacts to the aquatic environment and to human health if appropriate measures are not taken. Construction of canal subdivisions is discouraged. Such developments commonly result in the degradation of water quality and are often detrimental to fish and wildlife. In addition to the guidelines for associated access canals, seawalls and bulkheads, boat ramps, marinas, docks and piers, sewage treatment and disposal, and disposal of dredged material, the following guidelines apply:

a. Housing developments should be restricted to upland areas. Fill should not be placed in wetlands or other special aquatic sites. Houses on pilings should not be constructed over wetlands or submerged lands.

b. Waterfront housing developments should be situated so that sufficient water depths occur to avoid the need to dredge access channels. If access canals are needed, they should be routed from housing developments to the parent body of water by the shortest and least environmentally damaging courses.

c. If a canal subdivision is planned, such developments may require: 1) a detailed hydrologic study including hydrologic and circulation patterns; 2) inclusion of methods to ensure adequate circulation; 3) inclusion of a water quality monitoring and reporting program; 4) designation of individual(s) to be responsible for the monitoring and reporting program; and 5) designation of a responsible party in the event of problems such as fish kills and contaminant spills. These individuals may be financially responsible for remediation measures.

d. Canal depths for recreational craft should be no deeper than necessary for navigation, but not to exceed 6 feet below mean low water. Width of interior canals should be maximized (minimum 100 feet) in order to provide for better mixing of canal waters and water quality. Canals should be oriented with the predominant summer wind direction to maximize water exchange.

e. Dredging only to obtain fill material is generally not recommended.

f. A waste collection and treatment system infrastructure should be installed in coastal housing developments. The use of septic tanks is generally not a recommended method of waste disposal. Plans should be provided and coordinated with the County Health District for compliance with local and state regulations.

g. Sewage treatment plant effluent or other point-source discharges should not be discharged directly into canal waters or other poorly circulating water bodies. Discharges into surface waters should be a sufficient distance from canals and other small or poorly circulating waterbodies to ensure that the effluent is not carried into these areas by currents.

h. To prevent water quality degradation, surface drainage should be directed away from boat canals. In addition, an education program for residents should be considered which details why grass cuttings, garbage or other debris should not be dumped into the canal waterways and advising them on the prudent use of fertilizers, herbicides, pesticides and other toxic substances.

7.2.1.1.18 Mitigation

Sections 7.2.1.1.1 - 7.2.1.1.17 provide specific guidance for avoiding and reducing adverse impacts to fishery resources and their habitats. As a general rule, compensatory mitigation will be considered only after a project has been demonstrated to be water-dependent, has no feasible alternative, is clearly in the public interest, and all significant impacts are found to be unavoidable. In all cases, mitigation shall comply with the definition of mitigation that is provided at 40 CFR 1508.20 of the Council on Environmental Quality (CEQ) Recommendations. Those recommendations define mitigation as a sequential process whereby impacts are avoided, minimized, rectified, reduced over time, or are offset through compensation. As a follow-up to the CEQ recommendations, a Memorandum of Understanding (MOU) titled “Federal Guidance for the Establishment, Use and Operation of Mitigation Banks”, between EPA, USCOE, USDA, USDOI, and NOAA was published in the Federal Register on November 28, 1995. The MOU provides policy guidance for the establishment, use, and operation of mitigation banks for the purpose of providing compensatory mitigation for authorized adverse impacts to wetlands and other aquatic resources.

Despite increasing use of mitigation to offset wetland and other losses, there are situations (e.g., projects affecting large, high-quality seagrass beds) where the affected habitats are of such enormous value that the anticipated adverse impacts cannot be offset. In these situations mitigation should be used only after project relocation or abandonment are fully considered and rejected by the construction/regulatory agency. A review of the scientific literature suggests that created wetlands do not become functionally equivalent to nearby natural marshes for at least several years after construction. Therefore, it should not be assumed that wetlands created at a comparable acreage will fully mitigate the habitat values and functions of the impacted natural wetland.

As a general rule, mitigation that restores previously existing habitats is more desirable and likely to succeed than that which seeks to create new habitat. The numerous impacted wetlands that exist in the southeast provide substantial opportunity for wetlands restoration. Restoration may be relatively simple, such as restoring tidal flows to an impounded wetland area, or more complex such as restoring dredged cuts and disposal areas. Restoration of adversely impacted emergent and, to a lesser degree, submerged vegetation is a feasible and recognized option when implemented in association with the services of experienced restoration personnel.

The creation of new wetland habitat involves conversion of uplands or, in some situations, submerged bottom to vegetated wetlands or another desirable habitat such as oyster reef. Generation of wetland habitat should not involve converting one valuable wetland type to another. For example, building emergent wetlands in shallow water is unacceptable unless it can be demonstrated that the site is insignificant with regard to habitat or water quality function(s) or it previously supported wetland vegetation and restoration is desirable in terms of the ecology of the overall hydrological unit (e.g., estuary). Regardless of which option is used (restoration or creation), a quantitative, biologically-based, case-by-case evaluation should be employed to determine the proper amount of mitigation for each acre of habitat destroyed.

Four basic considerations involved in the planning for habitat generation are type of habitat to be created, and its location, size, and configuration. Each of these considerations must be applied to the specific ecological setting and in accordance with the following recommendations:

a. <u>Habitat type</u> - As a general rule the created habitat should be vegetatively, functionally, and ecologically comparable to that which is being replaced. For example, a smooth cordgrass marsh should be created if a smooth cordgrass marsh is eliminated. The principal exception would be those cases where a different habitat is shown to be more desirable based on overall ecological considerations. In no case should marine fishery productivity be diminished from that of the natural marsh that is removed in place of a man-made comparable marsh.

b. <u>Location</u> - Except in the case of overriding ecological considerations, the new site should be located as near as possible to the site that would be eliminated. In any event, the new site should be in the same estuarine system as the habitat that is being replaced. The replacement wetland should consider physical implications such as shoaling and existing circulation and drainage patterns.

c. Size - The habitat to be restored or created should be at least twice the (areal) size of that which would be adversely impacted. This requirement is designed to offset differences in productivity and habitat functions that may exist between established project site wetlands and newly developed replacement wetlands. This size difference also takes into account that the proposed wetlands creation project may fail.

d. Configuration - The configuration of replacement habitats is determined by the ecological setting and physical factors such as existing drainage and circulation patterns. Consideration should be given to maximizing edge habitat and to the needs of desirable biota that may inhabit the site.

e. Monitoring - A monitoring plan for a mitigation project site should be implemented to ascertain success rates and project design viability, at a minimum. Time frames of 3 to 5 years are recommended as minimum time frames to allow for project modifications and replantings, if needed.

7.2.1.2 Relative sea level rise and subsidence

In Louisiana, major public works projects are necessary to offset some of the wetland loss attributable to relative sea level rise and subsidence. Those projects would entail the diversion of freshwater and sediments from the Mississippi and, possibly, Atchafalaya Rivers. Diversions, while they could greatly reduce the loss of Louisiana coastal wetlands, could have negative social impacts by displacing fisheries from traditional fishing grounds. Perceived adverse fishery impacts have resulted in varying levels of resistance to diversion projects by some commercial and recreational fishers. However, many believe that without such major projects, the long-term sustainability of the affected estuarine-dependent fisheries is in clear jeopardy due to continued deterioration of essential fish habitat. Much less extensive mitigation could be achieved through dedicated dredging and beneficial use of spoil material to restore and renourish wetlands. Opportunities for wetland creation using spoil material are most viable in areas near Federally-maintained navigation channels and privately maintained canals.

7.2.1.3 Pipeline construction

The best management option for pipeline construction [in wetlands] is to push the pipe under the marsh to eliminate negative impacts from using heavy pieces of equipment. From a cost and logistical viewpoint, this may not always be feasible. Therefore, measures need to be taken to prevent pipeline routes (particularly the pipeline ditch) from subsiding and/or eroding (Polasek, 1997). One procedure is to periodically place sand-bag barricades to marsh elevation within the pipeline ditch to help combat tidal energies. In addition, surface barricades constructed from hay bales or silt fences could be placed at right angles across pipeline corridor strata to further minimize tidal and wave energies (Polasek, 1997). Decreasing wave and tidal energies would help to minimize erosion and increase water clarity, which would in turn encourage growth of submerged aquatics. One final technique would be to construct earthen soil plugs at locations where pipeline ditches intersect other ditches or canals. Plugging oil exploration canals in Louisiana proved successful in increasing submerged aquatic growth within the canal (Neill and Turner, 1987).

Regardless of which techniques are tried, Polasek (1997) has shown that double-ditching alone is not sufficient to revegetate pipeline construction routes.

7.2.2 Independent and Cooperative Habitat Restoration Efforts

7.2.2.1 Direct habitat loss

Direct loss of fishery habitat can be most readily mitigated by redesign or relocation to avoid significant impacts. Where that is not possible and a project need can be justified, offsite mitigation is often the only option to compensate for the habitat loss and degradation. In Louisiana, mitigation normally follow's the State's mitigation regulations which requires the replacement of lost habitat functions or, as a last resort, monetary contribution to the State's wetland trust fund. Mitigation can include wetland creation/restoration, normally in areas of open water which once supported marsh vegetation, and wetland enhancement. Wetland enhancement can take various forms, but usually involves restoring normal hydrologic pathways in wetlands previously impacted by commercial, industrial, and private development activities.

7.2.3 Outreach and Education

The Gulf Council integrates and adopts the NOAA 1995-2005 Strategic Plan Education and Outreach Goals as follows:

"NOAA's goal is to provide a strong information base for informed public policy decision making related to use of coastal ecosystems. NOAA [and the Gulf Council] will share management-oriented information with its counterparts in other agencies, academia, and the public. NOAA scientists and outreach specialists will collaborate with colleagues in resource and environmental agencies at the Federal and state/local level. They will provide advisory services to support technology transfer, facilitate development of the environmental services industry, identify low impact alternatives for common types of coastal development, and develop educational materials to enhance public appreciation of coastal ecosystem values."

The National Marine Fisheries Service, with the approval of its Final National Habitat Plan on August 30, 1996, implemented the following goal in support of Fishery Management Councils and the MSFCMA in the development of an outreach/communication plan:

"The agency's (NMFS) information exchange efforts include sharing research results, explaining National Habitat Program intentions and the importance to habitat, and maintaining regular communication with partners. This dialogue is essential to establish priorities, encourage partnerships, and announce successes. The Program will emphasize opportunities offering the greatest benefits. Limited resources will require a very focused outreach effort, e.g., sharing program priorities with potential partners or ensuring that basic ecological research results are provided to Councils and Commissions working with NMFS to identify essential fish habitats.

NMFS objectives include building support, inspiring partnerships, leveraging resources, and using those rewards to strengthen the Program."

7.2.4 Watershed Analysis and Freshwater Inflow Planning

Managing for an ecologically sound environment on a watershed basis is extremely complicated and politically involved. A primary management method to achieve a legislative goal with respect to freshwater inflows is to incorporate special conditions in state permits to store, take, or divert water. In general, these conditions will regulate the quantity and timing of the permitted water use. The legislation will need to recognize that the dilution of marine water by fresh water and the supply of nutrients and sediments are the three major influences that rivers and streams have on estuaries. The quantity and pattern of freshwater inflows over time is the normal mechanism that regulates the salinity of estuarine waters and the inflow of nutrients and sediments. Therefore, special conditions in water rights permits have to be designed so that the salinity and nutrient levels and sediment supplies are adequate over time to provide an environment in which the production of estuarine organisms may be maintained. In addition to managing the flows in rivers and streams, regulating the quality and quantity of wastewater discharges for the benefits of the states' estuaries must also become a recognized strategy.

7.2.4.1 Hydrologic modification

In Louisiana and other coastal states, mitigation of hydrologic modification projects can be achieved by design modifications to minimize direct and indirect impacts, beneficial use of dredged materials, and marsh management or flood control operation to reduce restrictions to fishery ingress and egress. Design modifications could include avoiding construction which would alter water flow through estuarine wetlands (i.e., avoid ponding or draining wetlands), reducing the extent of dredging and filling, using dredged material to restore wetlands, gapping or degrading spoil banks, and plugging canals.

7.2.4.2 Coastal hypoxia and contaminant loading

Collaborative efforts to address the northern Gulf's chronic hypoxia problem were prompted by a petition in 1995 by Earthjustice Defense Fund (formerly Sierra Club Legal Defense Fund) to the State of Louisiana and the Environmental Protection Agency (EPA) to hold an interstate management conference to discuss the issue. That meeting *(First Gulf of Mexico Hypoxia Management Conference)* was held December 5-6, 1995 in New Orleans, Louisiana.

Following that meeting the EPA convened a group of senior federal agency officials to discuss potential actions and scientific needs. Those officials appointed an interim working group to develop recommendations for action. Out of those recommendations, a formal coordinating body, the *Gulf of Mexico Hypoxia Task Force*, was established, composed of senior federal and state agency officials, with the task of investigating the causes of hypoxia and effects of nutrient management in the Mississippi River and Gulf of Mexico. The interim working group was reestablished as the *Coordinating Committee* to manage the various facets of the task. Key milestones in the overall effort include: 1) baseline characterizations, especially for nutrients; 2) reaching agreement on nutrient load reductions; 3) assessing costs of additional nutrient reduction; and 4) assessing the need for a longer term response plan.

A major task is to conduct a scientific assessment of the causes and consequences of Gulf of Mexico hypoxia. A *Hypoxia Assessment Workgroup*, being led by the National Oceanic and Atmospheric Administration (NOAA), is coordinating this assessment. The *Hypoxia Assessment Workgroup* met twice during 1997. The *Gulf of Mexico Hypoxia Task Force* held its first official meeting on October 29, 1997 where it began formation of an *Ecosystem/Watershed Management Committee*.

7.3 Habitat Areas of Particular Concern Within EFH

Within the NMFS Interim Final Rules, the NMFS recommends that FMPs identify habitat areas of particular concern (HAPC) within EFH. In response to this recommendation, the following general types of HAPC are identified for all FMP-managed species:

1. Nearshore areas of intertidal and estuarine habitats with emergent and submerged vegetation, sand and mud flats, shell and oyster reefs, and other substrates that may provide food and rearing for juvenile fish and shellfish managed by the GMFMC; and migration route areas for adult and juvenile fish and shellfish; and that are sensitive to natural or human-induced environmental degradation, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities. Examples include areas such as submerged aquatic vegetation, emergent vegetated wetlands, oyster reefs, shellfish beds, and certain intertidal zones. Many of these areas are unique and rare, and have a high potential to be affected by shore-based activities. The coastal zone is under the most intense development pressure, and estuarine and intertidal areas are limited in comparison with the areal scope of other marine habitats;

2. Offshore areas with substrates of high habitat value and diversity or vertical relief which serve as cover for fish and shellfish. These can be areas with rich epifaunal communities (e.g., coral, anemones, bryozoans, etc.) or various types of liverock and other hard bottom. Complex habitat structures may be most readily impacted by fishing activities; and

3. Marine and estuarine habitat used for migration, spawning, and rearing of fish and shellfish, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities.

In identifying specific habitat areas of particular concern within the above general habitat types, the GMFMC will solicit specific recommendations from its members and advisory panels, other state and federal agencies, and academia. This process will begin immediately upon development of the GMFMC's EFH coordination procedures and will be an ongoing and evolving function of the

Council's Habitat Committee and Advisory Panels. The following criteria will be used to designate specific HAPCs and these general criteria apply to each of the three general areas described above:

a. the importance of the ecological function provided by the habitat;

b. the extent to which the habitat is sensitive to human-induced environmental degradation;

c. whether, and to what extent, development activities are, or will be, stressing the habitat; and

d. the rarity of the habitat type.

Marine sanctuaries and national estuarine research reserves have been designated within the areas managed by the GMFMC. The GMFMC considers these to be HAPCs that meet the above general criteria. These HAPCs are specified as follows:

- **Florida Keys National Marine Sanctuary**

The Florida Keys marine ecosystem supports one of the most diverse assemblages of underwater plants and animals in North America. Although the Keys are best known for coral reefs, there are many other significant interconnecting and interdependent habitats. These include fringing mangroves, seagrass meadows, hardbottom regions, patch reefs, and bank reefs. This complex marine ecosystem is the foundation for the commercial fishing and tourism based economies that are vital to Florida. This area transitions between the area covered by the South Atlantic Fishery Management Council (SAFMC) and GMFMC. Habitat found here is important to the fisheries managed by both Councils and qualifies as a GMFMC HAPC under the general criteria a., b., c., and d., listed above.

- **Florida Bay**

Florida Bay lies at the southern tip of Florida between the mainland to the north, the Florida Keys to the east and south, and the Gulf of Mexico to the west. Florida Bay is characterized by numerous mangrove covered islands and submerged aquatic vegetation that provide important habitat for many of the fisheries managed by the GMFMC as well as the South Atlantic Fishery Management Council. Florida Bay is especially important habitat for pink shrimp, red drum, and spiny lobster. Florida Bay is stressed and has experienced algal blooms, anoxia, and die-off of submerged aquatic vegetation. There currently are joint State/Federal and private partnerships that are researching the problems in the Bay and seeking ways to improve it. This bay system is vitally important to fishery production and qualifies as an HAPC under the general criteria a., b., c., and d., listed above.

- **Flower Garden Banks National Marine Sanctuary**

One hundred miles off the coasts of Texas and Louisiana, a pair of underwater features rise from the floor of the Gulf of Mexico. The Flower Garden Banks are surface expressions of salt domes beneath the sea floor. This premiere diving destination harbors the northernmost coral reefs in the

United States and serves as a regional reservoir of shallow water Caribbean reef fishes and invertebrates. This area qualifies as an HAPC under the general criteria a., b., c., and d., listed above.

East and West Flower Garden Banks have previously been identified as HAPCs under the GMFMC's FMP for Coral and Coral Reefs.

- **Apalachicola National Estuarine Research Reserve**

Located 55 miles southeast of Panama City, Florida, the Reserve represents the coastal region of the northeastern Gulf of Mexico. Features include important habitats for saltwater fish and shellfish. This area qualifies as an HAPC under the general criteria a., b., c., and d., listed above.

- **Rookery Bay National Estuarine Research Reserve**

Located 5 miles south of Naples, Florida, this Reserve represents the West Indian biogeographical region. Important features include pristine mangrove forests and surrounding shallow bay waters that provide important fish habitats. This area qualifies as an HAPC under the general criteria a., b., and c., listed above.

- **Weeks Bay National Estuarine Research Reserve**

Located off U.S. Highway 98 between Mobile, Alabama and Pensacola, Florida, this Reserve represents the Louisianian Biogeographic Region. Weeks Bay is a shallow of Mobile Bay and is located in Baldwin County, receiving water from the Fish and Magnolia rivers to create a 200 square mile watershed that provides critical nursery for fish and shellfish. This area qualifies as an HAPC under the general criteria a., b., and c., listed above.

- **Grand Bay, Mississippi**

Located in southeast Jackson County, the Mississippi Site Selection and Advisory Committee selected this area in 1995 as a potential research reserve. The site encompasses approximately 15,000 acres of estuarine tidal marsh, shallow-water open bay, wet pine savanna, and coastal swamp habitats. Approximately 9,600 acres are state-owned estuarine marsh and shallow-bay bottoms that are currently recognized as the Grand Bay Estuarine Preserve. This area qualifies as an HAPC under the general criteria a., b., and c., listed above.

- **Florida Middle Grounds**

This area has been designated as an HAPC in the GMFMC's FMP for Coral and Coral Reefs. It comprises habitats of live hard bottom located on the outer edge of the continental shelf in the eastern Gulf of Mexico. It is approximately 160 km (99 miles) west-northwest of Tampa and 140 m (87 miles) south-southeast of Cape San Blas, Florida. The Florida Middle Grounds is the best known and most important coral area in the north-eastern Gulf of Mexico. Stony corals and octocorals dominate in this area. Red snapper and grouper are especially dependent on this area for habitat. This area qualifies as an HAPC under the general criteria a., listed above.

- **Dry Tortugas (Fort Jefferson National Monument)**

This area has been designated as an HAPC in the GMFMC's FMP for Coral and Coral Reefs. This approximate 26,166 ha (64,657 acres) area of water is located at the southwestern tip of the Florida reef tract. It includes the Fort Jefferson National Monument and reef resources that make up one of the most spectacular and least disturbed reef areas in south Florida. This area qualifies as an HAPC under the general criteria a. and d., listed above.

8.0 RECOMMENDATIONS FOR IMPROVING HABITAT INFORMATION

The chief concern related to living marine resources is how human activities impact fishery productivity. Research is needed to provide knowledge of the ecological processes that affect energy flow leading to fishery productivity and responses of living marine resources to habitat and environmental changes. This understanding of ecological processes must then be linked with information on the health, distribution, and abundance of ecologically important organisms. By understanding the ecological linkages to the production of fishery stocks, managers of fisheries and habitat will be better able to manage living marine resources and their Essential Fish Habitat (EFH).

8.1 Research Needs

Non-fishing-related

Research needed to provide the information necessary to protect, conserve and restore aquatic habitats has been identified in a NMFS Habitat Research Plan (HRP) by Thayer, et al. (1996). The HRP, depicted in Figure 41, systematically guides habitat research in four areas: (1) ecosystem structure and function; (2) effects of alterations; (3) development of restoration methods; and (4) development of indicators of impact and recovery. Additionally, the plan emphasizes a fifth area -- the need for synthesis and timely information dissemination to managers. Following is a brief synopsis of each of the five research areas identified in Thayer, et al. (1996) along with some specific research topics under each area.

Area 1: Ecosystem Structure and Function - This key area involves research to understand the structure and function of natural ecosystems, their linkages to one another, and the role they play in supporting and sustaining living marine resources (e.g., their distribution, abundance and health). Research should include studies on the relationship between habitat and yield of living marine resources, including seasonal and annual variability and the influence of chemical and physical changes on these relationships. Resulting information should provide a foundation for predicting organism and habitat response to perturbation, as well as for predicting recovery or restoration success. Specific research needs include:

- Assessment of the quantitative relationship between EFH and Federally managed species and the ecological systems or food webs that support them.

- Identification of optimum EFH for managed species, including habitat areas of particular concern.

- Habitat-related production of brown shrimp: a mechanistic model of shrimp growth and survival in estuaries.

- Effects of habitat characteristics on prey selection by southern flounder and on mortality of brown shrimp.

- Mapping of EFH for reef fish in the Gulf of Mexico.

- Identification of EFH for reeffish: priority conservation areas for potential snapper/grouper fishery reserves in the Eastern Gulf of Mexico.

- Identification and understanding of linkages between habitats, fisheries, and protected resources. This would include identification of the role of habitat mosaics or mixtures of habitats necessary to sustain fishery productivity.

- Development of simulation models of EFH interactions and the conduct of sensitivity analyses to determine important variables affecting productivity and health.

- Importance of seagrasses as EFH in the Gulf of Mexico through studies which evaluate growth and production of fishery organisms.

- A regional comparison of tidal marsh as EFH for fishery species through studies that not only document presence but also evaluate growth and production of fishery organisms.

- Evaluation of unvegetated flats as EFH within estuaries using both indices of presence as well as measures of growth and production of fisheries organisms.

- Assessment of food quality of essential hardbottom fish habitats using artificial substrates.

- Extent and function of offshore seagrass beds of the eastern Gulf of Mexico as an overlooked EFH.

- Characterization and quantification of EFH for juvenile jewfish.

- Mapping of shelf habitats presumed as important EFH.

<u>Area 2</u>: Effects of Habitat Alterations - This area involves research to quantify the responses of habitats and fishery resources to natural and man-made alterations. Research should include cause-and-effect studies designed to evaluate responses of fishery resources and habitats to physical and chemical modifications of coastal and estuarine systems. Resulting information should provide a basis for determining the degree of impact, the prediction of recovery rates, and the most effective restoration procedures and protective measures. Specific research needs include:

- Determination of the rates and amounts of EFH losses to natural forces and man-induced perturbations.

- Development of methodologies and processes to determine and track cumulative impacts to EFH.

- Effects of freshwater inflow modifications on EFH.

- Assessment of impacts of marsh management practices in coastal Louisiana.

- Relative significance of various organic and inorganic pollutants on EFH, current pollutant loads, and the assimilative capabilities of EFH.

- Effect of fire on brackish marsh EFH of brown shrimp and white shrimp.

- Refinement of EFH for commercially and recreationally important fishery species along the Gulf coast and resulting reduction in development of permit-related impacts.

- Causes, extent, and effects of hypoxia in the Gulf of Mexico.

Area 3: Habitat Restoration Methods - This area involves research designed to improve the current methods to clean up, restore, or create productive habitats, as well as the development and evaluation of new, innovative techniques. Studies should include analyzing the success of sediment sequestration; assessing bioremediation techniques; developing and evaluating new habitat restoration techniques; evaluating the role and size of buffers; and determining the importance of habitat heterogeneity in the restoration process. Resulting information should add to the scientific basis for predicting recovery and stability of restored and created systems. Perhaps most important, the research should generate guidelines for improving best management practices and restoration plans. Specific research needs include:

- Development of design specifications for restoring functional habitats and enhancing rates of biotic increase and stability of restored habitats.

- Development and implementation of Florida Bay restoration plan and initial evaluation of fishery and habitat responses relative to predictive models.

- Development and refinement of water control structures that maximize the passage of fishery organisms.

- Development of best management practices to reduce the effects of adverse hypoxic events on EFH within the Gulf of Mexico and adjacent watersheds.

- Development of simulation models to predict habitat development trajectories for restored EFH and to test expectations of success.

- Development of restoration techniques, siting criteria, and establishment guidelines for EFH in the Gulf of Mexico; including seagrass, marshes, and hardbottoms.

Area 4: Indicators of Impacts and Recovery - This area involves research aimed at the development of indicators to simplify the process of determining whether an ecosystem, habitat, or living marine resource is affected or is recovering. The development of indicators is critical for judging the status of a habitat or living marine resource and the need for corrective action. Studies should include time-dependent population analyses and contaminant-level follow-up evaluations for sediment, biota, and water. This type of research will help managers identify habitat status or "health"; standardize indicators for specific habitats through comparisons across geographic gradients and scales; and develop recommendations on the temporal efficacy of chemical "cleanup" techniques and most appropriate measures to assess success. Such guideposts will be used to develop and improve best management practice approaches. Specific research needs include:

- Identification of factors, chemical and physical, that limit the production of managed species.

- Construction of a nekton density database for estuarine habitats in the Gulf of Mexico and development of a user-friendly GIS system to display and analyze density data.

- Use of multiple stable isotopes and other tracers to identify functional linkages of fishery organisms to habitats as one measure of identifying EFH.

- Use of growth and RNA:DNA ratios as indicators of habitat function and EFH for fishery species.

- reparation and publication of a synthesis report on seagrass habitat restoration technologies and recovery of associated fishery organisms.

- Development of plan to reduce diseases/pathologies among fishery organisms in the Gulf of Mexico.

- Development of quantitative methods for assessing essential reef fish habitat.

Area 5: Synthesis and Information Transfer - This area involves the transfer of technology and information through the use of all available sources and the application of user-friendly information bases. The use of geographic information systems (GIS) is encouraged, as GIS provides the opportunity to amass large quantities of complex, geographically referenced data which provides the potential for making relational observations. Information synthesis and transfer must be provided in a useable format. Specific research needs include:

- Literature review and synthesis of all available information for managed fisheries species in the Gulf of Mexico.

- Evaluation of remote sensing technology for the assessment of the areal abundance of pelagic *Sargassum*.

- Map and incorporate in GIS database the seagrass habitat of the Big Bend region of Florida.

- Improvement in the ability to use remote sensing platforms to identify habitats and habitat quality.

- Improvement in the use of GIS technology to integrate remote sensing information, fisheries and protected resource data, and simulation models.

- A synthesis of fisheries habitat value of intertidal and shallow subtidal flats.

- Development of a GIS framework for spawning aggregation sites and environmental data and habitat maps of priority fishery reserve zones along the west Florida shelf.

In addition to the above research area needs, specific information needs on a species-by-species basis are reflected in the summary habitat tables presented in Section 5 of this amendment. All information provided in the summary habitat tables is an essential ingredient of the above research areas. Thus, any and all blanks contained in the tables represent research that is needed to better understand, define and describe EFH for managed species in the Gulf of Mexico.

Fishing-related

Auster and Langton (1998) reviewed nearly 80 years of research related to effects of fishing on the North American Continental shelf, but were unable to draw any conclusions regarding the overall impacts of fishing. They advise that primary information is lacking to strategically manage fishing impacts on EFH without invoking precautionary measures (specific measures not identified in report). A number of areas were highlighted where primary data are lacking, which would allow better monitoring and improved experimentation, leading to predictive capabilities. These are (taken verbatim from Auster and Langton, 1998):

1. The spatial extent of fishing induced disturbance. While many observer programs collect data at the scale of single tows or sets, the fisheries reporting systems often lack this level of spatial resolution. The available data makes it difficult to make observations, along a gradient of fishing effort, in order to assess the effects of fishing effort on habitat, community, and ecosystem level processes.

2. The effects of specific gear types, along a gradient of effort, on specific habitat types. These data are the first order needs to allow an assessment of how much effort produces a measurable level of change in structural habitat components and the associated communities. Second order data should assess the effects of fishing disturbance in a gradient of type 1 and type 2 disturbance treatments.

3. The role of seafloor habitats on the population dynamics of harvested demersal species. While there is often good time series data on late-juvenile and adult populations, and larval abundance, there is a general lack of empirical information (except in coral reef, kelp bed, and for seagrass

fishes) on linkages between EFH and survival, which would allow modeling and experimentation to predict outcomes of various levels of disturbance.

These data, and any resulting studies, should allow managers to regulate where, when, and how much fishing will be sustainable in regards to EFH. Conservation engineering should also play a large role in developing fishing gears which are both economical to operate and minimize impacts to environmental support functions. Because information regarding the effects of fishing on EFH is lacking in most cases, a top research priority should be the examination of the use of research closure areas to detect the effects of fishing on EFH by comparison with fished areas.

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10.0 PUBLIC HEARING LOCATIONS AND DATES

Public hearings were held from 7:00 p.m. to 10:00 p.m. as follows:

Wednesday, June 17, 1998
Ramada Airport Inn &
Conference Center
5303 West Kennedy Blvd
Tampa, Florida 33609

Thursday, June 18, 1998
Holiday Inn Beachside
3841 North Roosevelt Blvd
Key West, Florida 33040

Monday, June 22, 1998
New Orleans Airport Radisson
2150 Veterans Boulevard
Kenner, Louisiana 70062

Tuesday, June 23, 1998
J. L. Scott Marine Education Ctr.
115 East Beach Blvd (Hwy 90)
Biloxi, Mississippi 39530

Wednesday, June 24, 1998
Holiday Inn on the Beach
365 East Beach Boulevard
Gulf Shores, Alabama 36547

Thursday, June 25, 1998
National Marine Fisheries Service
Panama City Laboratory
3500 Delwood Beach Road
Panama City, Florida 32408

Tuesday, June 30, 1998
Hobby Airport Hilton
8181 Airport Boulevard
Houston, Texas 77061

Wednesday, July 1, 1998
Ellis Memorial Library
700 West Avenue A
Port Aransas, Texas 78373

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APPENDIX A - FIGURES

APPENDIX B - TABLES

APPENDIX C - ENVIRONMENTAL ASSESSMENT