Generic Essential Fish Habitat Amendment for modifying all Gulf of Mexico Fishery Management Plans

Generic Amendment 5 to the Shrimp, Reef fish, Coastal Migratory Pelagics, Spiny Lobster, Coral, and Red Drum Fishery Management Plans of the Gulf of Mexico

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AMENDMENT 5 TO THE SHRIMP, REEF FISH, COASTAL MIGRATORY PELAGIC, SPINY LOBSTER, CORAL, AND RED DRUM FISHERY MANAGEMENT PLANS IN THE GULF OF MEXICO REGION

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ABBREVIATIONS USED IN THIS DOCUMENT

BRT	boosted regressions tree
Council	Gulf of Mexico Fishery Management Council
EEZ	exclusive economic zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ER	eco-regions
FEIS	Final Environmental Impact Statement
FGBNMS	Flower Garden Banks National Marine Sanctuary
FMP	Fishery Management Plan
Gulf	Gulf of Mexico
HAPC	habitat areas of particular concern
HMS	highly migratory species
KDE	kernel density estimate
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MaxEnt	Maximum Entropy
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
SERO	Southeast Regional Office
South Atlantic Council	South Atlantic Fishery Management Council

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CHAPTER 1. INTRODUCTION

1.1 Background

In 1996, the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) was amended to require that each fishery management plan (FMP) describe and identify essential fish habitat (EFH), minimize to the extent practicable adverse effects on that habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of that habitat. The Magnuson-Stevens Act defines essential fish habitat as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

Consistent with the 1996 requirements of the Magnuson-Stevens Act, the Gulf of Mexico Fishery Management Council (Council) completed EFH Generic Amendment 1 in 1998 (October 1998; GMFMC 1998), which amended the seven Gulf FMPs in existence at the time (shrimp, reef fish, coastal migratory pelagics, spiny lobster, coral, red drum, and stone crab[1]). Additionally, EFH descriptions and identifications are required for each life stage for every species managed within an FMP. EFH Generic Amendment 1 included descriptions of essential habitat for each life stage of 26 representative species that constituted most of the landings from the Gulf of Mexico (Gulf). EFH Generic Amendment 1 also described threats to habitats, predator-prey relationships, factors resulting in EFH losses, conservation and enhancement measures for EFH, and included recommendations to minimize impacts from non-fishing threats.

EFH Generic Amendment 2 (GMFMC 2001) created two marine reserves (Tortugas Marine Reserves) and prohibited fishing. Like EFH Generic Amendment 1, this amendment affected all seven Gulf FMPs in existence at the time. The first reserve established was a single 60 square mile area to protect a spawning aggregation site for mutton snapper within Council jurisdiction. The other (125 square miles) affected all managed species and was created in the jurisdictions of the National Park Service, Florida Keys National Marine Sanctuary, Council, and State of Florida.

In 2000, a lawsuit was brought forth by a coalition of environmental groups challenging the National Marine Fisheries Service's (NMFS) approval of the EFH FMP amendments prepared by the Gulf and other Fishery Management Councils. The court found that EFH amendments were in accordance with the MSA, but in violation of the National Environmental Policy Act (NEPA). NMFS entered into a Joint Stipulation with the plaintiff environmental organizations that called for each affected Council to complete an Environmental Impact Statement (EIS). This resulted in the 2004 EFH Final Environmental Impact Statement (FEIS) (GMFMC 2004). The purpose of the EFH FEIS was to analyze (within each Gulf fishery) a range of alternatives to: (1) describe and identify EFH for the fishery, (2) identify other actions to encourage the conservation and enhancement of such EFH and (3) identify measures to prevent, mitigate or minimize to the extent practicable the adverse effects of fishing on such EFH.

[1] Note: In 2011, the Council rescinded jurisdictional management of stone crab and removed the FMP. Therefore, the Council no longer considers EFH descriptions and identifications for stone crab.

The EFH FEIS (GMFMC 2004) led to EFH Generic Amendment 3 (GMFMC 2005), which addressed EFH requirements by comparing benthic habitat maps and species life history attribute tables constructed from literature reviews. The EFH Generic Amendment 3 (GMFMC 2005) described and identified EFH as areas of higher species density, based on the National Oceanic and Atmospheric Administration (NOAA) Atlas (NOAA 1985) and functional relationships analysis for the Red Drum, Reef Fish, CMPs, Shrimp, Stone Crab, and Spiny Lobster FMPs; and on known distributions for the Coral FMP.

Broadly, four levels of increasing data requirement complexity are used to describe EFH:

- Level 1: Distribution data are available for some or all portions of the geographic range of the species
- Level 2: Habitat-related densities of the species are available
- Level 3: Growth, reproduction, or survival rates within habitats are available
- Level 4: Production rates by habitat are available

The lower characterization levels (one and two) can be satisfied using species presence data; however, upper levels (three and four) require more comprehensive data needs as these levels address functionality of habitat attributes to population dynamics. In some cases, species presence may not be available and an EFH level of 1 cannot be used. In these cases, habitat maps along with habitat use information obtained from a primary literature review is used describe EFH. Currently, the Council uses the approach of mapping particular benthic habitat features with known association for particular species. Increases in investigations using fishery independent survey methods in the Gulf have allowed for spatially explicit data collection of species abundance and distribution. Additionally, data collection of environmental covariates associated with species occurrence observations is available to identify potential drivers of the species distribution patterns.

As part of the most recent EFH review that was completed in 2016, species profiles were created for most species managed by the Council (corals were not included). The profiles highlight information regarding species distribution and briefly discuss new literature that could contribute to the identification and description of EFH. New data collected from literature reviews are added to the information in the habitat association tables taken from the EFH FEIS (2004) document and synopsized by life stage. Graphs of age and growth information were also generated for each species (if available). Throughout the species profiles, eco-regions (ER), identified in the EFH FEIS (GMFMC 2004) are referenced, as described in Table 1.1.1 and visualized in Figure 1.1.1

Table 1.1.1. Gulf of Mexico eco-regions and the corresponding NOAA Statistical (Stat) Grids.

Eco-region Name	Bounds	NOAA Stat Grid
1. South Florida	Florida Keys to Tarpon Springs	1-5
2. North Florida	Tarpon Springs to Pensacola Bay	6-9
3. East Louisiana, Mississippi, and Alabama	Pensacola Bay to the Mississippi Delta	10-12
4. East Texas and West Louisiana	Mississippi Delta to Freeport Texas	13-18
5. West Texas	Freeport, Texas to the Mexican border	19-21

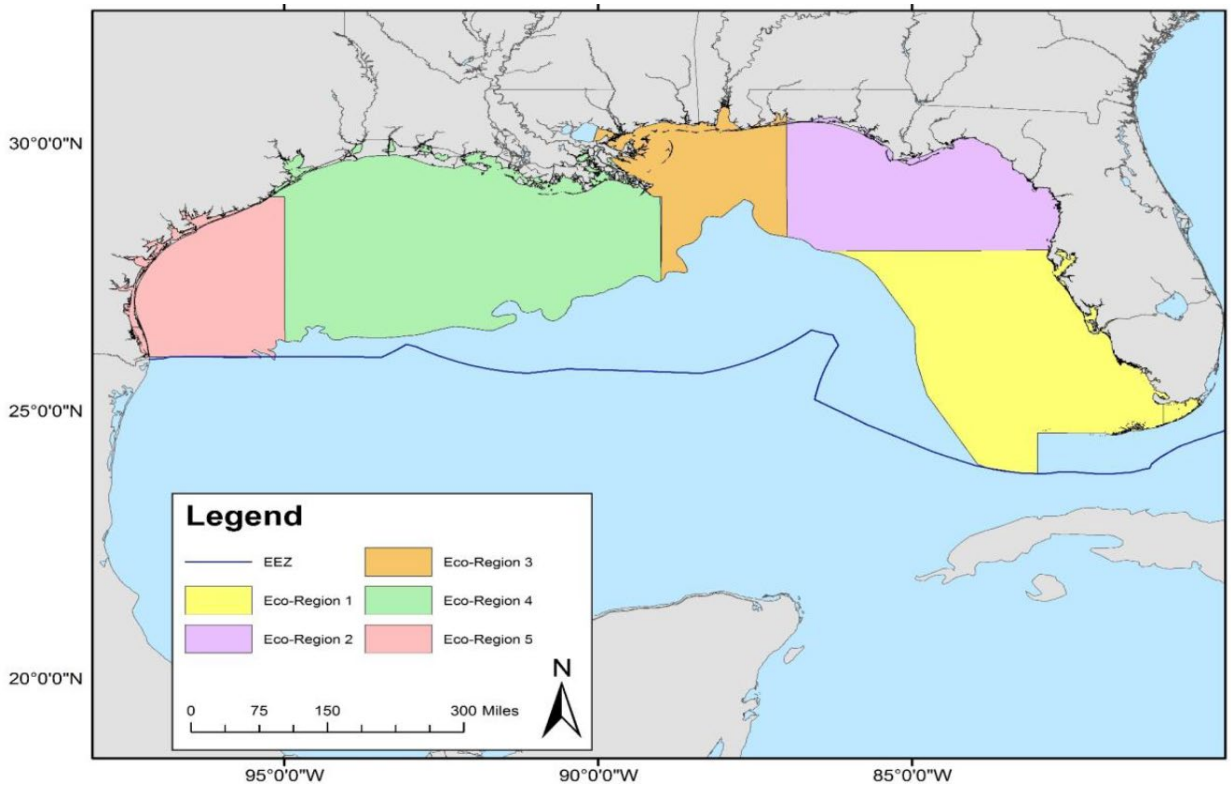

Figure 1.1.1 Map of eco-regions textually described in the table above and referenced in the habitat association tables.

Species profiles are also visualized. Each species profile also includes a map that depicts benthic habitat use for all life stages (composite). To create these maps, ER (Figure 1.1.1) and habitat zone (Figure 1.1.2) are used to clip the GIS information gathered for each habitat type (Table 1.1.2).

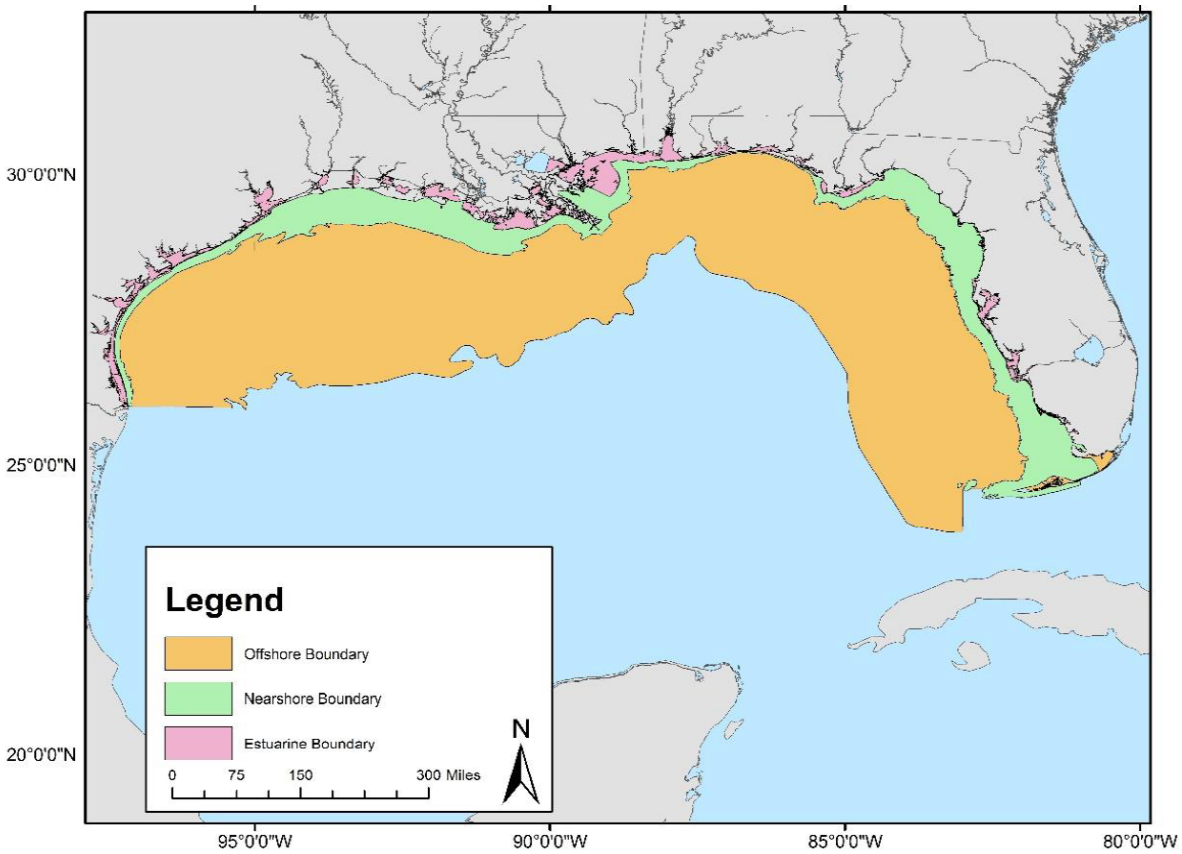

Figure 2.1.2 Spatial depiction of habitat zones: estuarine (inside barrier islands and estuaries), nearshore (60 feet [18m] or less in depth) and offshore (greater than 60 feet [18m] in depth).

Each map caption refers to the habitat types depicted and the specific depth range occupied by each species. Habitat zone is comprised of three categories: estuarine (inside barrier islands and estuaries), nearshore (60 feet (18m) or less in depth) and offshore (greater than 60 feet (18m) in depth; Figure 1.1.2). Habitat type is then subdivided into 12 categories distributed amongst the three zones. These 12 types are based on a combination of substrate and biogenic structure descriptions that are considered to provide the best overall categorization of fish habitats in the Gulf. In the estuarine component, EFH encompasses 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 (nearshore and offshore), EFH encompasses all marine waters and substrates (mud, sand, shell, rock, hard bottom, and associated biological communities) from the shoreline to the seaward limit of the exclusive economic zone (EEZ).

Table 1.1.2. Twelve habitat types used throughout the species profiles and terms related to those habitat types.

Habitat Type	Related Terms
Submerged Aquatic Vegetation (SAV)	Seagrasses, benthic algae
Mangroves	N/A
Drifting algae	*Sargassum*
Emergent marshes	Tidal wetlands, salt marshes, tidal creeks, rivers/streams
Sand/shell bottoms	Sand
Soft bottoms	Mud, clay, silt
Hard bottoms	Hard bottoms, live hard bottoms, low-relief irregular bottoms, high-relief irregular bottoms
Oyster reefs	N/A
Banks/shoals	N/A
Reefs	Reefs, reef halos, patch reefs, deep reefs
Shelf edge/slope	Shelf edge, shelf slope
Water Column Associated (WCA)	Pelagic, planktonic, coastal pelagic

Specifically, EFH consists of the following waters and substrate areas in the Gulf:

Red Drum: all estuaries; Vermilion Bay, Louisiana, to the eastern edge of Mobile Bay, Alabama, out to depths of 25 fathoms (150 feet, 46 m); Crystal River, Florida, to Naples, Florida, between depths of 5 and 10 fathoms (30-60 feet, 9-18 m); and Cape Sable, Florida, to the boundary between the areas covered by the GMFMC and the South Atlantic Fishery Management Council (South Atlantic Council) between depths of 5 and 10 fathoms (30-60 feet, 9-18 m).

Reef Fish and CMP FMPs: all estuaries; the US/Mexico border to the boundary between the areas covered by the Gulf and South Atlantic Councils from estuarine waters out to depths of 100 fathoms (600 feet, 182 m).

Shrimp FMP: all estuaries; the US/Mexico border to Fort Walton Beach, Florida, from estuarine waters out to depths of 100 fathoms (600 feet, 182 m); Grand Isle, Louisiana, to Pensacola Bay, Florida, between depths of 100 and 325 fathoms (600-1950 feet, 182-594 m); Pensacola Bay, Florida, to the boundary between the areas covered by the Gulf and South Atlantic Councils out to depths of 35 fathoms (210 feet, 64 m), with the exception of waters extending from Crystal River, Florida, to Naples, Florida, between depths of 10 and 25 fathoms (60-150 feet, and in Florida Bay between depths of 5 and 10 fathoms (30-60 feet, 9-18 m).

Spiny Lobster FMP: from Tarpon Springs, Florida, to Naples, Florida, between depths of 5 and 10 fathoms; and Cape Sable, Florida, to the boundary between the areas covered by the Gulf and South Atlantic Councils out to depths of 15 fathoms (90 feet, 27 m).

Coral FMP: the total distribution of coral species and life stages throughout the Gulf including: coral reefs in the North and South Tortugas Ecological Reserves, East and West Flower Garden Banks National Marine Sanctuary (FGBNMS), McGrail Bank, and the southern portion of Pulley

Ridge; hard bottom areas scattered along the pinnacles and banks from Texas to Mississippi, at the shelf edge and at the Florida Middle Grounds, the southwest tip of the Florida reef tract, and predominant patchy hard bottom offshore of Florida from approximately Crystal River south to the Florida Keys.

The EFH guidelines provide for the designation of subsets of EFH as Habitat Areas of Particular Concern (HAPC). The EFH Generic Amendment 3 (GMFMC 2005) identified several areas as HAPCs. Each proposed site is discrete, and meets one or more HAPC criteria:

1. Importance of ecological function provided by the habitat;
2. Extent to which the area or habitat is sensitive to human induced degradation;
3. Whether and to what extent development activities are stressing the habitat; and
4. Rarity of the habitat type.

Habitat Areas of Particular Concern were identified as the Florida Middle Grounds, Madison-Swanson Marine Reserve, Tortugas North and South Ecological Reserves, Pulley Ridge, and the individual reefs and banks of the Northwestern Gulf of Mexico: East and West FGBNMS, Stetson Bank, Sonnier Bank, MacNeil, 29 Fathom Bank, Rankin Bright Bank, Geyer Bank, McGrail Bank, Bouma Bank, Rezak Sidner Bank, Alderice Bank, and Jakkula Bank.

Amendment 9 to the FMP for Coral and Coral Reef Resources (Coral Amendment 9; GMFMC 2018) was implemented in 2020. This amendment established 8 new HAPCs without fishing regulations in the Gulf: South Reed; Garden Banks 299 and 535; Green Canyon 140/272,234, and 354; Mississippi Canyon 751 and 885. These areas were identified as having sufficient numbers and diversity of deep-water corals to be considered EFH.

The Council has addressed threats to habitat from fishing activities and, through a series of amendments to the original FMPs, has included management measures to minimize these adverse threats. No new management measures or regulations were proposed in the 1998 EFH Amendment (GMFMC 1998). The Council's EFH FEIS (GMFMC 2004) used a fishing gear sensitivity index and fishing effort to analyze the relative risk of impacts to EFH resulting from various fishing activities. EFH Generic Amendment 3 (GMFMC 2005) proposed four additional measures to prevent, mitigate, or minimize the adverse effects of fishing on EFH in the Gulf. These measures were to:

1. Prohibit bottom anchoring over coral reefs in some HAPC (East and West FGBNMS, McGrail Bank, Pulley Ridge, and North and South Tortugas Ecological Reserves) and on the significant coral communities on Stetson Bank.
2. Prohibit use of trawling gear, bottom longlines, buoy gear, and traps/pots on coral reefs throughout the Gulf EEZ (East and West FGBNMS, McGrail Bank, Pulley Ridge, and North and South Tortugas Ecological Reserves) and on the significant coral resources on Stetson Bank.
3. Require a weak link in the tickler chain of bottom trawls on all habitats. A weak link is defined as a length or section of the tickler chain that has a breaking strength that is less than the chain itself and is easily seen as such when visually inspected.
4. Establish an education program on the protection of coral reefs when using various fishing gears in coral reef areas for recreational and commercial fishermen.

Coral Amendment 9 (GMFMC 2018) established 13 HAPCs with fishing regulations related to prohibiting of fishing with bottom tending gear: West Florida Wall, Alabama Alps, L&W Pinnacles, Scamp Reef, Mississippi Canyon 118, Roughtongue Reef, Viosca Knoll 826, Green Canyon 852, AT 047, AT 357, Harte Bank, and Southern Bank. Under Coral Amendment 9, Viosca Knoll 862/906 was established as a HAPC with regulations prohibiting fishing with bottom-tending gear, but allowed royal red shrimp fisherman to keep their nets in the water, but off the bottom. Modification of fishing regulations was also implemented within the current Pulley Ridge HAPC. This modification prohibited all fishing gear with bottom-tending gear, except for longline gear.

Regulations at 50 C.F.R. § 600.815(a) specify the EFH information that must be included in the FMP and require that the regional Fishery Management Councils and NMFS perform a complete review of all EFH information at least once every 5 years. This required information is:

1. Description and identification of EFH, including maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found
2. Fishing activities that may adversely affect EFH
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH
4. Non-fishing activities that may adversely affect EFH
5. Cumulative impacts analysis
6. EFH conservation and enhancement recommendations
7. Prey species
8. Identification of Habitat Areas of Particular Concern (HAPC)
9. Research and information needs
10. Review and revision of EFH components of FMPs.

Reviews encompass both published and unpublished scientific literature/reports (gray literature), soliciting information from interested parties, and searching for previously unavailable or inaccessible data. Since the implementation of EFH Generic Amendment 3, two 5-year EFH reviews have been completed.

Extensive biological literature reviews are conducted on both published research and technical (not published) literature. Currently, the literature review used to inform EFH in the Gulf represents research from 2004 - 2016. Any literature that improves understanding of EFH is incorporated into the species profiles and their accompanying habitat association tables. The literature review includes specific searches for fishing and non-fishing impacts that are new or have changed since the previous 5-year review.

The first 5-year EFH review was completed in 2010 (GMFMC 2010). The report reviewed both the existing EFH descriptions and designations, and also any new relevant information (since the 2005 EFH Amendment, which conducted literature review thorough 2004). The 2010 review also examined changes and new information on fishing and non-fishing impacts that could adversely affect EFH. The review also described potential new methods of designating EFH. Lastly, the review considered HAPC designations and determined if current HAPC designations

are adequate or if areas need to be removed or added. This review was evaluated by NMFS and did not result in any changes to Gulf FMPs.

The second 5-year EFH review was completed in 2016 (GMFMC 2016). The report included extensive literature review which was conducted to determine if any new EFH information was available. Habitat association tables, developed in the EFH FEIS (GMFMC 2004), were revised to make them more readable and to incorporate new information from the literature review. This process served three primary purposes: (1) to make the tables more user-friendly, (2) to improve formatting such that they can easily transition from a textual document to web resources, and (3) to assign habitat designation information that can be geo-referenced for the creation of mapped descriptions of EFH by species and life stage. The habitat association tables were used to generate species profiles, that include brief synopses of pertinent literature obtained during the review, a description of habitat information by species and life stage, graphs of growth by age and recent fishing effort, a brief fishery history, and a composite map of benthic life stages for each species. The tables were also used to create more specific maps of species distribution by life stage. A literature review was also conducted of new information related to fishing and non-fishing impacts, focused particularly on the Deepwater Horizon oil spill, offshore aquaculture, and invasive species. Lastly, the report resulted in several web resources, including a searchable bibliography of all sources used to inform habitat association tables, an EFH mapping application which allows for visualization of EFH by species and life stage, and an HAPC mapping application.

One of the requirements for the 5-year reviews is to evaluate the EFH Generic Amendment 3 (GMFMC 2005) for errors in existing EFH descriptions or identification. This was completed during the 2010 5-year review (GMFMC 2010) and several items from the EFH Generic Amendment 3 (GMFMC 2005) were found to be inconsistent. The Council has not acted on the 5-year review results from the 2010 or 2016 review; thus, the FMP amendment needs to address the following EFH description or identification and the following inconsistencies remain:

- Some discrepancies between textual and mapped depictions of EFH (per the EFH Final Rule, the textual description is ultimately determinative of the limits of EFH).
- The mapped distribution of coral used to delineate EFH in the Coral FMP was based on a bottom sediment map derived from Sheridan and Caldwell (2002). During digitization of this map, an area was misclassified as hard bottom, when it should be sandy silt. This area should not be a part of coral EFH
- Coral EFH is described in EFH Generic Amendment 3 (GMFMC 2005) as "the total distribution of coral species and life stages throughout the Gulf of Mexico", as such, it is limited to which map is used to depict its distribution.
- Inconsistencies in digitization of the NOAA Atlas maps depicting Lake Rousseau as EFH for several FMPs, despite being a strictly freshwater lake with a lock and dam system that blocks marine fishery ingress or egress.

This review did not result in any changes to Gulf FMPs; however, the NMFS Southeast Regional Office (SERO) Habitat Conservation Division sent a letter to the Council recommending that the Council amend its FMPs to incorporate new habitat life-history functional relationships into existing EFH identification and descriptions, which will better inform the consultations on

actions that may adversely affect EFH, as required by section 305(b) of the Magnuson-Stevens Act.[2]

1.2 Proposed Methods to Describe and Identify EFH

Fishery Management Councils use different methods for identifying and describing EFH. These different approaches are largely due to disparities in available data sources, management goals, and species life histories. The methods used by the Council to identify and describe EFH are broad, generally qualitative, and focus on observed linkages in available habitat and use as described in the literature. This existing method can easily be updated and allows for the description and identification of EFH for all managed stocks, many of which are data poor. However, this approach may result in expansive EFH for certain stocks or species life stages that includes all of the EEZ, which may not be consistent with definition of EFH in the Magnuson-Stevens Act. Additionally, since the implementation of EFH Generic Amendment 3 (GMFMC 2005), more computational modeling techniques have become available to describe fish habitat use. These models allow for better refinement of EFH for species where available presence and environmental data is insufficient to construct habitat models.

For data-rich species in the Gulf, there are two statistical methods that could be used to update the current description and identification of EFH. Both models require some historical knowledge of species presence across the Gulf. Data used for the models would be obtained from a variety of fishery-independent surveys conducted in the Gulf (Grüss et al. 2018). These data are available for very few managed species and even more limited when differentiated by life stage within species (Table 1.2.1).

Table 1.2.1. Species and life stages where data is available for proposed alternative EFH modeling methodologies by FMP.

FMP	Aggregated data	Life stage data available
Reef fish	Black grouper Goliath grouper Vermillion snapper Yellowedge grouper Deepwater grouper Shallow water grouper Tilefish	Gag grouper Red grouper Red snapper
Shrimp		White Brown Pink
Coastal Migratory Pelagic	King mackerel Cobia	Spanish mackerel

The first proposed alternative approach would use a non-parametric kernel density estimate analysis which would delineate 'core areas' of species presence (Worton 1995; Getz and Wilmers 2004; Getz et al. 2007). Individual observations of a particular species (or life stage)

[2] https://drive.google.com/file/d/1wuuKSXO-S-MEJqPtEiRIl0dW-KMN5VLv/view?usp=sharing

are connected using an algorithm informed using a nearest neighbor determination (Getz and Wilmers 2004; Getz et al. 2007). These associations between spatial observations are used to construct convex hulls or polygons to generate an estimated area of habitat use. Broadly, the areas of these polygons can be used to estimate habitat used by a species and aid in determining if that estimated area is highly used (given the number of individual observations) or represents the extent of habitat for a very highly distributed species. For example, a species may localize in a certain 'core' area such that 75% of the observations are recorded in an area on the order of tens of kilometers, while outlining observations (~20%) may be many hundreds of kilometers away from that 'core' area but reveal the extent of the species distribution to be larger and encompass 95% of observations. It is important to consider, as options under this alternative, how large an extent (i.e. what percentage of observations) would represent EFH for a species and/or life stage. For the purposes of identifying and describing EFH, this approach may help better refine those determinations.

However, describing EFH using kernel density estimate would dissociate some linkages between habitat and species presence. While the use of kernel density estimate would allow for the refinement of EFH to areas of high use and reduce the likelihood of assigning EFH to the entire EEZ, associated habitat attributes are not directly incorporated. Instead, this approach acknowledges that there may be environmental drivers in species habitat use that are poorly understood, not measurable, or unknown. The development of kernel density estimate models to describe EFH therefore focuses more on reflecting areas of importance due direct quantification of fish presence rather than relying on an indirect and incomplete understanding of habitat linkages between benthic habitat and species presence.

The second proposed alternative approach would describe and identify EFH using boosted regressions tree modeling (Elith et al. 2008). Boosted regression tree models combine two algorithm concepts: regression trees and boosting. Regression trees allow for the identification of habitat variables that have high explanatory power and also report the values at which considered environmental factors significantly affect observations using a recursive bifurcation procedure. Next, repeated construction of many regression trees, or boosting, allows one to combine simple regression trees to assess model fit and improve predictability.

Unlike the kernel density estimate method, the boosted regression tree approach directly models the probability of species presence in relation to habitat and environmental drivers, and describes linkages between available habitat and species use. Boosted regression tree models can also help elucidate which habitat attributes contributes to habitat selection, which is important for understanding habitat function. Additionally, while the current methodology used to identify and describe EFH relies heavily on benthic habitat information, boosted regression tree modeling can incorporate physicochemical (e.g. water temperature, salinity, dissolved oxygen etc.) variables as well. This advancement may be beneficial for refining the description and identification of EFH. For example, for pelagic species, it is likely that associations with water column habitat attributes drive habitat selection more directly than benthic characteristics, and this could improve the description and identification of EFH for those species. While boosted regression tree modeling can be a powerful tool for investigating species habitat use, it requires extensive and historical data set of species presence and habitat information for model construction. These data sets are

not available for many managed species; especially those species that are uncommon or rarely encountered.

1.3 History of Management

EFH Generic Amendment 1 (GMFMC 1998): Amended the seven Gulf FMPs in existence at the time. Additionally, EFH descriptions and identifications are required for each life stage for every species managed within an FMP. EFH Generic Amendment 1 included descriptions of essential habitat for each life stage of 26 representative species that constituted most of the landings from the Gulf. EFH Generic Amendment 1 also described threats to habitats, predator-prey relationships, factors resulting in EFH losses, conservation and enhancement measures for EFH, and included recommendations to minimize impacts from non-fishing threats.

EFH Generic Amendment 2 (GMFMC 2001): Amended the seven Gulf FMPs in existence at the time and established two marine reserves (Tortugas Marine Reserves). These reserves allowed for research on value of no-use reserves.

EFH FEIS (GMFMC 2004): The purpose of this document was to analyze (within each Gulf fishery) a range of alternatives to: (1) describe and identify EFH for the fishery, (2) identify other actions to encourage the conservation and enhancement of such EFH and (3) identify measures to prevent, mitigate or minimize to the extent practicable the adverse effects of fishing on such EFH. This document satisfied the terms of a Joint Stipulation entered by NMFS and a coalition of environmental groups.

EFH Generic Amendment 3 (GMFMC 2001): This amendment described and identified EFH as areas of higher species density, based on the National Oceanic and Atmospheric Administration (NOAA) Atlas (NOAA 1985) and functional relationships analysis for the Red Drum, Reef Fish, CMPs, Shrimp, Stone Crab, and Spiny Lobster FMPs; and on known distributions for the Coral FMP.

EFH 5-year Review (GMFMC 2010): The report reviewed both the existing EFH descriptions and designations, and also any new relevant information (since the 2005 EFH Amendment, which conducted literature review thorough 2004). The 2010 review also examined changes and new information on fishing and non-fishing impacts that could adversely affect EFH. This review also identified a number of habitat description errors in EFH Amendment 3; however, no modifications to any FMPs were made at the time.

EFH 5-year Review (GMFMC 2016): The report reviewed both the existing EFH descriptions and designations, and also any new relevant information by updating habitat association tables to literature published through 2016. The review served three primary purposes: (1) to make the tables more user-friendly, (2) to improve formatting such that they can easily transition from a textual document to web resources, and (3) to assign habitat designation information that can be geo-referenced for the creation of mapped descriptions of EFH by species and life stage.

Amendment 9 to the Fishery Management Plan for Coral and Coral Reef Resources in Gulf of Mexico U.S. waters (GMFMC 2018): Established 13 new habitat areas of particular

concern with fishing regulations, designated 8 new areas without fishing regulations, and modified the regulations in 3 existing areas. These areas were identified as having sufficient numbers and diversity of deep-water corals to be considered EFH.

1.4 Purpose and Need

The purpose is to review and amend the description and identification of EFH for the Shrimp, Reef fish, Coastal Migratory Pelagics, Spiny Lobster, Coral, and Red Drum Gulf FMPs. This amendment incorporates all information required by 50 C.F.R. section 600.815(a).

The need is to consider contemporary habitat and species presence data sources, along with advances in computational modeling techniques to update the description and identification of EFH originally adopted in EFH Generic Amendment 3.

CHAPTER 2. MANAGEMENT ALTERNATIVES

2.1 Action 1 - Modify Description and Identification of Essential Fish Habitat for all Gulf Fishery Management Plans

Alternative 1: No Action – Retain current description and identification of essential fish habitat (EFH) for Gulf of Mexico (Gulf) Fishery Management Plans as outlined in EFH Generic Amendment 3.

Alternative 2: Continue to use methods of habitat mapping and life history association tables to describe and identify EFH. Update habitat mapping data from the National Oceanic and Atmospheric Administration (NOAA) Atlas to a more contemporary source. Update species life history and habitat attribute tables to include primary research and technical literature sources through 2020. This alternative could be used for any and all managed species.

Alternative 3: Use a non-parametric kernel density estimate (KDE) approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in Table 1.2.1

Option 3A: 50% KDE
Option 3B: 75% KDE
Option 3C: 95% KDE

Alternative 4: Use a boosted regression tree (BRT) modeling approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in Table 1.2.1

Option 4A: 30% BRT
Option 4B: 50% BRT
Option 4C: 95% BRT

Note: More than one alternative can be selected as preferred.

Discussion:

Alternative 1 would retain the current description and identification of EFH in all Gulf FMPs as adopted in Generic Amendment 3 (GMFMC 2005). The methodology used to currently describe EFH associates species life history tables with maps of known benthic characteristics. Originally, benthic habitat maps were informed through the NOAA Atlas (NOAA 1985). These data used to construct the NOAA Atlas were collected in 1985 and it is highly likely that habitat characterization in the Gulf has since changed; making the 1985 version of the NOAA Atlas outdated. Additionally, both 5-year EFH reviews (GMFMC 2010 and GMFMC 2016) have updated species life history and habitat attribute tables with more contemporary research literature. Incorporating new research study findings, along with updating the information used

to construct habitat maps, will improve EFH descriptions and likely more accurately identify and describe EFH relative to the current descriptions published in Generic Amendment 3 (GMFMC 2005). This new information would not be incorporated into the descriptions and identification of EFH under **Alternative 1**. Figure 2.1.1 provides an example of the EFH description for all life stages of gag grouper under **Alternative 1**.

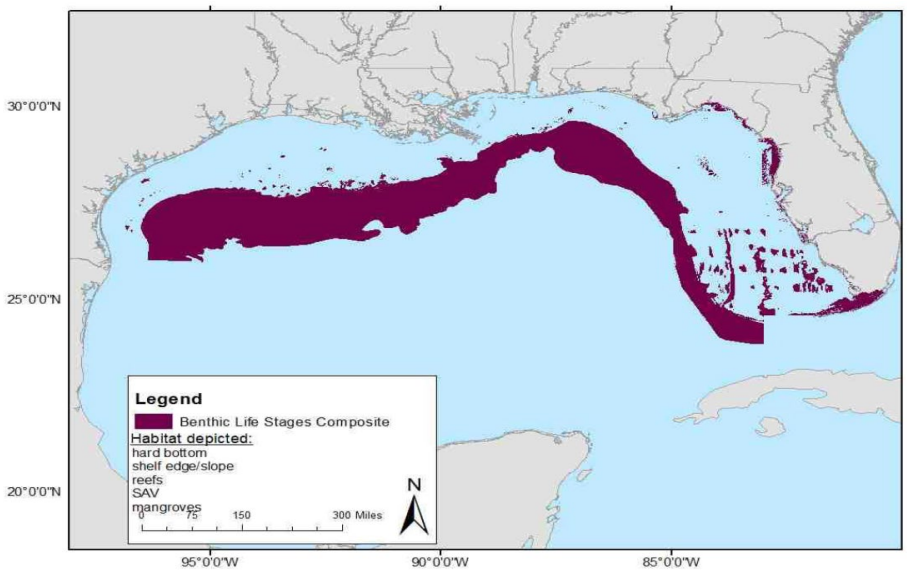

Figure 2.1.1. EFH for all combined life stages of gag grouper as described using methods outlined in **Alternative 1**.

Alternative 2 would retain the current methodological approach to identifying and describing EFH as discussed for **Alternative 1** but would update the data sources for constructing habitat maps from the 1985 NOAA Atlas. More recently developed benthic habitat maps would be used to visualize and identify EFH. Additionally, **Alternative 2** would incorporate more contemporary research literature into species life history and habitat association tables. Updates to these tables have been conducted during the periodic 5-year review process but are not currently incorporated in the various Gulf FMPs. The literature reviewed used to modify EFH in **Alternative 2** would include research published through 2020.

Alternative 3 would describe and identify EFH using a non-parametric kernel density estimate approach and would incorporate various fishery independent data sources of species presence (Grüss et al. 2018). The use of this method would focus identification and description of EFH on areas of persistent observations for species where the relationships between species presence and habitat association is poorly understood or unknown. The National Marine Fisheries Service (NMFS) has used a kernel density estimate approach to describe and identify EFH in Amendment 10 to the 2006 Consolidated Atlantic Highly Migratory Species (HMS) FMP. [3] HMS species are highly mobile and spend the majority of their life history in the water column not unlike coastal migratory and other species managed in the Gulf. Relative to **Alternatives 1** and **2**, this technique would be beneficial in describing EFH for species that are not directly

[3] https://media.fisheries.noaa.gov/dam-migration/final_a10_ea_signed_fonsi_092017.pdf

connected with benthic habitat characterizations. The results of a kernel density estimate analysis generate an extent of species presence observations as a percentage. Options considered for assigning a percentage of observations as EFH is presented under **Alternative 3 Options 3A-C**. **Option 3A** would set EFH at 50% kernel density estimate which would represent an area that contains 50% of species observations and would represent a 'core area' of habitat use (Worton 1995). **Option 3B** of 75% kernel density estimate would be more conservative and represent a larger spatial area. **Option 3C** would describe EFH at a 95% kernel density estimate which would encompass a much broader area and represents the most conservative approach to describing EFH. In HMS Amendment 10, a 95% kernel density estimate was assigned as EFH for managed species representing a relatively broad and conservative approach to identifying and describing EFH. A kernel density estimate analysis requires long-term knowledge of species presence; therefore, only species described in Table 1.2.1 would be applicable for consideration in **Alternative 3**. Figure 2.1.2 provides an example of the EFH description for adult gag grouper under **Alternative 3**.

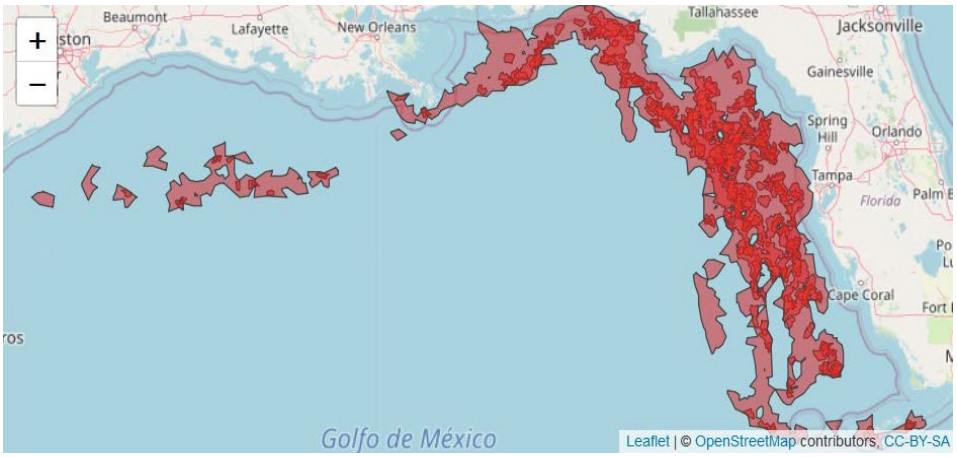

Figure 2.1.2. Example EFH map for adult gag grouper as described using methods outlined in Alternative 3. Areas of dark red represent more 'core' areas of use (~50% kernel density estimate) while light red represents a broader extent of habitat use (~95% kernel density estimate).

Similar to **Alternative 3**, **Alternative 4** would describe and identify EFH using a boosted regression tree modeling approach and incorporate various fishery independent data sources for species presence and environmental covariates. Boosted regression tree models are capable of integrating linkages between habitat attributes and species presence. This information is important for understanding habitat functionality and therefore describing EFH. A similar approach has been used in the Northern Pacific Fishery Management Region using maximum entropy models to identify areas of EFH. Similar to boosted regression tree, the maximum entropy methodology constructs probabilistic models of species presence as related to a number of both continuous and discrete habitat measures. Due to their ability to handle extreme complexities, these models better allow upper-level (levels 3 and 4; see section 1.1) descriptions of EFH, which is difficult to accomplish using methods described in **Alternatives 1-3**. The results of a boosted regression tree analysis provide probabilistic determinations of habitat use expressed as a percentage for EFH and are considered in **Alternative 4 Options 4A-C**. **Option 4A** would describe an area of EFH as predicted to have a 30% probability of observation which

results in a broader spatial description relative to the other alternative options. **Option 4B** would describe EFH has a 50% probability of encountering a species and/or life stage and would greatly refine the spatial extent of the area relative to **Option 4A**. **Option 4C** would describe areas of EFH as having a 95% probability of encountering a species or life stage and would result in very small area designations for EFH. Boosted regression tree modeling requires long-term knowledge of species presence and environmental covariates; therefore, only species described in Table 1.2.1 would be applicable for consideration in **Alternative 4**. Figure 2.1.3 provides an example of the EFH description for adult gag grouper under **Alternative 4**.

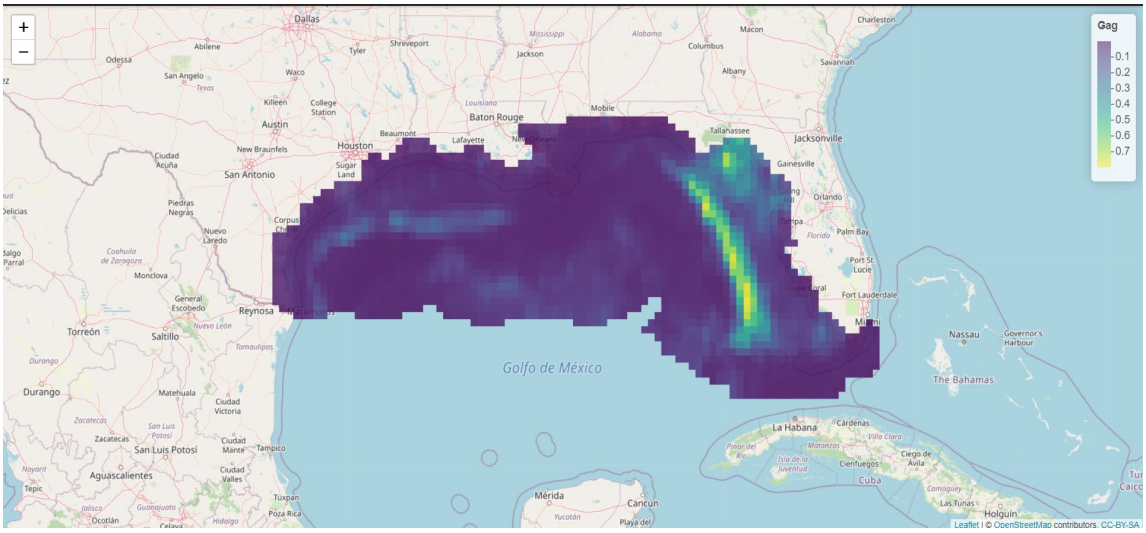

Figure 2.1.3. Example EFH map for adult gag grouper as described using methods outlined in Alternative 4. Dark blue areas represent a broader extent of habitat use and lower predicted probability of species occurrence (~ less than 30%). Green and yellow areas represent higher predicted probability of species occurrence (~ more than 50%).

Ideally, the method used to identify and describe EFH could be easily updated if a review of EFH provisions indicated that a change is warranted. Methods outlined in **Alternatives 2-4** could be readily updated as required. **Alternative 2** could be updated most quickly relative to **Alternatives 3** and **4**. Both **Alternatives 3** and **4** would require computational analysis through statistical software which can be time consuming. However, the data sources used to inform these analyses (Grüss et al. 2018) are established federal and state conducted fishery-independent surveys. It is likely these surveys will provide the spatiotemporal species presence and habitat data required to update models used to identify and describe EFH.

CHAPTER 3. REFERENCES

Elith, J., Leathwick, J.R., and T. Hastie. 2008. A working guide to boosted regression trees. Journal of Animal Ecology 77: 802-813

Getz W. M. and C.C. Wilmers. 2004. A local nearest-neighbor convex-hull construction of home ranges and utilization distributions. Ecography 27: 489-505

Getz, W.M., Fortmann-Roe, S., Cross, P.C., Lyons, A.J., Ryan, S.J. and C.C. Wilmers. 2007. LoCoH: Nonparametric kernel methods for constructing home ranges and utilization distribution. PloS ONE 2(2): e207. doi:10.1371/journal.pone.0000207

GMFMC. 1998. 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 (Mackerel) in the Gulf of Mexico and South Atlantic; Stone Crab Fishery of the Gulf of Mexico; Spiny Lobster Fishery of the Gulf of Mexico; Coral and Coral Reefs of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida, 244 pp.
https://gulfcouncil.org/wp-content/uploads/Oct-1998-FINAL-EFH-Amendment-1.pdf

GMFMC. 2001. Generic amendment addressing the establishment of the Tortugas Marine Reserves in the following Fishery Management Plans of the Gulf of Mexico: Coastal Migratory Pelagics (Amendment 13), Coral and Coral Reefs (Amendment 4), Red Drum (Amendment 4), Reef Fish (Amendment 19), Shrimp (Amendment 12), Spiny Lobster (Amendment 7), Stone Crab (Amendment 8). Gulf of Mexico Fishery Management Council, Tampa Florida, 194 pp.
https://gulfcouncil.org/wp-content/uploads/Generic-Tortugas-Amend.pdf

GMFMC. 2004. Final Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to the following fishery management plans of the Gulf of Mexico (GOM): Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral And Coral Reef Fishery of the Gulf Of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic, and the Coastal Migratory Pelagic Resources of the Gulf of Mexico And South Atlantic. Gulf of Mexico Fishery Management Council, Tampa, Florida, 682 pp.
https://gulfcouncil.org/wp-content/uploads/March-2004-Final-EFH-EIS.pdf

GMFMC. 2005. Generic Amendment Number 3 for Addressing Essential Fish Habitat Requirements, Habitat Areas of Particular Concern, and Adverse Effects of Fishing 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. Gulf of Mexico Fishery Management Council, Tampa, Florida, 106 pp.
https://gulfcouncil.org/wp-content/uploads/FINAL3_EFH_Amendment_508Compliant.pdf

GMFMC. 2010. Final Report Gulf of Mexico Fishery Management Council 5-Year Review of the Final Generic Amendment Number 3 Addressing Essential Fish Habitat Requirements, Habitat Areas of Particular Concern, and Adverse Effects of Fishing in the Fishery Management Plans of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 105 pp. https://gulfcouncil.org/wp-content/uploads/EFH-5-Year-Revew-plus-App-A-and-B_Final_12-2016.pdf

GMFMC. 2016. Final Report Gulf of Mexico Fishery Management Council 5-Year Review of the Final Generic Amendment Number 3 Addressing Essential Fish Habitat Requirements, Habitat Areas of Particular Concern, and Adverse Effects of Fishing in the Fishery Management Plans of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 502 pp. https://gulfcouncil.org/wp-content/uploads/EFH-5-Year-Revew-plus-App-A-and-B_Final_12-2016.pdf

GMFMC. 2018. Final amendment 9 to the fishery management plan for the coral and coral reefs of the Gulf of Mexico, U.S. Waters: Coral habitat areas considered for habitat area of particular concern designation in the Gulf of Mexico. Including final environmental impact statement. Gulf of Mexico Fishery Management Council, Tampa, Florida. 320 pp. http://gulfcouncil.org/wp-content/uploads/Final-Coral-9-DEIS-20181005_508C.pdf

Grüss, A., Perryman, H.A., Babcock, E.A., Sargarese, S.R., Thorson, J.T., Ainsworth, C.H., Anderson, E.J., Brennan, K., Campbell, M.D., Christman, M.C., Cross, S., Drexler, M.D., Drymon, J.M., Gardner, C.L., Hanisko, D.S., Hendon, J., Koenig, C.C., Love, M., Martinez-Andrade, F., Morris, J., Noble, B.T., Nuttall, M.A., Osborne, J., Pattengill-Semmens, C., Pollack, A.G., Sutton, T.T., and T.S. Switzer. 2018. Monitoring programs of the U.S. Gulf of Mexico: inventory, development and use of a large monitoring database to map fish and invertebrate spatial distributions. Reviews in Fish Biology and Fisheries. https://doi.org/10.1007/s11160-018-9525-2

NOAA. 1985. Gulf of Mexico coastal and ocean zones strategic assessment: Data Atlas. U.S. Department of Commerce. NOAA, NOS. December 1985.

Sheridan, P., and P. Caldwell. 2002. Compilation of data sets relevant to the identification of essential fish habitat on the Gulf of Mexico continental shelf and for the estimation of the effects 5-Year Review of EFH 166 Chapter 6. References of shrimp trawling gear on habitat. NOAA Technical Memorandum NMFSSEFSC-483, 56 p. + CD.

Worton, B.J. 1995. Using Monte Carlo simulation to evaluate kernel-based home range estimators. The Journal of Wildlife Management 59:4 794-800