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Draft Report

5-Year Review of Essential Fish Habitat Requirements

Including Review Of Habitat Areas Of Particular Concern And Adverse Effects Of Fishing And Non-Fishing In The Fishery Management Plans Of The Gulf Of Mexico

October 2016

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COVER SHEET

Name of Action

Essential Fish Habitat

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ABBREVIATIONS USED IN THIS DOCUMENT

AP	Advisory Panel
CL	Carapace length
CMP	Coastal Migratory Pelagic Resources in the Gulf of Mexico and Atlantic Region
Council	Gulf of Mexico Fishery Management Council
DO	Dissolved oxygen
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ER	Eco-region
F	Instantaneous fishing mortality rate
FL	Fork length
FMC	Fishery management council
FMP	Fishery Management Plan
Gulf	Gulf of Mexico
FGBNMS	Flower Garden Banks National Marine Sanctuary
FMP	Fishery Management Plan
GMFMC	Gulf of Mexico Fishery Management Council
HAPC	Habitat Areas of Particular Concern
HAT	Habitat association table
K	Instantaneous growth rate
L	Life History
M	Instantaneous natural mortality rate
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act)
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ppt	Parts per thousand (salinity)
SAFMC	South Atlantic Fishery Management Council
SAV	Submerged Aquatic Vegetation
SE	Standard error
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment, and Review
SL	Standard length
SSC	Science and Statistical Committee
TL	Total length
WCA	Water column associated

Z	Instantaneous total mortality rate

1.0 INTRODUCTION

In 1996, amendments were made to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) that established a mandate to identify and protect marine and anadromous fish habitat. The MSA requires that the regional Fishery Management Councils, in cooperation with National Marine Fisheries Service (NMFS), delineate essential fish habitat (EFH) in fishery management plans (FMP) or amendments to FMPs for all federally managed fisheries. Essential fish habitat is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. 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, 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).

In addition to this requirement, a complete review of all EFH information must be conducted as recommended by the Secretary of Commerce, but at least once every 5 years.

Subpart J of 50 CFR Part 600 provides guidelines for conducting these reviews, specifically highlighting what the Councils should include in each FMP as it pertains to EFH:

1. Descriptions and identification of EFH
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**

Specifically, under component 10, Subpart J states that Councils and NMFS should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted based on available information. This review should encompass both published and unpublished scientific literature/reports, soliciting information from interested parties, and searching for previously unavailable or inaccessible data.

This report documents the second 5-year EFH review (2010 - 2015) from the Gulf of Mexico Fishery Management Council (Council). The findings in this report will help the Council and NMFS make informed decisions regarding whether or not there is a need to revise the identification and descriptions of EFH for one or more species/life stages.

1.1 History of Management

The MSA was enacted in 1976, established the EEZ from state waters out to 200 nautical miles, and created eight regional fishery management councils (FMCs), tasked with designing FMPs to regulate fishery resources within the EEZ. The overarching goal of the MSA is to promote long-term biological and economic sustainability of the fisheries in the United States EEZ.

The first major revisions to the MSA were made in 1996 through passing of the Sustainable Fisheries Act. Amendments pertaining to EFH required that marine and anadromous fisheries habitat be identified and protected. Specifically, each regional FMC, and its supporting NMFS office are required to identify and describe EFH in each FMP or amendments to FMPs for all federally managed species. Additionally, federal action agencies that fund, permit, or carry out activities that may threaten EFH must consult with NFMS regarding any potential adverse impacts of their actions on EFH, and respond in writing to NMFS and FMC recommendations. In the Gulf of Mexico, the Council completed EFH Amendment 1 (October 1998) that amended all seven FMPs and 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 Amendment 1 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.

In 2000, a lawsuit was brought forth by a coalition of environmental groups challenging the identification and description of EFH, the court decided that EFH amendments by several Councils (including the Gulf Council) were found in accordance with the MSA, but in violation of the National Environmental Policy Act (NEPA). NMFS was ordered to complete new and more thorough NEPA analyses for each EFH amendment in question. This resulted in the 2004 EFH Environmental Impact Statement (EIS) (GMFMC 2004). The goal of 2004 EFH EIS 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. Fishery management plans must describe and identify EFH for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of that EFH.

The EFH EIS led to EFH Generic Amendment 3 (GMFMC 2005), which addressed EFH requirements, HAPCs, and adverse effects of fishing in the fisheries for shrimp, red drum, reef fish, stone crab, coral, and coral reefs in the Gulf, as well as spiny lobster and the coastal migratory pelagic (CMP) resources of the Gulf and Atlantic Ocean. Management measures included; prohibiting bottom anchoring to protect coral reefs in the East and West Flower Garden Banks National Marine Sanctuary (FGBNMS), McGrail Bank, Pulley Ridge, and the North and South Tortugas Ecological Reserves, as well as Stetson Bank; HAPCs' prohibiting longlines, buoy gear, and all traps/pots to protect coral reefs in those same HAPCs; and requiring a weak link in the tickler chain of bottom trawls on all habitats throughout the Gulf EEZ.

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 information (since the 2005 EFH Amendment, which conducted literature review thorough 2004), that could improve our current knowledge of EFH. 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, it reviewed HAPC designations and determined if current HAPC designations are adequate or if areas need to be removed or added. This review did not result in any changes to Gulf FMPs.

1.2 Previous Designations and Measures

1.2.1 Previous EFH Designations

The 2005 EFH Amendment delineated 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. 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 (SAFMC) 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 GMFMC and the SAFMC 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 GMFMC and the SAFMC 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 GMFMC and the SAFMC 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 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.

1.2.2 Previous EFH-HAPC Designations

The EFH guidelines provide for the designation of subsets of EFH as HAPC. The 2005 EFH Amendment 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.

Additionally, Reef Fish Amendment 30B (GMFMC 2008) established a closed season on The Edges and Steamboat Lumps reserves.

1.2.3 Previous Measures to Minimize Fishing Impacts to EFH

The GMFMC has addressed threats to habitat from fishing activities and has included management measures to minimize these adverse threats since the first FMPs were published in the late 1970's. No new management measures or regulations were proposed in the 1998 EFH Amendment. The Council's 2004 EFH EIS used a fishing gear sensitivity index and fishing effort to analyze the relative risk of impacts to EFH resulting from various fishing activities. The 2005 EFH Amendment 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 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 all 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.

1.3 Approach

The objectives of this 5-year review included:

- Refine existing habitat association tables (HATs)
- Conduct an exhaustive literature review
  - to fill gaps in HATs
  - and update any out-of-date information
- Refine the mapped representations of EFH by species and/or life stage (where applicable)
- Create species profiles which include:
  - known habitat information for each species by life stage
  - literature review
  - age and growth information (if available)
  - description of fishery
  - composite map of EFH use by benthic life stages
- Review of fishing and non-fishing impacts on EFH
- Review role of artificial reefs as a management tool
- Supplementary web-based resources:
  - comprehensive and searchable bibliography
  - interactive EFH maps
  - interactive HAPC map

Council staff conducted an extensive literature review to determine if any new EFH information was available. Habitat association tables, developed in the 2004 EFH EIS, were revised to make them more concise and incorporate new information from the literature review. This process served three primary purposes: (1) to make the tables more user-friendly, (2) improve formatting such that they can easily transition from a textual document to web resources, and (3) 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, these include brief synopses of pertinent literature obtained during the review, a description of habitat information by species and life stage, graphs of growth 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. Council staff conducted a literature review on new information related to fishing and non-fishing impacts, focused particularly on the *Deepwater Horizon* oil spill, offshore aquaculture, and invasive species. Lastly, this review resulted in several web resources, including a query-able 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. These are described in further detail later in this review.

2.0 BRIEF REVIEW OF EXISTING EFH DESCRIPTIONS AND DESIGNATIONS

One of the requirements for this document was to review the 2005 EFH Amendment for errors in existing essential fish habitat (EFH) descriptions or identification. This was completed during the 2010 5-year review and several items from the 2005 EFH Amendment were found to be in error. Because the 2010 review did not result in any amendment level changes to description or identification of EFH, these errors remain and can be found in the Gulf of Mexico Fishery Management Council (Council) document GMFMC (2010) section 2.0, or here: **https://gulfcouncil.org/Beta/GMFMCWeb/downloads/EFH%205-Year%20Review%20Final%2010-10.pdf.**

Generally, these errors were as follows:

- 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 2005 EFH Amendment 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.
- Errors in digitization of the NOAA Atlas maps depicting Lake Rousseau as EFH for several Fishery Management Plans, despite being a strictly freshwater lake with a lock and dam system that blocks marine fishery ingress or egress.

3.0 RESULTS OF REVIEW

An extensive literature review was conducted on published research and gray literature from 2004 - 2016. Any literature that improved our understanding of essential fish habitat (EFH) was incorporated into the species profiles that follow, and their accompanying habitat association tables. A literature review was also conducted on fishing and non-fishing impacts that are new or have changed since the 2010 5-year review. In addition, this section includes recommendations from the Coral Science and Statistical Committee (SSC), Coral Advisory Panel (AP), and Shrimp AP on coral habitat areas of particular concern (HAPC) designations.

3.1 Species Profiles

Species Profiles have been created for all the species managed by the Gulf of Mexico Fishery Management Council (Council). The profiles highlight information regarding species distribution and briefly discuss new literature obtained that contributes to the identification and description of EFH. These new data collected from literature review were added to the information in the habitat association tables from the EFH Environmental Impact Statement (EIS) (2004) document and synopsized by life stage. Plots of age and growth information were generated for each species (if available).

Throughout the species profiles, eco-regions are referenced. These are described below:

Table 1. Gulf of Mexico eco-regions and the corresponding NOAA Statistical Grids.

Eco-region Name	Bounds	NOAA Stat Grids
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

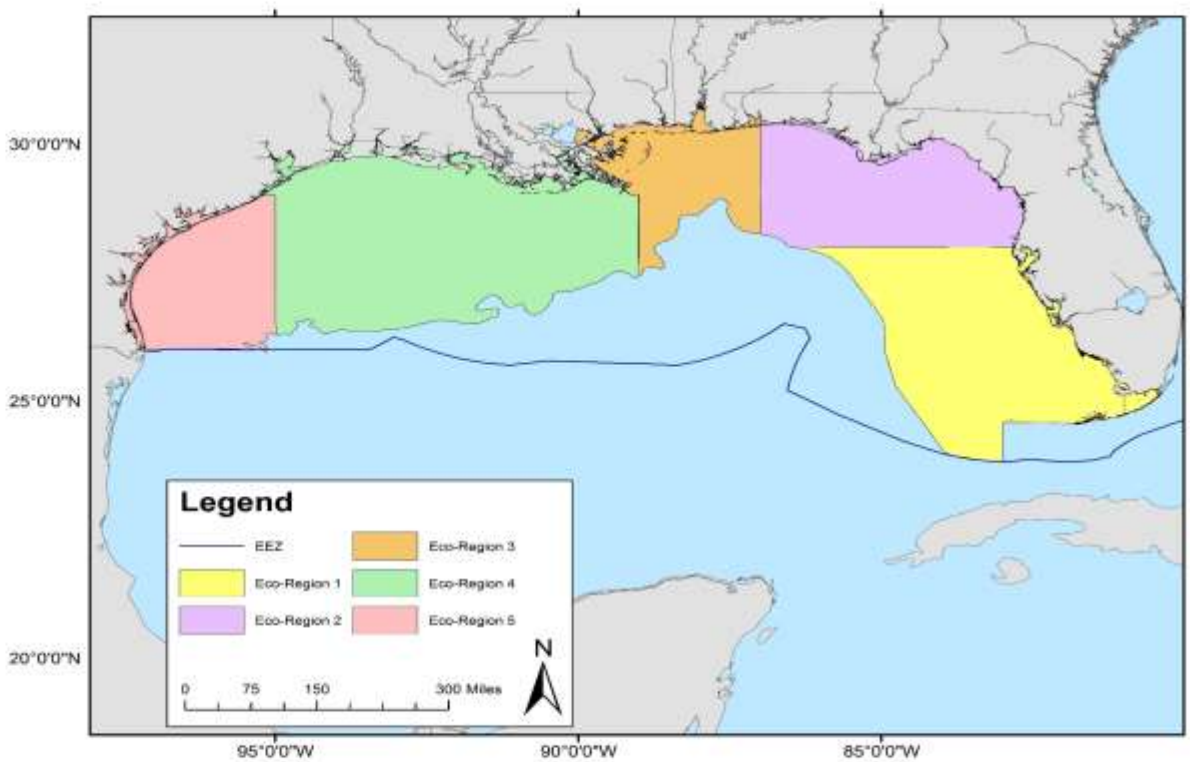

Figure 1. Map of eco-regions textually described in the table above and referenced in the habitat association tables.

3.1.1 Coastal Migratory Pelagics

King Mackerel (*Scomberomorus cavalla*)

Distribution

King mackerel occur throughout the Gulf and Caribbean Sea and along the western Atlantic from the Gulf of Maine to Brazil. In the Gulf, with centers of distribution in south Florida and Louisiana. Adults are water column associated and can be found over reefs and in coastal waters, although they rarely enter estuaries. Migrations to the northern Gulf in the spring are believed to be temperature dependent, and the species is found in waters greater than 20°C. While adults can be found at the shelf edge in depths to 200 m, they generally occur in less than 80 m, at oceanic salinities from 32-36 ppt. Adults spawn over the outer continental shelf from May to October, with the northwestern and northeastern Gulf considered important spawning areas. The pelagic eggs are found offshore over depths of 35-180 m in spring and summer. Larvae occur over the middle and outer continental shelf, principally in the north central and northwestern Gulf, and juveniles are found from inshore to the middle shelf (GMFMC 2004).

Summary of new literature review

Three new pieces of literature were found that reinform current habitat utilization information. GMFMC (2010) mapped the distribution and abundance of king mackerel larvae from the Southeast Area Monitoring and Assessment Program (SEAMAP) bongo net collection surveys which demonstrated larvae being caught in ER 1-2 from late August to mid-October. Another study by Rooker et al. (2004) examined tropic relationships among fish associated with *Sargassum* mats using stable carbon and nitrogen isotopes. They found that adult king mackerel were consuming prey items inhabiting these mats. SEDAR 16 (2009) and SEDAR 38-AW-01 (2014) addressed mortality and life history parameters for adult king mackerel. They were as follows: L_{inf} = 1154.1 mm FL, k = 0.19, t_0 = -2.60, maximum age = 24 years, and M = 0.174.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 3-5 in offshore waters with depths from 35-180 m. They are water column associated and are primarily found in the Gulf during spring and summer. Eggs hatch in 18-21 hours at 27°C.

Larvae:

Larvae are found throughout the Gulf in offshore waters with depths from 35-180 m (based on spawning adult depth distributions). They are water column associated and have highest abundances from May through October. They are collected at temperatures from 20-31°C. Larvae prey on other larval fish including carangids, clupeids and engraulids. Their predators include young pelagic fish (i.e. tuna, dolphin). They exhibit enhanced growth in the north central and northwestern Gulf, which is likely associated with the Mississippi River plume. No information is available for postlarval fish, though it's reasonable to assume they use similar habitats as larvae.

Juveniles:

Early juvenile king mackerel are found in ER 3-5 in nearshore waters with depths less than or equal to 9 m. They are water column associated and occur seasonally from May through October, peaking in July and October. Their prey items include fish and some squid, and they are preyed upon by larger pelagic fish. They face fishing mortality from bycatch in the shrimp fishery and directed catch in the commercial and recreational fisheries. As with larvae, they exhibit enhanced growth in the north central and northwestern Gulf, which is likely associated with the Mississippi River plume. Late juveniles are found under similar conditions to early juveniles. They are found in ER 3-5 in nearshore waters though their depth distribution and seasonality is unknown. They feed on estuarine dependent fish and some squid.

Adults/Spawning Adults:

Adult king mackerel are found throughout the Gulf in both nearshore and offshore waters with depths from 0 to 200 m. They are water column associated and have been caught at temperatures greater than 20°C. They feed on fish, squid, and shrimp, and their feeding is sometimes associated with *Sargassum*. Their predators include larger fish, sharks, dolphin, and tuna. They are subject to fishing mortality and experience natural mortality rates of $M = 0.174$. Their growth rates are highest in the eastern Gulf. For the entire Gulf, life history parameters are as follows: $L_{inf} = 1154.1$ mm FL, $k = 0.19$, maximum age = 24 years, and $t_0 = -2.60$. Spawning adults have a truncated range compared to adults. Spawning occurs in offshore waters of ER 3-5 at depths from 35-180 m and temperatures greater than 20°C from May through October. Adults migrate to the northern Gulf in the spring and return to south Florida in the eastern Gulf, and Mexico in the western Gulf, in the fall.

Composite habitat maps are not available for this species because all of their life stages are water column associated.

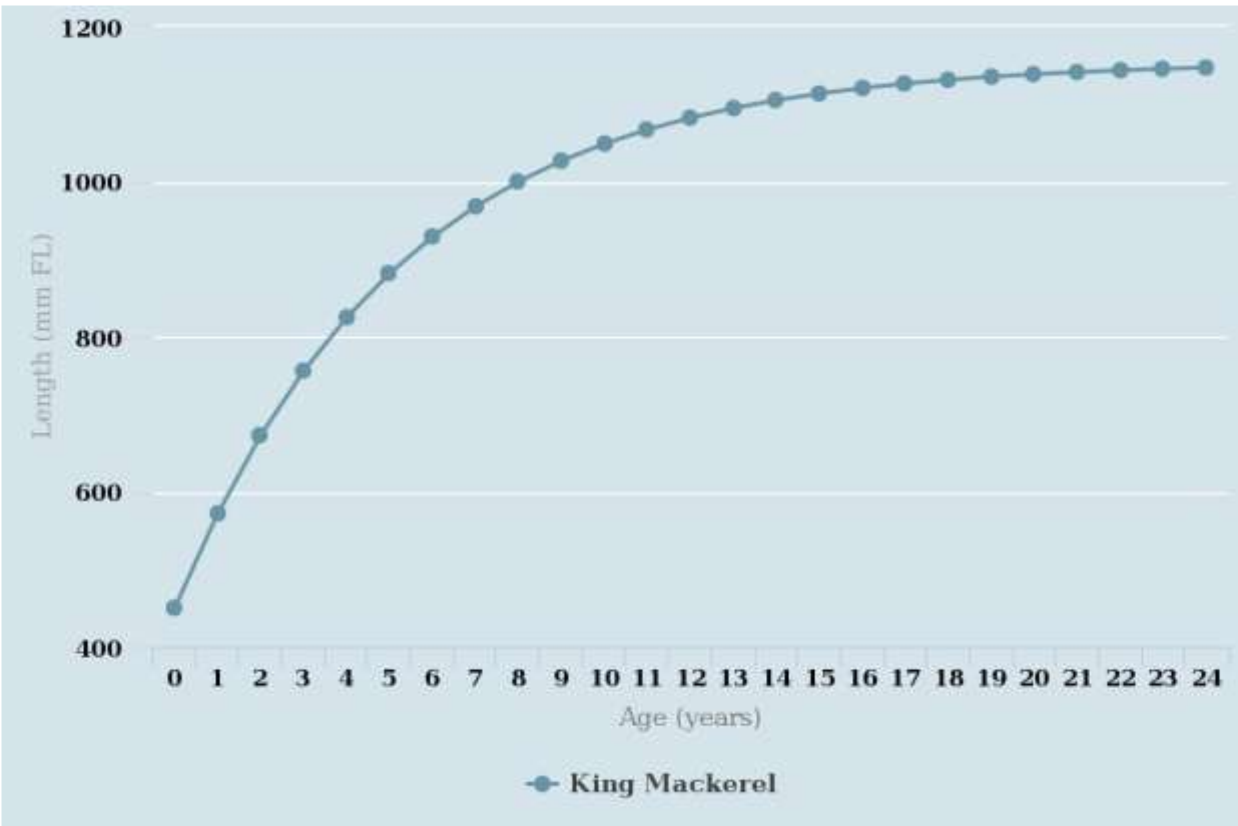

Figure 2. Predicted length at age for all king mackerel collected in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of $L_{inf} = 1154.1$ mm FL, $K = 0.19$, $t_0 = -2.60$, and maximum age = 24 years (SEDAR 38-AW-01 2014).

Spanish Mackerel (*Scomberomorus maculatus*)

Distribution

Spanish mackerel occur throughout the coastal zones of the western Atlantic from southern New England to the Florida Keys and throughout the Gulf. In the Gulf their distribution is centered off of Florida. Adults are found in coastal waters, and may enter estuaries in pursuit of baitfish. Migrations to the northern Gulf in the spring are temperature dependent, and the species is found in waters greater than 20°C, and out to depths of 75 m at oceanic salinities. Adults spawn over the inner continental shelf from May to September, with the north central and northeastern Gulf considered important spawning areas. Their eggs occurr over the inner continental shelf at depths less than 50 m in spring and summer. Larvae occur over the inner continental shelf, principally in the northern Gulf (GMFMC 2004).

Summary of new literature review

Several new studies were found that refine the current descriptions of habitat use by Spanish mackerel. The distribution and abundance of larval Spanish mackerel were mapped in GMFMC (2010) from collections conducted during SEAMAP sampling. These maps suggest high abundances of Spanish mackerel larvae throughout the Gulf depending on the season. Auster et al. (2009) studied behaviors among predator and prey species on live hard bottom habitats off the coast of Georgia. They observed Spanish mackerel feeding on juvenile tomtate, round scad, and mackerel scad in these habitats. Lindquist et al. (2005) described the vertical and horizontal distribution of larval and juvenile fish on oil rigs in the north central Gulf. While artificial reefs are not considered essential fish habitat, the authors did observe larval and juvenile Spanish mackerel on these structures. Schrandt et al. (2015) examined local abundance patterns, migration patterns via temporal abundance trends, and spatial abundance patterns of Spanish mackerel in Alabama coastal waters. They found the presence of juvenile and adult fish over a wide range of environmental parameters, including temperatures of 15.5-34.0°C, salinities of 0-31 ppt, dissolved oxygen levels of 2.8-10.8 mg/L, and depths of 1.8-9.0 m. The SEDAR 28 (2013) stock assessment on Spanish mackerel in the Gulf estimated natural mortality M, and life history as follows: M = 0.37/yr, t_0 = -0.5, k = 0.61, L_{inf} = 560 mm FL, and from Nobel et al. (1992), maximum age = 11 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 2-3 during the spring and summer. They are water column associated in nearshore and offshore waters with depths less than 50 m. They hatch in 25 hours at 26°C.

Larvae:

Larvae are found throughout the Gulf in nearshore and offshore waters with depths of 9-84 m. They are water column associated and have been collected at temperatures from 20-32°C. They are most prevalent from May through October, consume larval fish and some crustaceans, and are predated upon by other immature fish.

Juveniles:

Early juvenile Spanish mackerel are found in the water column of estuarine and nearshore waters in ER 2-3. They are most prevalent from March through November at water temperatures of 15.5-34.0°C and depths of 1.8-9.0 m. They prey on fish, some crustaceans, gastropods, and shrimp, and their predators are pelagic fishes. They are exposed to mortality as bycatch in the shrimp trawl fishery. Late juveniles are also water column associated in ER 2-3 from March through November at temperatures of 15.5-34.0°C. Unlike early juveniles, they occupy estuarine, nearshore, and offshore waters with depths of 1.8-50 m. They feed on fish and squid, and their predators are pelagic fishes. They also are subject to mortality via shrimp trawl bycatch, and are vulnerable to the recreational fishery. Juveniles have been collected in salinities of 0-31 ppt and dissolved oxygen concentrations of 2.8-10.8 mg/L.

Adults/Spawning Adults:

Adult Spanish mackerel are water column associated in ER 1-3. They occupy estuarine, nearshore, and offshore waters with depths of 3-75 m and water temperatures from 15.5-34.0° C. They are found in the northern Gulf during spring, and south Florida and Mexico in the fall. They feed on fish, crustaceans, and squid, and predators include larger pelagic fish. They have an M = 0.37/yr, are subject to fishing mortality, and are impacted by baitfish harvest. Females grow faster and live longer than males, and estimated life history parameters are t_0 = -0.5, k = 0.61, L_{inf} = 560 mm FL, and maximum age = 11 years. Adults spawn in ER 2-3 in nearshore and offshore waters at depths less than 50 m and temperatures greater than 25° C. They are water column associated and spawning takes place from May through September. The northeastern and north central Gulf are considered important spawning areas. Adults have been collected in salinities of 0-31 ppt and dissolved oxygen concentrations of 2.8-10.8 mg/L.

Composite habitat maps are not available for this species because all of their life stages are water column associated.

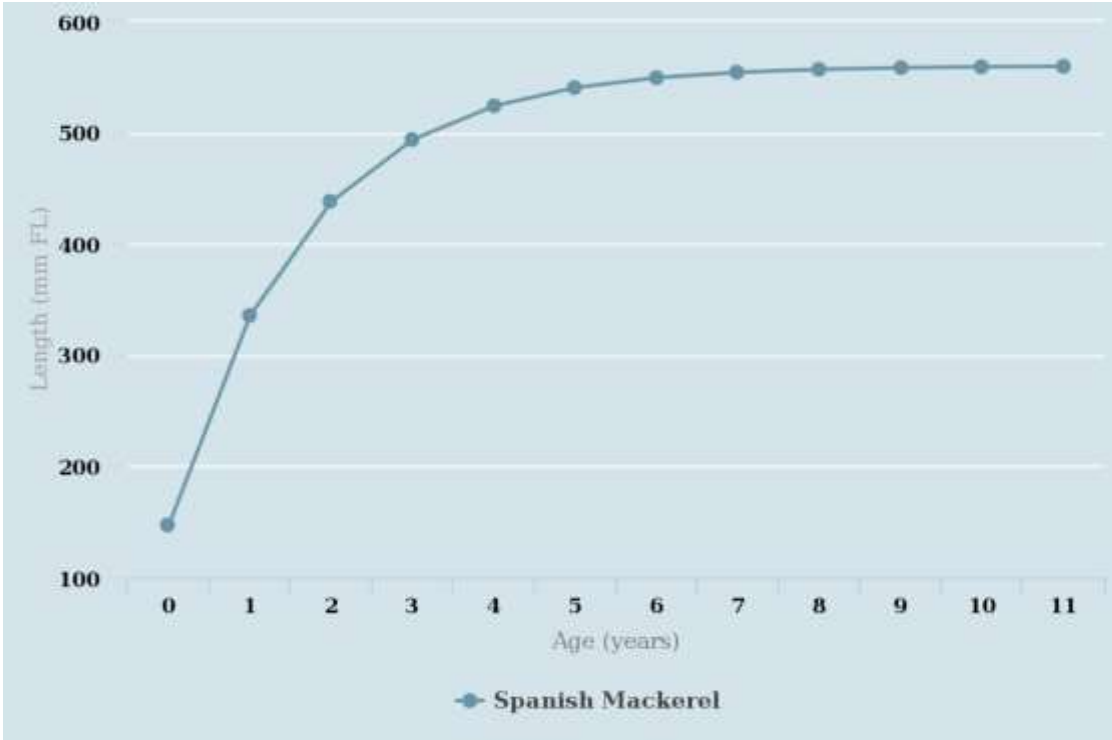

Figure 3. Predicted length at age for all Spanish mackerel collected from the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 560 mm FL, K = 0.61, t_0 = -0.5 (SEDAR 28 2013), and maximum age = 11 years (Nobel et al. 1992).

Cobia (*Rachycentron canadum*)

Distribution

In the Gulf of Mexico (Gulf), cobia are found in coastal and offshore waters (from bays and inlets to the continental shelf) from depth of 1-70 m. Adults feed on fishes and crustaceans, including crabs. Spawning occurs in coastal waters from April through September at temperatures ranging from 23-28° C. These fish perform a seasonal migration, commonly seen among other species in the family. Eggs are found in the top meter of the water column, drifting with the currents. Larvae are found in surface waters of the northern Gulf, where they likely feed on zooplankton. Juveniles occur in coastal and offshore waters feeding on small fishes, squid, and shrimp. They may be preyed upon by dolphinfish (GMFMC 2004).

Summary of new literature review

Two new pieces of literature were added to the previous information available on habitat utilization for cobia. Rooker et al. (2006) assessed the fish and coral populations on two hard banks (hard bottom) in the northwestern Gulf. Side scan sonar surveys were also conducted to better characterize habitat on these banks. Cobia were among the fish observed on the banks, though the authors do not include an estimate of abundance or frequency of sightings in this paper. Several parameters estimated by the life history working group of the Southeast Data, Assessment, and Review (SEDAR) 28 (2013) were added to the habitat information. These estimates were natural mortality (M) of 0.38/year, 50% maturity at age two, and life history parameters of L_{inf} = 1281.5 mm fork length (FL), k = 0.42, t_0 = -0.53, and maximum age = 11 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Cobia eggs are found in eco-regions (ER) 2-5 in estuarine and nearshore waters during the summer, and have been collected at temperatures of 28.1-29.7°C and salinities of 30.5-34.1 parts per thousand (ppt). They are water column associated and are generally found in the upper meter of water. In laboratory culture, eggs hatch within 36 hours.

Larvae:

Larvae are found in ER 2-5 in estuarine, nearshore, and offshore waters with depths of 3.1-300 m from May through September. They are water column associated, and have been collected at temperatures of 24.2-32.0°C and salinities of 18.9-37.7 ppt. Laboratory studies show that they reach 22 mm standard length (SL) in 22 days and feed on zooplankton, primarily copepods. Postlarvae are found in northern Gulf (ER 3-5) in nearshore and offshore waters at depths of 11-53 m, primarily in or near the surface (based on studies in the South Atlantic). They are water column associated at temperatures of 25.9-30.3°C and salinities of 28.9-30.2 ppt. In the lab they reach 25 mm standard length (SL) in 25 days and feed on the same prey items as larvae. Postlarvae have been collected from May through July.

Juveniles:

Juvenile cobia are found in ER 3-5 in nearshore and offshore waters and are water column associated. Early juveniles have been collected from April through July at temperatures of 16.8-25.2°C and salinities of 30.0-36.4 ppt (in the U.S. South Atlantic). They occupy depths from 5-300 m and a study from the South Atlantic reported them primarily in or near surface waters. In the lab, they feed on *Gambusia*, shrimp, and fish parts, and reach approximately 55 mm SL in 50 days. Late juveniles are found from May through October at depths of 1-70 m (based on adult distributions), and feed on fish, shrimp and squid. No temperature or salinity information is available for late juveniles, though these parameters are likely similar to adults. One predator of note is dolphinfish. In the lab, they reach 231 mm SL in 130 days.

Adults/Spawning Adults:

Adult cobia are found throughout the Gulf in nearshore and offshore waters. They are present from March through October in the northern Gulf and November through March in the southern Gulf and south Florida. They are water column associated, and can be found on banks/shoals (hard bottom) at depths of 1-70 m, temperatures of 23.0-28.0°C, and salinities of 24.6-30.0 ppt. Primary prey items for adult cobia include crustaceans and fish. Their estimated M = 0.38/yr and they have a lifespan of nine to 14 years (males) and 10 to 13 years (females). Cobia experience rapid growth in the first two years of life, and life history parameters have been estimated as L_{inf} = 1281.5 mm FL, k = 0.42, t_0 = -0.53, and maximum age = 11 years. Also, cobia migrate seasonally. Spawning occurs from April through September in the northern Gulf (ER 3-5). Spawning adults occupy the same temperature and salinity ranges as adults, and likely the same depth distributions. Fifty percent of individuals are estimated to be mature at age two.

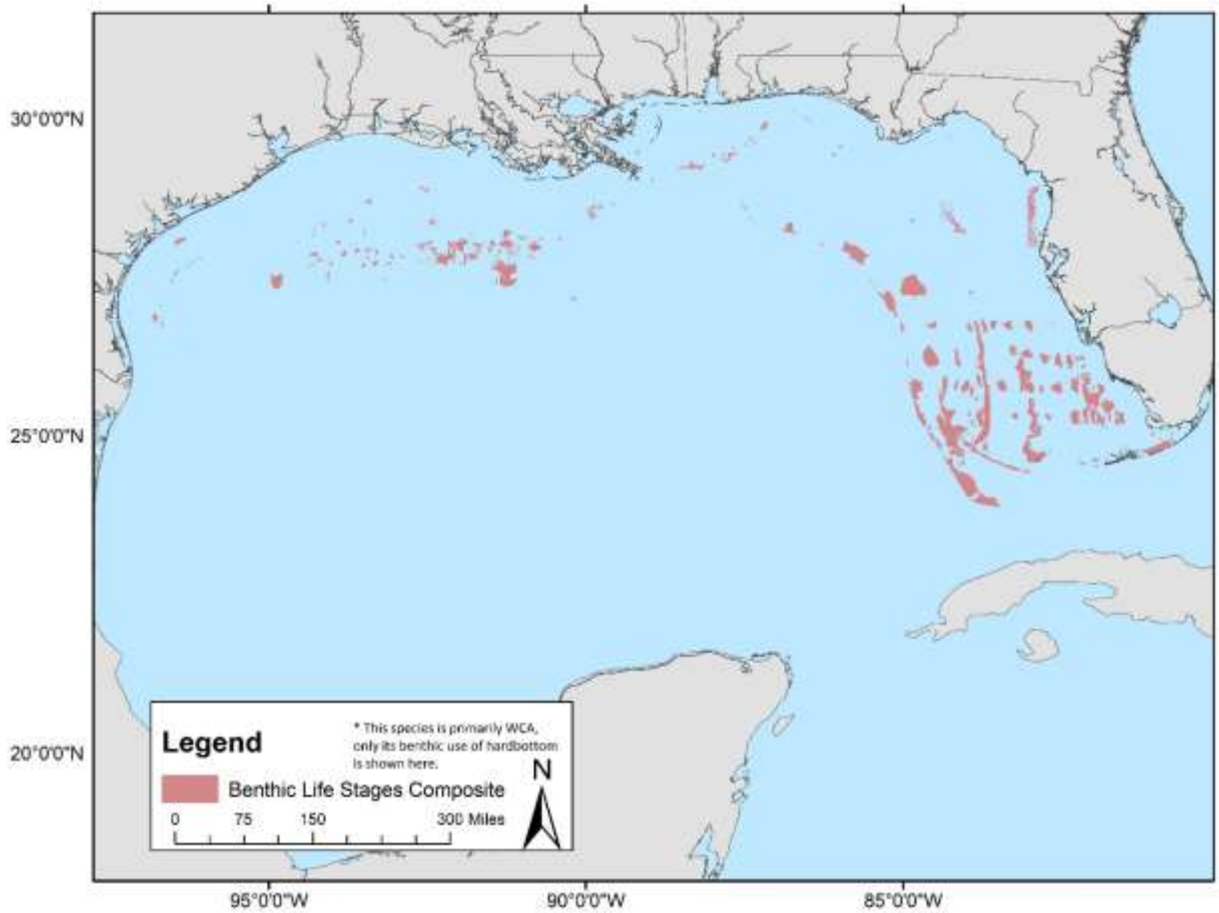

Figure 4. Map of benthic habitat use by all life stages of cobia.

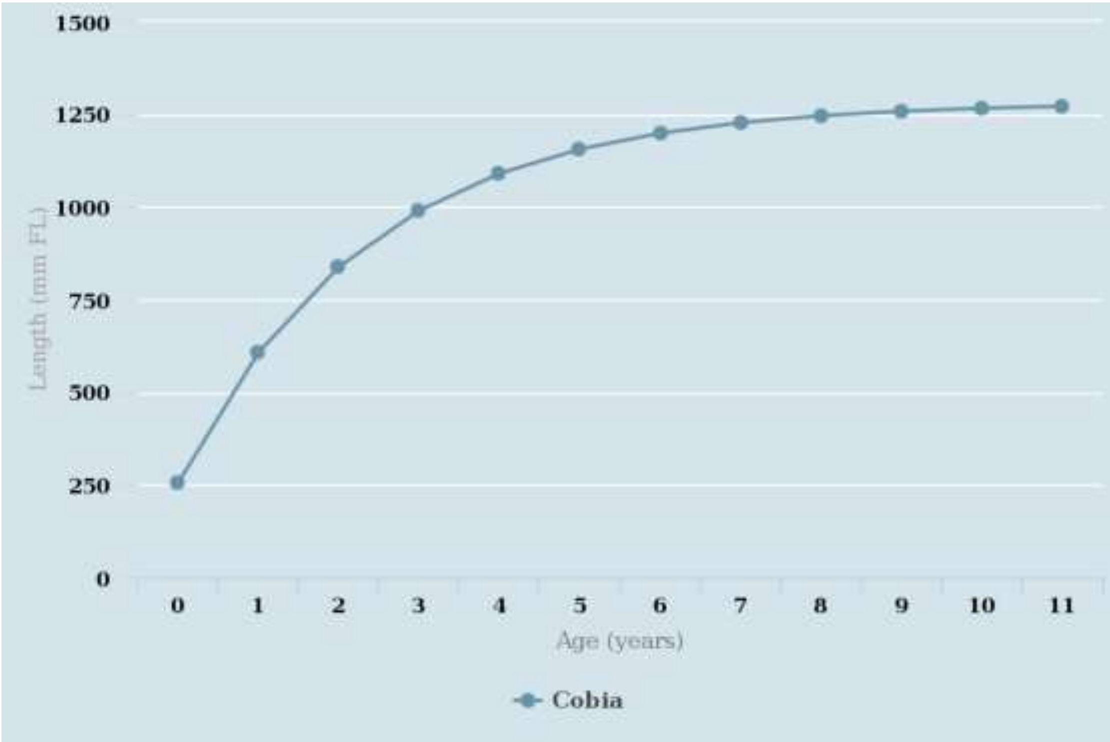

Figure 5. Predicted length at age for all cobia collected in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1281.5 mm FL, K = 0.42, t_0 = -0.53, and maximum age = 11 years (SEDAR 28 2013).

3.1.2 Coral

Distribution

The current definition of Coral EFH is that wherever corals occur is considered EFH. The Council is currently investigating new areas that warrant habitat area of particular concern (HAPC) status; HAPCs are a subset of EFH. Recent scientific studies in the Gulf have provided new information that warrants re-examining the existing HAPC boundaries and designating new HAPCs. The recently initiated document will contain a more thorough review of coral EFH.

Currently, the Council has black corals (antipatharians) and stony corals (scleractinians) in its management unit; however, an upcoming amendment may evaluate incorporating octocorals (alcyonaceans) that occur in deep-water into the fishery management unit. Stony corals are typically found on hard substrates such as basalt, limestone, or authigenic carbonate. Black corals are generally found on hard substrate, but certain species are specific to soft sediments. The West Florida Shelf has the deepest known hermatypic coral in U.S. waters. Areas in the northern section of the Pulley Ridge HAPC have been characterized as sand, pavement, or low relief outcrops, with the pavement and low relief outcrops containing several species of sessile and encrusting invertebrates and algae (GMFMC 2010). The West Florida Shelf is a carbonate platform that is a mixture of siliciclastic and carbonate sediments. Off the coast of Louisiana, Mississippi, and Alabama, a series of features with relief (2 m to more than 20 m) have either clusters of features, or linear ridges (Rezak et al. 1989; Schroeder et al. 1989). The northwestern Gulf is very broad and predominantly comprised of soft sand and clay. Salt diapirs dominate the hard substrate north of Matagorda Bay, Texas (e.g. the Flower Garden Banks National Marine Sanctuary), and drowned barrier reefs provide the hard substrate south of Matagorda Bay for south Texas Banks (Southern Bank and Harte Bank) (Rezak et al. 1990; Roberts 2011).

3.1.3 Red Drum

Red Drum (*Sciaenops ocellatus*)

Distribution

Red Drum are found in the western Atlantic from Massachusetts to northern Mexico. They are distributed throughout the Gulf of Mexico (Gulf). Depending on life stage, they are found from estuarine to offshore waters and occur over a variety of habitat types including submerged aquatic vegetation (SAV), soft bottom, hard bottom, emergent marsh, sand/shell, and early life stages are water column associated.

Summary of new literature review

New literature by Anderson (2013) examined juvenile red drum thermotolerance by simulating cold fronts in a laboratory setting, and found that red drum experienced mortality when briefly exposed to temperatures ≤ 3°C, and following prolonged exposure to 5° C, suggesting that severe winters may cause high mortality for juveniles. Herzka et al. (2002) addressed settlement of red drum larvae using stable isotopes, and determined that peak larval red drum settlement occurs between 6-8 mm total length (TL). SEDAR 44 (2015) proposed an age constant M = 0.07-0.13. SEDAR 49 DW report estimated life history parameters as L_{inf} = 881 mm fork length (FL), k = 0.32, t_0 - =1.29, and Wilson and Nieland (2000) reported a maximum age = 42 years. Stunz et al. (2002) compared early juvenile red drum densities among various habitat types and found that peak recruitment occurred from September through December and that seagrass meadows had the highest densities of new settlers. Previous literature suggests that adults spawn in deeper water at the mouths of bays and inlets, and on the Gulf side of barrier islands (Pearson 1929; Simmons and Breuer 1962; Perret et al. 1980). However, a recent study by Holt (2008) found that red drum spawn along all nearshore regions of the central Texas coast. Lastly, Murphy and Taylor (1990), were cited in the previous habitat association table (HAT), additional data was added to this review from that paper. The authors calculated length where 50% of males are mature = 529 mm FL, and for female fish = 825-900 mm FL, these fish were collected from the Tampa Bay, Florida area.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs hatch mainly in the Gulf outside estuaries (Perret et al. 1980; Pattillo et al. 1997), and are water column associated. Eggs are present from late summer through early fall, and peak between late August and mid-October. They tend to be found in water temperatures ranging from 20-30°C, with optimal temperature being 25°C. Eggs hatched at salinities of 10-40 ppt in hatcheries at 25°C.

Larvae:

Larvae are transported back to estuaries for maturation (Perret et al. 1980; Pattillo et al. 1997), where the settle onto benthic substrate between 6-8 mm TL. Larval stages are present in estuaries from August through November. They occur in open bays, estuaries with or without SAV, and tidal flats. They are found in temperatures ranging from 18.3-31.0°C and at salinities of 8-36.4 ppt. Their primary prey items are copepods, and are predated upon by larger piscivorous fishes.

Juveniles:

Juvenile red drum have been reported in quiet, shallow, protected waters with grassy or muddy bottoms (Simmons and Breuer 1962), and around the perimeter of marshes in estuaries (Perret et al. 1980). Early juveniles can be found in these habitats during early winter, after which the late juveniles move offshore. Their temperature preference ranges from greater than 5-30°C, and they are most abundant at salinities of 20-40 parts per thousand (ppt). Primary prey items include copepods, mysids, amphipods, shrimp, polychaetes, insects, fish, isopods, bivalves, and decapod crabs. Primary predators include larger piscivorous fish (amberjack, sharks). They are also vulnerable to mortality stemming from extreme temperature variability (i.e. cold fronts).

Adults/Spawning Adults:

Adults move offshore as they age, with schools of large individuals found in waters less than 70 m. Previous literature suggests that adults spawn in deeper water at the mouths of bays and inlets, and on the Gulf side of barrier islands (Pearson 1929; Simmons and Breuer 1962; Perret et al. 1980). However, a recent study by Holt (2008) found that red drum spawn along all nearshore regions of the central Texas coast. Spawning occurs from mid-August through October, peaking from September-October. Adults have been observed in water temperatures from 2-33°C, and are abundant in salinities of 25-35 ppt. Prey items include crab, shrimp, and fish, and they are predated upon by sharks. Life history and mortality estimates for adults are as follows: M (age-constant) = 0.07-0.13, L_{inf} = 881 mm FL, k = 0.32, t_0 - =1.29, and maximum age = 42 years. Fifty percent of males are estimated to be mature at 529 mm FL and for females at 825-900 mm FL.

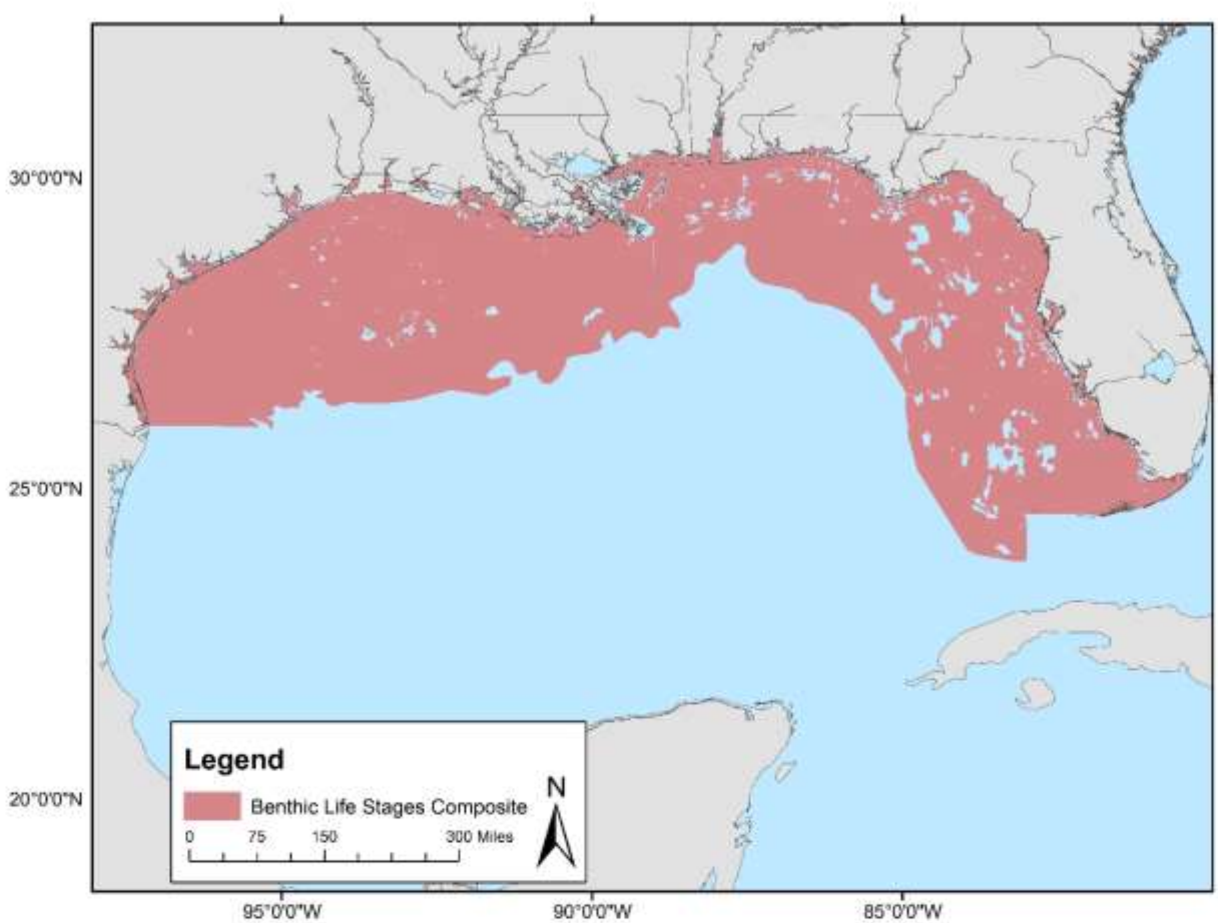

Figure 6. Map of benthic habitat use by all life stages of red drum.

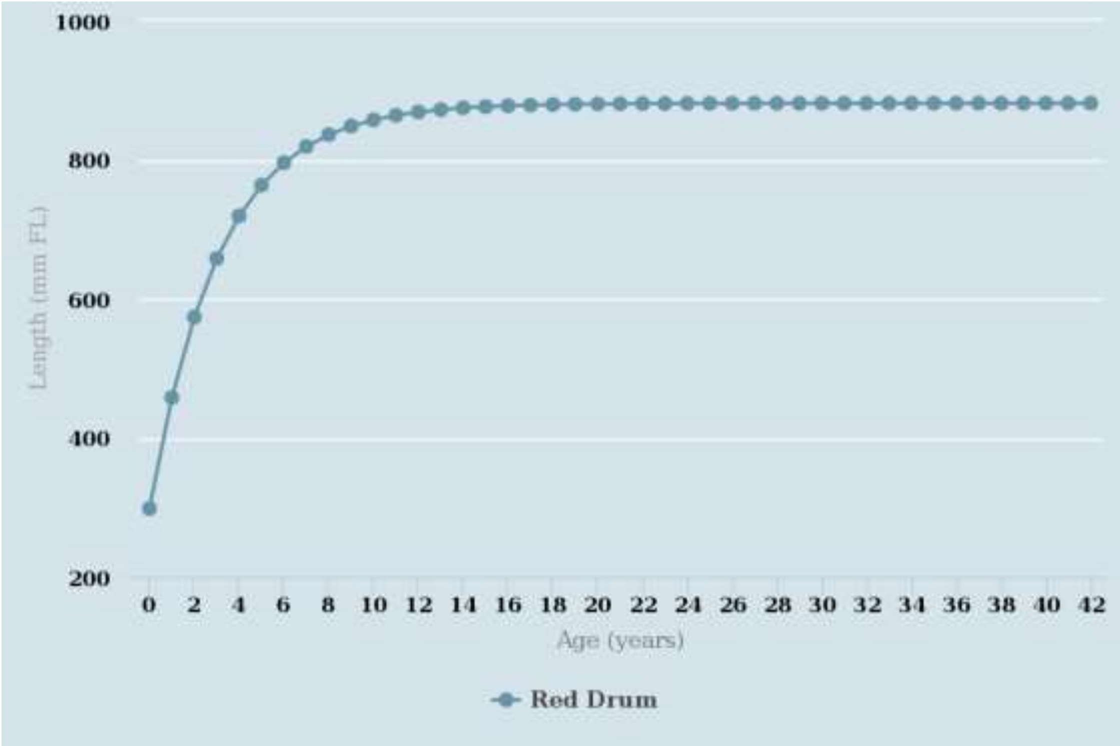

Figure 7. Predicted length at age for all red drum collected in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 881 mm FL, K = 0.32, t_0 = -1.29 (SEDAR 49 DW Report 2016), and maximum age = 42 years (Wilson and Nieland 2000).

3.1.4 Reef Fish

Queen Snapper (*Etelis oculatus*)

Distribution

Queen snapper are found in the western Atlantic from North Carolina, throughout the Caribbean and south to Brazil. They are also found near Bermuda and in the Gulf. Pre-settlement life stages are water column associated and are most prevalent from 0-100 m, based on research in the Straits of Florida. They settle to hard bottom, and data from the Caribbean suggests that adults also use shelf edge/slope habitat. Adult and spawning adult depth range is from 95-680 m. Very limited information is available on water parameters where queen snapper have been captured, however adults have been document at temperatures from 16-18°C.

Summary of new literature review

All new literature came from studies conducted outside the Council’s jurisdiction. D'Alessandro et al. (2010) studied larvae in the Straits of Florida and found they were most prevalent from September through November in the water column from depths of 0-100 m, and that they have a pelagic larval duration of less than or equal to 36 days. The authors also calculated morality and growth data as follows: Z = -0.113 ± 0.023 SE, SL-age curve = 0.113, and K = 0.040 ± 0.003 SE. Gober et al. (2005) conducted research on queen snapper in the Caribbean. They found that adults occupied shelf edge/slope habitat and preyed on squid. Also, they found small queen snapper in the stomach of a beardfish (*Polymixia lowei*), suggesting that this species is a predator for juvenile queen snapper. They calculated a mortality of Z/K = 3.73, and an L_{inf} = 905.7 mm FL. Bryan et al. (2011) submitted SEDAR 26-DW-01 that references SEDAR 4 Doc-7, which stated that adult queen snapper feed on shrimp and small fish, and young feed on crustaceans. Lastly, Rosario et al. (2006) studied reproduction of queen snapper in Rincón, Puerto Rico. Authors found that spawning occurred year-round, with peaks in October-November. Fifty percent maturity for females occurred at 310 mm FL and for males at 220 mm FL, all fish were mature at 370 mm FL.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in eco-region ER-1 in offshore waters. They are WCA, and are presumed to occur over depths of 95-680 m based on spawning adult distribution.

Larvae:

Larvae are found in ER-1 in offshore waters. They are WCA, and in the Straits of Florida they are most prevalent in the upper 100 m of the water column. Also in the Straits of Florida they have the highest abundances from September to November, and have the following mortality and growth parameters: Z = -0.113 ± 0.023 SE, SL-age curve = 0.113, and K = 0.040 ± 0.003 SE.

Juveniles:

Juveniles are found in ER-1 in offshore waters. Early juveniles occupy the water column, and all juveniles are presumed to occur in 95-680 m depths based on adult distribution. Studies outside the Gulf document juveniles consuming crustaceans, and the beardfish being a predator.

Adults/Spawning Adults:

Adults occupy offshore waters at depths of 95-680 m in ER-1 with temperatures of 16-18°C. They grow up to 1000 mm TL and can reach at least 30 years old. In the Gulf they use hard bottom habitats. Studies from outside the Gulf have documented queen snapper on shelf edge/slope habitats. Also outside the Gulf they are known to consume squid and small fish. They have a Z/K = 3.73 and L_{inf} = 905.7 mm FL, with females being larger than males. Spawning adults are also found in offshore waters at depths of 95-680 m in ER-1. Research outside the Gulf has found that spawning occurs year-round, peaking from October through November, with fifty percent of females estimated to be mature at 310 mm FL and for males at 220 mm FL, all individuals were mature at 370 mm FL.

Figure 8. Map of benthic habitat use by all life stages of queen snapper.

Mutton Snapper (*Lutjanus analis*)

Distribution

Mutton snapper can be found in the western Atlantic from Massachusetts and Bermuda south to Brazil, and in the Caribbean and Gulf. They are most abundant in the Antilles, the Bahamas and southern Florida. In the Gulf, mutton snapper occur in ER-1 and use primarily reef and SAV habitats depending on life stage, however spawning adults can be found on banks/shoals, hard bottom, and shelf edge/slope as well.

Summary of new literature review

Several studies were found that identified more habitats that spawning adult mutton snapper use. Burton et al. (2005) studied aggregations on Riley's Hump which is a bank/shoal (hard bottom) habitat type, and Gleason et al. (2011) documented spawning aggregations on hard bottom and shelf edge/slope habitats. Lindeman (1997) studied mutton snapper larvae and determine that they had a mean pelagic larval duration of 31 days. Faunce et al. (2007) compiled a data workshop report (SEDAR15A-DW-15) which established that spawning occurs from March through July, and the SEDAR 15A Update Assessment (2015) calculated natural mortality and life history rates as follows: M = 0.17/yr, L_{inf} = 861 mm TL, K = 0.165, t_0 = -1.23, and maximum age = 40 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in the water column in ER-1 during late spring through summer.

Larvae:

Larvae are found in the water column in ER-1 during early summer to mid-summer and have a larval pelagic duration of 31 days.

Juveniles:

Juveniles are found during the summer in ER-1. They settle to SAV and move to reefs with growth.

Adults/Spawning Adults:

Adults and spawning adults are found in ER-1. Adults occupy SAV and reefs year-round. They feed on crustaceans, fish and gastropods. Mortality and life history parameter estimates are M = 0.17/yr, L_{inf} = 861 mm TL, K = 0.165, t_0 = -1.23, and maximum age = 40 years. Spawning adults are found in offshore waters from March through July utilizing reefs, banks/shoals, hard bottom, and shelf edge/slope habitats in depths from 25-95 m. They are susceptible to heavy fishing pressure while aggregating to spawn.

Figure 9. Map of benthic habitat use by all life stages of mutton snapper.

Figure 10. Predicted length at age for all mutton snapper collected in the south Atlantic and Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 861 mm TL, K= 0.17, t_0 = -1.23, and maximum age = 40 years (SEDAR 15A Update 2015).

Blackfin Snapper (*Lutjanus bucanella*)

Distribution

Blackfin snapper occur throughout the Gulf, but are most common off of west Florida. This species of snapper occupies shelf edge habitats, where they feeds on fish and crustaceans. They are most commonly found at depths of 40 to 300 m. Juveniles occur in shallower hard bottom areas at 12-40 m.

Summary of new literature review

Three studies contributed new information to our knowledge of habitat use by blackfin snapper. Arena et al. (2004) studied juvenile blackfin snapper on reef tracts and artificial reefs near Broward County, Florida. Natural reefs were surveyed in 3-30 m and artificial reefs were at depths of 7-23 m. All observations of snapper were recorded on artificial reefs, none were seen on natural reefs. Pattengill-Semmens and Cavanaugh (2007) monitored fish assemblages on modified reefs in the Florida Keys National Marine Sanctuary. These modified reefs were the *Spiegel Grove* artificial reefs and an area of Molasses Reef that had been damaged by the *M/V Wellwood* and subsequently replenished with limestone reef modules. Adult blackfin snapper were observed on the *Spiegel Grove*. Lastly, Weaver et al. (2006) used submersibles to survey

Alderdice, McGrail, and Sonnier Banks in the northwestern Gulf. They documented the presence of blackfin snapper on Sonnier Banks, which occur in ER 4-5 at depths of 19-60 m.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occur in ER 1-2 in offshore waters. They are water column associated at depths of 40-300 m (based on spawning adult distributions) and can be found year-round.

Larvae:

Larvae occur in ER 1-2 at depths of 40-300 m (based on spawning adult distributions). No other information is available for this life stage, though they likely use similar habitat as eggs.

Juveniles:

Juveniles can be found on hard bottom habitats in nearshore and offshore waters of ER 1-2. They've been found as shallow as 7 m (in southeastern Florida) and out to 40 m. They are found in the spring in the Virgin Islands.

Adults/Spawning Adults:

Adults and spawning adults are found in offshore waters with depths of 40-300 m in ER 1-2. They use shelf edge/slope and hard bottom habitat. They can be found year-round and spawning peaks in the spring and fall. Adults prey on fish and crustaceans.

As noted above, Weaver et al. (2006) observed blackfin snapper on banks in ER 4-5, life stage wasn't stated though they were likely late juveniles or adults, suggesting that bank/shoal habitats in these ER's may be habitat for either life stage. Also, despite not being considered essential fish habitat, juvenile blackfin appear to use artificial reefs as habitat.

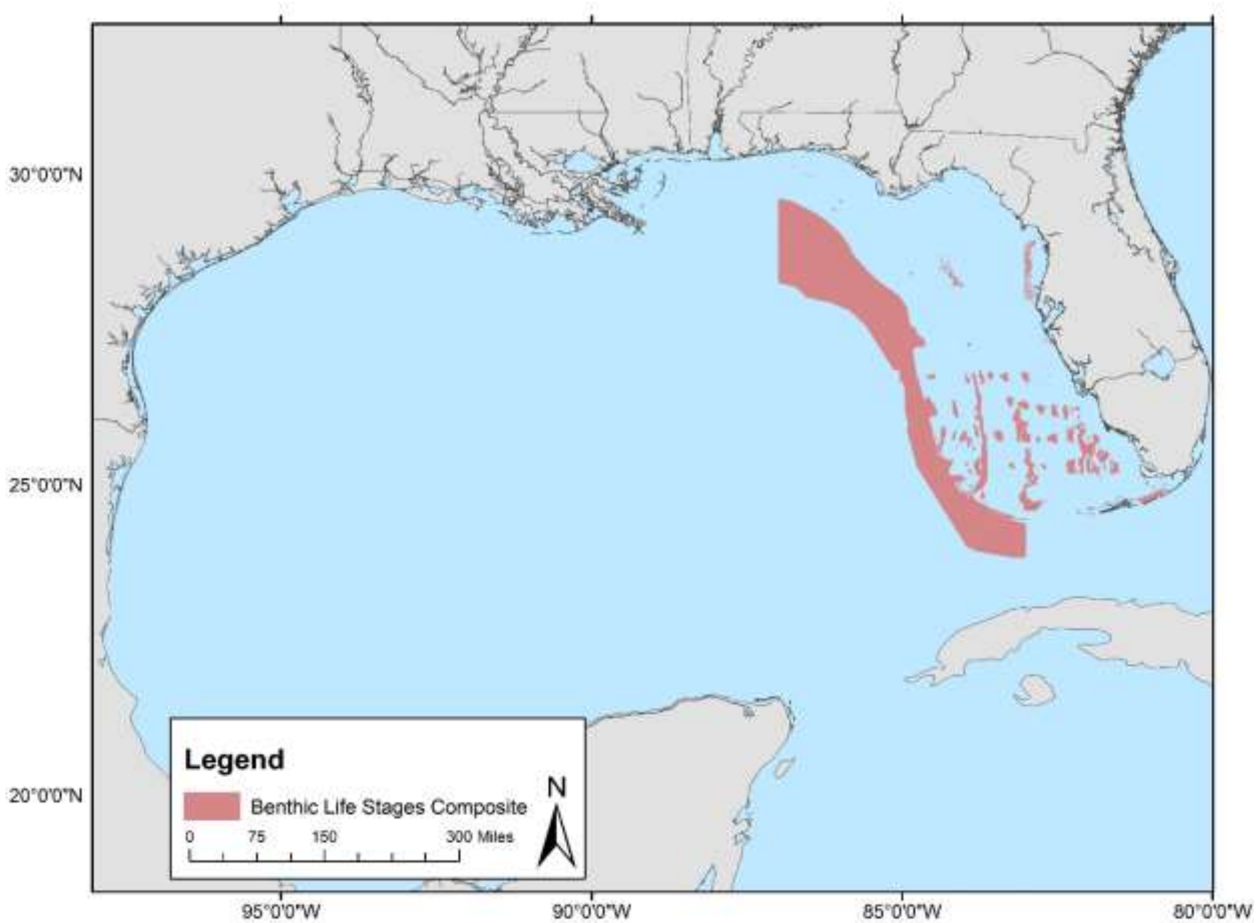

Figure 11. Map of benthic habitat use by all life stages of blackfin snapper.

Red Snapper (*Lutjanus campechanus*)

Distribution

Red snapper occur throughout the Gulf shelf. They are particularly abundant on the Campeche Banks and in the northern Gulf. The species is demersal and is found over sandy and rocky bottoms, around reefs, and underwater objects from shallow water to 200 m, and 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.

Summary of new literature review

New literature on red snapper is published frequently. This review yielded several papers that helped to fill gaps relating to red snapper habitat for a variety of life stages. Gallaway et al. (2009) wrote a review paper highlighting many details about red snapper life history. They cite Rabalais et al. (1980) and Minton et al. (1983) who found that approximately 50% of eggs hatch within 20-27 hours of fertilization. Gallaway et al. (2009) also cited Gallaway et al. (1999) who found the highest densities of juveniles red snapper at depths of 18-55 m. Kraus et al. (2006) evaluated the reef fish community on a mid-shelf bank (Sonnier Bank) in ER-4 and observed adult red snapper, highlighting a new habitat type used by that life stage. Several studies examined adults to identify season, depth, temperature and locations used during spawning. Kulaw (2012) examined reproductive biology of female red snapper on natural shelf-edge banks, and both standing and toppled petroleum platforms, and found that 50% maturity was reached at age 3-5 and 400-450 mm TL, and all females were mature at age eight and 700 mm TL. Fitzhugh et al. (2004) also studied reproduction in red snapper and determined that spawning occurs from April through October based on observations of females with hydrated ova and via gonadosomatic index values. They also found spawning occurred at depths from 30-126 m and temperatures of 16-29°C. More habitat information has become available for juvenile red snapper since 2004 when the habitat association tables were last updated. Rooker et al. (2004) studied juvenile red snapper on bank and soft bottom habitats in ER-5. They found settlement size to be 16-19 mm SL, growth rates between 0.817-0.830 mm/d, and estimated a pelagic larval duration of 28 days. Szedlmayer and Lee (2004) examined diet shifts in juveniles and found that early juveniles fed on shrimp, chaetognaths, squid and copepods, and late juveniles fed on fish, squid, crabs and shrimp. They also noted collection of juveniles from waters with temperatures between 20-28°C and salinities of 30-35 ppt. According to Szedlmayer and Mudrak (2014), dissolved oxygen less than 0.4 mg/L caused a loss of juvenile red snapper on artificial reefs. The last new study on juveniles was conducted by Wells et al. (2008) who examined the effect of trawling on juvenile red snapper habitat and life history. They quantified growth rates over various habitat types and found that fish collected on sand habitats had the highest average growth at 1.01 mm/d. The last new piece of literature was the SEDAR 31 (2015) update assessment of red snapper which estimated an average mortality for age 2+ = 0.094/yr, age 1 = 1.2/yr, and age 0 = 2.0/yr. The assessment also provided von Bertalanffy growth parameters; L_{inf} (max. TL mm) = 856.4, K = 0.19, and t_0 = -0.39, and a maximum age = 48 years. They also reported a batch fecundity estimate of 27-142 eggs/g fish weight.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found throughout the Gulf and are WCA. They occur in offshore waters from depths of 18-126 m (based on spawning adult depth distributions) and have a 50% hatch time of 20-27 hours.

Larvae:

Red snapper larvae are found throughout the Gulf in offshore waters at depths from 18-126 m (based on spawning adult depth distributions). They are WCA and are most abundant from July through November at temperatures of 17.3-29.7°C and salinities of 32.8-37.5 ppt. Their estimated pelagic larval duration is 28 days, and postlarvae settle at 16-19 mm TL. In the lab, larvae prey on alga and rotifers.

Juveniles:

Juveniles, both early and late, are found throughout the Gulf in nearshore and offshore waters and occupy reefs, hard bottom, banks/shoals, soft bottom, and sand/shell habitats. They have growth rates of approximately 0.817-1.01 mm/day. Early juveniles are found from July through November at temperatures of 17.3-29.7°C, salinities of 30-35 ppt, DO concentrations greater than 0.4 mg/L, and depths from 17-183 m. Prey items include zooplankton, shrimp, chaetognaths, squid, and copepods. Late juveniles are found year-round at temperatures of 20-28°C, salinities of 30-35 ppt, DO greater than 0.4 mg/L, and depths from 18-55 m. They prey on fish, squid, crabs and shrimp. Both early and late juveniles are subject to mortality via shrimp trawl bycatch and have M of 2.0/year (age 0) and 1.2/year (age 1). Despite not being considered essential fish habitat at this time, juvenile red snapper use artificial reefs as habitat.

Adults/Spawning Adults:

Adult red snapper are found throughout the Gulf, year-round, in nearshore and offshore waters. They occupy reefs, hard bottom, and banks/shoal habitats at depths of 7-146 m, temperatures of 14-30°C, and salinities of 33-37 ppt. Prey include fish, shrimp, squid, octopus, and crabs. One of their primary predators are sharks. They face mortality from a directed fishery, which they enter at age two, and M is estimated to be 0.094/year. Life history parameters have been estimated at L_{inf} (max. TL mm) = 856.4, K = 0.19, t_0 = -0.39, and maximum age = 48 years. Spawning occurs in offshore waters on sand/shell and bank/shoal habitats from April through October at temperatures of 16-29°C and depths of 18-126 m. Fifty percent maturity occurs for females at age 3-5 and 400-450 mm TL, and 100% maturity occurs by age eight and 700 mm TL. Batch fecundity has been estimated at 27-142 eggs/g (fish weight). Despite not being considered EFH at this time, adult red snapper use artificial reefs as habitat.

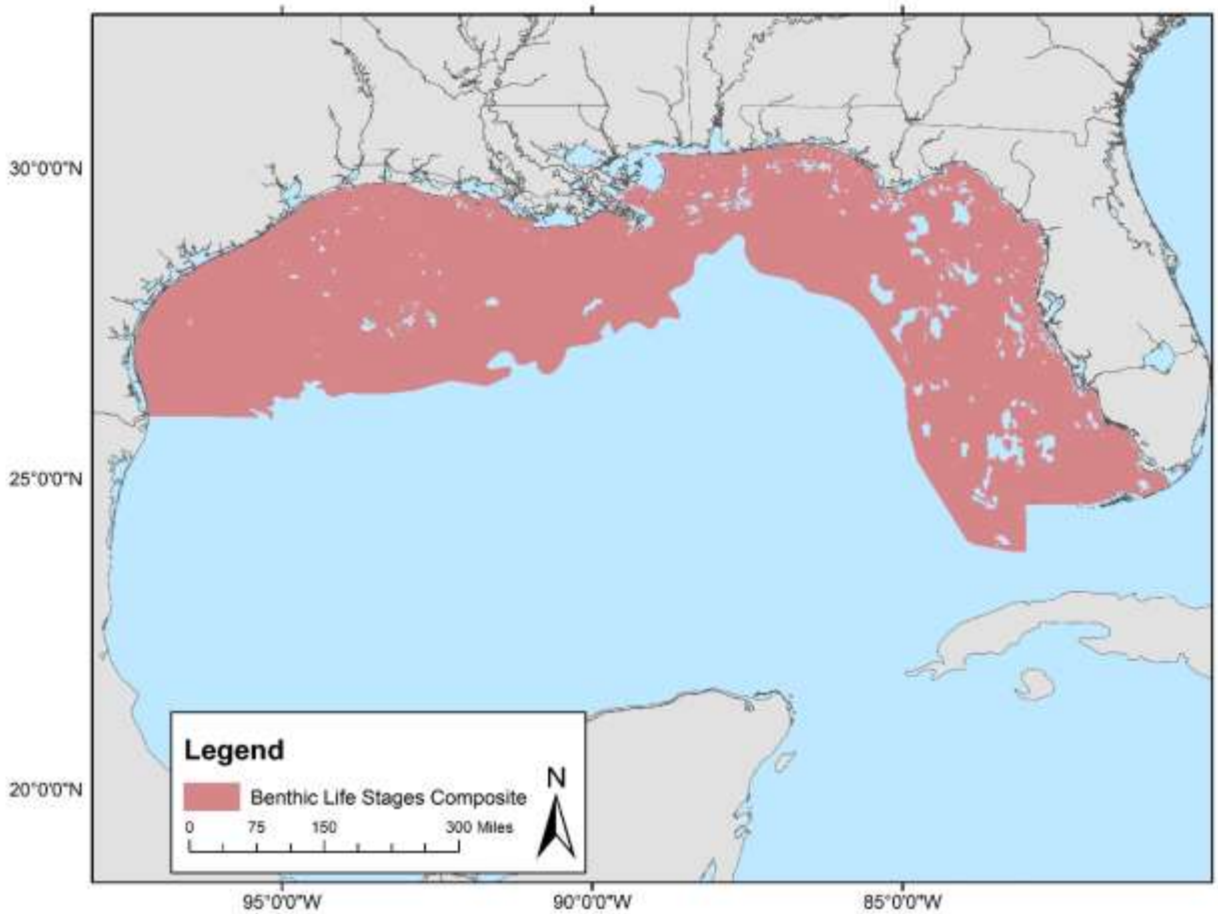

Figure 12. Map of benthic habitat use by all life stages of red snapper.

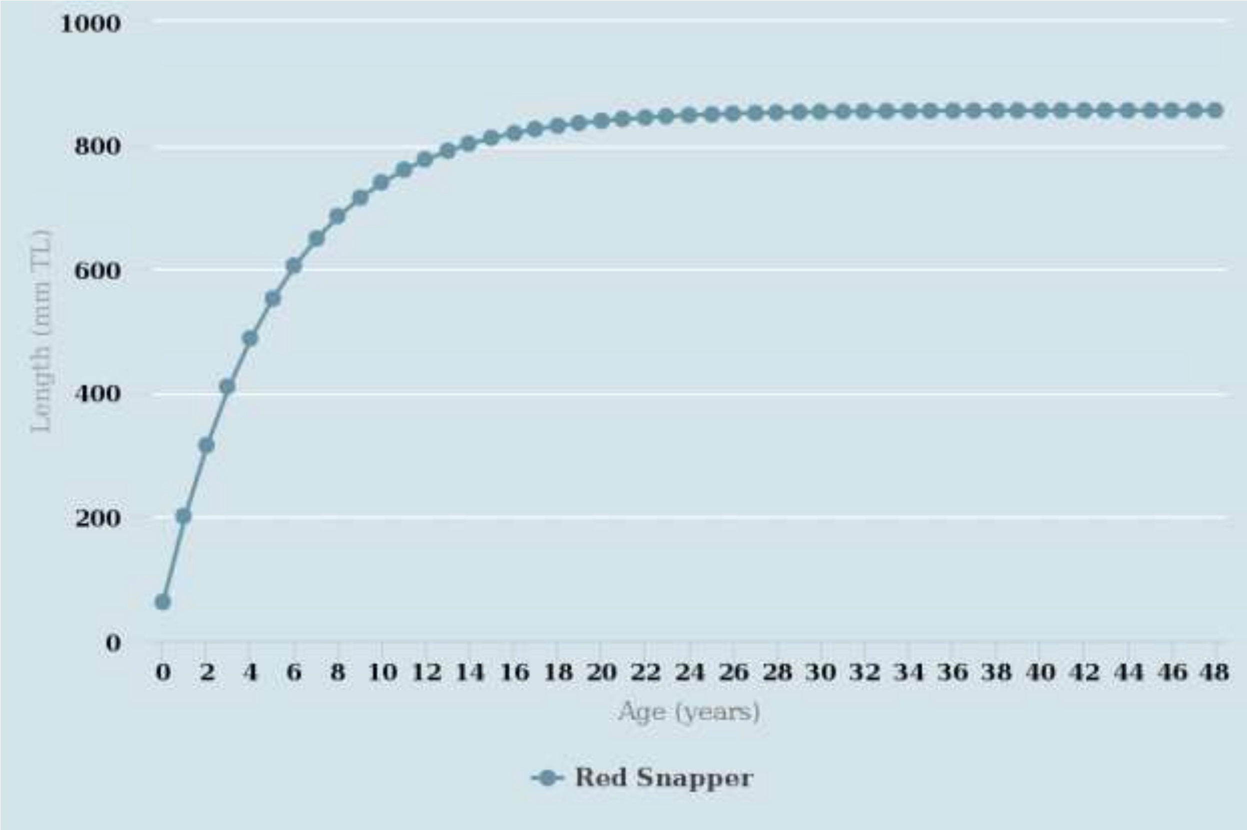

Figure 13. Predicted length at age for all red snapper collected in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 856.4 mm TL, K = 0.19, t_0 = -0.40, and maximum age = 48 years (SEDAR 31 2015).

Cubera Snapper (*Lutjanus cyanopterus*)

Distribution

This species occurs infrequently in the Gulf, but is most common off southwestern Florida. It is the largest of the snapper species occurring in the western Atlantic. Adult cubera snapper are found on both shallow and deep reefs, wrecks (to at least 85 meters deep), and in mangroves. Unusual among snappers, they have a high range of salinity tolerance and can enter water that is nearly fresh (e.g. the intra-coastal waterway on the east coast of Costa Rica). Spawning aggregations have been observed in June and July. Two spawning sites have been recorded in the eastern Gulf: both wrecks located in 67-85 m of water, off Key West and the Dry Tortugas. Similar aggregations have been recorded in Belize, Buttonwood Cay and Cay Bokel (GMFMC 2004).

Summary of new literature review

The literature review for cubera snapper yielded three studies that added information to what is currently known about habitat use. Kadison et al. (2006) studied spawning aggregations of cubera and dog snapper in the U.S. Virgin Islands. Spawning adults were observed on Grammanik Bank, which has hard bottom and reef substrate and lies in 35-40 m of water. Spawning aggregations were observed at temperatures greater than 26.9°C. The authors also note that cubera snapper are transient spawners (Domeier and Colon 1997). Another study on spawning adults was conducted by Heyman et al. (2005) in Belize. Spawning aggregations were observed by divers on Gladden Spit, which is a reef promontory near the continental shelf edge. Spawning occurred from April to July, peaking in May.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER-1 in nearshore and offshore waters at depths of 10-85 m (based on spawning adult distribution) during the summer. They are water column associated.

Larvae:

Larvae are found in ER-1 in nearshore and offshore waters at depths of 10-85 m (based on spawning adult distribution). Other habitat information is unknown, though likely similar to that of eggs.

Juveniles:

Juveniles are found in ER-1 in estuarine, nearshore, and offshore waters at depths of 0-85 m (based on adult distribution). They use submerged aquatic vegetation, mangrove, and emergent marsh habitat at temperatures of 24.5-31.0°C.

Adults/Spawning Adults:

Adult cubera snapper are found in ER-1, in estuarine, nearshore and offshore waters in depths of 0-85 m, and use mangrove and reef habitats. Spawning occurs on reef, shelf edge/slope, hard bottom, and bank/shoal habitats from April through July, peaking in May, at temperatures greater than 26.9°C (from studies conducted outside Gulf of Mexico Fishery Management Council (Gulf Council) jurisdiction), and depths of 10-85 m.

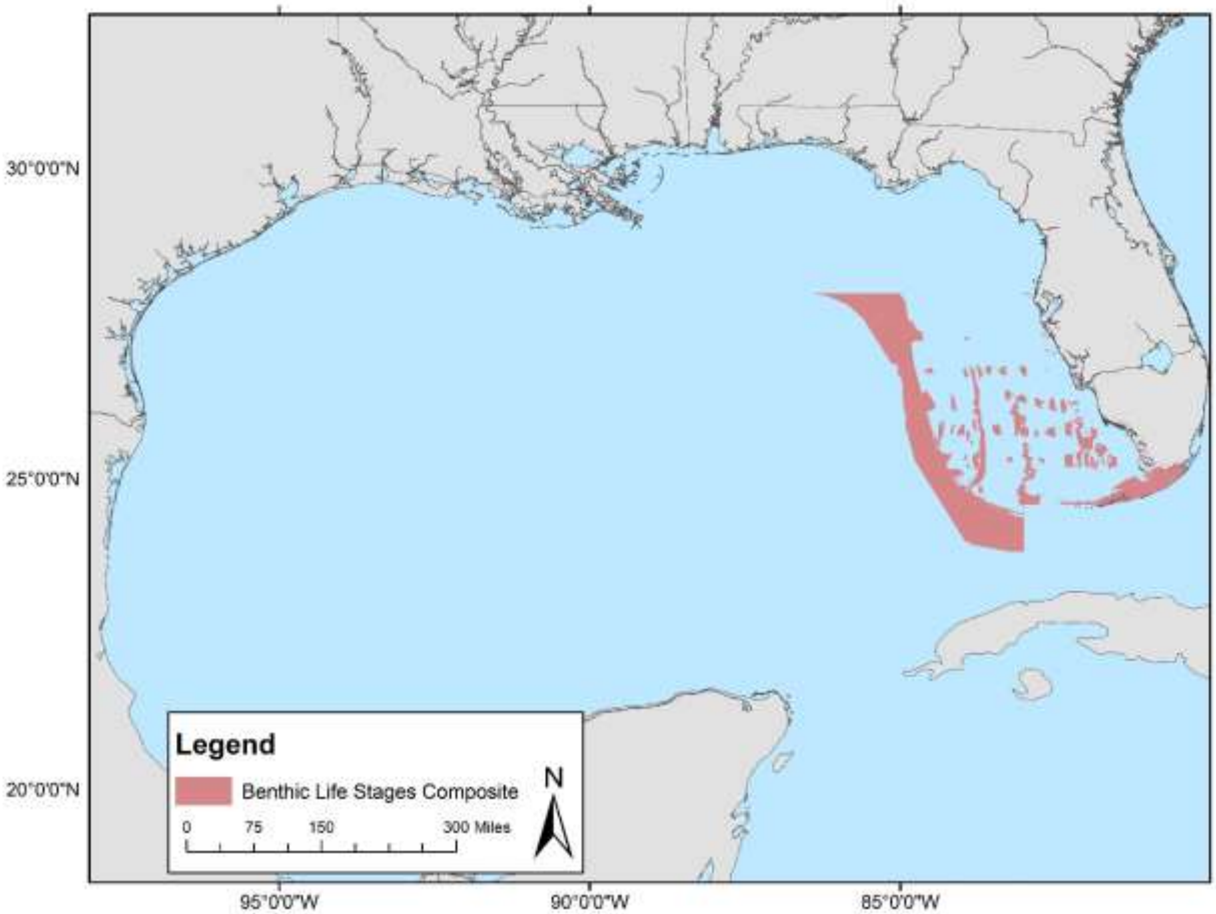

Figure 14. Map of benthic habitat use by all life stages of cubera snapper.

Gray Snapper (*Lutjanus griseus*)

Distribution

Gray or mangrove snapper occur in estuaries and shelf waters of the Gulf, and are particularly abundant off south and southwest Florida. 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 grass beds, 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 are marine, estuarine, and riverine dwellers, often found in estuaries, channels, bayous, ponds, grass beds, marshes, mangrove swamps, and freshwater creeks. They appear to prefer *Thalassia spp.* grass flats, marl bottoms, seagrass meadows, and mangrove roots (GMFMC 2004).

Summary of new literature review

The literature review for gray snapper yielded five studies that have contributed more information to knowledge about habitat use for the species. Allman and Goetz (2009) examined variations in population structure of gray snapper by region along the west Florida shelf. Fish were sampled from recreational and commercial fisheries. The oldest aged fish was 26 years. The authors estimated (Z) as 0.22 throughout the region for recreational and commercially sampled fish. Faunce and Serafy (2007) studied vegetated, nearshore habitat use by gray snapper and bluestriped grunt in southeastern Florida. The study showed that initial recruitment occurred from September through October, and collected individuals with lengths averaging 78 mm TL during that time. The authors concluded that juvenile gray snapper settle to and remain in seagrass beds for about 8 months (80-100 mm TL) after which they move into mangrove habitats. Fischer et al. (2005) studied age, growth, and mortality of gray snapper collected from recreational harvest at ports in Louisiana. The estimated life history parameters from this study were L_{inf} = 656.4 mm TL, k = 0.22, t_0 = 0, and maximum age = 28 years. The authors used catch curves to produce a Z = 0.17 and M was estimated at 0.15. They also found that recruitment to the fishery began at age 4, and the maximum fish age was 28. Kraus et al. (2007) conducted surveys to assess species and benthic habitat composition on Sonnier Bank and found that gray snapper occurred here at less than 31 m, and were one of the most abundant species in the snapper-grouper-grunt complex at this site. Powell et al. (2007) compiled a summary of information on life history, diet, abundance, and distribution of 46 species residing within Florida Bay. Within this literature summary, it was noted that male gray snapper mature at about 185 mm standard length (SL) and females at 200 mm SL (Starck and Schroeder 1970). Pre-settlement duration for gray snapper is 25-33 days (Allman and Grimes 2002; Tzeng et al. 2003; Lindeman 1997) and Allman and Grimes (2002) collected juvenile gray snapper from seagrass habitats with depths of 1-3 m and estimated a growth rate of 0.60-1.02 mm/day.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2 in offshore waters from June through September. They can be found in the water column above depths of 0-180 m (based on spawning adult distributions). They have a pre-settlement duration of 25-33 days.

Larvae:

Gray snapper larvae are found in ER-1 and ER-2 in offshore waters from April through November, with abundances peaking from June through August. They've been collected at temperatures of 15.6 to 27.2°C, and are found in the water column above depths of 0-180 m (based on spawning adult distributions). They have a pre-settlement duration of 25-33 days. In a lab setting, larvae prey on zooplankton, and their predators are carnivorous fish. Upon settling out of the water column, postlarvae inhabit SAV and feed on copepods and amphipods.

Juveniles: Early juveniles are found in ER-1 and ER-2 in estuarine waters with depths from 1-3 m and at temperatures of 12.8-36.0°C. Habitats used by early juveniles include SAV, mangroves, and emergent marsh. In southeastern Florida, gray snapper settle out of the water column from September to October at an average of 78 mm TL and are residents of SAV for about eight months before moving into mangrove habitats at lengths of 100-120+ mm TL. Juveniles have a growth rate of 0.60-1.02 mm/day. Late juveniles move into deeper waters, up to 180 m (based on adult distributions) with growth, and transition to adult habitat types. They feed on penaeid shrimp, crabs, fish, mollusks, and polychaetes.

Adults/Spawning Adults:

Adult gray snapper are found throughout the Gulf in estuarine, nearshore, and offshore waters with depths of 0-180 m and temperatures of 13.4-32.5°C. Gray snapper use hard bottom, soft bottom, reef, sand/shell, bank/shoal, and emergent marsh habitats. They feed on fish, shrimp and crabs. Recruitment to the fishery begins at age four, and the species has a maximum age of 28. Their life history parameters have been estimated at L_{inf} = 656.4 mm TL and k = 0.22, t_0 = 0, and maximum age = 28 years and mortality estimates are Z = 0.17-0.22 and M = 0.15. Spawning occurs year-round in south Florida and during the summer throughout the rest of the Gulf on reef and hard bottom habitats at depths from 0-180 m. Male gray snapper mature at 185 mm TL and females mature at 200 mm TL.

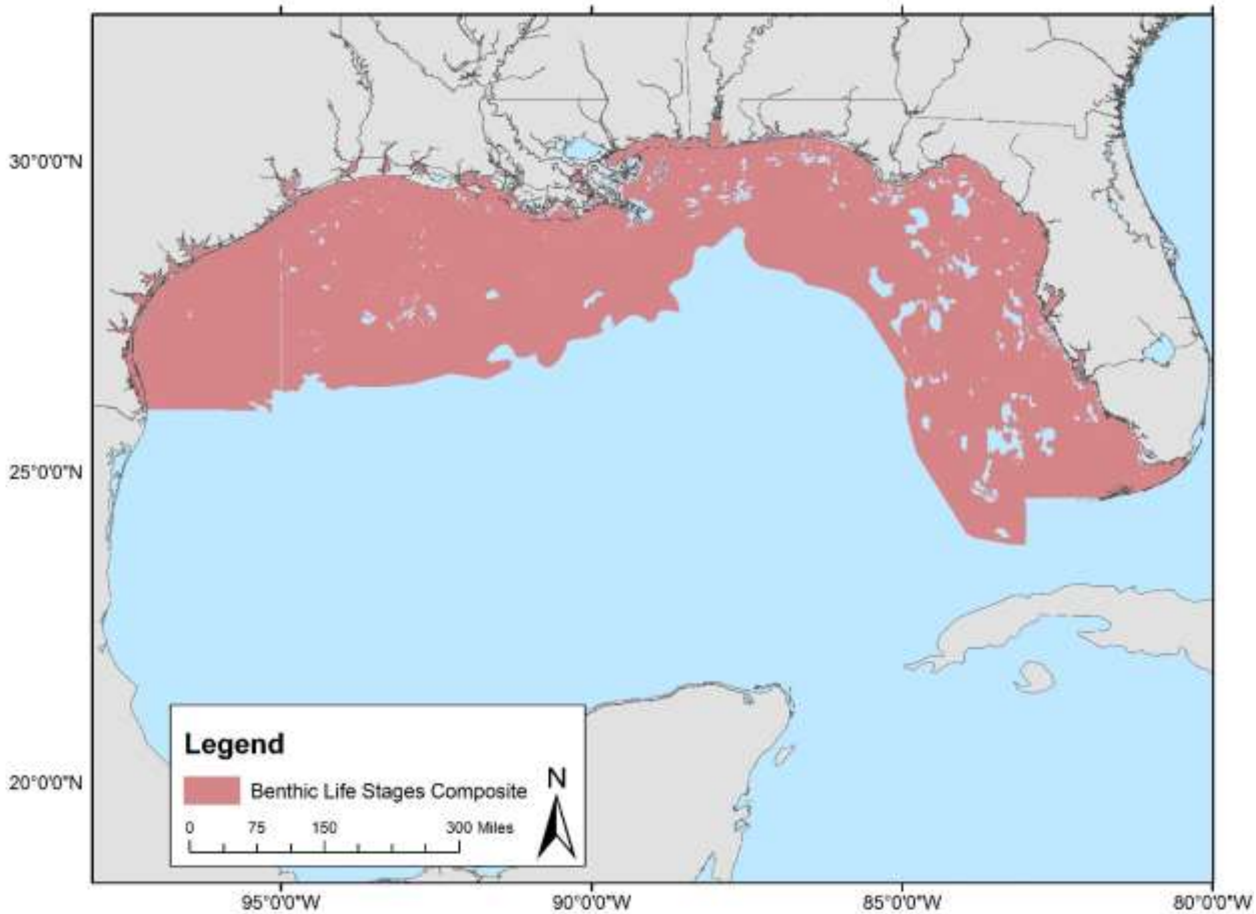

Figure 15. Map of benthic habitat use by all life stages of gray snapper.

Figure 16. Predicted length at age for male and female gray snapper collected from the waters off of Louisiana. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 656.40 mm TL, K = 0.22, t_0 = 0.00, and maximum age = 28 years (Fischer et al. 2005).

Lane Snapper (*Lutjanus synagris*)

Distribution

Lane snapper can be found throughout the Gulf, and also in the western Atlantic from North Carolina to southeastern Brazil. Juveniles and adults are found across most habitat types including SAV, sand/shell, reefs, soft bottom, banks/shoals, and mangroves. Adults occupy nearshore and offshore waters, at depths from 4-132 m and temperature of 16-29°C.

Summary of new literature review

New studies have been identified that address mortality and growth for several different lane snapper life stages. Most of these were conducted outside the Gulf. D'Alessandro et al. (2010) studied larval lane snapper in the Straits of Florida and found that most larvae were collected in the upper 50 m of the water column from June to August. They report a $Z = -0.429 \pm 0.053$ standard error (SE), a SL-age curve = 0.032 and K from 0.042-0.047 ± 0.008 SE for larvae collected from east and west sites along the Straits of Florida. Another study by D'Alessandro et al. (2013) collected larvae and juveniles in the lower keys on the Atlantic side at average water temperatures of 28.4-30.4°C, and found that larvae are subject to size-selective mortality, whereas juveniles undergo growth-selective mortality. Additionally, they reported a pelagic larval duration of 25.6 days, and back calculated spawning dates from 29 May to 29 July. Freitas et al. (2014) studied spawning adults on the Abrolhos Shelf in Brazil. They reported spawning occurring on reef and shelf edge habitat from February through March and September through October at depths of 30-70 m. In this location, 50% of females were estimated to be mature at 230 mm TL and 100% maturity at greater than 350 mm TL. Fifty percent of males were estimated to be mature at 242 mm TL and 100% at greater than 377 mm TL. Lastly, the authors assessed fecundity and found that females at 255 mm TL had less than 104,749 oocytes/female and those at 560 mm TL had 568,400 oocytes/female. The last study from outside the Gulf, Lindeman et al. (1998), documented juveniles on the east coast of Florida utilizing mangrove habitat. One study was identified with research conducted in the Gulf that added to the existing knowledge of lane snapper habitat utilization. Mikulas and Rooker (2008) studied juveniles in eco-regions ER 4-5 on bank (hard bottom) habitats with depths from 8-24 m, temperatures of 28-29.5°C, salinities of 30-35.5 ppt, and dissolved oxygen (DO) concentrations of 4.4-5.7 mg/L. They calculated a daily Z = 0.097-0.165 and growth rates of 0.9-1.3 mm/d. They reported a minimum settlement length of 15.1 mm SL and minimum settlement age of 25 days, with back calculated hatch dates of early May to late August. SEDAR 49 DW (2016) estimated life history parameters for adult lane snapper as L_{inf} = 449 mm FL, K = 0.17, t_0 = -2.59, and maximum age = 19 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs can be found throughout the Gulf in offshore waters. They are WCA with depths presumed to be from 4-132 m based on other life stages. They are found seasonally from March through September, peaking in July and August

Larvae:

Larvae are found throughout the Gulf. Based on research conducted outside Council's jurisdiction, they occupy the water column early on, then settle to SAV. They are found at depths from 0-50 m, and at average temperatures of 28.4-30.4°C, and are prevalent from June through August. In the Straits of Florida, Z = -0.429 ± 0.053 SE, SL-age curve = 0.032, and K from 0.042-0.047 ± 0.008 SE. They are thought to be subject to size-selective mortality, and have an average pelagic larval duration of 25.6 days. In the lab, they fed on plankton and rotifers, and experienced death by day 10 at 25°C.

Juveniles:

Juveniles are found throughout the Gulf from late summer through early fall at temperatures of 28-29.5°C and depths from 0-24 m. Other reported environmental parameters include salinities of 30-35.5 ppt and DO of 4.4-5.7 mg/L. They occupy a variety of habitats including SAV, sand/shell, reefs, soft bottom, banks/shoals, and mangroves (outside the Gulf) and feed on copepods, grass shrimp, and other small inverts. Mortality estimates are Z = 0.097-0.165 and growth rates of 0.9-1.3 mm/d, with a reported minimum settlement length of 15.1 mm SL and minimum settlement age of 25 days. A study outside the Gulf suggest that juvenile lane snapper are subject to growth-selective mortality.

Adults/Spawning Adults:

Adults and spawning adults are found throughout the Gulf. Adults use nearshore and offshore waters with depths from 4-132 m and at temperatures of 16-29°C. They occupy sand/shell, hard bottom, reef, and bank/shoal habitats, and prey on fish, crustaceans, annelids, mollusks, and algae. Mortality estimates include Z = 0.38-0.58 and M = 0.11-0.24. Maximum age and maximum length are 19 years and 673 mm TL with males growing faster and larger than females. Life history parameter estimates are L_{inf} = 449 mm FL, k = 0.17, t_0 = -2.59. Adults spawn from May to August and use offshore waters. Studies from outside the Gulf have documented spawning aggregations on reefs and shelf edge/slope habitats at depths of 30-70 m. At the Abrolhos Shelf in Brazil, 50% of females are estimated to be mature at230mm TL and 100% maturity at greater than 350 mm TL. Fifty percent of males are estimated to be mature at 242 mm TL and 100% at > 377 mm TL. Lastly, fecundity estimates for females at 255 mm TL were < 104,749 oocytes/female and those at 560 mm TL were 568,400 oocytes/female. While not considered EFH at this time, adults have been identified on artificial reefs.

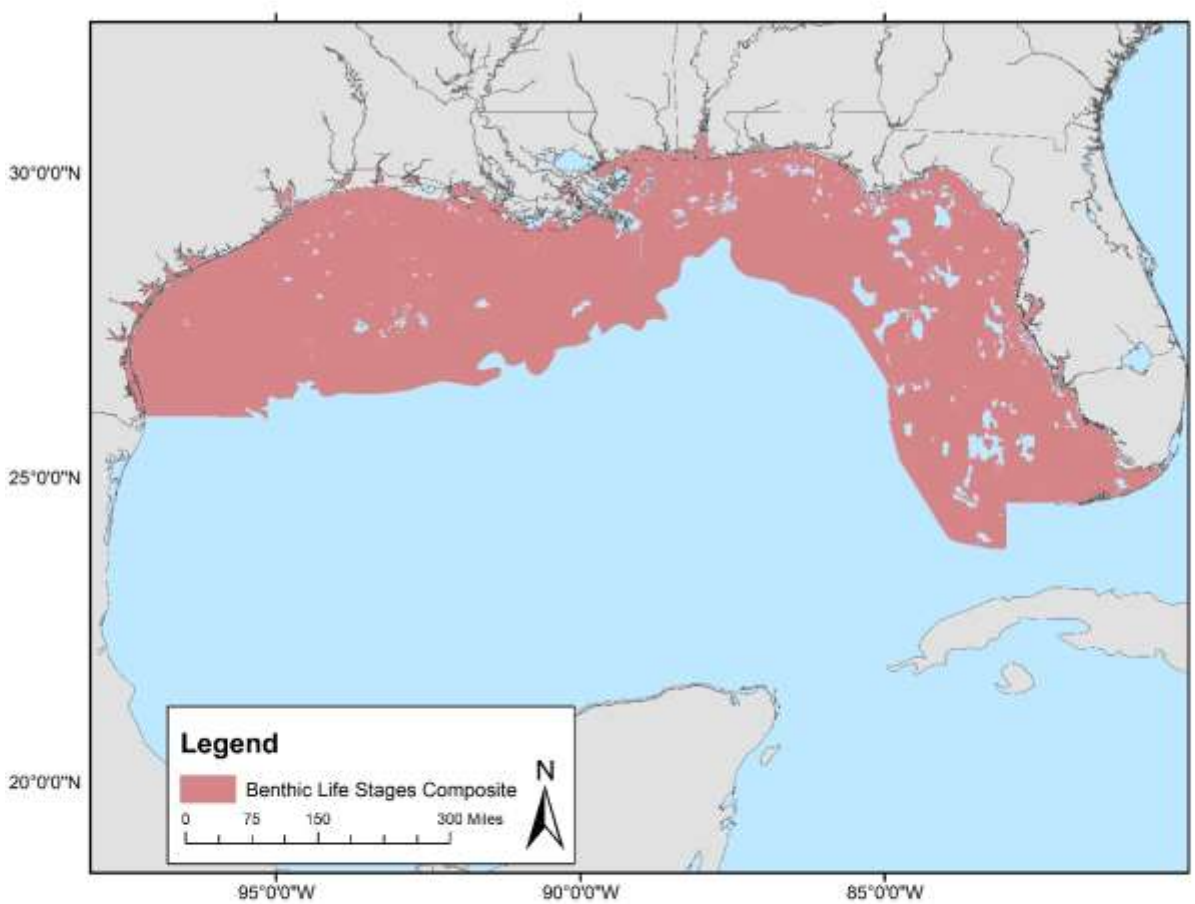

Figure 17. Map of benthic habitat use by all life stages of lane snapper.

Figure 18. Predicted length at age for all lane snapper collected in the northern Gulf and Bermuda. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 449 mm FL, K = 0.17, t_0 = -2.59, and maximum age = 19 years (SEDAR 49 DW Report 2016).

Silk Snapper (*Lutjanus vivanus*)

Distribution

Silk snapper are found across the Gulf, but are most common off southwestern Florida. Silk snapper is a deeper water species that occupies offshore waters and are found near the edge of continental and island shelves, usually ascending to shallower waters at night. It is common between 90 and 140 m, but can be found in waters greater than 200 m. Juveniles are found in shallower water than adults. Very little habitat information is known about life stages other than adults.

Summary of new literature review

Several new studies were found during the literature review and in some cases, more information from previously ascertained literature was added. Ault et al. (1998) use fishery-independent dive surveys and fishery-dependent headboat catches to estimate fishing mortality and life history parameters for 35 economically and ecologically important species in the Florida Keys. For silk snapper, M = 0.230, L_{inf} = 781.1 mm total length (TL), K = 0.092, t_0 = -2.309, and maximum age = 9 years. Allen (1985) was cited previously in the environmental impact statement (2004) habitat association tables, and here more information was added about prey items. They include fish, shrimp, crabs, gastropods, cephalopods, tunicates, and urochordates. Studies from Jamaica and Puerto Rico examined spawning adult silk snapper and found that 50% of females were estimated to be mature at 500-550 mm FL and 50% of males at 380-600 mm FL (Boardman and Weiler 1979; Thompson and Munro 1973). Sylvester and Damman (1973) collected silk snapper from the Virgin Islands in order to ascertain more information on their depth distribution, relative abundance, and length frequency distributions. They collected silk snapper from both hard bottom and soft bottom habitat types during their study. Lastly, Rivas (1970) reported geographical, depth and temperature information for 11 species of snapper in the western Atlantic, and found silk snapper in temperature of 13-27°C

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occupy offshore waters with depths between 90-200 m (based on adult distribution) year-round in ER-1.

Larvae:

Larvae occupy offshore waters with depths between 90-200 m (based on adult distribution) year-round in ER-1.

Juveniles:

Juveniles occupy offshore waters with depths between 30-40 m (based on a study in the Caribbean). Early juveniles are found year-round. Late juveniles feed on fish, shrimp and crabs, and are preyed on by sharks, grouper, and barracuda. They are primarily found in ER-1

Adults/Spawning Adults:

Adults and spawning adults are found in offshore waters in ER-1. They occupy depths of 90-200 m (based on adult distribution). Their predators include sharks, grouper and barracuda. Adults prey on fish, shrimp, crabs, gastropods, cephalopods, tunicates, and urochordates. They use shelf edge/slope habitats, soft bottom, and hard bottom habitats in the U.S. Virgin Islands. In the western Atlantic they can be caught in water temperatures from 13-27°C. Mortality and life history estimates are as follows: M = 0.230, L_{inf} = 781.1 mm, K = 0.092, t_0 = -2.309, and maximum age = 9 years. Spawning adults prey on fish, shrimp and crabs, they spawn year-round, peaking from July to August. In the Caribbean, 50% maturity in female fish is estimated to occur between 500-550 mm FL and in males between 380-600 mm FL.

Figure 19. Map of benthic habitat use by all life stages of silk snapper.

Figure 20. Predicted length at age for all silk snapper collected in the Florida Keys. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 781.10 mm TL, K = 0.09, t_0 = -2.31, and maximum age = 9 years (Ault et al. 1998).

Yellowtail Snapper (*Ocyurus chrysurus*)

Distribution

Yellowtail snapper are distributed throughout the shelf area of the Gulf, but are most common off central and southern Florida. This species occurs over hard, irregular bottoms, such as coral reefs and near the edge of shelves and banks. Spawning occurs February through October (peaks from February to April and September to 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 spp.* 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 (GMFMC 2004).

Summary of new literature review

The literature review resulted in several new studies that contributed to the previous information gathered on habitat use for yellowtail snapper. First, Ault et al. (2014) examined ecological indicators of fishing impacts on exploited populations, specifically hogfish, black grouper, and yellowtail snapper. The two indicators examined were catch per unit effort and average size (length or weight), from which they estimated fishing mortality for the three aforementioned species. For yellowtail snapper, their estimations of annual fishing mortality fell between 0.22-0.25. Next, Bartels and Ferguson (2006) collected early juvenile yellowtail snapper in seagrass beds on the Atlantic side of the Middle Florida Keys. Few yellowtail snapper were collected, despite this, the sample site depths varied from 0.3-1.2 m and this information was added to the collection of habitat information because no other information was found describing depths occupied by early juveniles. Larvae were studied by D'Alessandro et al. (2010) and D'Alessandro et al. (2013). D'Alessandro et al (2010) examined larval distribution and ecology in the Straits of Florida. For larval yellowtail snapper, 118 fish were collected, primarily from the upper 25 m of the water column. Instantaneous growth rate was estimated as $K = 0.048 \pm 0.007$ from the western Straits and 0.41 ± 0.009 from the eastern Straits. The other larval study, D'Alessandro (2013) sampled multiple cohorts of three species of lutjanids in the Florida Keys to examine drivers of mortality during early life stages. Information of particular interest for habitat utilization purposes was the average pelagic larval duration for yellowtail snapper of 25.3 days. A stock assessment (SEDAR 27A 2012) on yellowtail snapper was conducted by the Florida Fish and Wildlife Conservation Commission (FWC). The maximum age of yellowtail snapper used in the stock assessment was 23 years. SEDAR 27A (2012) cited McClellan and Cummings (1998) who reported that spawning occurred most typically from April to August. Fifty percent of females were estimated to be mature at 232 mm TL and 1.7 years old. The estimated constant rate M was 0.194. Lastly, life history parameters were estimated at $L_{\text{inf}} = 618.0$ mm TL, $K = 0.133$, and $t_0 = -3.132$. A study by Trejo-Martínez et al. (2010) caught yellowtail snapper on a monthly basis off of Campeche Bank from February 2008 through January 2008. Various spawning metrics were reported by the authors, one of which was an estimation of 50% of males are mature at 194 mm FL. Lastly, Watson et al. (2002) conducted visual censuses of juvenile yellowtail snapper in the British Virgin Islands. In this study they reported on settlement, movement and early juvenile mortality. They noted that early juveniles (< 80 mm TL) were observed in seagrass, but did not observe them on rocky hard bottom habitat where older juveniles were observed.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2 in nearshore and offshore waters from February through October. They can be found in the water column above depths of one to 183 m (based on adult depth distributions).

Larvae:

Larvae and postlarvae are found in ER 1-2 in nearshore and offshore waters. They inhabit the water column above depths of one to 183 m (based on adult depth distributions). In the western Straits of Florida, K was estimated as 0.048 ± 0.007; and in the eastern Straits as 0.41 ± 0.009. Pelagic larval duration for yellowtail snapper averages 25.3 days.

Juveniles:

Early juveniles are found in ER 1-2 in estuarine and nearshore waters. They occupy SAV and mangroves in the fall at temperatures of 24-30°C and depths of 0.3-1.2 m (in the South Atlantic). They feed on zooplankton. Late juveniles are also found ER 1-2 in estuarine and nearshore waters. However, with growth they move out of the SAV and mangroves, and onto reefs and hard bottom (based on a study in the British Virgin Islands) at temperatures of 24-30°C, and depths of one to 183 m (based on adult depth distributions). Late juvenile yellowtail snapper also prey on zooplankton.

Adults/Spawning Adults:

Adult yellowtail snapper are found in ER 1-2 in nearshore and offshore waters on reefs and hard bottom habitats. They've been collected at temperatures of 18-34°C and depths of one to 183 m. They prey on benthic and pelagic reef fish, crustaceans, and mollusks. One study reports an estimated fishing mortality of 0.22-0.25/yr and *M* of 0.194. Yellowtail snapper reach a maximum observed age of 23 years, and their life history parameters have been estimated as L_{inf} = 618.0 mm TL, K = 0.133, and t_0 = -3.132. Spawning occurs from April through August. Length at 50% maturity for females was estimated at 232 mm TL and age is 1.7 years, and length at 50% maturity for males was estimated at 194 mm FL (based on a study conducted on Campeche Bank). Also, females with hydrated oocytes have been found from May through September.

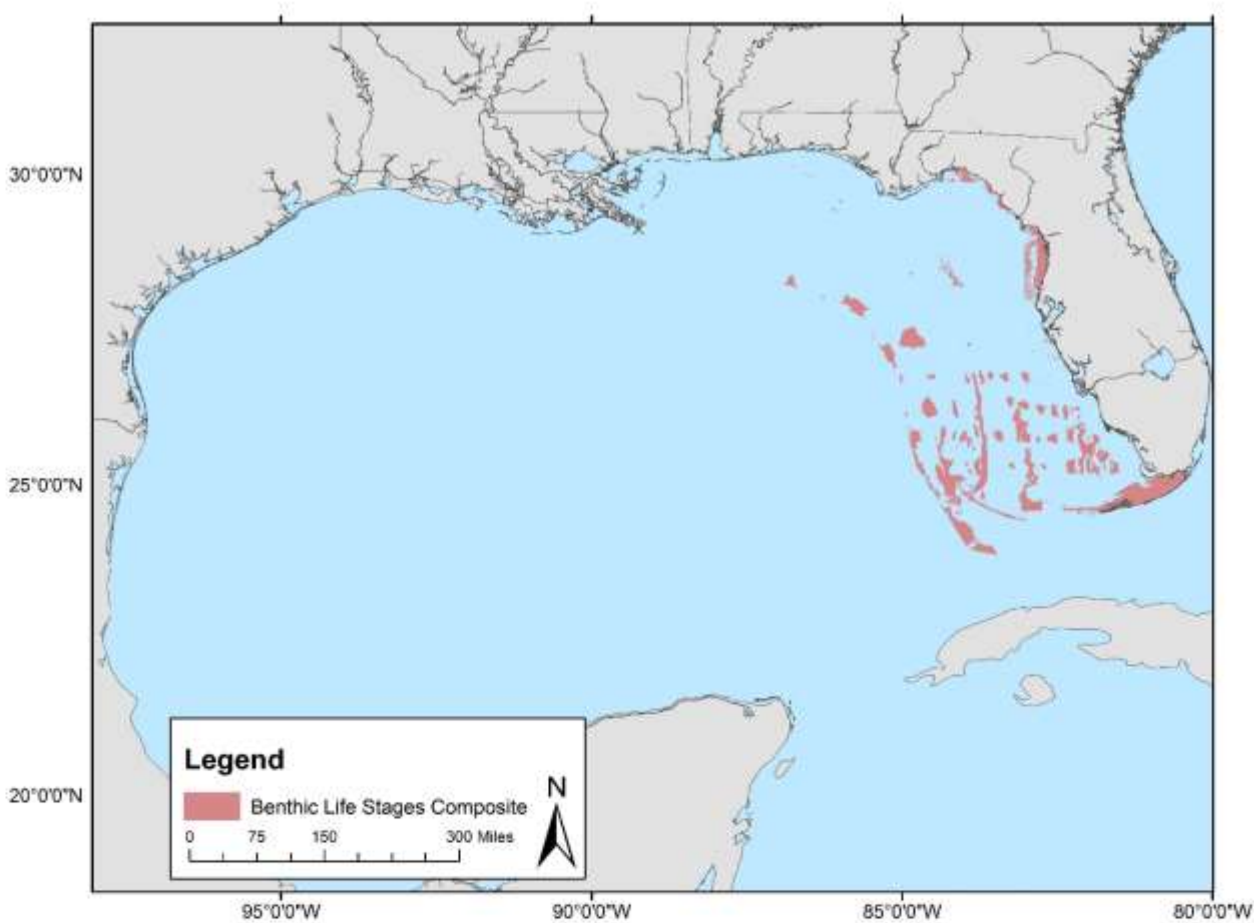

Figure 21. Map of benthic habitat use by all life stages of yellowtail snapper.

Figure 22. Predicted length at age for all yellowtail snapper collected in the south Atlantic and Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 618 mm TL, K = 0.13, t_0 = -3.13, and maximum age = 23 years (SEDAR 27A 2012).

Wenchman (*Pristopomoides aquilonaris*)

Distribution

Found throughout the Gulf, wenchman occupy hard bottom habitats of the mid to outer shelf where they feed mainly on small fish. They are found at depths ranging from 19-481 m, but are most abundant between 80-200 m. They occupy waters with temperatures of 9.1-28.7°C, salinities of 28.2-36.6 ppt and DO concentrations of 3.4-8.0 mg/L (GMFMC 2004).

Summary of new literature review

Very little is known about habitat utilization by wenchman, particularly larval and juvenile life stages. Two new studies were found during literature review that added to our understanding of wenchman habitat distribution. Anderson et al. (2009) studied the age and growth of wenchman in the northern Gulf. They estimated the following life history parameters: L_{inf} = 240 mm FL, K = 0.18, t_0 = -4.75, and maximum age (in otolith increments) = 14. Grace et al. (2010) summarized fishery-independent bottom trawl survey data for deep-water fish and invertebrates in the Gulf. They caught a total of 68,327 wenchman at depths from 48-481 m (mean = 136 m), temperatures from 9.1-28.7°C (mean = 18.0°C), salinities of 28.2-36.6 ppt (mean = 36.1 ppt), and DO concentrations of 3.4-8.0 mg/L (mean = 4.2 mg/L).

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 3-5 in offshore waters. They are WCA above depths of 80-200 m (based on spawning adult distributions). They've been collected in the summer at 20°C.

Larvae:

Larvae are found in ER 3-5 in offshore waters. They are WCA above depths of 80-200 m (based on spawning adult distributions) during the summer.

Juveniles:

Juveniles are found in ER 3-5 in offshore waters at depths of 19-481 m (based on adult distributions).

Adults/Spawning Adults:

Adults and spawning adults are found in ER 3-5 in offshore waters. Adults occupy hard bottom and shelf edge/slope habitat at year-round depths of 19-481 m and temperatures of 9.1-28.7°C. They feed on small fish and have life history parameters of L_{inf} = 240 mm FL, K = 0.18, t_0 = -4.75, and maximum age (in otolith increments) = 14. Spawning adults occupy shelf edge/slope habitats during the summer at depths of 80-200 m and have been collected from water with a temperature of 20°C.

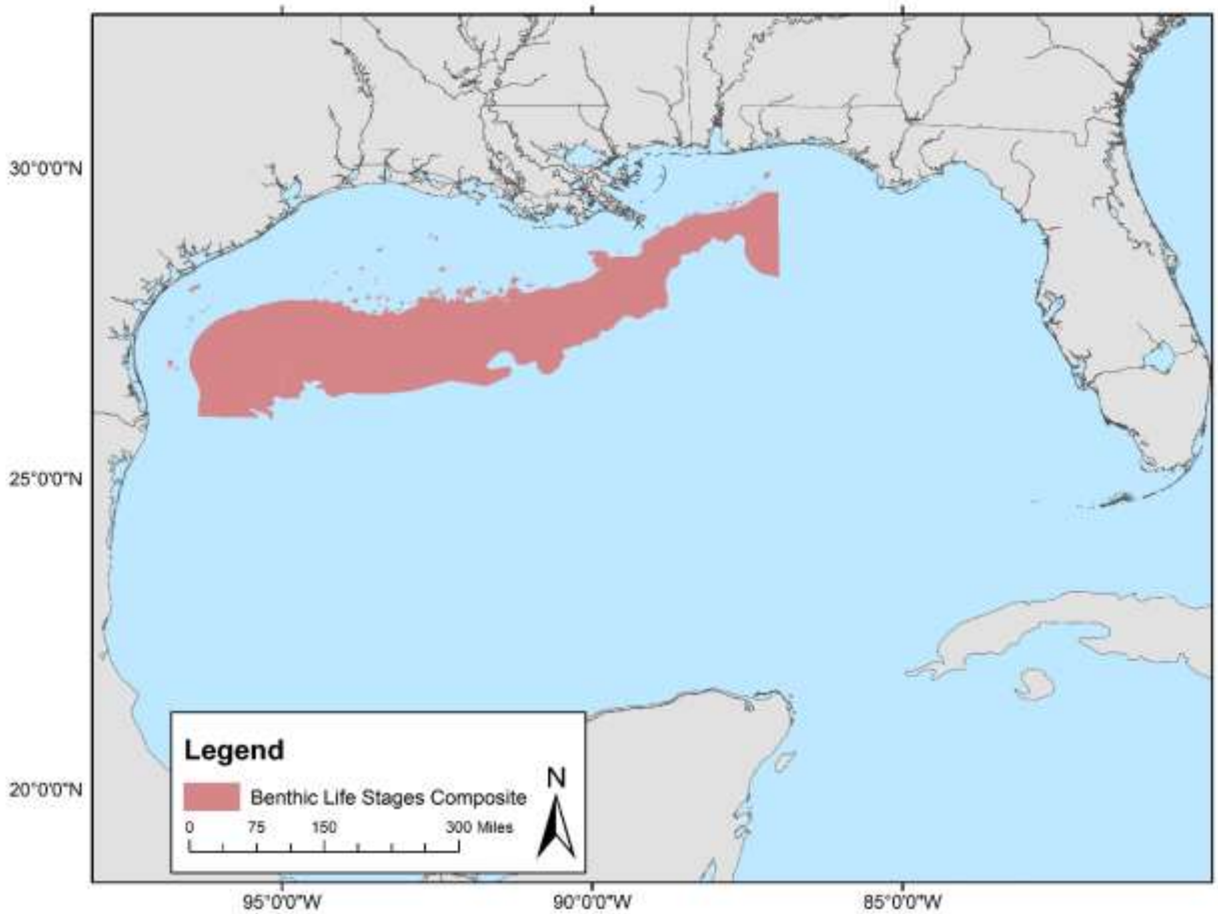

Figure 23. Map of benthic habitat use by all life stages of wenchman.

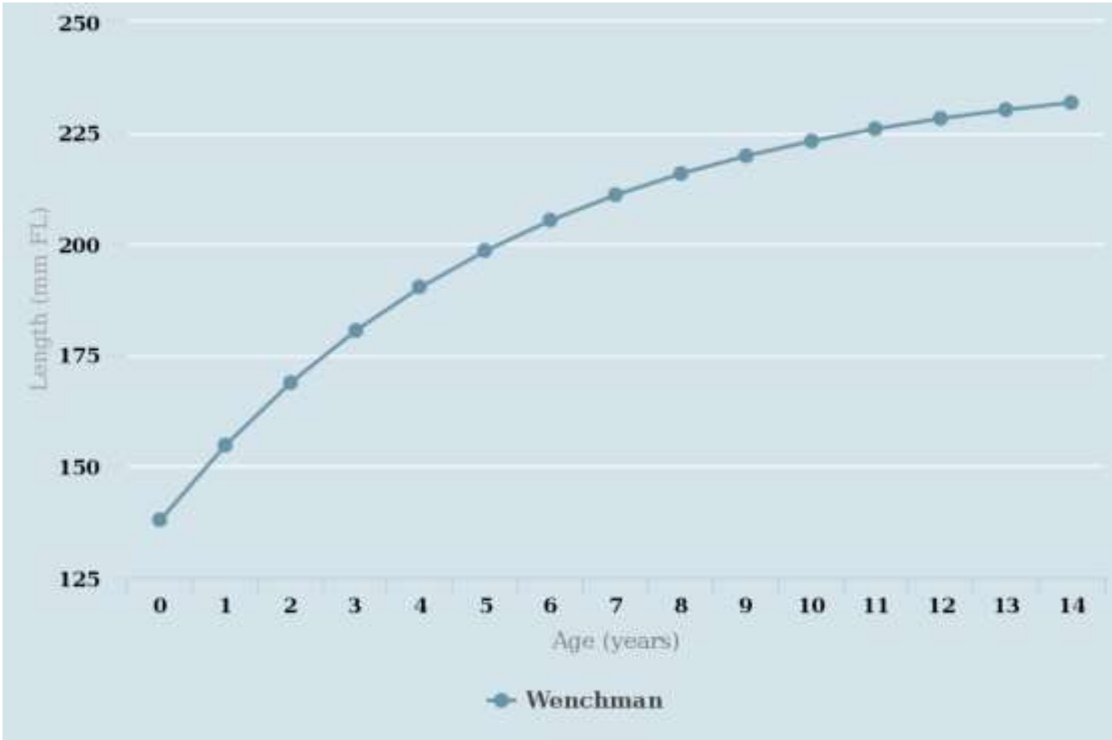

Figure 24. Predicted length at age for all wenchman collected in the northern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 240 mm FL, K = 0.18, t_0 = -4.75, and maximum age = 14 years (Anderson et al. 2009).

Vermilion Snapper (*Rhomboplites aurorubens*)

Distribution

Vermilion snapper are found throughout the shelf areas of the Gulf, but are most common off west Florida. The species is demersal, occurring over reefs and rocky bottom from depths of 18 to 100 m. Spawning occurs from May to September in offshore waters. Juveniles occupy reefs, underwater structures and hard bottom habitats at depths of 18 to 100 m.

Summary of new literature review

No habitat association tables were available for vermilion snapper when starting this review. Therefore all information incorporated here is new. One study was found that examined larval distribution and ecology for several snapper species in the Straits of Florida (D'Allessandro et al. 2010). A majority of vermilion snapper larvae were collected at depths of 30-40 m, in the water column. The highest abundances of vermilion were collected from June through November. Fecundity estimates were made by Grimes and Huntsman (1980) from fish collected off of the Carolinas. The estimations ranged from 8,168 to 1,789,998 ova/female (3-8 years old and 136-2,293 g). Dahl and Peterson (2010) studied density and diet of invasive lionfish in the northern Gulf. They found that juvenile vermilion snapper were a primary diet item of lionfish at artificial reef sites. The remainder of the studies summarized here were conducted on adult vermilion snapper. Baras et al. (2014) studied residency times of benthic fish at artificial reefs off the coast of Georgia. Vermilion were observed year-round, but most prevalent from July through September. During the study, temperatures ranged from 16.4 - 26.2°C, and salinities ranged from 32.7 - 36.3 ppt. Johnson et al. (2010) studied several life history parameters in vermilion collected between Pensacola, Florida and Gulfport, Mississippi from fishery dependent and fishery independent sources. The authors estimated Z as 0.39 ± 0.05 (mean ± SE). The diet portion of the study identified benthic tunicates and amphipods as the most important prey items for vermilion snapper. There was also evidence of cannibalism on juveniles. Kraus et al. (2006) characterized the habitat and species diversity on Sonnier Bank in the northwestern Gulf, and observed aggregations of vermilion snapper, in addition to other exploited reef fish. Hood and Johnson (1999) studied life history of vermilion snapper in the eastern Gulf. Fish collected for this study were spawning from May to September (based on gonadosomatic index values). On the west Florida shelf, adult vermilion snapper were most prevalent at depths of 60-100 m on reef and hard bottom habitats (Saul et al. 2013). Allman (2007) studied spatial variation in vermilion snapper from the northeast Gulf. The author studied snapper sampled from seven low relief, natural limestone bottom reefs sites at depths of 30-68 m, over a two year period. It was noted that deep sites had older fish and the author suggests this could be due to an ontogenetic shift, or influenced by heavier fishing pressure that occurs closer to shore. A diet study by Grimes (1979) reported that early juveniles primarily consumed copepods and nematodes, intermediate juveniles consumed fish scales and copepods, and late juveniles and adults consumed small pelagic crustacea and cephalopods. Lastly, SEDAR 45 (2016) estimated life history parameters for vermilion snapper in the Gulf as follows: L_{inf} = 344 mm FL, K = 0.3254, and t_0 = -0.7953, and maximum age = 26 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found throughout the Gulf in offshore waters and are WCA above water depths of 18-100 m (based on adult distributions).

Larvae:

Larvae are found throughout the Gulf in offshore waters and are WCA. In the Straits of Florida, they are most abundant from June through November and are collected at depths of 30-40 m

Juveniles:

Juvenile vermilion are found throughout the Gulf in nearshore and offshore waters at depths of 18-100 m (based on adult distributions). They occupy hard bottom and reef habitat types, and a predator includes the invasive lionfish and likely other larger reef fish.

Adults/Spawning Adults:

Adult vermilion snapper are found throughout the Gulf in nearshore and offshore waters with depths of 18-100 m. They occupy bank/shoal, reef, and hard bottom habitats. Off the coast of

Georgia, vermilion are found on these habitats year-round at temperatures of 16.4-26.2°C and salinities of 32.7-36.3 PSU. They prey on benthic tunicates, amphipods, and cannibalize juveniles (rare). Instantaneous total mortality has been estimated as Z = 0.39 ± 0.05 (mean ± SE) and life history parameters are L_{inf} = 344 mm FL, k = 0.3254, and t_0 = -0.7953, and maximum age = 26 years. Spawning occurs from May through September.

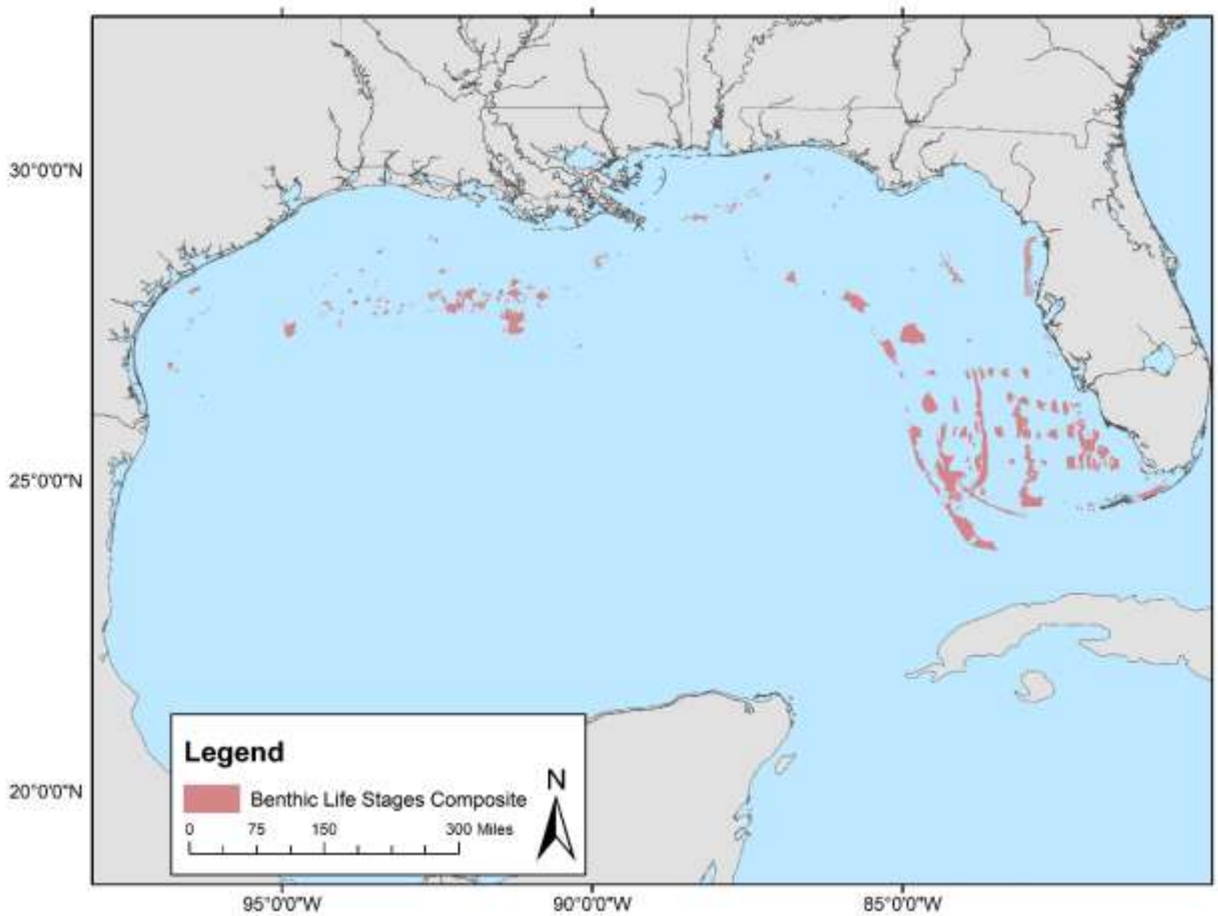

Figure 25. Map of benthic habitat use by vermilion snapper.

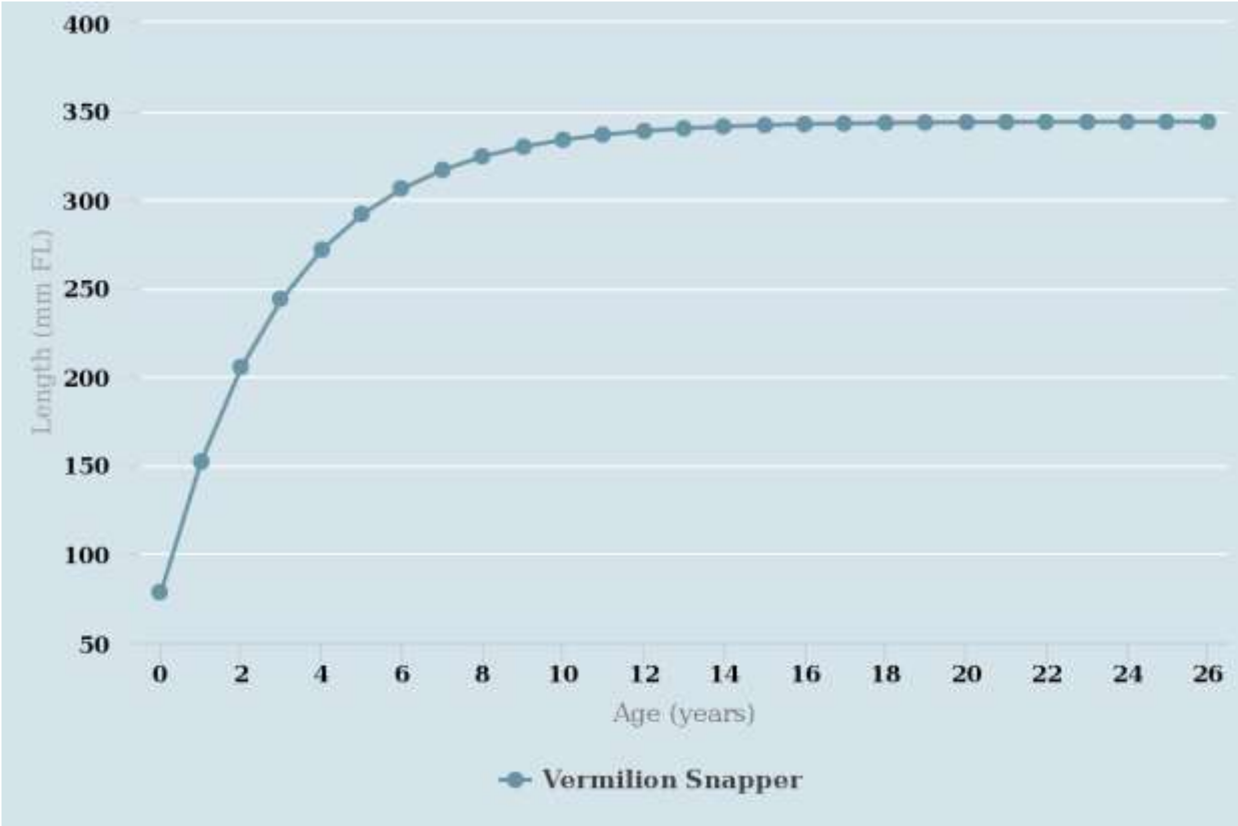

Figure 26. Predicted length at age for both sexes of vermilion snapper from the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 344.0 mm FL, K = 0.33, t_0 = -0.80, and maximum age = 26 years (SEDAR 45 2016).

Speckled Hind (*Epinephelus drummondhayi*)

Distribution

The speckled hind is a deep water grouper distributed in the north and eastern Gulf on offshore hard bottom habitats, including rocky bottoms, and both high and low profile hard bottoms. Adults are considered to be an apex predator on mid shelf reefs, feeding on a variety of fishes, invertebrates and cephalopods. They occur between 25-183 m and are most common at 60-120 m depth. Juveniles are most commonly found in the shallow portion of the depth range (GMFMC 2004).

Summary of new literature review

Very few studies have been conducted on life history or habitat use by speckled hind, particularly in the Gulf. Bryan et al. (2013) used remotely operated vehicles to survey low-relief substrate and high relief vessel (artificial) reefs off southeast Florida. During their surveys they noted juvenile speckled hind on vessel reefs. Koenig et al. (2005) examined habitat and fish populations on deep-sea *Oculina* coral habitat off the coast of Florida, and found juvenile speckled hind occupying intact coral habitat on Jeff's and Chapman's reefs within the Experimental *Oculina* Research Reserve. The authors suggest that this habitat type may act as a nursery area for speckled hind and possibly other species of commercial importance. Lastly, Ziskin et al. (2011) estimated a variety of life history parameters in adult and spawning adult speckled hind from fish collected during fishery-independent surveys and commercial catches in the western Atlantic from 1977-2007. The oldest and largest fish caught were 35 years and 973 mm TL, respectively. The authors estimated mortality from 2004-2004 as follows: $M = 0.13$, $F = 1.14$, and $Z = 1.27$. Life history parameters were estimated as $L_{\text{inf}} = 888$ mm TL, $K = 0.12$, $t_0 = -1.8$, and maximum age = 45 years (SEDAR 49 DW 2016). Fifty percent of females were estimated to be mature at 532 mm TL and 6.6 years. Speckled hind underwent 50% transition at 627 mm TL and 6.9 years, and spawning adults were caught at depths from 44-183 m.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in offshore in ER 1-2. They are WCA, presumably above depths of 44 m (from on a study from the western Atlantic) to 183 m, based on depth occupied by spawning adults.

Larvae:

Larvae are found offshore in ER 1-2. They are WCA, presumably above depths of 44 m (from on a study from the western Atlantic) to 183 m, based on depth occupied by spawning adults.

Juveniles:

Juveniles are found offshore in ER 1-2 at depths of 25-183 m, based on adult distributions. A study from southeast Florida suggests that reefs may act as nursery habitats for juvenile speckled hind.

Adults/Spawning Adults:

Adults and spawning adults are found offshore in ER 1-2. Adults use hard bottom habitat at depths of 25-183 m. They prey on fish, cephalopods and other invertebrates. They are threatened by overfishing and have mortality estimates as follows: $M = 0.13$, $F = 1.14$, and $Z = 1.27$ (based on a study in the western Atlantic). They recruit to the fishery between ages 6-7. From a study in the western Atlantic, maximum age is 35 years and maximum length is 973 mm TL. Life history parameters estimated in SEDAR 49 DW (2016) are $L_{\text{inf}} = 888$ mm TL, $K = 0.12$, $t_0 = -1.8$, and maximum age = 45 years. Spawning adults use shelf edge/slope habitats and spawn from April through May and July through September at depths of 44 m (in the western Atlantic) to 183 m. Fishing can affect sex ratio and spawning biomass, and males are rare. Speckled hind are protogynous hermaphrodites, and females caught in the western Atlantic reached 50% maturity at 532 mm TL and 6.6 years, and underwent 50% transition at 627 mm TL and 6.9 years. Lastly, females can produce up to 2 million eggs in one spawning.

Figure 27. Map of benthic habitat use by all life stages of speckled hind.

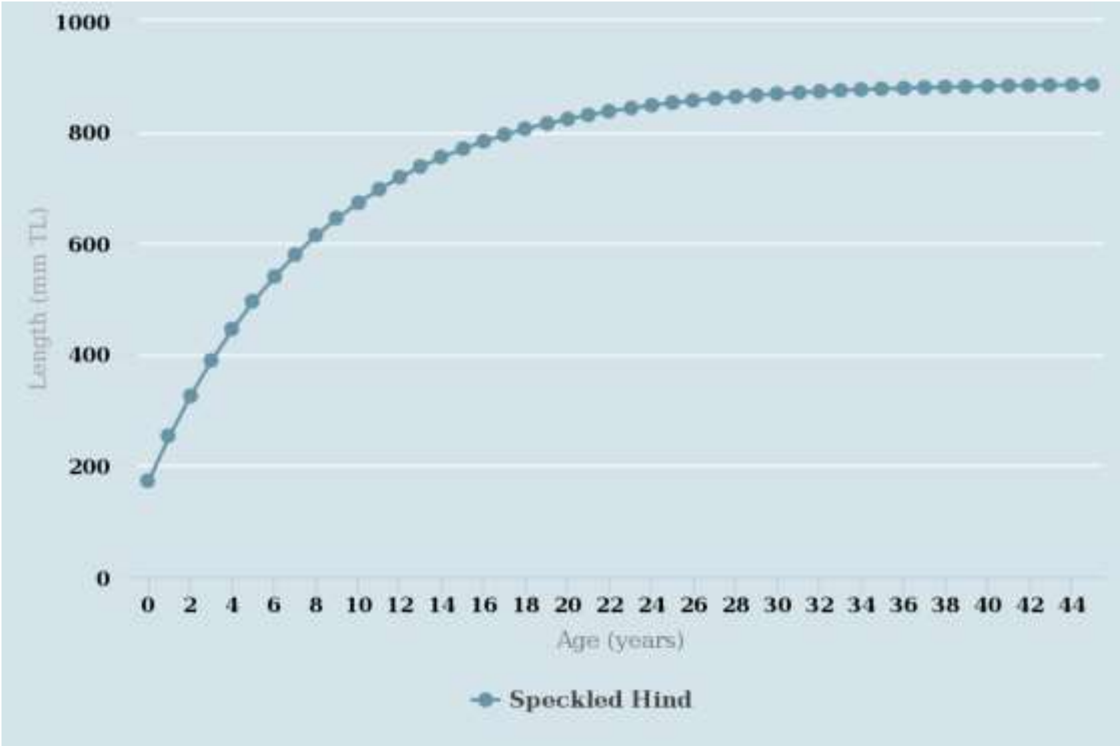

Figure 28. Predicted length at age for both sexes of speckled hind from the southeastern United States. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 888 mm TL, K = 0.12, t_0 = -1.80, and maximum age = 45 years (Ziskin et al. 2011).

Goliath Grouper (*Epinephelus itajara*)

Distribution

Goliath grouper are a protected species found in the shallow waters of the Gulf, and are most abundant on the southwest Florida and Campeche Banks. Younger adults are found inshore around docks, bridges and jetties, and reef crevices, while large adults prefer offshore ledges and wrecks. The species depth range in the Gulf is to 95 m, with the highest abundance at 2-55 m. Early juveniles are found in bays and estuaries, inshore grass beds, canals, and mangroves. Larger juveniles are also found around ledges, reefs, and holes in shallow waters. Spawning occurs from June to December, with peaks between July and September. Spawning occurs off southeast and southwest Florida, and other parts of the Gulf around offshore structures, wrecks and patch reefs (i.e. high-relief structures). Spawning aggregations can contain 10-150 individuals and have been reported from depths of 36-46 m (GMFMC 2004).

Summary of new literature review

Two scientific publications were found during literature review that added to the habitat information available for goliath grouper. Koenig et al. (2007) examined goliath grouper use of mangrove habitat. The study was conducted in Ten Thousand Islands, Everglades National Park, and Florida Bay. Sample locations had water depths less than 0.1 to 2.0 m. They found a juvenile growth rate in recaptured fish of 0.300 mm/day, and that emigration from mangrove habitat occurred between ages five and six. Another study on juvenile goliath grouper was conducted by Lara et al. (2009). Their study location was in the Ten Thousand Islands region. Otolith analyses revealed that goliath grouper have a pelagic larval duration of 30-80 days. Updated life history parameters were estimated as L_{inf} = 2221 mm total length (TL), k = 0.0937, t_0 = -0.6842 (SEDAR 23 2011), and maximum age = 37 years (Bullock et al. 1992)

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs can be found in ER-1 and ER-5 in offshore waters at depths of 36-46 m (based on spawning adult distributions) during late summer and early fall. They are water column associated.

Larvae:

Larvae are can be found in ER-1 and ER-5 in offshore waters at depths of 36-46 m (based on spawning adult distributions) during late summer and early fall. They are WCA, and have a pelagic larval duration of 30-80 days. Postlarvae recruit to mangroves with age.

Juveniles:

Early juvenile goliath grouper are found in ER-1 and ER-5 in estuarine and nearshore waters with depths of less than 1 to 5 m. They use submerged aquatic vegetation, mangrove, and emergent marsh habitat types, and have a growth rate of about 0.300 mm/day. Prey include crustaceans. Late juveniles emigrate from mangroves between ages five and six, after which they use reefs and hard bottom habitat. Late juveniles feed on crustaceans.

Adults/Spawning Adults:

Adult goliath grouper are found in ER-1 and ER-5. They use nearshore and offshore waters at depths of less than 1 to 95 m and temperatures of 20-25°C. Goliath grouper occupy reef, hard bottom, and bank/shoal habitats. Also, while not considered essential fish habitat, goliath are found on artificial reefs, especially wrecks. Prey items include crustaceans (especially lobster), fish, and mollusks (especially cephalopods). Goliath grouper are vulnerable to overfishing, and while fishing is currently prohibited on this species, previous mortality estimates were as follows: Total instantaneous mortality (Z) = 0.85, fishing instantaneous mortality (F) = 0.70, M = 0.15. Goliath grouper have a slow growth rate, their life history parameters have been estimated as L_{inf} = 2221 mm TL, k = 0.0937, t_0 = -0.6842, and maximum age = 37 years. Spawning occurs in offshore waters at depths of 36-46 m on reefs and hard bottom habitat from June through December, peaking from July to September.

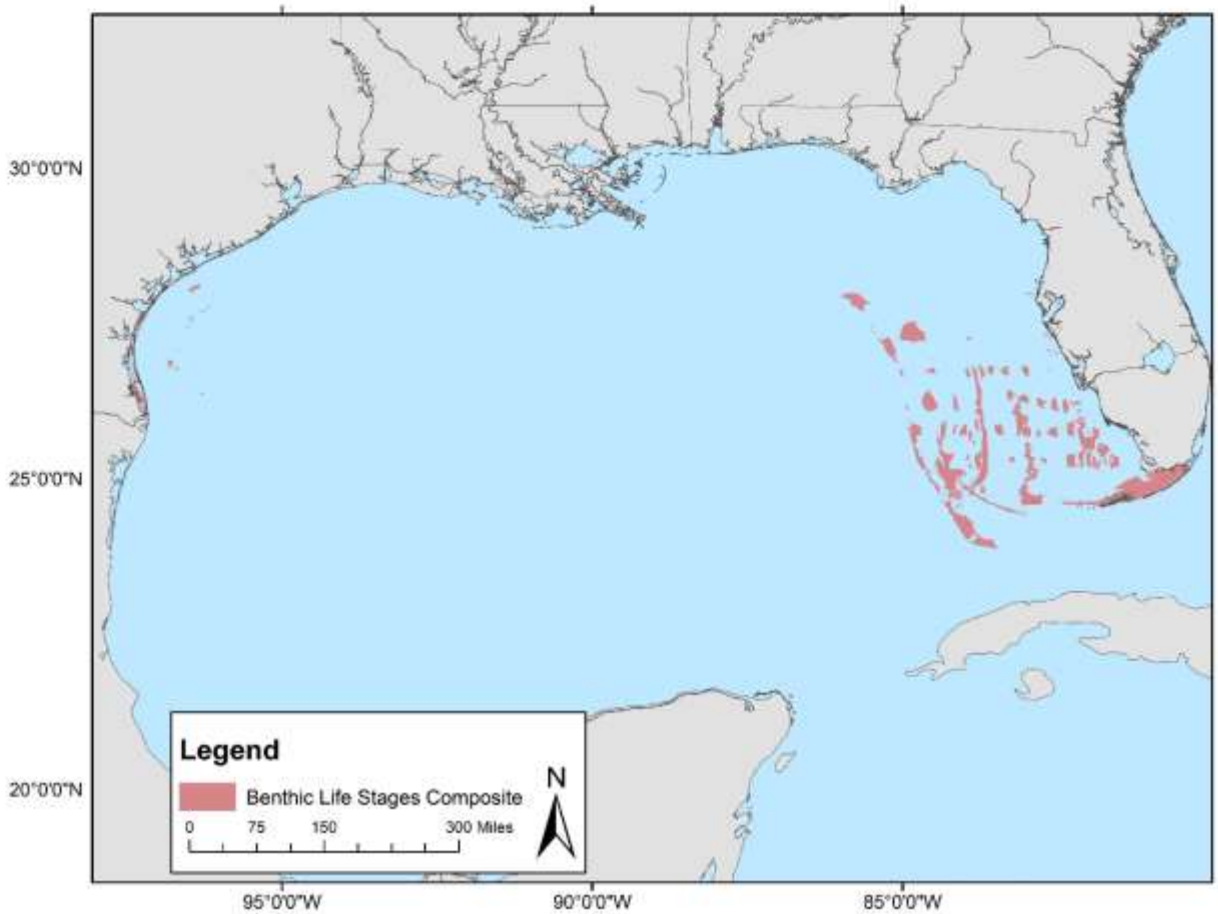

Figure 29. Map of benthic habitat use by all life stages of goliath grouper.

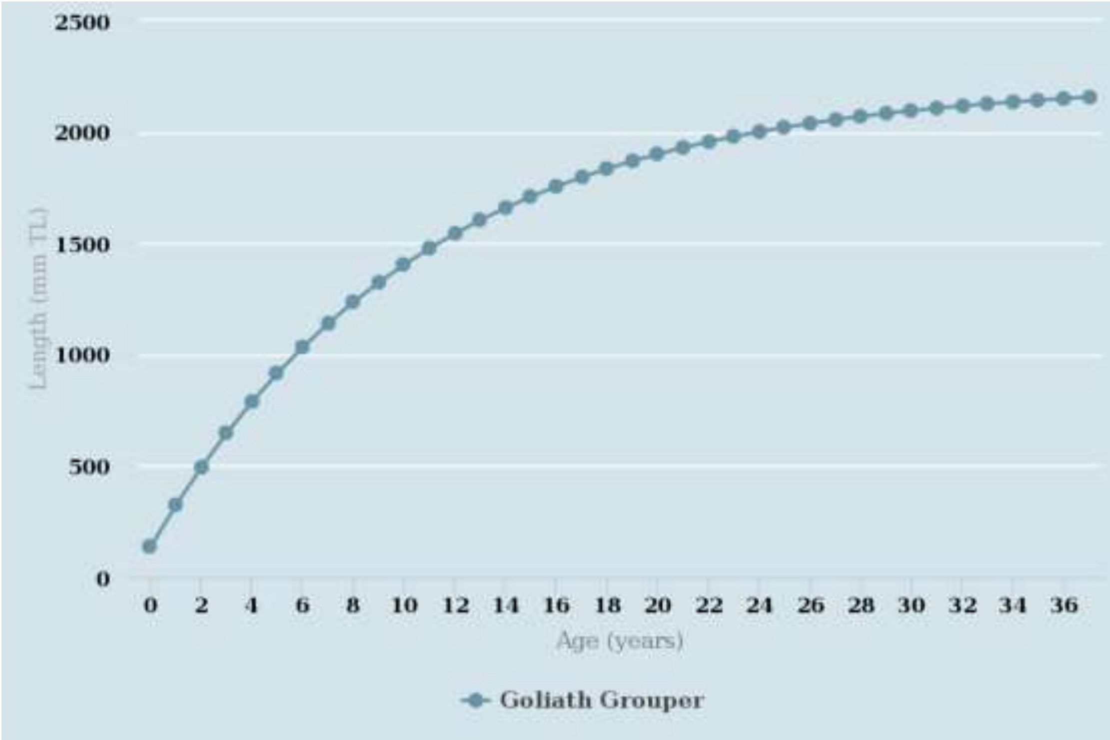

Figure 30. Predicted length at age for both sexes of goliath grouper in the eastern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 2221 mm TL, K = 0.09, t_0 = -0.68 (SEDAR 23 2011), and maximum age = 37 years (Bullock et al. 1992).

Red Grouper (*Epinephelus morio*)

Distribution

Red Grouper can be found throughout the western Atlantic from North Carolina to southern Brazil, and in the Gulf, Caribbean, and Bermuda. Within the Gulf, red grouper primarily occupy eco-regions ER 1-2. Depending on life stage they can be found in nearshore and offshore waters from 0 - 100 m, and at temperatures from 15 - 30°C. Early life stages are WCA, and juveniles settle on SAV and hard bottom habitats. They move offshore with growth, and onto reefs and hard bottom. They've been documented as spawning on hard bottom and shelf edge/slope habitats.

Summary of new literature review

Literature review yielded several new studies addressing habitat, spawning period, and mortality and growth information. Coleman et al. (2011) identified shelf edge/slope and hard bottom as habitats for spawning adults in ER-2. A study by Giménez-Hurtado et al. (2009) addressed M rates at all life stages of red grouper on Campeche Bank, Mexico. The ranges of M included, M = 194.93 (eggs), M = 13.03-153.10 (larvae), and M = 2.52-5.73 (juveniles). Sedberry et al. (2006)

collected spawning adult red grouper on shelf edge/slope habitat at 16.97-24.08°C in the western Atlantic. SEDAR 12 (2006) assigned a maximum age of 29 years to red grouper, and SEDAR 42 (2015) and SEDAR 42-DW-10 (2015) established estimates of growth, maturity and mortality as follows: $Z = 0.39$, M (> age 2) = 0.1194-0.2583, 50% mature = 2.8 years, 292 mm FL, 50% transition = 707 mm FL, 11.2 years, $L_{inf} = 829 \pm 5.50$ mm FL, $K = 0.1251 \pm 2.0 \times 10^{-3}$, $t_0 = 1.2022 \pm 3.4 \times 10^{-2}$, and maximum age = 29 years. Lastly, Lowerre-Barbieri et al. (2014) found that red grouper were spawning capable on the West Florida Shelf from March to June.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in offshore waters with depths from 20-100 m. They use the water column from May to April, and hatch within 30 hours at 24°C. Morality estimates from Campeche Bank, Mexico are $M = 194.93$. Eggs require salinity of at least 32 ppt for buoyancy.

Larvae:

Larvae are found in offshore waters with depths from 20-100 m during May and June. They prey on zooplankton, and have an optimal temperature preference of 27.4-28.5°C. They use the water column for 30-50 days and leave the plankton at about 20 mm SL. Morality estimates from Campeche Bank, Mexico are $M = 13.03$-153.10 depending on age.

Juveniles:

Early juveniles are found in estuarine and nearshore waters with depths from 0-15 m on SAV or hard bottom habitats. They've been collected at temperatures of 16.1-31.2°C and salinities of 20.7-35.5 ppt. Low dissolved oxygen concentrations (3.9-4.7 mg/L) can cause mortality. Late juveniles can be found in estuarine, nearshore, and offshore waters on hard bottom habitat at depths from 0-50 m. Juveniles feed on demersal crustaceans and fishes. Their predators are larger fish. Mortality estimates from Campeche Bank, Mexico are $M = 2.52$-5.73 depending on age. Late juveniles are subject to catch/release mortality when caught in depths greater than 44 m, and growth can be influenced by food availability and population density.

Adults/Spawning Adults:

Adults are found in nearshore and offshore waters on hard bottom or reef habitat at depths from 3-190 m and temperatures of 15-30°C. They prey on fish, crustaceans, and cephalopods, and face predation from top predators such as sharks and barracudas. Adults are at risk for mortality from competition for food and shelter, predation, catch/release mortality, red tide, and sudden temperature decreases. Mortality estimates include $Z = 0.39$ and M (> age 2) = 0.1194-0.2583. Life history parameter estimates are $L_{inf} = 829 \pm 5.50$ mm FL, $K = 0.1251 \pm 2.0 \times 10^{-3}$, $t_0 = 1.2022 \pm 3.4 \times 10^{-2}$, and maximum age = 29 years. Spawning adults are found in offshore waters on shelf edge/slope or hard bottom habitats from March through June at depths of 20-100 m. On Campeche Bank, Mexico they have been collected at temperatures of 16.97-24.08°C. Population density and environmental stress may influence sexual transition timing. Fifty percent maturity occurs at 2.8 years and 292 mm FL, 50% transition occurs at 11.2 years and 707 mm FL. Red grouper are protogynous hermaphrodites, and adults are more abundant in the fishery during summer months and move offshore during winter. While not considered essential fish habitat, adults can be found on artificial reefs.

Figure 31. Map of benthic habitat use by all life stages of red grouper.

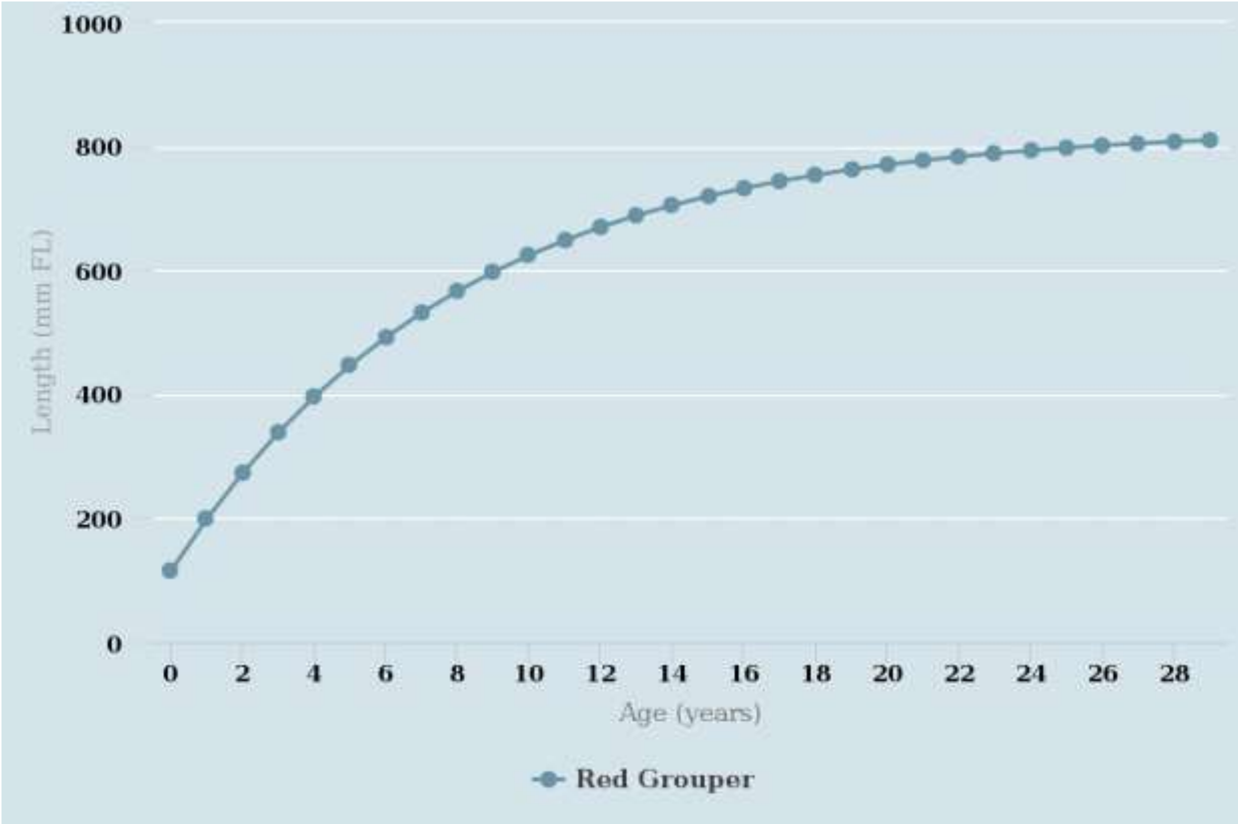

Figure 32. Predicted length at age for both sexes of red grouper in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 828.9 mm FL, K = 0.13, t_0 = -1.20, and maximum age = 29 years (SEDAR 42-DW-10 2014).

Yellowedge Grouper (*Hyporthodus flavolimbatus*)

Distribution

Yellowedge grouper are a deep water species found throughout the Gulf continental shelf, with areas of high abundance off of Texas and west Florida. On the outer continental shelf in the eastern Gulf, the species occupies high relief hard bottoms, rocky out-croppings and are often found co-occurring with snowy grouper and tilefish. In the central and western Gulf, adult yellowedge grouper occupy hard bottom where available, but also burrow in soft bottom habitat. Major components of the diet comprise brachyuran crabs, fishes and other invertebrates. The species depth range is from 35-370 m with adults most common in waters greater than 180 m deep. Juveniles occupy a shallower depth range of 9-110 m.

Summary of new literature review

New studies found during this review added to known habitat and life history for larvae, juveniles, adults and spawning adults. It is of note that Richards (1999) stated that egg and larval stages of yellowedge grouper are indistinguishable from snowy grouper. Cook (2007) studied age, growth and reproduction of yellowedge grouper from the northern Gulf using samples collected from commercial harvest and scientific cruises during 1979-2005. Fish (primarily adults) were collected from soft (central, western Gulf) and hard bottom (eastern Gulf) habitats in offshore waters with temperatures of 10.7-27.0°C, salinities of 25.3-38.0 ppt, and DO concentrations of 2.1-9.6 mg/L. The oldest successfully aged fish was 85 years old, and mortality was estimated as follows: Z = 0.128, M = 0.048-0.090 (depending on estimation method used), and F = 0.038-0.080. Larvae were successfully distinguished by Marancik et al. (2012) in the Straits of Florida as occurring from July through October. SEDAR 22-DW-08 reported on yellowedge grouper age, growth, and reproduction in the northern Gulf. Fish were collected using bottom longline gear by both commercial and scientific sources, scientific trawls surveys and by commercial hand line gear. The longest collected fish was 1228 mm TL. Estimated life history parameters were L_{inf} = 1005 mm TL, K = 0.059, and t_0 = -4.75, female age and length at 50% maturity were eight years and 547 mm TL, respectively. Transition occurred in 50% of fish at 815 mm TL and 22 years. The authors reported spawning capable fish collected from February through September, and November in the Gulf, peaking from March to September. The only study found that expanded the knowledge of juvenile yellowedge grouper habitat was SEDAR 22-DW-08. The authors reported on abundance indices from sub-adult yellowedge grouper collected during summer and fall groundfish surveys in the northern Gulf. They found that juveniles occupied a shallower depth range than adults at 9-110 m. Lastly, Sedberry et al. (2006) identified spawning locations off of the southeastern United States for a variety of reef fish. Yellowedge grouper were found primarily on shelf edge and upper slope reefs, with spawning restricted to reef habitats on the upper slope. Spawning capable fish were collected at 14.47°C.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occur throughout the Gulf in offshore waters. They are WCA above depths of 35-370 m (based on spawning adult distribution)

Larvae:

Larvae occur throughout the Gulf in offshore waters. They are WCA above depths of 35-370 m (based on spawning adult distribution). Postlarvae can be found from July to October in waters of the western Straits of Florida.

Juveniles:

Juvenile yellowedge grouper are found throughout the Gulf in nearshore and offshore waters at depths of 9-110 m, and late juveniles can be found on hard bottom habitats.

Adults/Spawning Adults:

Adults and spawning adults are found throughout the Gulf in offshore waters with depths of 35-370 m. Adults occupy hard bottom and soft bottom habitats, and have been documented on the shelf edge/slope off the southeastern U.S. Water parameters at locations of capture included temperatures from 10.7-27.0°C, salinities from 25.3-38.0 ppt and DO concentrations of 2.1-9.6

mg/L. They feed on brachyuran crabs, fish, and other invertebrates. Mortality estimates are Z = 0.128, M = 0.048-0.090, F = 0.038-0.080, and life history information is as follows: maximum age = 85 yrs, maximum length = 1228 mm TL, L_{inf} = 1005 mm TL, K = 0.059, and t_0 = -4.75. Spawning adults use reef habitats on the upper slope at temperatures of 14.47°C in the southeastern U.S. In the Gulf, spawning occurs from February through September and in November, peaking from March through September. Yellowedge grouper are protogynous hermaphrodites. Fifty percent of females mature at 547 mm TL and eight years old. Fifty percent transition occurs at 815 mm TL and 22 years.

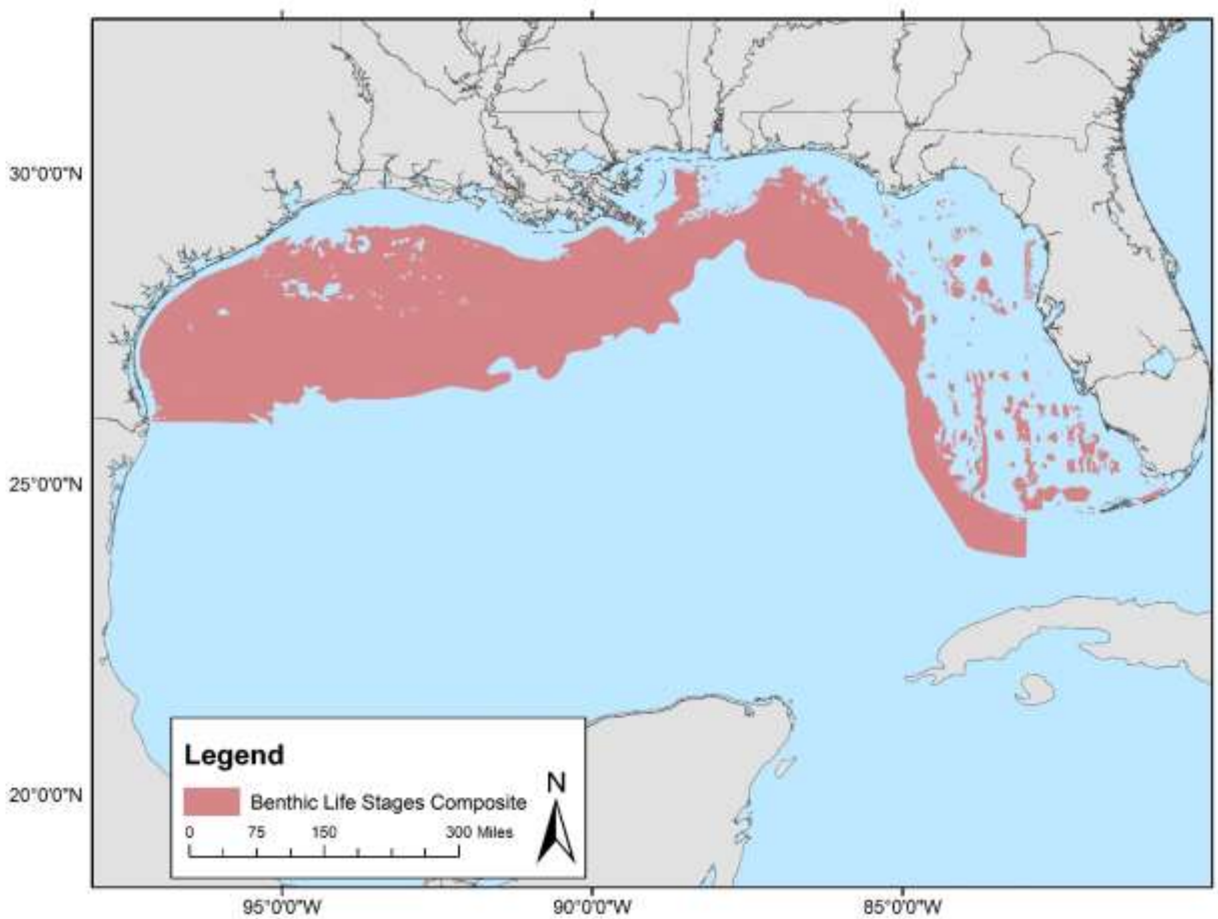

Figure 33. Map of benthic habitat use by all life stages of yellowedge grouper.

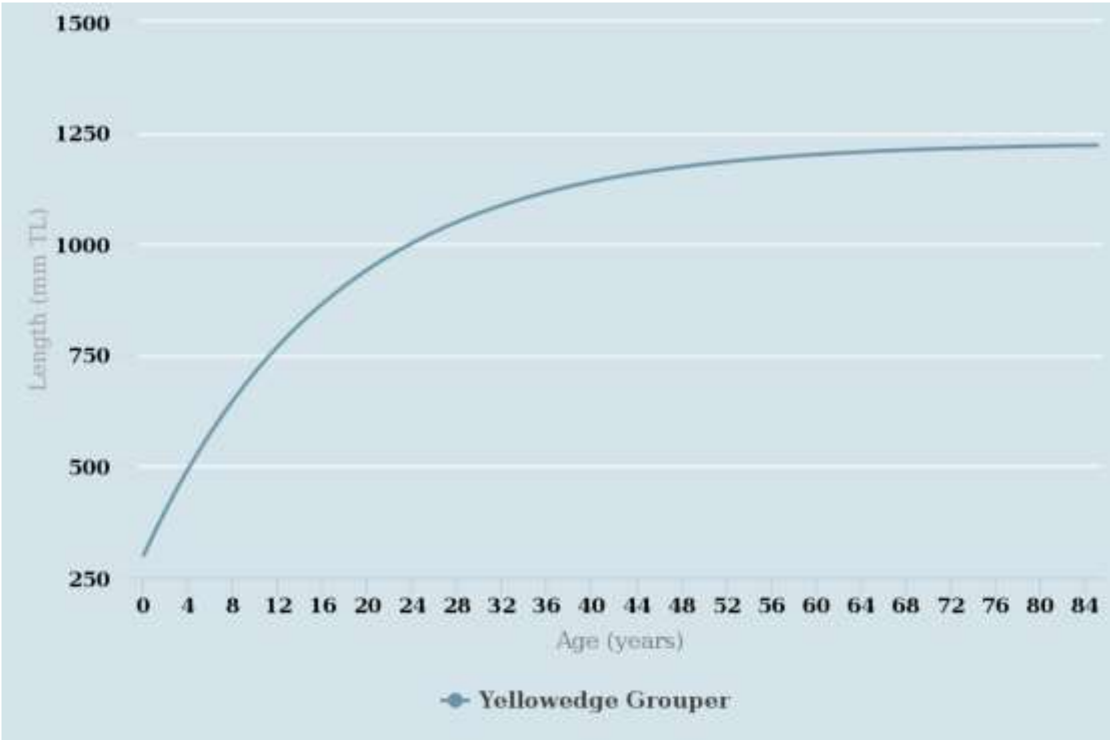

Figure 34. Predicted length at age for both sexes of yellowedge grouper from the northern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1228 mm TL, K = 0.06, t_0 = -4.75 (SEDAR 22-DW-08 2010), and maximum age = 85 years (Cook 2007).

Warsaw Grouper (*Epinephelus nigritus*)

Distribution

Warsaw grouper are a deep-water species distributed throughout the Gulf, in association with hard bottoms. They occur from 40-525 m, more commonly down to 250 m, and prefer rough, rocky bottoms with high profiles such as steep cliffs and rocky ledges. Adults feed on crabs, shrimp, lobsters, and fish. Juveniles occur in shallower (20-30 m) reef habitats and may enter bays, moving into deeper water as they grow (GMFMC 2004).

Summary of new literature review

Information was added to habitat association tables (HAT) for warsaw grouper from a previously cited source and several new sources. Manooch and Mason (1987) studied age and growth in warsaw and black grouper from North Carolina to the Florida Keys. Samples were collected from headboat landings. The oldest aged fish was 41 years. The authors estimated life history parameters of L_{inf} = 2394 mm TL, K = 0.0544, and t_0 = -3.616. In SEDAR 4-SAR 1 (2004), warsaw grouper M was estimated to be 0.10 in the south Atlantic. Lastly, Weaver et al. (2006) gathered geographical and biological information for the Tortugas South Reserve, which resulted in base maps and visual survey data. One of the structures identified was Miller's ledge, a shelf edge reef. A bicolor phase warsaw grouper was observed on Miller's ledge, suggesting that it may be a spawning habitat for the species.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in offshore waters throughout the Gulf. They are WCA and presumed to occur above waters with depths of 40-525 m based on spawning adult distributions.

Larvae:

Larvae are found in offshore waters throughout the Gulf. They are WCA and presumed to occur above waters with depths of 40-525 m based on spawning adult distributions.

Juveniles:

Juveniles are found in offshore waters throughout the Gulf. Late juveniles occupy depths of 20-30 m, and early juveniles are presumed to do the same once they settle out of the water column. Late juveniles inhabit reefs.

Adults/Spawning Adults:

Adults and spawning adults occupy offshore waters throughout the Gulf in depths from 40-525 m. Adults use shelf edge/slope and hard bottom habitats, as do spawning adults which also use reefs. Adults have been caught at water temperatures of 12-25°C. They feed on crabs, shrimp, lobsters, and fish. Warsaw grouper are vulnerable to overfishing, which can affect size structure. In the south Atlantic they have an M = 0.10 and in the western Atlantic they have the following life history information: maximum length = 2300 mm, maximum age = 41 years, L_{inf} = 2394 mm TL, K = 0.0544, and t_0 = -3.616. Adults spawn during late summer, are protogynous hermaphrodites, and mature at age 9.

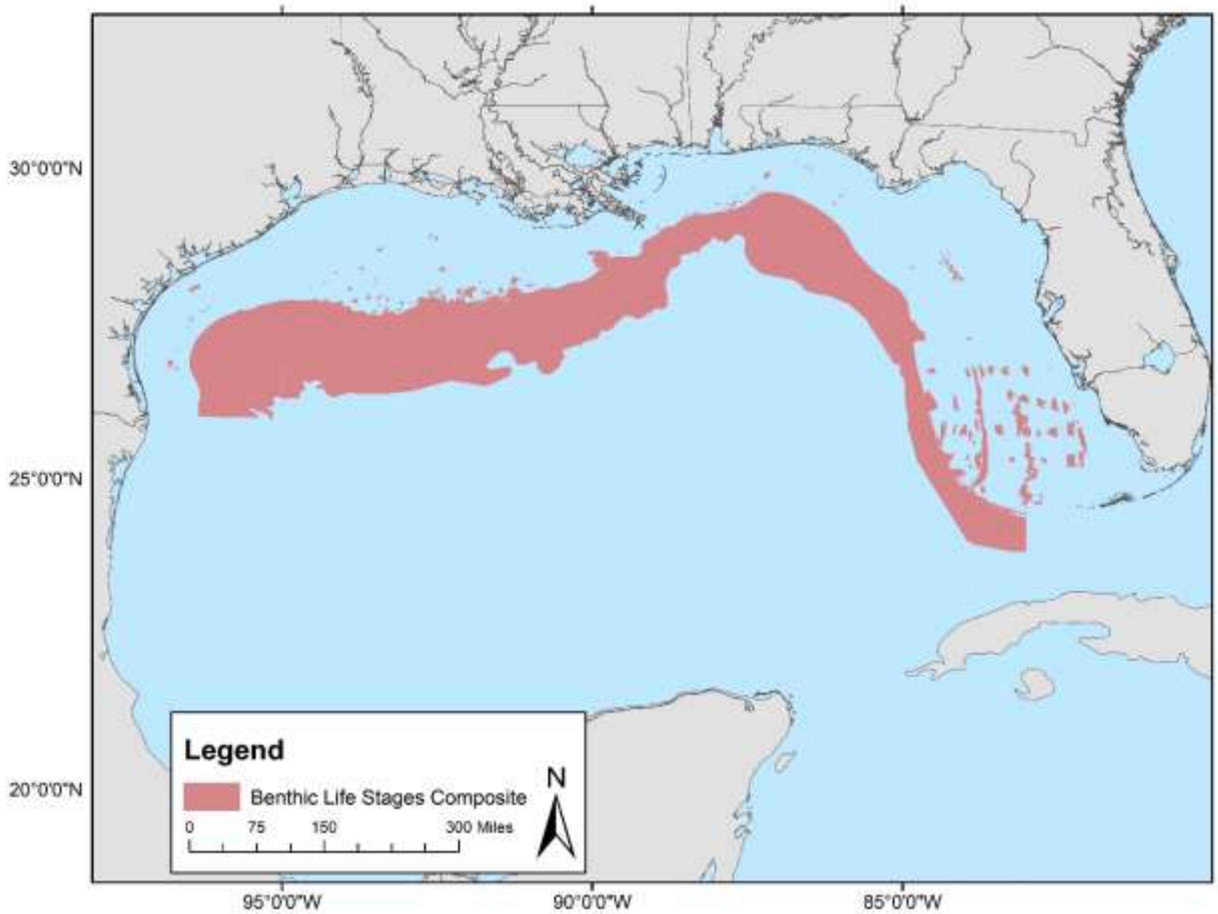

Figure 35. Map of benthic habitat use by all life stages of warsaw grouper.

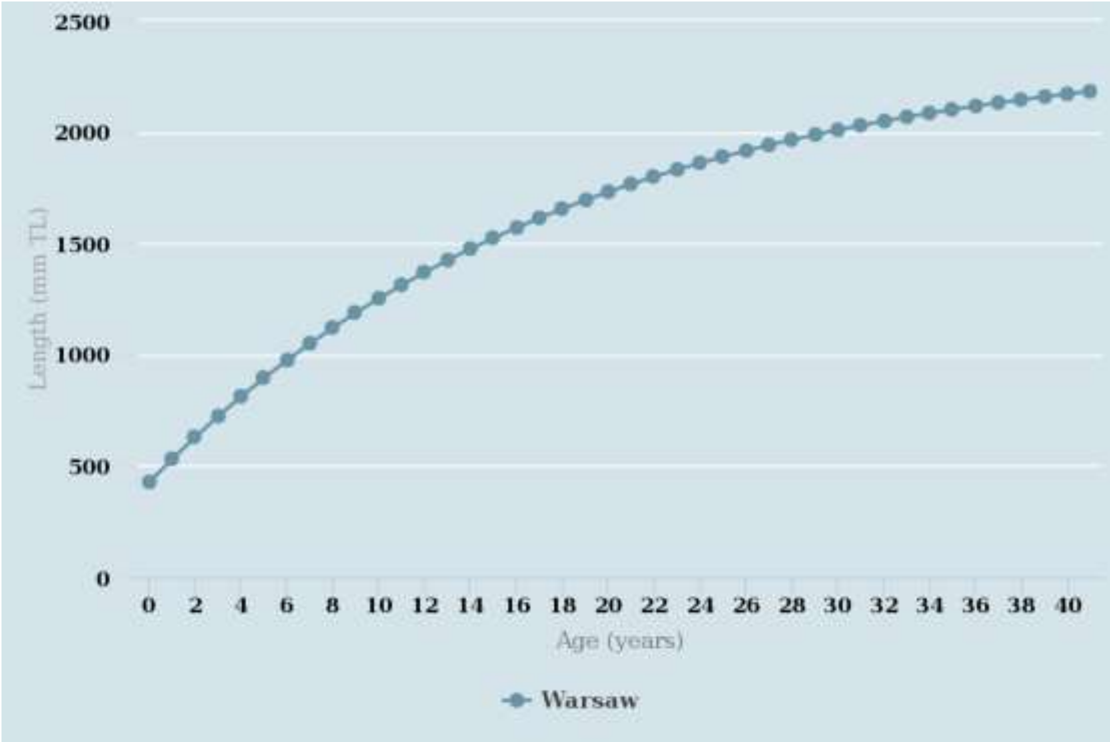

Figure 36. Predicted length at age for both sexes of warsaw grouper from the southeast United States. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 2394 mm TL, K = 0.05, t_0 = -3.62, and maximum age = 41 years (Manooch and Mason 1987).

Snowy Grouper (*Epinephelus niveatus*)

Distribution

In the Gulf, snowy grouper are found in largest numbers in deep waters off of South Florida and the northwestern coast of Cuba. Adults commonly occur on hard bottoms and reefs (particularly Florida *Oculina* reefs) in waters with depths from 30-525 m. They are often found with other deep-water species such as yellowedge grouper and tilefishes. Adults feed on fish, crabs and other crustaceans, cephalopods and gastropods. As with other groupers, the young occur in shallower habitats, such as nearshore reefs, and move into deeper water with growth (GMFMC 2004).

Summary of new literature review

Several studies have been published since the last review that expand on what is known about snowy grouper life history or habitat utilization in the Gulf. Dance et al. (2011) noted occurrences of juveniles snowy grouper on artificial reefs in ER-2, while artificial reefs are not considered essential fish habitat, it is worth noting, due to the paucity of information available about the juvenile life stage. Kowal (2010) studied life history of snowy grouper from fish collected throughout the Gulf via commercial and fishery-independent sources. A majority (83%) of fish were caught from Florida (ER 1-2), though a portion of samples were landed in Louisiana, Mississippi, and Texas. Sexual transition was observed to begin at 6-7 years and about 475 mm FL. SEDAR 36 (2013) assessed snowy grouper in the south Atlantic estimated M = 0.12. SEDAR 49 DW (2016) reported life history parameters as follows: L_{inf} = 1064.62 mm TL, K = 0.094, t_0 = -2.884, and maximum age = 35 years. Lastly, two studies from outside the Gulf, in the western Atlantic from the Carolinas to Florida, documented adults and spawning adults occupying reef and shelf edge/slope habitats (Sedberry et al. 2006), and determined that 50% of female snowy grouper were estimated to be mature 541 mm TL and 4.92 years (Wyanski et al. 2000).

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs can be found in ER-1 in offshore waters, presumably above depths of 30-525 m (based on spawning adult distributions). They are WCA.

Larvae:

Larvae can be found in ER-1 in offshore waters, presumably above depths of 30-525 m (based on spawning adult distributions). They are WCA. They've been collected in June and October at water temperatures of 28°C.

Juveniles:

Juveniles can be found in ER-1. Early juveniles occupy reefs in nearshore waters greater than one meter. Late juveniles may be found in nearshore or offshore waters on reefs from depths of 17-60 m. They prey on fish, gastropods, cephalopods, and other invertebrates and are subject to trawl bycatch mortality. They've been collected at temperatures of 15-29°C off the Carolinas.

Adults/Spawning Adults:

Adults and spawning adults are common in offshore waters at depths from 30-525 m in ER 1-2. Adults occupy hard bottom and reef habitats in the Gulf, and have been documented on shelf edge/slope habitat in the western Atlantic. They've been caught at water temperatures of 12-26°C. Primary prey items include fish, crabs, crustaceans, cephalopods, and gastropods. They are vulnerable to fishing pressure and in the south Atlantic M = 0.12. Adults have reached a maximum age of 44 years, length of 1200 mm and weight of 30 kg. They recruit to the fishery at age eight, and have estimated life history parameters of L_{inf} = 1064.62 mm TL, K = 0.094, t_0 = -2.884, and maximum age = 35 years. Spawning adults have been observed on reef and shelf edge/slope habitats in the western Atlantic. They spawn from April to July in the Florida Keys and May to August in west Florida. Overfishing can cause sex ratio imbalance due to snowy grouper being protogynous hermaphrodites. Fifty percent of females are estimated to be mature at 541 mm TL and 4.92 years, transition from females to males begins at 6-7 years and about 475 mm FL. Forty percent of fish greater than or equal to eight years (700 mm) are male.

Figure 37. Map of benthic habitat use by all life stages of snowy grouper.

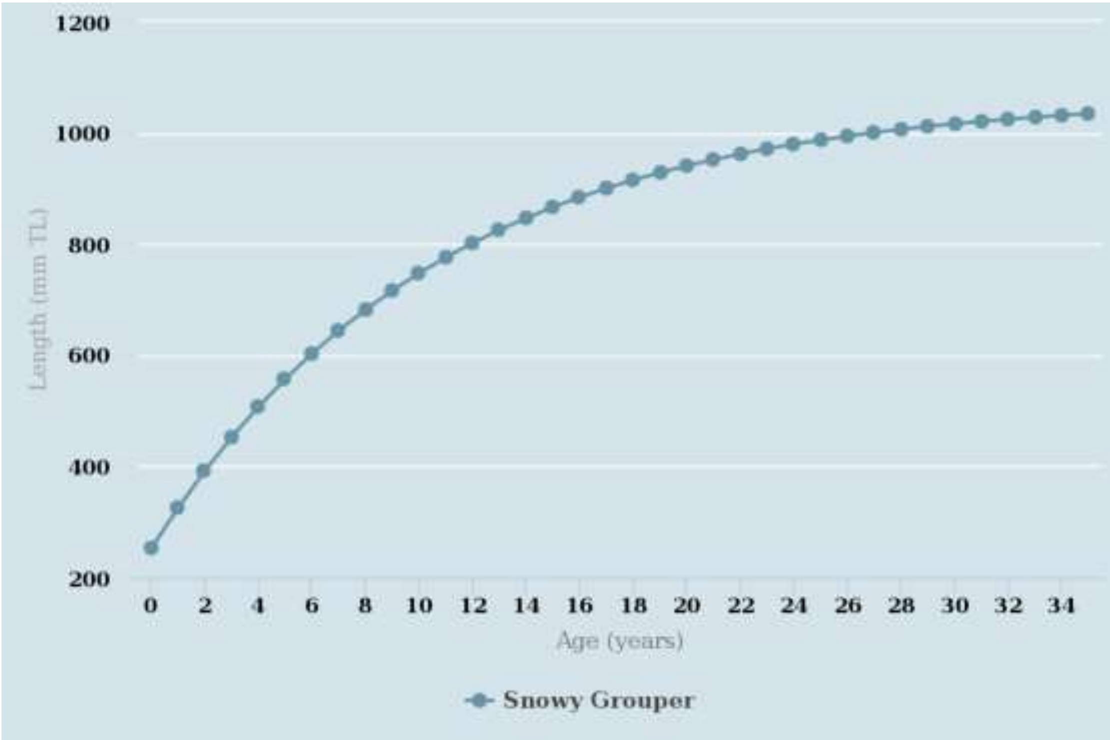

Figure 38. Predicted length at age for both sexes of snowy grouper from the south Atlantic. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1064.62 mm TL, K = 0.09, t_0 = -2.88, and maximum age = 35 years (SEDAR 36 2013).

Black Grouper (*Mycteroperca bonaci*)

Distribution

The black grouper is found along the eastern Gulf 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, irregular bottoms, ledges and high-to-moderate relief habitat. Spawning occurs from late winter through to spring and summer throughout all adult areas. Spawning aggregations have been observed in the Florida Keys at 18 to 28 m. Juveniles occupy submerged aquatic vegetation (SAV) and mangroves in shallow water and move offshore to reefs and hard bottom habitats with growth.

Summary of new literature review

Several studies were found that added to current habitat information for black grouper. Brule et al. (2003) analyzed reproduction in black grouper from the southern Gulf, specifically Campache Bank and Alacranes Reef. The authors found that females ranged in size from 570 - 1235 mm and males from 860 - 1320 mm. Sex change occurred between 855 - 1250 mm. Another study, Paz and Sedberry (2007), assessed spawning black grouper. This study was conducted in Belize and identified spawning aggregations in this region. The authors found black grouper formed small spawning aggregations located on various reef formations including elbows, promontories, and linear shelf-edge reefs. Also, they observed black grouper at bottom temperatures of 24-27°C. Brule et al. (2005) examined diet composition of juvenile black grouper from the Yucatan Peninsula. Black grouper were collected at depths of 1-10 m and fed primarily on fish and crustaceans. Koch (2011) also studied juvenile black grouper and their spatial ecology in the upper Florida Keys. Spur and groove habitat was the most frequently used habitat type during the study. Juvenile black grouper also used artificial and hard bottom habitat. Lastly, SEDAR 19 (2010) established mortality and life history parameter estimations for Gulf and South Atlantic black grouper, they were as follows: natural mortality (M) = 0.136, L_{inf} = 1334 mm TL, k = 0.1432/yr, t_0 = -0.9028/yr, and maximum age = 33 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2 in offshore waters, and are water column associated at depths from 18-28 m (based on spawning adult distribution).

Larvae:

Larvae are found in ER 1-2 in offshore waters, and are water column associated at depths from 10-150 m (based on spawning adult distribution).

Juveniles:

Early juveniles are found in ER 1-2. They use SAV in estuarine and nearshore waters with depths from 1-10 m (based on study conducted in the southern Gulf) and have been collected at temperatures of 31°C. With growth and transition to late juveniles, habitat use shifts to reefs, hard bottom, and mangroves and depth range extends to 19 m. All juveniles are found year-round and their primary prey items are fish and crustaceans.

Adults/Spawning Adults:

As with the other life stages, adult black grouper are found in ER 1-2. They occupy reefs and hard bottom habitats in nearshore and offshore waters with depths of 10-150 m, and have been collected at temperatures of 16-28°C. Black grouper prey on fish, and their predators include sharks and larger groupers. Mortality threats stem from overfishing and M = 0.136. Adult growth is rapid in the first three to four years. Estimated life history parameters are L_{inf} = 1334 mm TL, K = 0.1432/yr, t_0 = -0.9028/yr, and maximum age = 33 years. Spawning black grouper are found in depths from 18-28 m in ER 1-2. Spawning season occurs from February through March at water temperatures of 24-27°C (based on a study from Belize). Habitat types used by black grouper during spawning include reefs, hard bottom, and in Belize, shelf edge/slope. Spawning aggregations are vulnerable to overfishing. Size ranges from 570 - 1235 mm for females, and males from 860 - 1320 mm, and sex change occurred between 855 - 1250 mm (based on a study conducted in the southern Gulf).

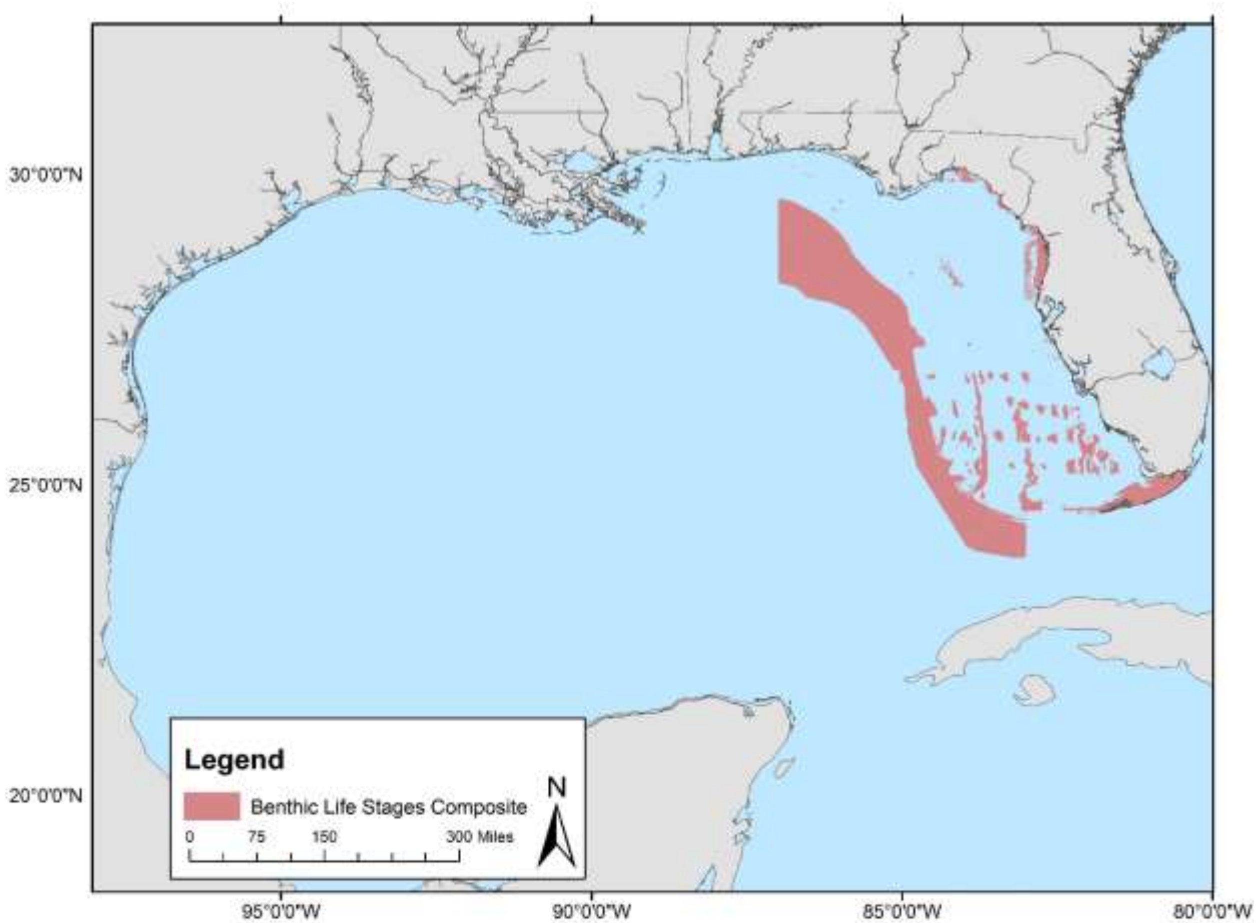

Figure 39. Map of benthic habitat use by all life stages of black grouper.

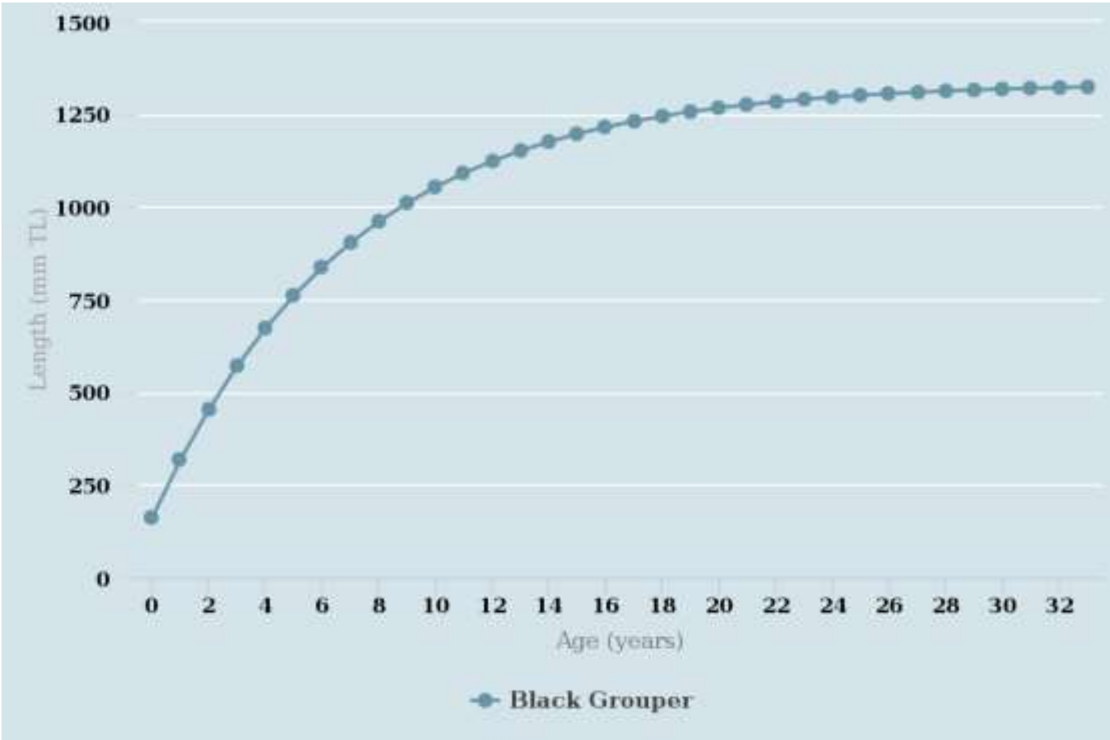

Figure 40. Predicted length at age for both sexes of black grouper from the south Atlantic and Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1334 mm TL, K = 0.14, t_0 = -0.90, and maximum age = 33 years (SEDAR 19 2010).

Yellowmouth Grouper (*Mycteroperca interstitialis*)

Distribution

In the Gulf, yellowmouth grouper occur off of the Campeche Banks, the west coast of Florida, Texas Flower Garden Banks National Marine Sanctuary (FGBNMS), and the northwest coast of Cuba. They occupy rocky bottoms and coral reefs, and feed on fishes, crustaceans, and other invertebrates. Spawning occurs primarily in spring and summer, with peaks in April and May off the west coast of Florida. Juveniles commonly occur in mangrove-lined lagoons and move into deeper water as they grow (GMFMC 2004).

Summary of new literature review

New literature added was obtained from three studies. One had already been used to inform some of the habitat association table for yellowmouth grouper, and additional information from it was added. Bullock and Murphy (1994) studied adults and spawning adults in the Florida Middle Grounds and found that spawning occurred year-round, but peaked from April to May. The authors estimated life history and mortality parameters as follows: Z = 0.25-0.25, L_{inf} = 828 mm TL, K = 0.076, t_0 = -7.5, and maximum age = 28 years. They also examined maturity and found that female yellowmouth grouper begin to mature at 400 mm TL (two years) and all were mature by 450 mm TL (age four). Transitional fish were found to range from 505-643 mm TL and were ages 5-14 years old. The smallest and youngest mature males caught were 505 mm TL and four years. One of the new studies added, Burton et al. (2014) studied adult yellowmouth grouper in the southeastern U.S. and estimated M = 0.14. Lastly, Pattengill-Semmens (2007) studied fish assemblages in the FGBNMS and found yellowmouth grouper occupying bank habitat, which was previously undocumented as a habitat type used by the species.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in offshore waters of ER-1 and ER-5 at depths of 20-189 m based on spawning adult distributions. They are water column associated.

Larvae:

Larvae are found in offshore waters of ER-1 and ER-5 at depths of 20-189 m based on spawning adult distributions. They are WCA.

Juveniles:

Juveniles are found in ER-1 and ER-5, in mangrove-lined lagoons in the Gulf. They have been observed at depths of 18-24 m, and late juveniles prey on fish in Curacao and Bonaire.

Adults/Spawning Adults:

Adult yellowmouth grouper are found in ER 1-2 and ER 4-5 in offshore waters with depths of 20-189 m and temperatures of 19-24°C. They occupy hard bottom, reef, and bank/shoal habitat types and prey on fish, crustaceans, and other invertebrates. Their predators include sharks and larger fish. Life history and mortality parameters have been estimated as follows: Z = 0.25-0.25, L_{inf} = 828 mm TL, K = 0.076, and t_0 = -7.5. They are a long lived, and slow growing species with fastest growth in the first two years. They've been captured at a maximum length of 830 mm TL and age of 28 years. They are vulnerable to overfishing and, in the southeastern U.S., M = 0.14. Spawning adults occupy ER 1-2 and ER-5 in offshore waters at depths of 20-189 m. They are protogynous hermaphrodites with female maturity occurring at 400-450 mm TL (2-4 years), and transition taking place at 505-643 mm TL (5-14 years).

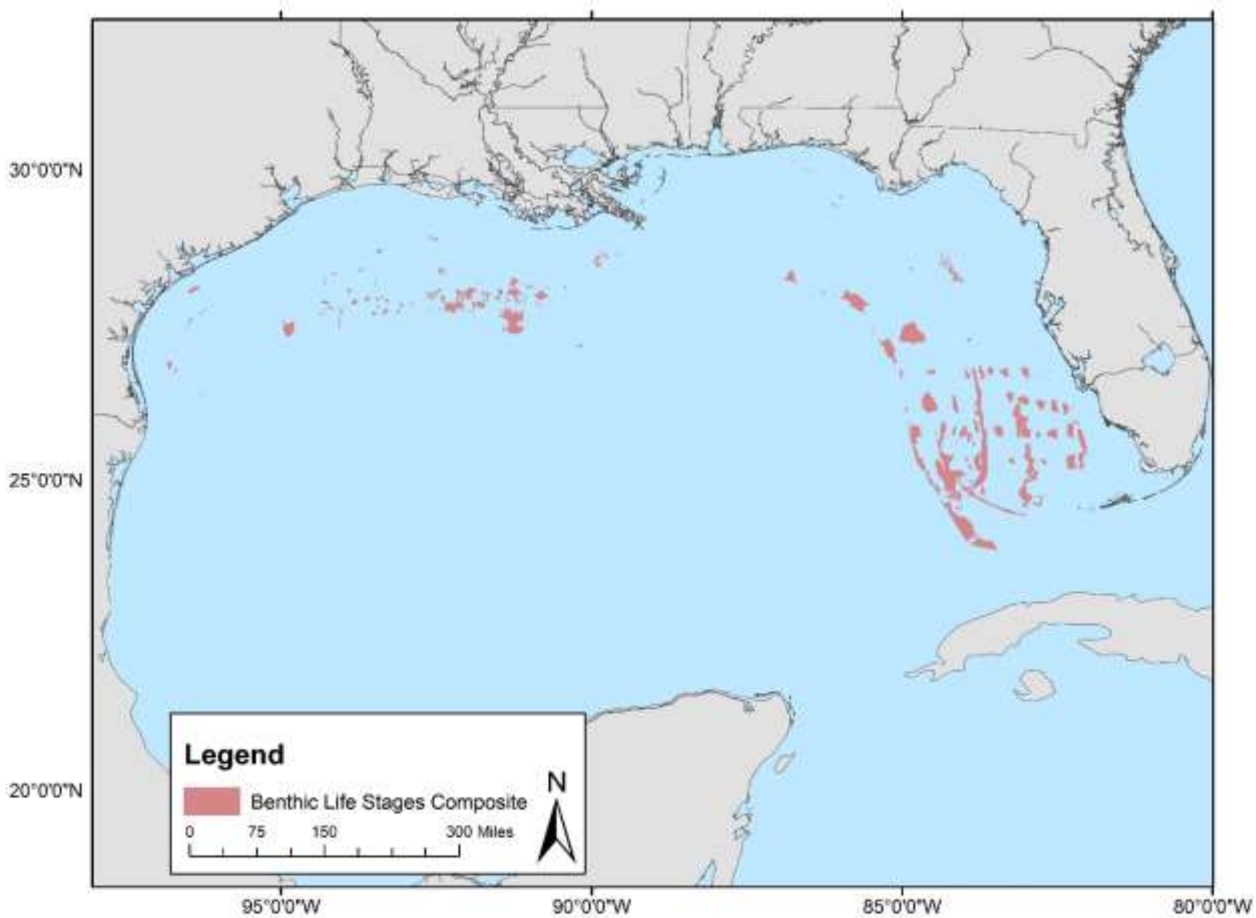

Figure 41. Map of benthic habitat use by all life stages of yellowmouth grouper.

Figure 42. Predicted length at age for both sexes of yellowmouth grouper in the eastern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 828 mm TL, K = 0.08, t_0 = -7.50, and maximum age = 28 years (Bullock and Murphy 1994).

Gag (*Mycteroperca microlepis*)

Distribution

Gag are demersal and most common in the eastern Gulf, especially the west Florida shelf. Adults occupy hard bottom substrates, including offshore reefs and wrecks, coral and live bottoms, and depressions and ledges. Spawning adults form aggregations in depths of 50 to 120 m, with the densest aggregations occurring around the Big Bend area of Florida. Spawning occurs near the shelf edge break from December to May with a peak in the early spring (February-March) on the west Florida shelf. Madison-Swanson is a 298 square km (115 square mile) area, south of Panama City, Florida, containing high-relief hard bottom habitat, and is a known spawning ground for gag. Eggs are pelagic, occurring from December to 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 from April through 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 (GMFMC 2004).

Summary of new literature review

Multiple studies were found during the gag grouper literature review that contributed more information to knowledge of the species. Coleman et al. (2011) used acoustic surveys and videography to describe primary habitat types for four economically important fish species. They found that gag use shelf edge/slope and hard bottom habitats at depths of 80-120 m with spawning occurring from December to May and peaking from February and March in ER-2. Fitzhugh et al. (2005) studied fertilization and settlement of gag along the west Florida shelf and documented that pelagic larval durations (PLD) ranged from 29 to 52 days. Casey et al. (2007) examined habitat use by juvenile gag in Charlotte Harbor, Florida (ER-1). The authors collected juvenile gag year-round, with abundances peaking from April through December. The greatest relative abundances of juvenile gag were on SAV, but mangrove-line shorelines also represented suitable habitat for gag, which hadn't been previously reported. While not considered essential fish habitat at this time, two publications noted the present of juvenile and adult gag on artificial reefs in ER 2-3. (Lukens 1981; Keil 2004). Lastly, the SEDAR 33 (2014) stock assessment designated an M of 0.1342 and life history parameters of L_{inf} = 1277.95 mm FL, k = 0.1342, t_0 = -0.6687, and maximum age = 31 years for adult gag.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs can be found in ER 1-2 in offshore waters from December through April in the water column at depths from 50-120 m (depth based on spawning adult distributions). In the laboratory, they hatch in 45 hours at 21°C.

Larvae:

Larvae can be found in ER 1-2 in offshore waters during early spring in the water column at depths from 50-120 m (depth based on spawning adult distributions). Pelagic larval duration is from 29-52 days. Postlarvae recruit into estuaries and settle on seagrass. Successful larval transport into estuaries is dependent on oceanographic conditions.

Juveniles:

Early juvenile gag are found in ER 1-2 in estuarine and nearshore waters with depths from 0-12 m. They are present on SAV and mangroves in late spring and early fall, and have been collected at temperatures of 22-32°C and salinities of 25.9-35.5 ppt. Mortality is relatively minimal while in SAV and association with SAV occurs rapidly. Availability of estuarine habitat is critical to survival and growth. Late juveniles are found in ER 1-2 in estuarine, nearshore, and offshore waters with depths from 1-50 m. They use SAV and mangroves at smaller sizes, and recruit offshore in the fall to hard bottom and reef habitats. They've been collected at temperatures form 22-32°C and salinities of 28.8-37.6 ppt. Late juveniles face mortality threats from predators such as larger gag and larger fishes in general, and also from the directed recreational and shrimp fisheries. Prey items for early juveniles include crustaceans such as amphipods, copepods, and grass shrimp. Late juveniles feed on decapod crustaceans and fish.

Adults/Spawning Adults:

Adult gag are found throughout the Gulf in nearshore and offshore waters on hard bottom and reef habitats. They've been collected year-round at temperatures of 14-24°C and depths from 13 to 100 m. They prey on fish, crustaceans, and cephalopods, and their primary predators are sharks. Gag have an *M* of 0.1342 and mortality can be caused by sudden low temperatures and fishing. Life history parameters for adult gag are L_{inf} = 1277.95 mm FL, k = 0.1342, t_0 = -0.6687, and maximum age = 31 years. Spawning occurs offshore throughout the Gulf on shelf edge/slope and hard bottom habitats at temperatures of 21-30°C and depths of 50-120 m. Spawning season is from December through May, peaking in February and March. Spawning aggregations are vulnerable to the fishery, and annual fecundity is estimated at 0.065 to 61.4 million eggs/female/year. Gag are considered protogynous hermaphrodites.

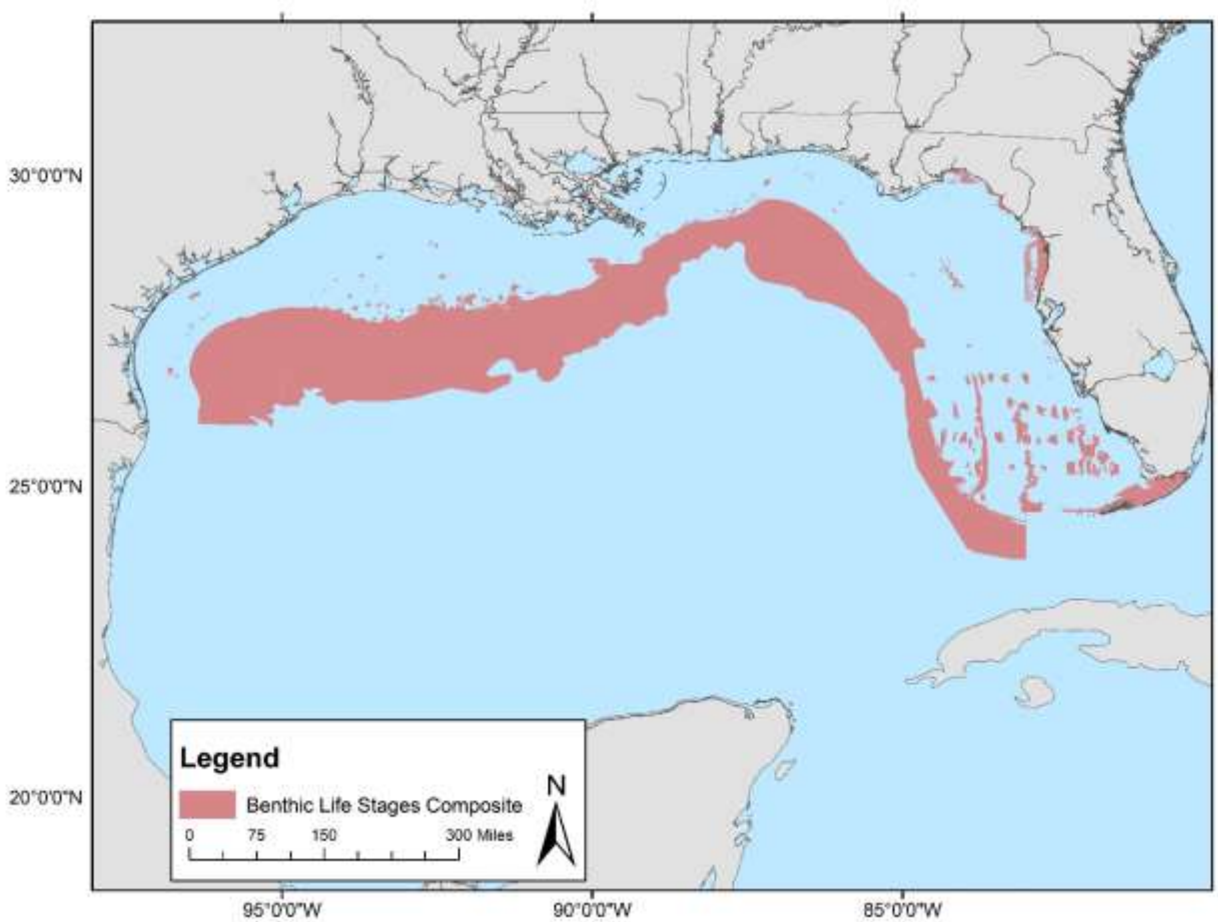

Figure 43. Map of benthic habitat use by all life stages of gag.

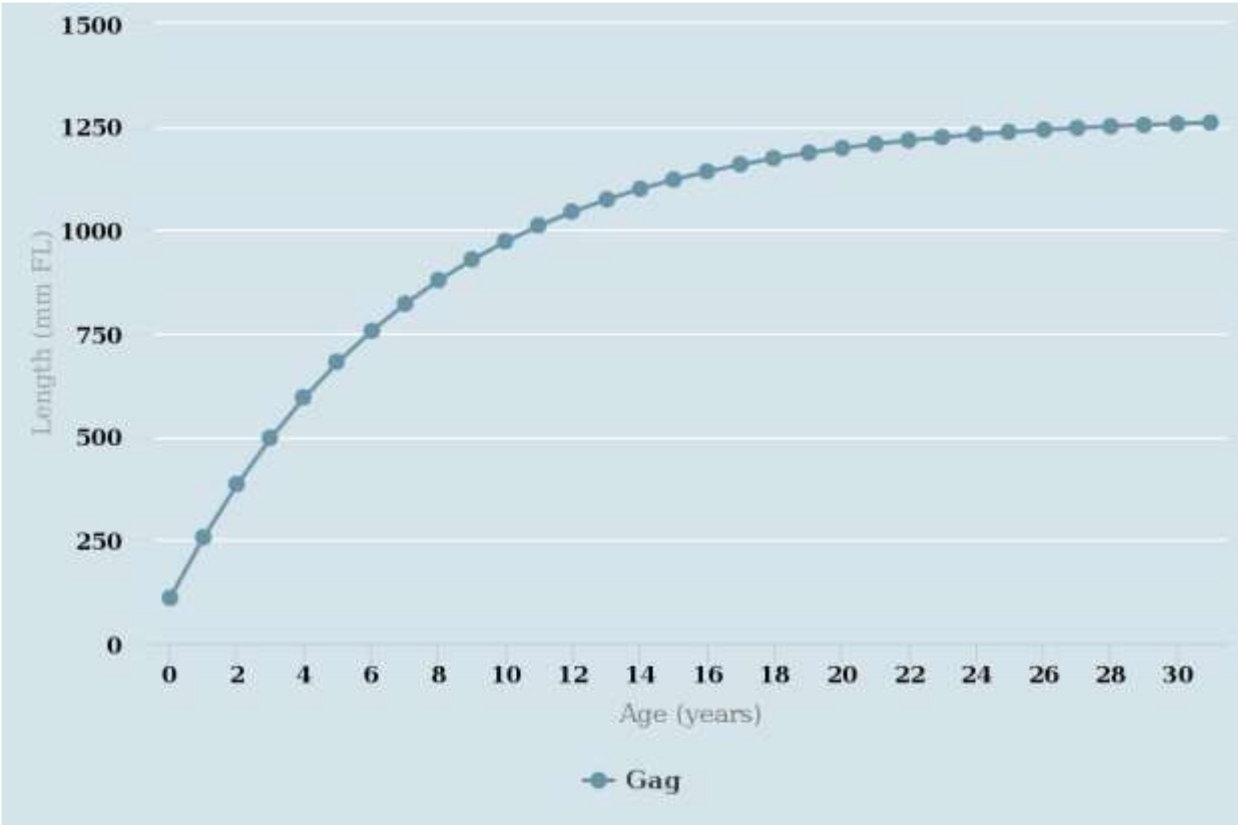

Figure 44. Predicted length at age for both sexes of gag in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1277.95 mm FL, K = 0.13, t_0 = -0.67, and maximum age = 31 years (SEDAR 33 2014).

Scamp (*Mycteroperca phenax*)

Distribution

Scamp are demersal, and widely distributed throughout shelf areas of the Gulf, especially off Florida. They are found in both nearshore and offshore waters from depths of 12-189 m. They occur primarily in ER 1-2, but juveniles have been documented recruiting to bank/shoal habitats in ER-4. Adults use hard bottom and reef habitats and spawn on the shelf edge/slope, reef or hard bottom habitats, and early life stages are found in the water column.

Summary of new literature review

Minimal new literature was found addressing scamp habitat. One study by Gledhill and David (2002) reported spawning aggregations on hard bottom habitat within the Madison-Swanson marine protected area while surveying fish assemblages in both Steamboat Lumps and Madison-Swanson marine protected areas. Koenig et al. (2005) studied fish populations on *Oculina* coral ecosystems in the western Atlantic and found that scamp occurred in higher densities on more intact and dense habitats, and also on artificial reef ball clusters of 10 or more. Lastly, Rooker et al. (2007) examined recruitment of reef fishes on Sonnier Bank in ER-4 and reported the occurrence of juvenile scamp on the bank.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in the water column, offshore, in water depths from 60-189 m (based on spawning adult distribution) in ER 1-2 during the spring.

Larvae:

Larvae are found in the water column, offshore, in water depths from 60-189 m (based on spawning adult distribution) in ER 1-2 during the spring.

Juveniles:

Juvenile scamp commonly use hard bottom and reef habitat in ER 1-2 and occurrences have been documented in ER-4 on bank/shoal habitats. They occupy both nearshore and offshore waters in depths from 12-33 m.

Adults/Spawning Adults:

Adults use nearshore and offshore waters in depths of 12-189 m and temperatures of 14-28°C in ER 1-2. They occupy hard bottom and reef habitats and prey on fish, crustaceans, and cephalopods. They face predations by sharks and are subject to catch/release mortality when caught at depths greater than 44 m. Also, they reach maximum size slowly. Spawning adults primarily use shelf edge/slope, reef, and hard bottom habitats in offshore waters at depths from 60-189 m. Spawning occurs from February through June at temperatures greater than 8.6°C. They are protogynous hermaphrodites, and fishing pressure may reduce the proportion of males in the population.

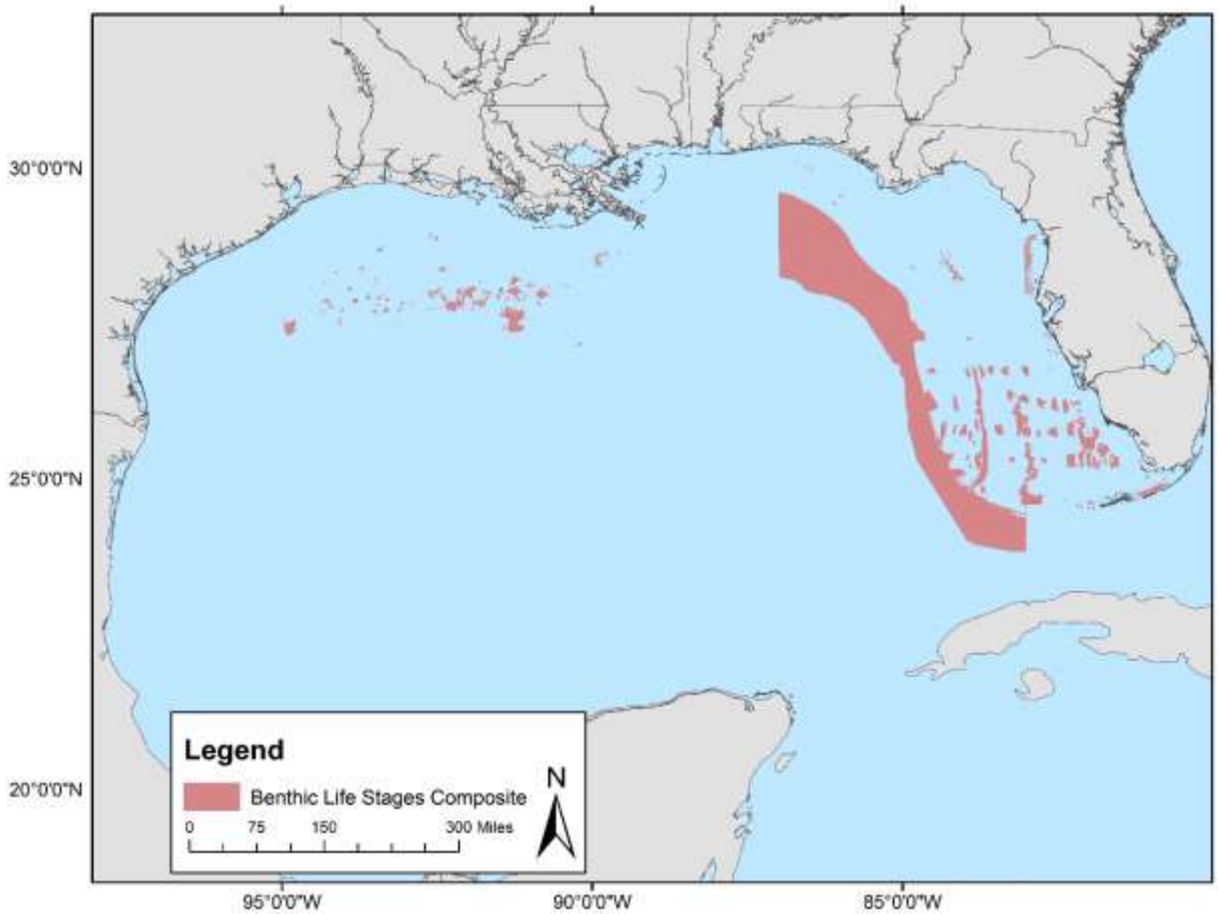

Figure 45. Map of benthic habitat use by all life stages of scamp.

Yellowfin Grouper (*Mycteroperca venenosa*)

Distribution

The yellowfin grouper is not common in the Gulf, occurring primarily in the southern Gulf and West Indies. Its habitat is comprised of rocky bottoms and coral reefs from the shoreline to mid-shelf depths. These groupers prefer reef ridge and high-relief spur and groove reefs. Adults and juveniles feed primarily on fish, but also on squid and shrimp. This species is able to capture swift-moving fish. Juveniles occupy shallow seagrass beds and move to deeper rocky bottoms with growth. Spawning takes place from March to August in the eastern Gulf (GMFMC 2004).

Summary of new literature review

There were no studies found during literature review that reported yellowfin grouper habitat utilization in U.S. Gulf waters. Cushion (2010) studied life history traits of red hind, yellowfin grouper and Nassau grouper in the Bahamas. The author documented maximum age of yellowfin grouper to be 13 years, with life history parameters of L_{inf} = 977 mm TL, K = 0.14, and t_0 = -

1.50. Also, 50% of females were estimated to be mature 561 mm TL and 4.66 years. Length and age at 50% transition were 716-871 mm TL and 8-9 years. Nemeth et al. (2006) studied yellowfin grouper spawning aggregations in the U.S. Virgin Islands, specifically on Grammanik Bank. Yellowfin grouper use this habitat, which is characterized by a coral bank, bordered by shallower hard bottom ridges along the shelf edge. Nemeth et al. (2007) also studied spawning aggregations of yellowfin grouper, this time at Mona Island, Puerto Rico, here fish were observed using high relief shelf edge habitat at 25-30 m, suggesting that during spawning, adults may use shallower depth ranges. Lastly, Sierra et al. (2001) found that juveniles and adults in Cuba feed primarily on fish, but also on shrimp and squid.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER-1 in offshore waters at depths of 25-30 m (based on spawning adult distributions in Puerto Rico).

Larvae:

Eggs are found in ER-1 in offshore waters at depths of 25-30 m (based on spawning adult distributions in Puerto Rico).

Juveniles:

Early juveniles can be found in estuarine and nearshore waters of ER-1, utilizing SAV in 2-4 m of water. Late juveniles move further offshore with age and use both SAV and hard bottom habitat. In Cuba, late juveniles feed on fish, shrimp, and squid.

Adults/Spawning Adults:

Adult yellowfin grouper are found in ER-1 in nearshore and offshore waters with depths of 2-214 m and temperatures of 15-26°C. The use reef and hard bottom habitats. Their predators include sharks and prey are fish, squid, and shrimp (from study in Cuba). They are vulnerable to fishing pressure, and reach maximum lengths of about 900 mm TL. In the Bahamas, life history parameters have been estimated as follows: L_{inf} = 977 mm TL, K = 0.14, and t_0 = -1.50 with a maximum age of 13 years. Spawning adults occupy offshore waters in ER-1. They spawn from March to August, are protogynous with smallest males found at 540 mm TL, and fishing may affect sex ratios. In Puerto Rico spawning occurs in 25-30 m of water. In the U.S. Virgin Islands, spawning habitat includes shelf edge/slope, reefs, hard bottom, and banks/shoals. Fifty percent of females are estimated to be mature 561 mm TL and 4.66 years, and length and age at 50% transition are 716-871 mm TL and 8-9 years for fish harvested in the Bahamas.

Figure 46. Map of benthic habitat use by all life stages of yellowfin grouper.

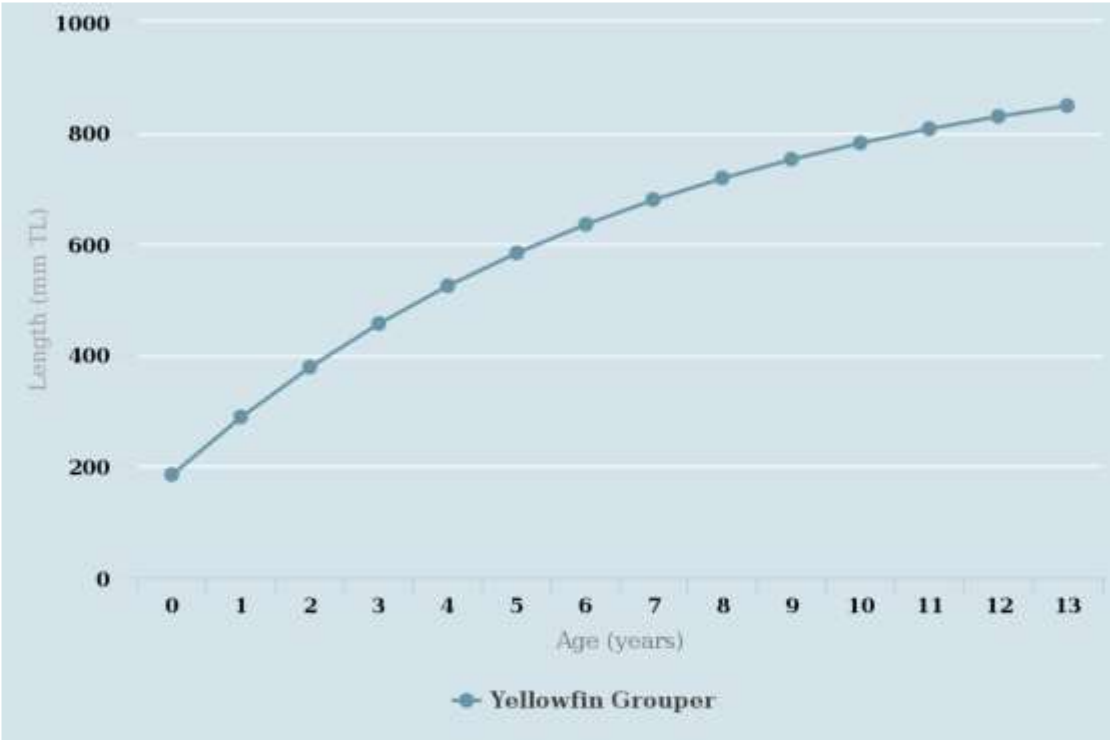

Figure 47. Predicted length at age for both sexes of yellowfin grouper from the Bahamas. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 977 mm TL, K = 0.14, t_0 = -1.50, and maximum age = 13 years (Cushion 2010).

Goldface Tilefish (*Caulolatilus chrysops*)

Distribution

Very little research has been conducted on goldface tilefish. They may have a similar distribution to blueline tilefish, which is as follows. Blueline tilefish are distributed mainly on the eastern/southeastern Gulf and the Campeche Yucatan outer continental shelf, shelf edge and upper slope. Blueline tilefish are found over irregular bottom, including troughs and terraces, sand, mud and rubble, and shell hash. They construct burrows in soft sediments and may also use existing holes and crevices (GMFMC 2004).

Summary of new literature review

Three studies were found during literature review that contributed to what is known about goldface tilefish and their habitat use. Churchill (2015) studied trophic interactions of deep-sea animals in the Gulf. Sampling took place on the West Florida Slope and across the northern Gulf slope (ER 2-3). Three goldface tilefish were collected during the study at a mean depth (± SD) of 291 (± 54) m. This study was deemed appropriate for addition to habitat information despite the small samples size, due to the paucity of data available for this species. Dooley (1978) wrote a National Oceanic and Atmospheric Administration (NOAA) technical report on the systematics and biology of tilefish. For goldface tilefish, spawning capable females were caught in September in North Carolina, and one fish was landed with stomach contents including bivalves, urchin parts, worm tubes and crab parts (also in North Carolina). Again in North Carolina, depth distribution was from 90 to 131 m on rubble bottom. Dooley (1978) also reported that all tilefish likely have pelagic larvae, until they transition to juveniles, upon which they take up a benthic habitat. In a NOAA technical memorandum (Lumsden et al. 2007), the state of deep corals in the United States are discussed and goldface tilefish are mentioned as being caught in deepwater on soft sediment benthos.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

No species specific information available. All tilefish likely have water column associated eggs. Goldface tilefish eggs likely have a similar distribution as blueline tilefish.

Larvae:

No species specific information available. All tilefish likely have water column associated (WCA) larvae, which settle to the benthos with growth. Goldface tilefish larvae likely have a similar distribution as blueline tilefish.

Juveniles:

No species specific information is available. Goldface tilefish juveniles likely have a similar distribution as blueline tilefish.

Adults/Spawning Adults:

Adults can be found in ER 2-3 in offshore waters on the shelf edge/slope at a mean depth (± SD) of 291 (± 54) m. Off of North Carolina, they prey on bivalves, urchins, worms and crabs. Spawning capable females have been collected in September in North Carolina.

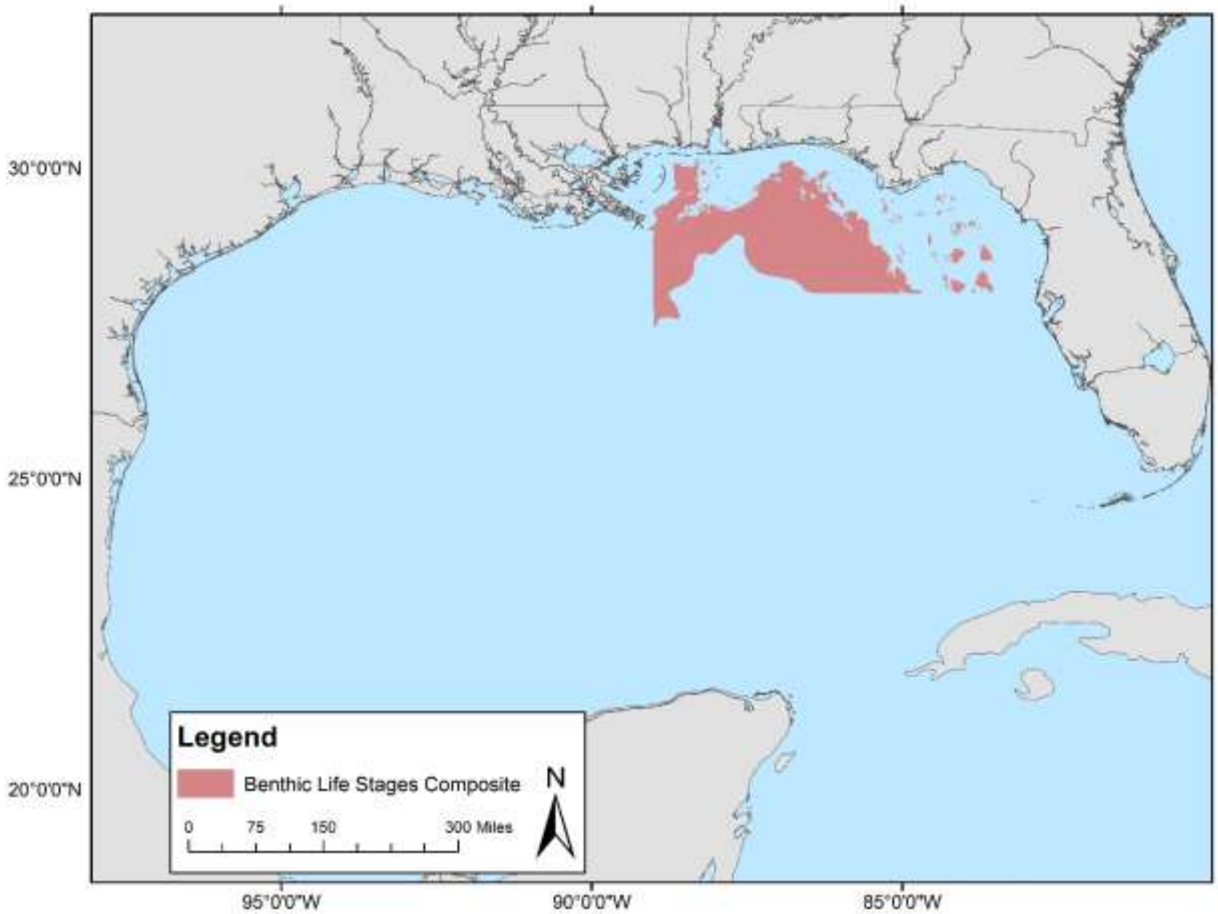

Figure 48. Map of benthic habitat use by all life stages of goldface tilefish.

Blueline Tilefish (*Caulolatilus microps*)

Distribution

Blueline tilefish are distributed mainly on the eastern/southeastern Gulf and the Campeche Yucatan outer continental shelf, shelf edge and upper slope. Anchor tilefish are most common in the northern and western Gulf. Blueline tilefish are found over irregular bottom, including troughs and terraces, sand, mud and rubble, and shell hash. They may be associated with goldface tilefish and blackline tilefish, and they occur in the same habitat/fish assemblage as snowy, Warsaw, and yellowedge groupers, silk and vermilion snappers and *Pagrus pagrus*, the common seabream (GMFMC 2004).

Summary of new literature review

Two new sources of information were found that contributed to knowledge of habitat utilization by blueline tilefish. Sedberry et al. (2006) examined spawning condition of 28 species of reef fish collected from the Carolinas, Georgia, and the east coast of Florida. Blueline tilefish were only collected off of South Carolina on shelf edge and upper slope reefs at depths of 46-256 m. Spawning capable females were collected from February through October, with peak spawning occurring March through September and at temperatures of 8.87-16.28°C. The other source was SEDAR 32 (2013) stock assessment report conducted on south Atlantic blueline tilefish. The stock assessment estimated M = 0.1 and life history parameters as L_{inf} = 600.3 mm FL, k = 0.33, t_0 = -0.5, and maximum age = 43 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2 in offshore waters and are water column associated. They are found at depths of 46-256 m based on spawning adult distributions in the south Atlantic.

Larvae:

Larvae and postlarvae are found in ER 1-2 in offshore waters and are water column associated. They are found at depths of 46-256 m based on spawning adult distributions in the south Atlantic.

Juveniles:

Early and late juveniles are found in ER 1-2 in offshore waters at depths of 60-256 m based on adult distributions. No other habitat information is available for juveniles, though it is likely that they use similar habitats as adults once they settle out of the water column.

Adults/Spawning Adults:

Adult blueline tilefish are found in ER 1-2 in offshore waters at depths of 60-256 m and temperatures from 13.8 to 18°C. They use hard bottom, sand/shell, soft bottom, and shelf edge/slope habitats. Blueline tilefish prey include demersal fish and benthic invertebrates. They are subject to fishing mortality and M = 0.1. Adults experience rapid growth during the first two years and in the south Atlantic life history parameter estimates are L_{inf} = 600.3 mm FL, k = 0.33, t_0 = -0.5, and maximum age = 43 years. Spawning occurs in ER 1-2 in offshore waters. In the south Atlantic, spawning capable females were caught at depths of 46-256 m and temperatures of 8.87-16.28°C on shelf edge/slope habitats from February through October with peak spawning occurring from March to September. Female blueline tilefish mature at 420-450 mm TL and males mature at 500 mm TL.

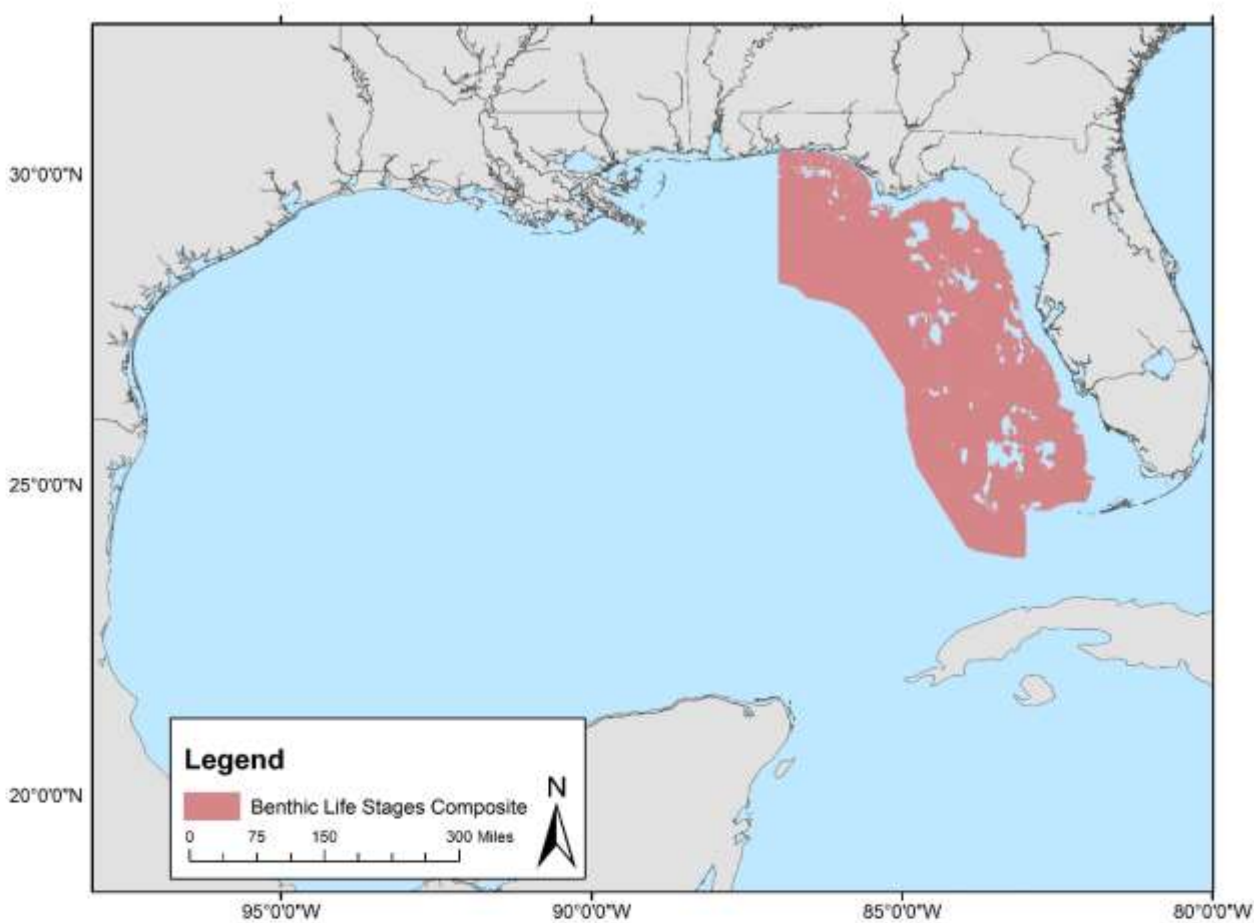

Figure 49. Map of benthic habitat use by all life stages of blueline tilefish.

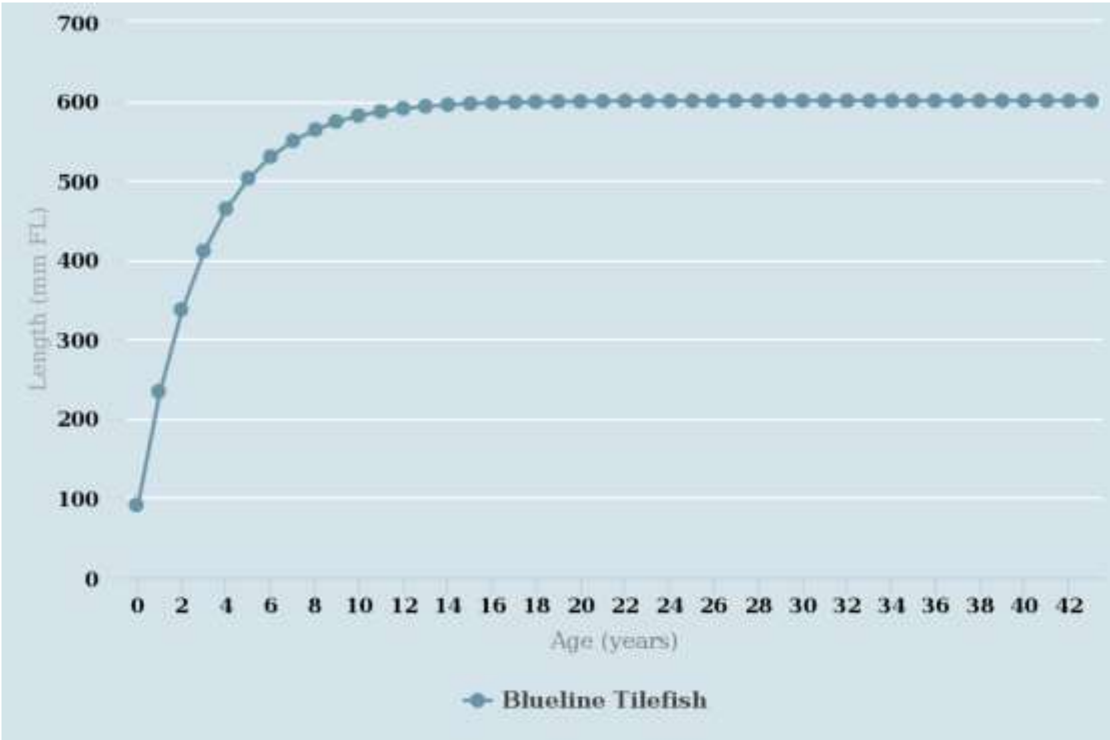

Figure 50. Predicted length at age for both sexes of blueline tilefish from the south Atlantic. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 600.30 mm FL, K = 0.33, t_0 = -0.50, and maximum age = 43 years (SEDAR 32 2013).

Tilefish (*Lopholatilus chamaeleonticeps*)

Distribution

Tilefish (also known as golden tilefish) occur throughout the deeper waters of the Gulf. The species is demersal, occurring at depths from 80-450 m, but is most commonly found between depths of 250-350 m. Preferred habitats are soft bottom (particularly malleable clay), on the shelf edge/slope. Eggs and larvae are pelagic; early juveniles are pelagic-to-benthic. Late juveniles burrow and occupy shafts in the substrate. Adults also burrow along the outer continental shelf and on flanks of submarine canyons.

Summary of new literature review

Two studies were found that added to current information about tilefish habitat use. The first, McEachran and Fechhelm (2006), added to the list of prey items consumed by adult tilefish, these include: bivalve mollusks, squids, polychaetes, holothurians, decapod crustaceans, elasmobranchs, and ray-finned fishes. The authors also state that maximum known length is 1000 mm SL. Lombardi-Carlson (2012), conducted a comprehensive study of tilefish from the southeast Atlantic and Gulf. Fish collected from commercial long-line gear along the east coast of Florida were aged both traditionally and with lead-radium dating, the two methods agreed in regards to longevity being 26 ± 6 years. The author also established that spawning occurs from January through June, peaking in April, in both the Gulf, and eastern Florida. Male maturity occurred at less than 1 year and 150 mm FL, and female maturity occurred at 2.5 years and 331 mm FL, there was also evidence to suggest that tilefish are protogynous hermaphrodites. Natural mortality was estimated at $M = 0.10$ (SEDAR 22-DW-01 2010). Life history parameters were estimated in SEDAR 22-DW-01 (2010) as $L_{\text{inf}} = 830$ mm total length (TL), $K = 0.13$, $t_0 = -2.14$, and maximum age = 40 years.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occur in throughout the Gulf in offshore waters during late spring and summer. They are WCA and can be found over water with depths of 80-450 m (based on spawning adult distribution). In the lab, they've hatched in 40 hours at 22.0-24.6°C.

Larvae:

Larvae occur in throughout the Gulf in offshore waters during summer. They are WCA and can be found over water with depths of 80-450 m (based on spawning adult distribution).

Juveniles:

Juveniles occur in throughout the Gulf in offshore waters. Early juveniles are WCA, until they settle at 9.0-15.5 mm SL. Upon settlement (late juveniles) they use soft bottom habitat along the shelf edge/slope at depths of 80-450 m (based on adult distributions). Their predators include larger tilefish and other fish species.

Adults/Spawning Adults:

Adults and spawning adults occur throughout the Gulf in offshore waters, and occupy soft bottom habitat along the shelf edge/slope at depths of 80-450 m. Adults have been collected at temperatures of 9-14.4°C. Their predators include sharks and other tilefish, and prey items are as follows: bivalve mollusks, squids, polychaetes, holothurians, decapod crustaceans, elasmobranchs, and ray-finned fishes. They are subject to $M = 0.10$, in addition to fishery over-exploitation and mass mortality events from cold water intrusion. They reach a maximum length of 1000 mm SL, and have life history parameters of $L_{\text{inf}} = 830$ mm TL, $K = 0.13$, $t_0 = -2.14$, and maximum age = 40 years. Off the east coast of Florida longevity is 26 ± 6 years. Males grow faster than females are reach larger sizes. Spawning adults are subject of fishing pressure that may cause males to spawn at smaller sizes. Males mature at less than 1 year and 150 mm FL, and females mature at 2.5 years and 331 FL. Spawning occurs from January to June, peaking in April, and research suggests that tilefish may be protogynous hermaphrodites.

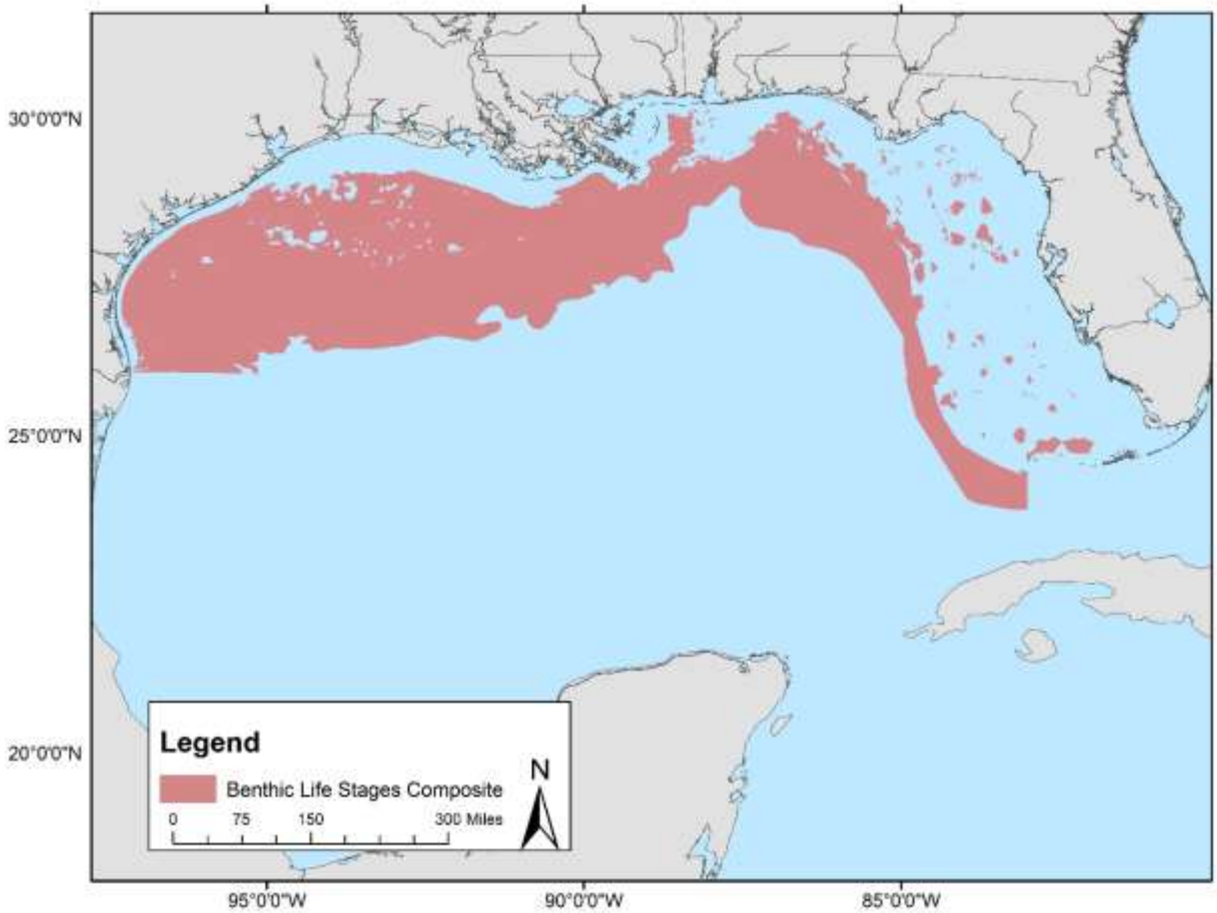

Figure 51. Map of benthic habitat use by all life stages of tilefish.

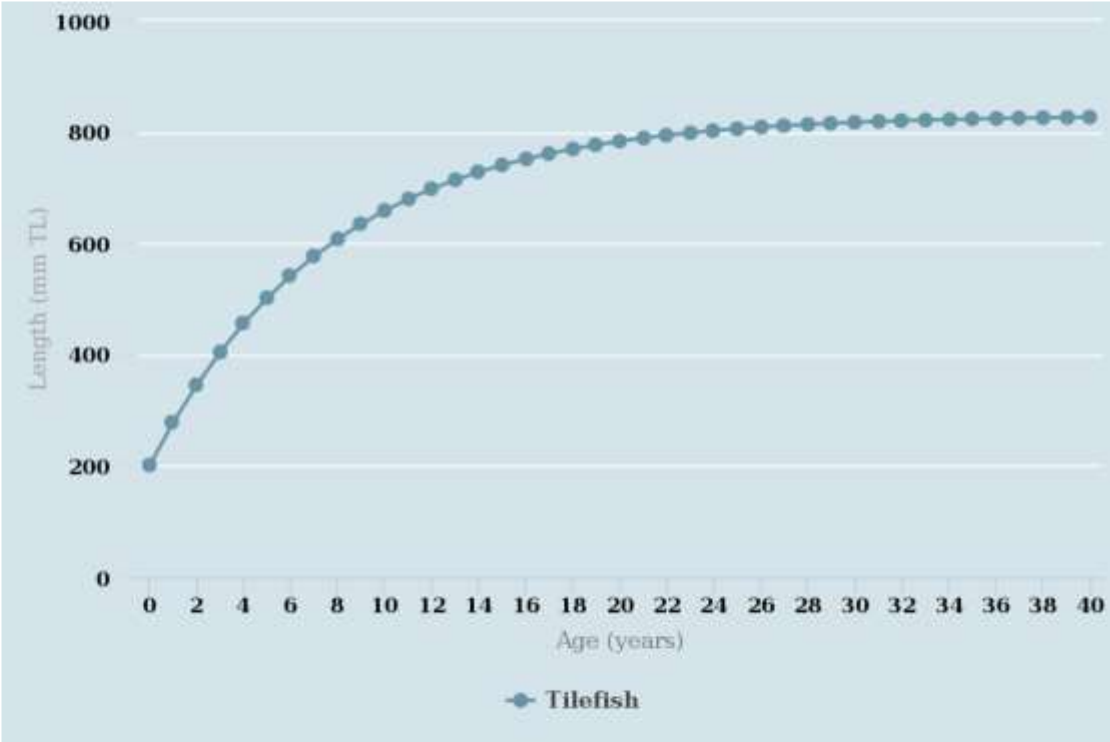

Figure 52. Predicted length at age for both sexes of tilefish from the northeastern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 830 mm TL, K = 0.13, t_0 = -2.14, and maximum age = 40 years (SEDAR 22-DW-01 2010).

Greater Amberjack (*Seriola dumerili*)

Distribution

Greater amberjack are can be found circumglobally. In the Gulf, they are found primarily offshore and have been documented in depths up to 187 m. As suggest by their offshore distribution, they use waters that have salinity and dissolved oxygen content within typical oceanic parameters. All life stages can be water column associated, additionally postlarvae and juveniles are found in drifting algae. Late juveniles and adults are associated with hard bottom, and adults and spawning adults have been documented on reefs based on research conducted in the south Atlantic and Caribbean.

Summary of new literature review

Several studies were identified that added information to the depth range occupied by adults. Burns et al. (2007) tagged greater amberjack from the Florida Keys to Pulley Ridge and collected them from a minimum depth of 4.6 m. Reed et al. (2005) documented greater amberjack at a maximum depth of 187 m on hard bottom habitat with a temperature of 14.25°C and dissolved oxygen concentration of 2.99 mg/L. Gledhill and David (2002) also documented late juveniles and adults on hard bottom habitat in the Gulf. Another habitat type identified for adults were banks/shoals (Kraus et al. 2006). Hoffmayer et al. (2003) found that both postlarvae and juvenile greater amberjack use *Sargassum* mats. Four studies better informed habitat information for spawning adults. Wells and Rooker (2004) identified spawning season to occur from February through April in ER-4. They also examined mortality and growth rates for juvenile greater amberjack and found $Z = 0.0045$, and a growth rate of 1.65-2.00 mm/day. Also in the Gulf, Murie and Parkyn (2008) identified peak spawning to occur from March through May. They also found that females were larger than males, and that for females, 50% maturity occurs at 900 mm FL and age four. Two studies from outside the Gulf found that reefs were an essential habitat for spawning adults (Harris et al. 2007; Heyman and Kjerfve 2008). Harris et al. (2007) studied greater amberjack from North Carolina to Key West, Florida and found that spawning occurred from April through May, also females age 3-7 had a potential annual fecundity of 25,472,100-47,194,300 oocytes, and that 50% maturity in males occurs at 644 mm FL. Lastly, while artificial reefs are not designated as EFH, greater amberjack have been documented utilizing them (Dance et al. 2011; Patterson et al. 2014). Estimated life history parameters for adults were $L_{inf} = 1436$ mm FL, $k = 0.175$, $t_0 = -0.954$, and maximum age = 15 years (SEDAR 33 2014).

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are WCA (pelagic), and hatch in two days.

Larvae:

Larvae are found offshore, year-round and are WCA or use drifting algae as habitat

Juveniles:

Juveniles can be found on a variety of habitats in nearshore or offshore waters, including the water column, drifting algae, and upon settling out of the water column, they also occupy hard bottom habitats. They are found summer through fall, and prey on invertebrates. Their mortality $Z = 0.0045$, and they have a growth rate of 1.65-2.00 mm/day.

Adults/Spawning Adults:

Adults can be found year-round in nearshore or offshore waters, and are associated with the water column, hard bottom, banks/shoals, and reefs (in the Atlantic and Belize) in depths of 4.6-187 m. They prey on fish, crustaceans, and cephalopods. Females are generally larger than males, and have a longer life span. Additionally, they've been documented at a dissolved oxygen of 2.99 mg/L and temperature of 14.25°C. Estimated life history parameters are $L_{inf} = 1436$ mm FL, $k = 0.175$, $t_0 = -0.954$, and maximum age = 15 years. Spawning adults are found in offshore waters on reefs (in the Atlantic and Belize) or the water column. Spawning occurs from February through May. Fifty percent maturity in females occurs at 900 mm FL and age four in the Gulf, and at 644 mm FL for males in the Atlantic. Additionally, females in the Atlantic ages 3-7 have a potential annual fecundity of 25,472,100-47,194,300 oocytes.

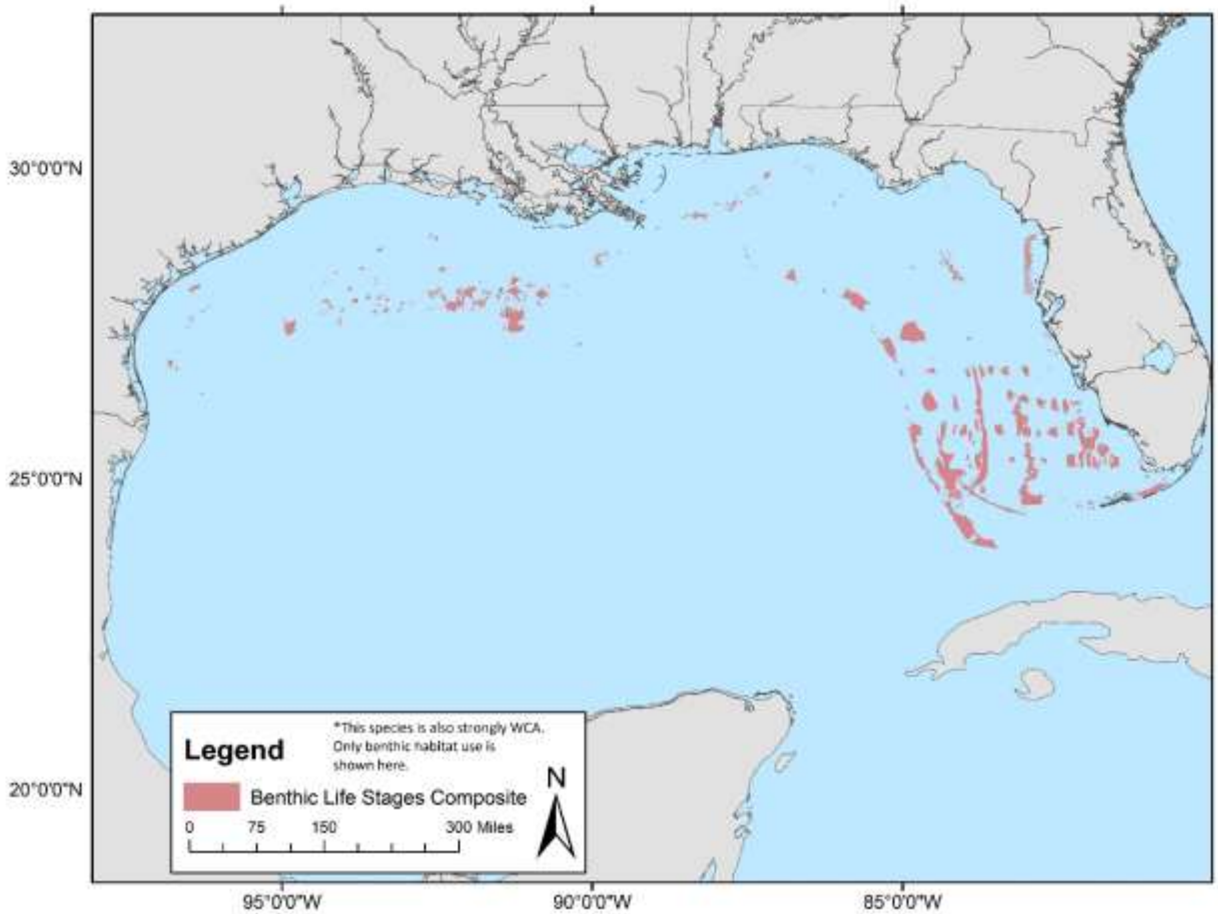

Figure 53. Map of benthic habitat use by all life stages of greater amberjack.

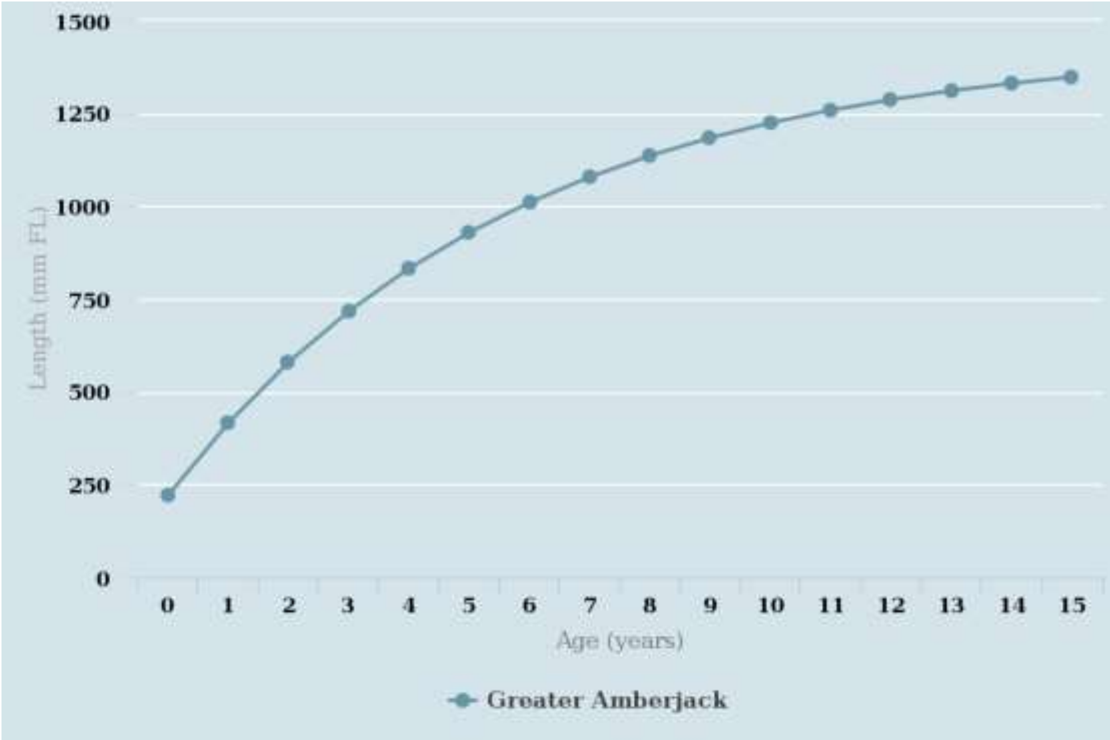

Figure 54. Predicted length at age for both sexes of greater amberjack in the Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 1436 mm FL, K = 0.18, t_0 = -0.95, and maximum age = 15 years (SEDAR 33 2014).

Lesser Amberjack (*Seriola fasciata*)

Distribution

Lesser amberjack can be found in waters throughout the western Atlantic from Massachusetts to Brazil. In the Gulf, they are found in all ER in offshore waters. Depending on life stage, they occupy drifting algae, hard bottom, or reef habitats, in depths of 55-348 m (based on fish collected from southeast Florida).

Summary of new literature review

Very minimal literature was available on this species. Bunkley-Williams and Williams (2004) studied juvenile and adult lesser amberjack in the Caribbean and southeast Florida, and collected fish from depths of 55-348 m. While not considered EFH at this time, it is of note that Dance et al. (2011) documented lesser amberjack on artificial reefs in ER 2-3. Lastly, Glenhill and David (2002) collected amberjack from hard bottom and reef habitats from Madison-Swanson and Steamboat Lumps marine protected areas.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occur throughout the Gulf.

Larvae:

Larvae occur throughout the Gulf.

Juveniles:

Early juveniles are found in all ERs, offshore on drifting algae from late summer through fall, presumably in waters with depths from 55-348 m. Late juveniles occupy offshore waters on drifting algae, hard bottom, or reef habitats from late summer through fall. They've been caught in waters from 55-348 m in southeastern Florida.

Adults/Spawning Adults:

Adults are found on hard bottom and reef habitat at depths of 55-348 m (data from southeastern Florida), year-round, in offshore waters throughout the Gulf. They feed on squid, and females are slightly larger than males. Spawning adults are also found in all ERs in offshore waters on hard bottom habitat, presumably occupying similar depths as adults. They spawn from September to December and February to March.

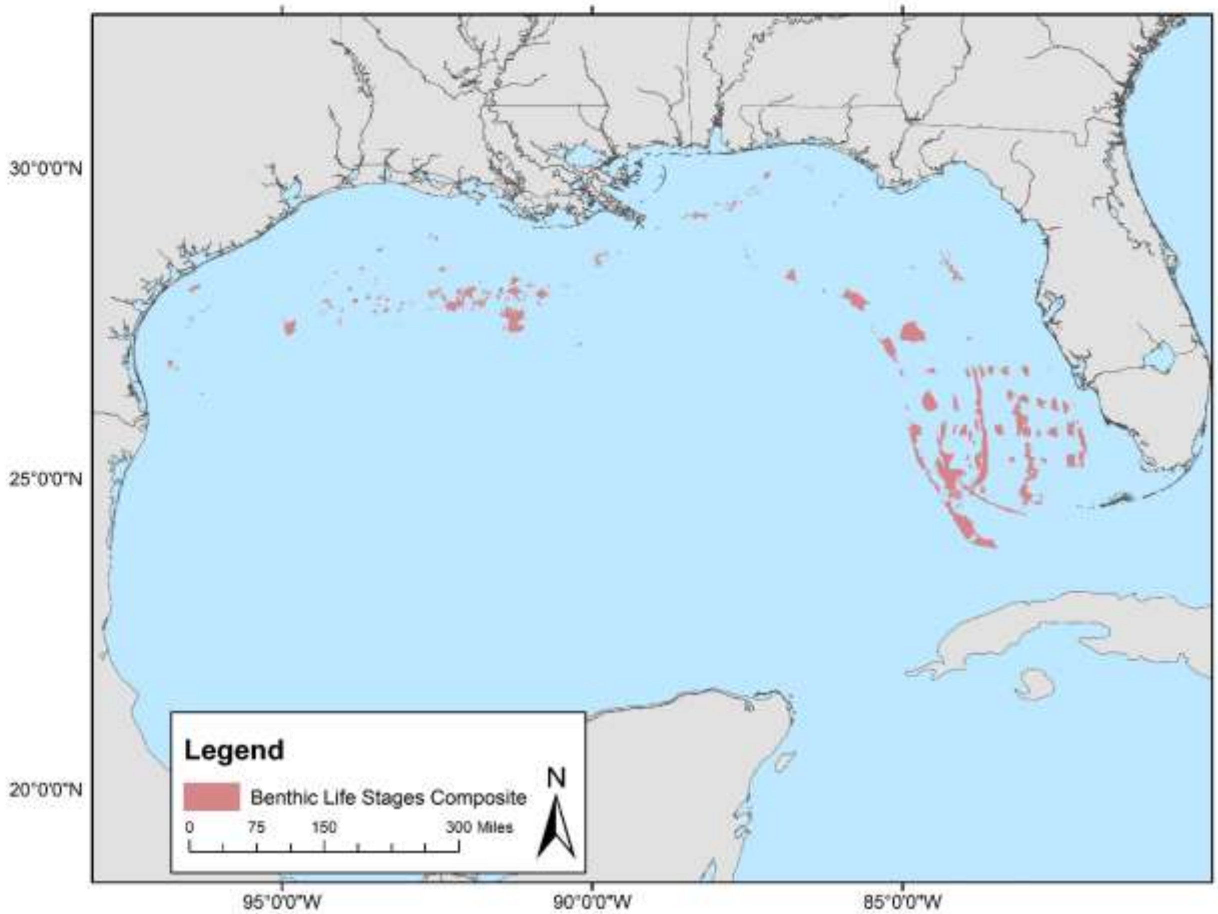

Figure 55. Map of benthic habitat use by all life stages of lesser amberjack.

Almaco Jack (*Seriola rivoliana*)

Distribution

Almaco jack occur throughout the Gulf of Mexico (Gulf). Adults are benthopelagic and form small groups. Juveniles are frequently associated with floating objects, and eggs are water column associated. Minimal habitat information is available for this species.

Summary of new literature review

Several studies were found during new literature review that expanded on the habitat information for this species. A diet study by Casazza (2008) off the coast of North Carolina revealed that juvenile almaco jack feed on fish, shrimp, and copepods. Coleman et al. (2010) found that adults in eco-region (ER) two use shelf edge and hard bottom habitat at depths of 80-120 m. In ER-5, adults use bank habitat at depths of 69-83 m (Hicks et al. 2014). Reed et al. (2006) conducted a study off the east coast of Florida that showed adults using reef habitat at depths of 70-179 m.

Lastly, Reeves (2015) studied juvenile almaco jack in ER four and found that they occurred inshore at depths of 6.7-16.8 m and temperatures of 23.3-31.7 °C on artificial reefs (oil rigs specifically).

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs occur from the Florida Keys to Pensacola Bay in the eastern Gulf, and Freeport, Texas to the Mexico border in the western Gulf. Primarily prevalent from spring through fall in the water column.

Larvae:

Larvae occur from the Florida Keys to Pensacola Bay in the eastern Gulf, and Freeport, Texas to the Mexico border in the western Gulf.

Juveniles:

Juveniles occupy the entirety of the Gulf, from August through January and July through October. They use drifting algae and artificial reefs (not currently considered essential fish habitat (EFH) as habitat, and can be found nearshore and offshore. They have been observed in depths of 6.7-16.8 m, and consume fish, shrimp, and copepods.

Adults/Spawning Adults:

Adults occupy the entire Gulf and are found in the northern portion during summer months and year-round in the southern portion. They are found offshore in depths of 21-179 m, and are associated with artificial reefs (not currently considered EFH), shelf edge, hard bottom, bank, and reef habitats. Primary prey items are fish. Spawning occurs from spring-fall, in ER 1-3, though the northern Gulf is probably not an important spawning area.

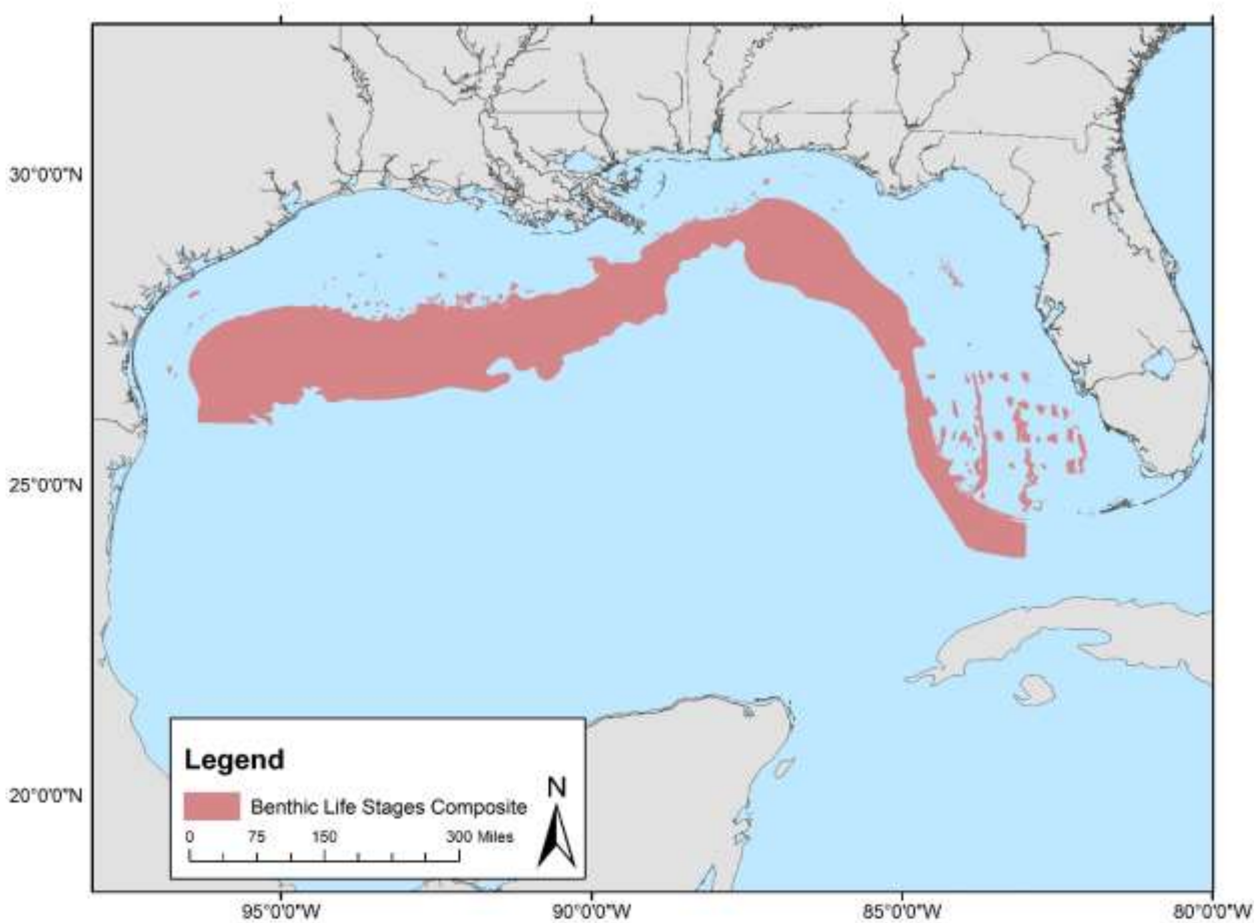

Figure 56. Map of benthic habitat use by all life stages of almaco jack.

Banded Rudderfish (*Seriola zonata*)

Distribution

Adult banded rudderfish are pelagic or epibenthic and confined to coastal waters over the continental shelf where they feed on fish and shrimps. They are not common in the central part of the northern Gulf. They spawn in offshore waters of the eastern Gulf, the Yucatan Channel and Straits of Florida. Juveniles occur in offshore waters and associate with jellyfish, such as *Physalia*, and drifting weeds, such as *Sargassum*.

Summary of new literature review

No new literature was found that expanded on current knowledge of essential fish habitat or habitat association for banded rudderfish.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2 in nearshore and offshore waters at depths of 10-130 m (based on spawning adult depths).

Larvae:

Larvae and postlarvae likely occupy the same types of habitat. Larvae are water column associated in nearshore and offshore waters of ER 1-2 at depths of 10-130 m (based on spawning adult depths). They are present during most months, excluding February, April, September and December.

Juveniles:

Juveniles occupy ER 1-2 in nearshore and offshore waters. They are water column associated and use drifting algae (*Sargassum*) in waters with depths of 10-130 m (based on adult depth distributions). This life stage can be found year-round.

Adults/Spawning Adults:

Adult and spawning adult banded rudderfish occupy nearshore and offshore waters in ER 1-2. They are found in depths from 10-130 m and are water column associated. Adults can be found year-round and prey upon fish and shrimp. Spawning may be continuous, or occurring during two seasons; winter through spring, and fall.

Gray Triggerfish (*Balistes capriscus*)

Distribution

Gray triggerfish are found in the eastern Atlantic from the Mediterranean to Moçamedes, Angola, and in the western Atlantic from Nova Scotia (Canada), Bermuda, and the northern Gulf to Argentina (Robins et al. 1999). In the Gulf, they can be found in all ER at depths from 10-100 m. They occupy habitat types including the water column, reefs, *Sargassum* (drifting algae), and mangroves depending on the life stage.

Summary of new literature review

Several studies were found that reveal new habitat related information on gray triggerfish. Burton et al. (2015) calculated mortality and growth for juvenile and adult triggerfish from the southeastern United States. Their research indicated that $Z = 0.95$ and $M = 0.28$. Life history parameters were estimated as follows: L_{inf} = 589.7 mm FL, $k = 0.14$, $t_0 = -1.66$ (SEDAR 43-WP-10 2015), and maximum age = 15 years (SEDAR 43 2015). Spawning adults can be found at temperatures between 20.9-30.0°C, salinities of 29.8-35.6 ppt and dissolved oxygen concentrations from 4.9-6.8 mg/L, additionally they are harem spawners (MacKichan and Szedlmayer 2007; Simmons and Szedlmayer 2012). Adult males are larger than females, and eggs face predation threat from a several families including: Labridae, Haemulidae, Serranidae, and Lutjanidae (Simmons and Szedlmayer 2012). Lastly, research by Simmons and Szedlmayer (2011) suggests that gray triggerfish spend the first 4-7 months of life in the pelagic zone before recruiting to benthic structures. It's also of note that late juveniles and adults occupy artificial reefs, although these structures are not considered essential fish habitat (MacKichan and Szedlmayer 2007; Simmons and Szedlmayer 2011; Simmons and Szedlmayer 2012).

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found throughout the Gulf, both nearshore and offshore water and are benthically associated. They are presumed to occur at depths from 10-100 m based on spawning adult distributions. They hatch in 48-55 hours and are found in late spring and summer. Their primary predators are Haemulidae and *Lutjanus campechanus*.

Larvae:

Larvae are found throughout the Gulf and occupy water column and *Sargassum* (drifting algae) habitats. They spend 4-7 months in the pelagic zone and are likely predated upon by pelagic fishes.

Juveniles:

Juveniles occur throughout the Gulf, and depending on age (first 4-7 months of life in pelagic zone), occupy *Sargassum* (drifting algae), mangroves, and reefs. Their prey items include algae, hydroids, barnacles, and polychaetes, and they are preyed on by larger pelagic fishes. Late juveniles are suspected to occupy depths from 10-100 m based on adult distribution. Additionally, late juveniles have mortality rates as follows: $Z = 0.95$ and $M = 0.28$ (this data comes from the southeastern US).

Adults/Spawning Adults:

All adults are found throughout the Gulf, both nearshore and offshore in depths of 10-100 m. They use reef and hard bottom habitats, and consume bivalves, barnacles, polychaetes, decapod crabs, gastropods, sea stars, sea cucumbers, brittle stars, sea urchins, and sand dollars. Their primary predators are greater amberjack, sharks and groupers. They face morality threats from both predation, and the recreational (age three) and commercial (age four) fisheries. Growth occurs rapidly in the first year, then slows. Adults have life history and morality estimates as follows: Z = 0.95, M = 0.28 (mortality data comes from the southeastern US), Linf = 589.7 mm FL, k = 0.14, t0 = -1.66, and maximum age = 15 years. Spawning adults have been documented at salinities of 29.8-35.6 ppt and dissolved oxygen concentrations of 4.9-6.8 mg/L. They are harem spawners, and males are larger than females. Lastly, fecundity estimates based on size are: 300 mm = 49,000 egg/female, 410 mm = 66,000 eggs/female, and 560 mm greater than 90,000 eggs/female**.**

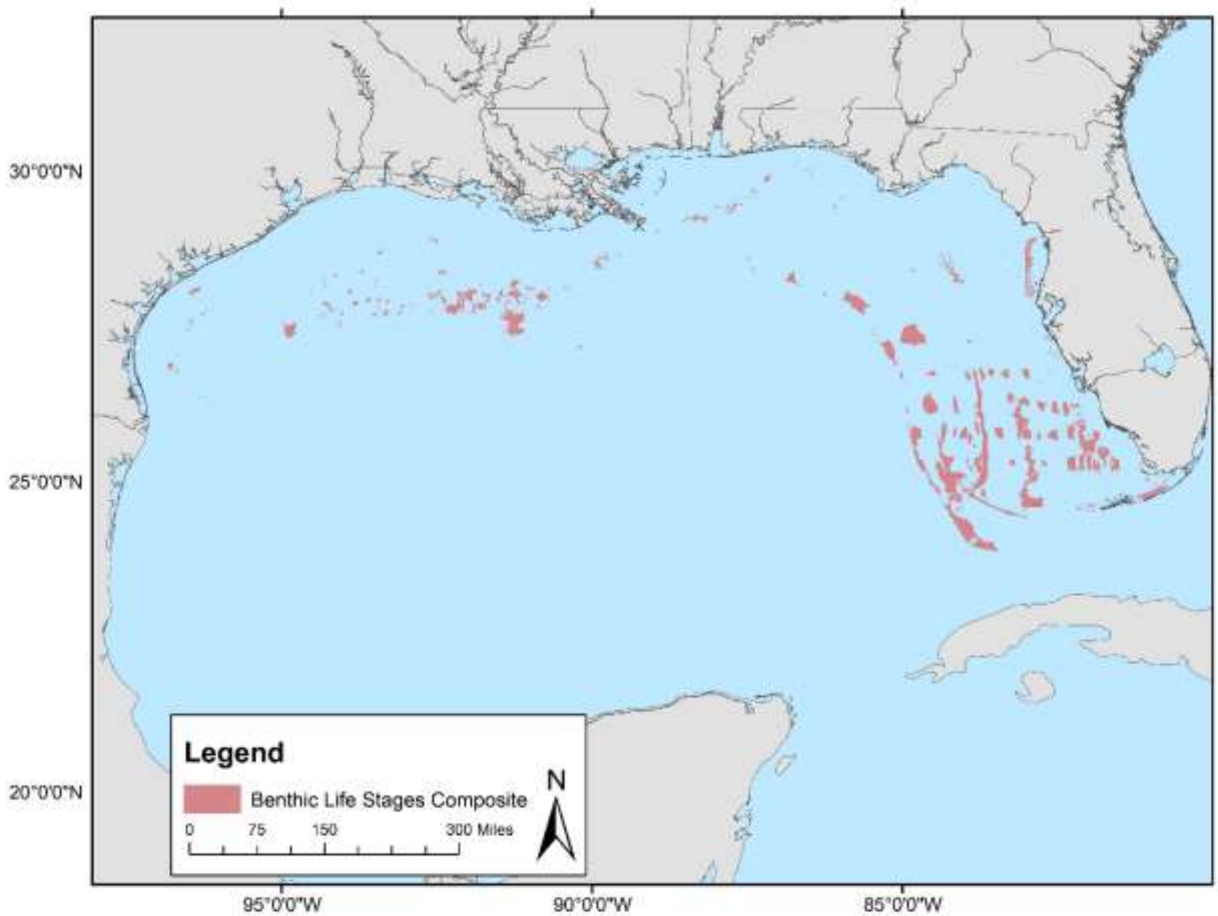

Figure 57. Map of benthic habitat use by all life stages of gray triggerfish.

Figure 58. Predicted length at age for both sexes of gray triggerfish in the northern Gulf. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 589.7 mm FL, K = 0.14, t_0 = -1.66 (SEDAR 43-WP-10 2015), and maximum age = 15 years (SEDAR 43 2015).

Hogfish (*Lachnolaimus maximus*)

Distribution

Hogfish inhabit areas of moderate to high relief in shelf waters. They range from North Carolina, south through the Caribbean Sea and Gulf, to the northern coast of South America. Juveniles can be found in shallow seagrass beds in Florida Bay, where they feed on benthic crustaceans, mollusks, and echinoderms. Adults are widely distributed on coral reefs and rocky flats, where they consume bivalves, gastropods, sea urchins, crabs, and other mollusks (Sierra et al. 1994; Randall 1967).

Summary of new literature review

Prior to this review, no habitat association table existed for hogfish. As such, all literature is 'new'. Please reference below or habitat association table for detailed habitat use information.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Eggs are found in ER 1-2, and are WCA. They occur seasonally from April through December and hatch in about 23 hours at 25.5°C. One of their predators are yellowtail snapper.

Larvae:

Larvae and postlarvae occur in ER 1-2, and are WCA. The larval stage lasts from 23 hours to 13 days and post-larval stage lasts from 13 days to 34 days, after which they settle to SAV.

Juveniles:

Juveniles occupy estuarine and nearshore waters, utilizing SAV from December through April.

Adults/Spawning Adults:

Adults occupy hard bottom and reef habitats in nearshore and offshore waters with depths less than 30 m, salinities from 29-36 PSU and dissolved oxygen concentrations of 6.0-9.60 mg/L. They are found year-round and have been collected at temperatures from 15.7-31.2°C. They primarily consume benthic invertebrates. While not considered EFH at this time, adults have been found occupying artificial reefs. Maximum observed age for females is 10 years, and 23 years for transitioned males. Life history and mortality for adults have been estimated as follows: M/yr = 0.16-1.47 (depending on calculation method), L_{inf} = 849.0 mm FL, k = 0.11, t_0 = -1.33, and maximum age = 25 years. Spawning adults can be found in nearshore and offshore waters with depths from 1-69 m. They spawn on reef, sand, or hard bottom habitats from December to July, peaking from March to April. They consume sand-dwelling mollusks and sea urchins. They are protogynous and harem spawners. Fifty percent maturity of females occurs at 169.0 mm FL and 1.1 years, for males it occurs at 426 mm FL and 6.5 years. Batch fecundity estimates can be calculated as follows: 839.0 x weight (g)$^{0.48}$ and 7773.0 x age$^{0.78}$.

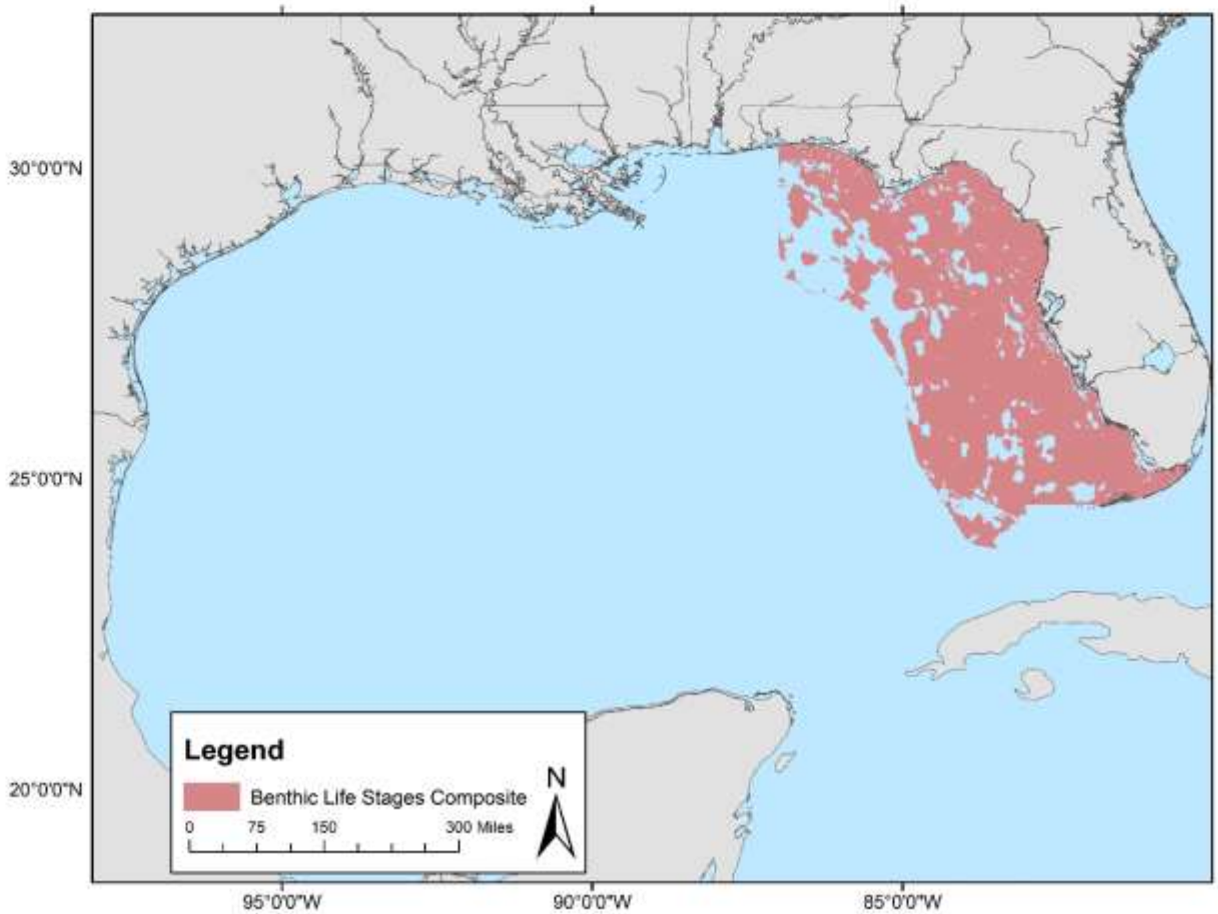

Figure 59. Map of benthic habitat use by all life stages of hogfish.

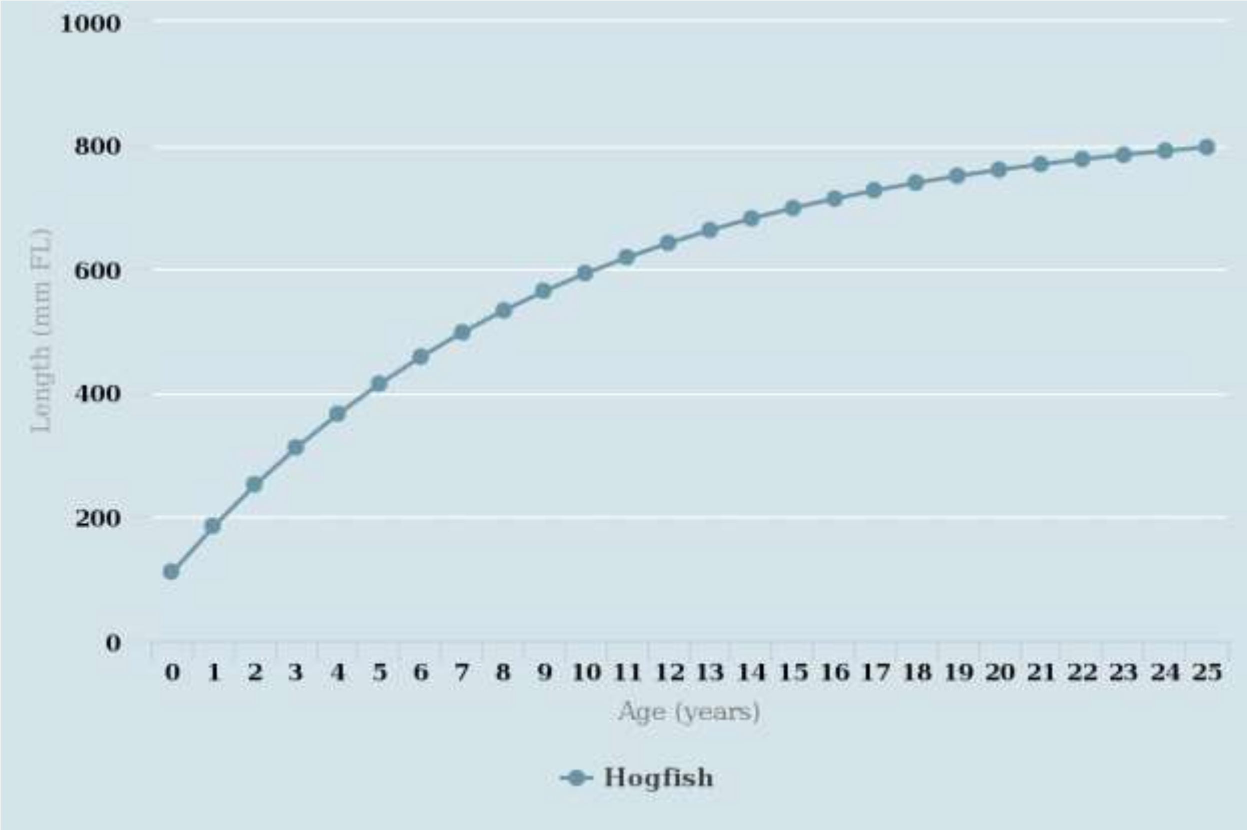

Figure 60. Predicted length at age for both sexes of hogfish from the West Florida stock. Predictions are generated from the von Bertalanffy growth equation using parameter estimates of L_{inf} = 849.0 mm FL, K = 0.11, t_0 = -1.33, and maximum age = 25 years (SEDAR 37 2013).

3.1.5 Shrimp

Brown Shrimp (*Penaeus aztecus*)

Distribution

Brown shrimp are found within estuaries to offshore depths of 110 m in the Gulf of Mexico (Gulf), ranging mainly from Apalachicola Bay to the Yucatan Peninsula. They spawn in depths greater than 18 m during fall and spring, and year-round in depths greater than 64 m. Postlarvae migrate to estuaries through passes on flood tides at night, mainly from February to April, with a minor peak in the fall (GMFMC 2004).

In estuaries, brown shrimp postlarvae and juveniles are associated with shallow vegetated habitats, but are also found over silty sand and non-vegetated mud bottoms. The density of late postlarvae and juveniles is highest in marsh edge habitat and submerged vegetation associated with decaying vegetation or organic matter (Williams 1955; Mock 1967; Jones 1973), followed by tidal creeks, inner marsh, shallow open water and oyster reefs; in unvegetated areas muddy substrates seem to be preferred (GMFMC 2004).

Sub-adult brown shrimp leave estuaries at night on an ebb tide during full and new moons (Copeland 1965). The particular stimulus causing the brown shrimp emigration is a matter of debate. Brown shrimp 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) and are associated with silt, muddy sand and sandy substrates. Following their initial emigration from estuaries, they may continue a gradual migration to deeper Gulf waters (GMFMC 1981a; GMFMC 2004).

Summary of new literature review

Several new studies were found that primarily add to current information about growth and production in brown shrimp. Clark et al. (2004) modeled habitat-use by juvenile brown shrimp in Galveston Bay, Texas. This technique allowed for estimation of the overall population of brown shrimp in shallow water habitats in the bay. The estimate was 1.3 billion juvenile shrimp. Craig et al. (2005) studied the spatial distribution of brown shrimp in response to population abundance and hypoxia. The authors found that during years of severe hypoxia, shrimp densities were high both inshore and offshore of the hypoxic region, suggesting that those shrimp that haven't migrated offshore will remain nearshore during hypoxic events and those that have already moved offshore may push further out to avoid hypoxic areas. Rozas and Minello (2011) examined variation in shrimp growth rates given varying salinities, and related this information to how river diversions can impact nekton populations. One of the species studied was brown shrimp and the authors found that growth was slower under conditions of intermediate salinity (mean salinities = 1.4-2.1). They concluded that this was likely due to increased metabolic costs and decreased food resources. Next, Rozas et al. (2007) used data collected monthly over 11 years (1982-1992) to compare nekton densities in marsh edge and adjacent soft bottom habitats in Galveston Bay, Texas. Their results indicated that nekton densities were higher over marsh habitat than soft bottom. For brown shrimp, they showed that populations declined during this time period as wetlands and marsh edge were reduced. Rozas et al. (2014) reported the effect of Deepwater Horizon oil on shrimp growth rates. The study was conducted in Barataria Bay, Louisiana at 25 locations designated as heavily, moderately, lightly, very lightly, or not oiled. Growth rates for juvenile brown shrimp were 0.9 mm/day in non-oiled locations and 0.4 mm/day at heavily oiled locations, suggesting that brown shrimp residing in heavily oiled marsh shoreline experience reduced growth rates compared to those in unoiled habitat. Lastly, Craig and Crowder (2005) examined hypoxia-related habitat loss and its impacts on spatial distribution and energy expenditure in Atlantic croaker and brown shrimp. As with Craig et al. (2005), this study found higher densities of sub-adult brown shrimp inshore and offshore of the hypoxic areas. Additionally, when hypoxic waters were not present or were minimal, sub-adult brown shrimp were found at temperatures of 18 to 28°C.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Fertilized Eggs (0.26 mm diameter):

Eggs are found in eco-regions (ER) three, four and five in offshore waters with depths of 18-110 m (based on spawning adult distributions). Eggs are most prevalent in fall and spring on soft bottom or sand/shell habitats with temperatures greater than 24°C. Eggs hatch 24 hours after spawning.

Larvae/Pre-settlement Postlarvae (< 14 mm):

Larval and pre-settlement postlarval brown shrimp are found in ER 3-5 in estuarine, nearshore, and offshore waters with depths of 0-82 m. They are water column associated (WCA) and can be found year-round with peak abundances occurring in the spring. They have been collected at temperatures of 28-30°C and salinities of 24-36 parts per thousand (ppt). Prey items include phytoplankton and zooplankton, and predators are fish species and some zooplankton.

Late Postlarvae/Juveniles (14-80 mm):

Late postlarvae and juvenile brown shrimp are found in ER 3-5 during the spring through fall in estuarine waters with depths less than one meter, temperatures of 7-35°C, salinities of 2-40 ppt, and experience mortality at dissolved oxygen (DO) concentrations less than one parts per million (ppm). They occupy nearly all estuarine environments, including submerged aquatic vegetation (SAV), emergent marsh, oyster reef, soft bottom, and sand/shell habitats. Prey include benthic algae, polychaete worms, and peracarid crustaceans, and main predators are fish, specifically southern flounder, spotted seatrout, red drum, Atlantic croaker, pinfish, and sea catfish. This life stage experiences mortality from a variety of sources including predation and mass kills due to cold temperatures in shallow water. They are also threatened by loss of important habitats such as marsh edge. Normal growth rates are approximately 0.9 mm/day. Higher growth is seen in marshes than soft bottom and with carnivorous feeding. Reduced growth occurs in low salinity environments due to increased metabolic costs and decreased food resources. Decreased growth has also been show to occur in heavily oiled habitats. Population estimates in shallow water habitats of Galveston Bay, Texas are approximately 1.3 billion.

Sub-adults:

Sub-adults are found in ER 3-5 in estuarine and nearshore waters on soft bottom and sand/shell habitats at depths of 1-18 m, temperatures of 18-28°C, salinities of 0.9-30.8 ppt, and experience mortality at DO concentrations less than one meter. This life stage is most abundant in the spring through fall, and feeds on polychaetes, amphipods, and other benthic invertebrates. Mortality stems from predation; predators include fish, specifically southern flounder, spotted seatrout, red drum, Atlantic croaker, pinfish, and sea catfish, also from cold fronts and hypoxia. Impoundments of estuarine areas have been shown to decrease production and correlations exist between the abundance of sub-adults and landings offshore.

Non-spawning/Spawning Adults:

Adult brown shrimp are found in ER 3-5 on soft bottom and sand/shell habitats in offshore waters with salinities of 2-35 ppt and DO concentrations greater than 2 ppm. They are omnivorous, feeding at night, and are preyed upon by larger fish. Non-spawning adults have been collected at temperatures of 10-37°C and depths of 14-110 m in the summer and fall. Spawning occurs at depths of 18-110 m during the fall and spring and year-round at depths greater than 64 m.

Brown shrimp spatial distributions are affected by hypoxia and populations have shown declines with wetland and marsh edge loss.

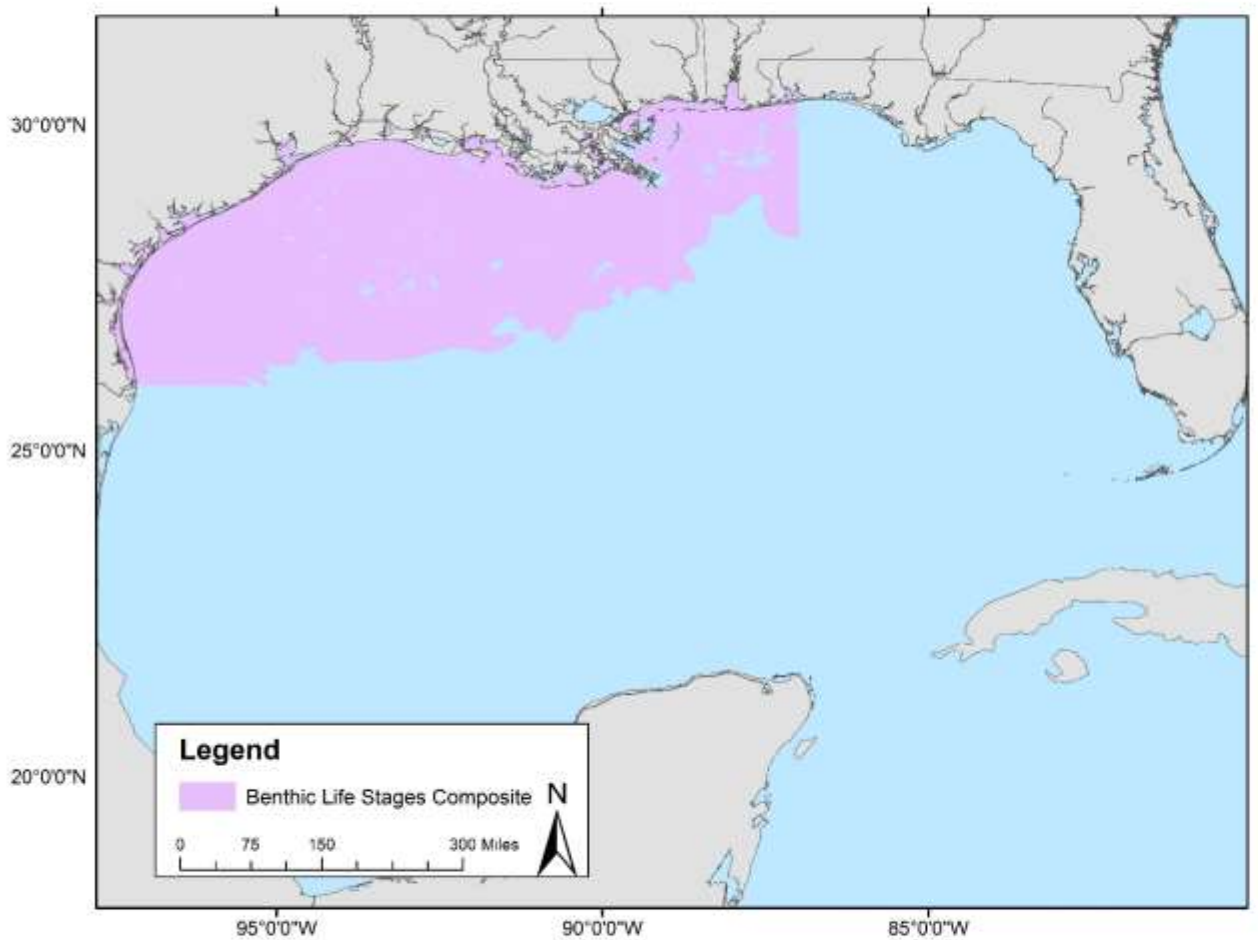

Figure 61. Map of benthic habitat use by all life stages of brown shrimp.

White Shrimp (*Penaeus setiferus*)

Distribution

White shrimp are found in estuaries and out to depths of 40 m (but usually less than 27 m) from Florida's Big Bend through Texas. White shrimp spawn in depths between 9-34 m (but usually less than 27 m) from spring through fall. White shrimp postlarvae enter estuaries through passes from May-November with peaks in June and September. White shrimp migration is in the upper two meters of the water column at night and at mid-depths during the day. White shrimp postlarvae and juveniles inhabit mostly mud and peat bottoms with large amounts of decaying matter or vegetative cover, and they tend to be more active during the day than the other two species (Clark and Caillouet 1975). Juveniles have been reported to prefer lower salinity areas of estuaries (less than 10 ppt), however, Clark et al. (1999) found no significant relation between juvenile white shrimp densities and salinity. They did, however, find significantly higher densities of juveniles in marsh edge microhabitats. Juvenile white shrimp were found to feed on sand, detritus, organic matter, mollusk fragments, ostracods, copepods, insect larvae, and forams (Darnell 1958). Sub-adult white shrimp leave estuaries in late August and September on ebb tides during full moons (Whitaker 1982), and the timing appears to be related to shrimp size and environmental conditions (e.g. sharp temperature drops in fall and winter). Adult white shrimp inhabit nearshore Gulf waters to depths less than 30 m on bottoms of soft mud or silt (GMFMC 2004).

Summary of new literature review

Most of the new literature found addressed the postlarval/juvenile life stage. One study included stage duration, growth and mortality information for all life stages. This study by Baker et al. (2014) incorporated the aforementioned information (compiled by a number of different studies) to generate a model that explores how variability in juvenile growth and mortality could impact the population's growth rate. The authors found that juvenile survival make drive adult stock size, emphasizing the importance of understanding the factors that influence juvenile survival and growth. For the egg and larval white shrimp stages daily instantaneous mortality (*Z)* was 0.373 and the duration of these stages was 16 days (Dall et al. 1990; Lindner and Cook 1970). Juvenile daily *Z* ranged from 0.014 to 0.126, growth rates were estimated at 0.3-1.2 mm/day, and stage duration was 79 days (Zein-Eldin and Griffith 1969; Baker and Minello 2010; Rozas and Minello 2009; Rozas and Minello 2011; Knudsen et al. 1996; Webb and Kneib 2004; Minello et al. 2008). Sub-adult white shrimp daily *Z* ranged from 0.023 to 0.048, estimated growth rates were 0.4-1.5 mm/day, and stage duration was 33 days (Lindner and Cook 1970; Klima 1974; Baxter and Holloway 1981). Lastly, for adults daily *Z* ranged from 0.004-0.034, growth rates were from 0.4-1.0 mm/day, and stage duration lasted approximately 237 days (Klima 1964; Klima 1974).

The remainder of new literature found focused solely on the late postlarvae/juvenile life stage. Caudill (2005) studied nekton use and explored the value of *Spartina alterniflora*, *Avicennia germinans* (black mangrove), and transition (*S. alterniflora* and *A. germinans*) habitats for fish and crustaceans in Caminada Bay, Louisiana. Mangroves are a previously unreported habitat type used by white shrimp, however the author found they were more associated with mangroves than the other habitat types considered. Additionally, white shrimp biomass with significantly higher in the mangrove habitats than in the *Spartina* habitats. Diop et al. (2007) developed a model to predict abundance and catch of white shrimp in Louisiana given life stage counts and environmental parameters. They concluded that juvenile white shrimp abundances were greater with increased temperature, salinity, and turbidity. Minello et al. (2008) estimated the abundance and production of nekton in Galveston Bay, Texas using landscape analysis given data on small scale distribution patterns to estimate population abundance. The estimated population abundances were coupled with data on size frequencies, size-weight relationships, and growth rates for brown shrimp, white shrimp, and blue crab to estimate and compare annual production between open-water and salt marsh habitats. For white shrimp, marsh production was higher than open-water and estimated at 109 kg/ha.

Hypoxic zones impact the northern Gulf on an annual basis, and may have negative implications for the fish and invertebrate populations (and their associated fisheries) living in the affected areas. O'Connor and Whitall (2007) investigated relationships between shrimp catch and hypoxia in the northern Gulf. Interestingly, they found no statistically significant relationships between the hypoxic zone and annual white shrimp catch. Lastly, Shervette and Gelwick (2008) examined variations in growth, density, and survival in three different juvenile shrimp habitat types (emergent marsh, oyster reefs, soft bottom). Their results showed greater densities of white shrimp in oyster reef and emergent marsh habitat. They collected larger individuals on soft bottom habitats. Growth rates were highest in oyster reef habitats, and survival was highest in emergent marsh and soft bottom habitats. The authors concluded that juvenile white shrimp may be more driven to select habitat based on food availability than protection from predation, given their high densities in oyster reefs despite greatest risk of predation.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Fertilized Eggs:

White shrimp eggs are found in ER 2-5 in estuarine, nearshore, and offshore waters from spring through fall. They occupy waters with depths of 9-34 m, hatch 10-12 hours after spawning, and the egg/larval stage lasts about 16 days. Daily Z has been estimated as 0.373.

Larvae/Pre-settlement Postlarvae:

White shrimp larvae and pre-settlement postlarvae are found in ER 2-5 in estuarine, nearshore, and offshore waters from spring through fall. They are found in waters with depths of 0-82 m and temperatures of 17.0-28.5°C. This life stage consumes phytoplankton and zooplankton, and their predators are fish and some zooplankton. The duration of the egg/larval stage lasts about 16 days. Larvae and pre-settlement postlarvae migrate through passes at night in shallow water and during the day at mid-depths, from May through November.

Late Postlarvae/Juveniles:

White shrimp late postlarvae and juveniles are found in ER 2-5 in estuarine and nearshore waters from late spring through fall on emergent marsh, SAV, oyster reef, soft bottom, and mangrove habitats. They are found in waters with depths of less than one meter, temperatures of 13-31°C (postlarvae) and 9-33°C (juveniles), salinities of 0.4-37 ppt, and DO concentrations greater than 1.0 ppm. This life stage is omnivorous, consuming detritus, annelid worms, pericarid crustaceans, caridean shrimp, and diatoms, and their predators are primarily fish. Late postlarvae and juveniles experience a daily *Z* of 0.014-0.126, and growth rates of 0.3-1.2 mm/day. These growth rates increase at temperatures of 18-32.5°C and decrease at 35°C. Growth is slower at less than 18°C. The duration of this stage is 79 days. Research suggests white shrimp occur at greater abundances with increases in temperature, salinity, and turbidity. Greatest densities have been found on oyster reefs and emergent marsh compared to soft bottom. The largest shrimp have been collected from soft bottom (compared to emergent marsh or oyster reefs). Highest growth occurred on oyster reefs and highest survival on emergent marsh and soft bottom. Mass mortality has occurred in shallow waters after cold fronts.

Sub-adults:

White shrimp sub-adults are found in ER 2-5 in estuarine, nearshore, and offshore waters during summer and fall on soft bottom and sand/shell habitats. They are found in waters with depths of less than 27 m, temperatures of 7-38°C, DO concentrations of greater than two ppm, and salinities of 2-35 ppt. This life stage is omnivorous, and their predators are primarily larger fish. Adults experience a daily *Z* of 0.004-0.034, and growth rates of 0.4-1.5 mm/day. The duration of this stage is 33 days. Migration from estuaries occurs in late August and September and is related to shrimp size and the environmental conditions in the estuary (e.g. temperature decreases).

Adults/Spawning Adults:

White shrimp adults are found in ER 2-5 in estuarine, nearshore, and offshore waters during late summer and fall on soft bottom habitats. They are found in waters with depths of 1-30 m, temperatures of greater than 6°C (based on a study conducted outside the Gulf of Mexico Fishery Management Council’s (Council) jurisdiction), and salinities of 1-21 ppt. This life stage is omnivorous, consuming annelids, insects, detritus, gastropods, copepods, bryozoans, sponges, corals, fish, filamentous algae, vascular plant stems and roots, and their predators are primarily fish. Sub-adults experience a daily *Z* of 0.023-0.048, and growth rates of 0.4-1.0 mm/day. The duration of this stage is 237 days. Trophic models developed for bycatch management indicate that reducing discards from the fishery can affect shrimp productivity. Spawning occurs in ER 2-5 in estuarine, nearshore, and offshore waters from spring through late fall, peaking from June to July at depths of 9-34 m and salinities greater than or equal to 27 ppt.

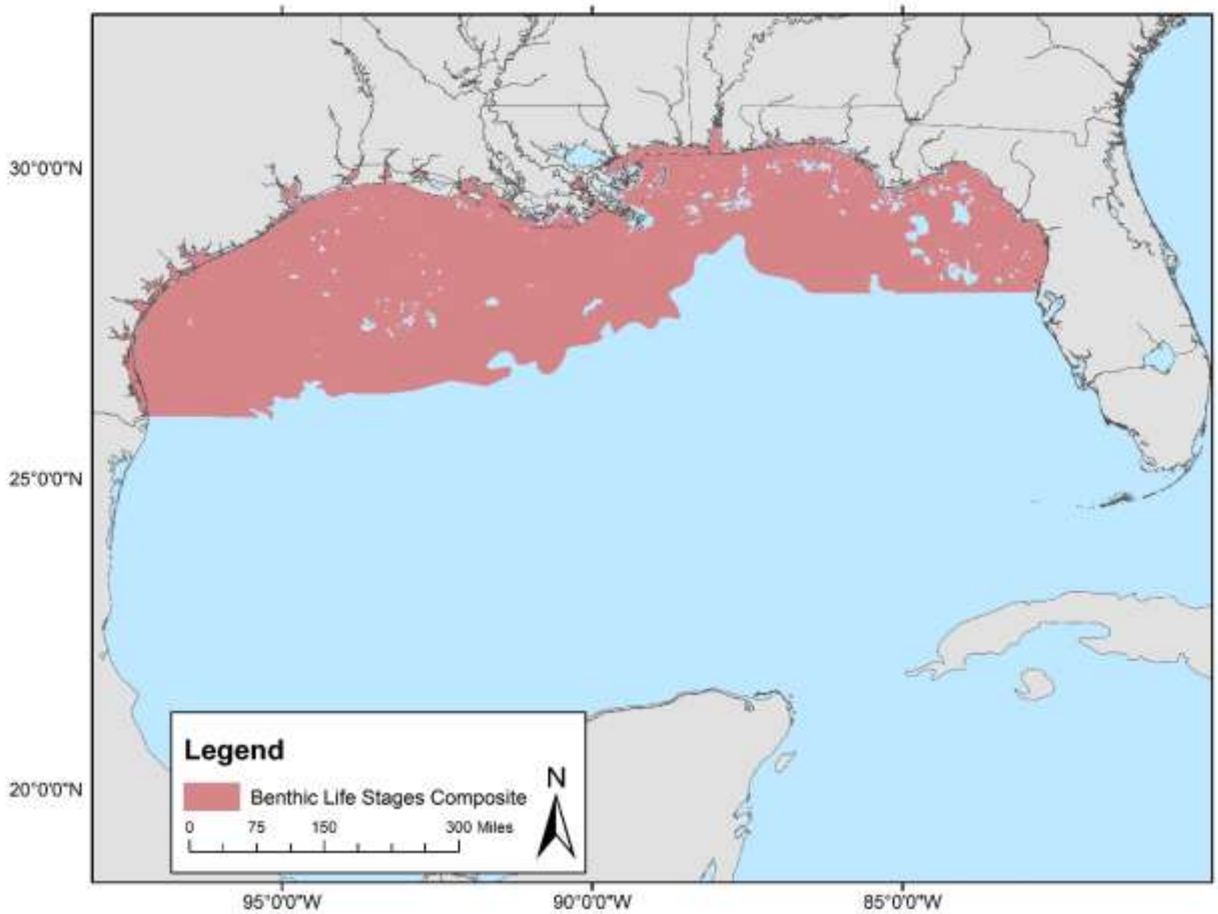

Figure 62. Map of benthic habitat use by all life stages of white shrimp.

Pink Shrimp (*Penaeus duorarum*)

Distribution

Pink shrimp occur in estuaries and to depths of 110 m (most abundant less than 50 m) and are the dominant shrimp species off South Florida. Pink shrimp spawn year-round in the Tortugas, but most intensively during spring through fall, at depths of 22-47 m (Ingle et al. 1959; Tabb et al. 1962) and temperatures between 19.6-30.6°C (Jones et al. 1970). Off Tampa and Apalachicola Bays, spawning was most intense during the summer (Christmas and Etzold 1977). Pink shrimp postlarvae migrate into the estuaries at night, primarily during the spring and fall, usually on flood tides through passes or open shoreline. Postlarval and juvenile pink shrimp are commonly found in seagrass habitats where they burrow into the substrate by day and emerge to feed at night. Pink shrimp densities are highest in or near seagrasses, low in mangroves, and near zero or absent in marshes. They tend to prefer calcareous-type sediments found most commonly in Florida and sand/shell mud mixtures (Springer and Bullis 1954; Williams 1958; Perez-Farfante 1969; GMFMC 2004).

Gut contents of juvenile pink shrimp have been found to contain macrophytes, red and blue-green algae, diatoms, dinoflagellates, polychaetes, nematodes, shrimp, mysids, copepods, isopods, amphipods, mollusks, forams, and fish (Eldred et al. 1961). In the Everglades, Yokel et al. (1969) found that pink shrimp emigrated from the estuary mainly at night on ebb tides and more intensively during new and full moons. Adult pink shrimp are most abundant in Gulf waters from 9-48 m deep on coarse mixtures of sand and shell with less than one percent organic material (GMFMC 2004).

Summary of new literature review

Extensive research has been done on pink shrimp in the Gulf, and several more studies were found during the literature review. Boudreaux et al. (2006) studied species compositions of sessile and motile organisms inhabiting intertidal oyster reefs in a lagoon on the southeastern coast of Florida. The authors collected 145 sub-adult pink shrimp on oyster reefs. This habitat type was previously unreported for this species. Criales et al. (2007) investigated the transport of pink shrimp larvae on the southwestern Florida shelf at three locations with varying depths using planktonic trawl nets. The greatest abundances of larval shrimp were found at the Marquesas station, located 30 km north of Marquesas at a depth of 20 m. Monsreal-Vela et al. (2016) tested several models pertaining to estimating growth of juvenile and sub-adult shrimp species. Shrimp were collected from Celestun Lagoon in the south Gulf during a shrimp trawl survey carried out monthly from February 2010 to April 2011. Three growth models were tested for best fit with the collected data using Akaike information criterion (AIC). The best fitting model was the Indeterminate Tanaaka model (1982) and using this model, growth rates for late postlarvae/juvenile and sub-adult pink shrimp varied from 0.05-2.08 mm carapace length (CL)/week. Lastly, Zink et al. (2013) examined how temperature and salinity influence biomass productivity in postlarval/juvenile pink shrimp. In the lab, they applied three temperature and three salinity treatments, and assessed the growth of randomly selected shrimp in these treatments every seven days. Their conclusions were that biomass production increased with temperature and decreased at the highest salinity (55). Suggesting that shrimp populations in naturally hypersaline environments may experience reduced production compared to those in environments with lower salinities.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Pink shrimp eggs are found in ER 1-3 and ER-5. They occur in offshore waters at depths from 9-48 m (based on spawning adult distributions) and temperatures greater than 27°C. They can be found year-round on sand/shell habitats.

Larvae/Pre-settlement Postlarvae:

Larvae and pre-settlement postlarvae occur in estuarine, nearshore, and offshore waters of ER 1-3 and ER-5 at depths of 1-50 m. They are WCA and can be found year-round at temperatures of 15-35°C and salinities of 0-43 ppt (optimum 10-22 ppt). They recruit to nearshore environments through passes or open shorelines, primarily on flood tides at night. Additionally, wind speed affects larval transport. This life stage feeds on phytoplankton and zooplankton, and face predation from invertebrates and fish. They experience higher mortality above 35°C.

Late Postlarvae/Juveniles:

Late postlarvae and juvenile pink shrimp occur in estuarine and nearshore waters of ER 1-3 and ER-5 at depths of less than 1-3 m. They use a range of habitats including SAV, soft bottom, sand/shell, and mangroves (in low densities). They are present on these habitats year-round in Florida and from fall through spring in Texas. Additionally, they are found at temperatures of 6-38°C, salinities of 0-65 ppt (optimum greater than 30 ppt), and DO concentrations of 2.5-6.0 mg/L. Prey items for this life stage include seagrass, annelids, small crustaceans, shrimp, bivalves, and predators are fish, specifically spotted seatrout, red drum, and toadfish, among others. This life stage does not have any records of mass mortality due to cold fronts, and in the southern Gulf their growth rate ranges from 0.05-2.08 mm CL/week. Production for this life stage has been positively linked to freshwater input and inshore seagrass beds. Additionally, one lab study found increased biomass production with increasing temperatures and reduced production at hypersalinity (55).

Sub-adults:

Sub-adult pink shrimp occur in estuarine, nearshore, and offshore waters of ER 1-3 and ER-5 at depths of 1 to 65 m. They use a range of habitats including SAV, soft bottom, sand/shell, oyster reefs (on the southeastern coast of Florida), and mangroves (in low densities). They are present on these habitats year-round in Florida and from fall through spring in Texas. Additionally, they are found at temperatures of 6-38°C, salinities of 10-45 ppt, and DO concentrations of 2.5-5.0 mg/L. Prey items for this life stage include seagrass, annelids, small crustaceans, shrimp, bivalves, and predators are fish, specifically spotted seatrout, sand seatrout, gray snapper, mackerels, red drum, and grouper. This life stage avoids cold by migrating to deeper waters and experiences low predation offshore. They have a growth rate of 0.05-2.08 mm CL/week in the southern Gulf. Catch and effort offshore late in the season is correlated with subsequent landings, and recruitment is low for this life stage after protracted periods of drought.

Non-spawning/Spawning Adults:

Non-spawning and spawning adults occur in nearshore and offshore waters in ER 1-3 and ER-5, where they occupy sand/shell habitats. They are carnivorous and their predators include larger fish and sharks, though they experience low predation offshore. Both stages are found at temperatures of 16-31°C and salinities of 25-45 ppt. Their production is correlated with freshwater in western Florida, but there is no apparent effect of seagrass mortality inshore. Non-spawning adults are found year-round at depths of 1-110 m and spawning adults are found year-round off of Florida and spring through fall off of Texas at depths of 9-48 m.

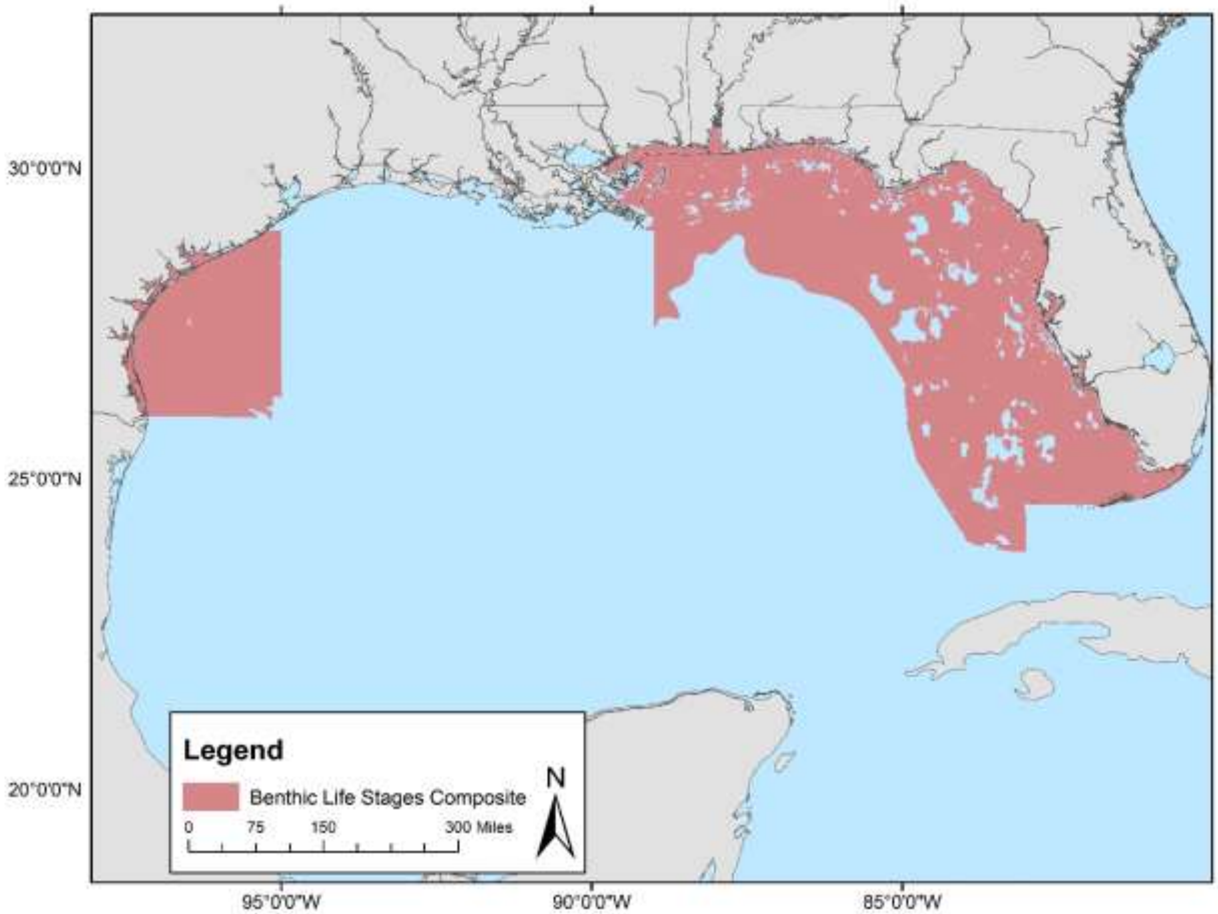

Figure 63. Map of benthic habitat use by all life stages of pink shrimp.

Royal Red Shrimp (*Pleoticus robustus*)

Distribution

This species differs from the penaeid species in that it is not estuarine dependent, spends its entire life cycle in open Gulf waters, may have up to five year classes occurring together, and lives in a relatively stable environment. In addition, no individuals mature during year the first year (i.e., age 0). The species is known to occur from Martha's Vineyard, Massachusetts through the Gulf, and the Caribbean Sea to French Guiana, where they live on the upper continental shelf at depths between 180-730 m. Royal reds are scarce in less than 250 m and not abundant at depths greater than 500 m. The highest concentration has been reported in the northeastern part of the Gulf at depths between 250-475 m (GMFMC 2004).

Summary of new literature review

Several new studies were found during literature review about adult and spawning adult life stages. Grace et al. (2010) conducted trawl surveys to assess deep-water fish and invertebrate populations throughout the Gulf. Royal reds were collected during this survey at salinities of 33.1-36.0 ppt and DO concentrations of 3.5-9.0 mg/l. Reed and Farrington (2010) also examined distributions of deep-water species, specifically golden crab, tilefish, and royal red shrimp, using submersible and ROVs off eastern Florida. Part of their paper included a literature review that cited Kilma (1969) in Perez Farfante (1977) who reported the largest royal reds at 184 mm for males, and 229 mm for females. They also cited Perez Farfante (1977) and Anderson and Lindner (1971) with sexual maturity being reached at 125 mm total length (TL) for males and 155 mm TL for females. Lastly, a report by Ross (2005) addressed fauna associated with deep corals off of the southeastern US and included royal reds in this report. This habitat type hasn't been previously reported for royal reds.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Eggs:

Royal red eggs are found year-round, associated with shelf edge/slope habitats in offshore waters at depths of 250-550 m and temperatures of 9-12°C.

Larvae:

Larvae are presumed to be found at depths of 250-550 m based on spawning adult distributions. This is the only habitat information available for larvae and postlarvae.

Juveniles:

Juveniles are presumed to be found at depths of 250-550 m based on spawning adult distributions. This is the only habitat information available for early and late juveniles.

Adults/Spawning Adults:

Adult and spawning adult royal red shrimp are found throughout the Gulf. Adults occupy shelf edge/slope, soft bottom, sand/shell, and in the southeastern US, reef habitats at depths from 140-750 m. They can be collected year-round, and prey on small benthic organisms. Water parameters when collected were temperatures between 5-15°C, salinities of 33.1-36.0 ppt, and DO concentrations of 3.5-9.0 mg/l. The largest collected individuals were 184 mm for males and 229 mm for females, and can live up to five years. Spawning occurs year-round at depths of 250-550 m on shelf edge/slope habitats. Sexual maturity is reached by royal red shrimp at 125 mm TL for males and 155 mm TL for females. All length data reported here comes from fish collected off the southeastern US.

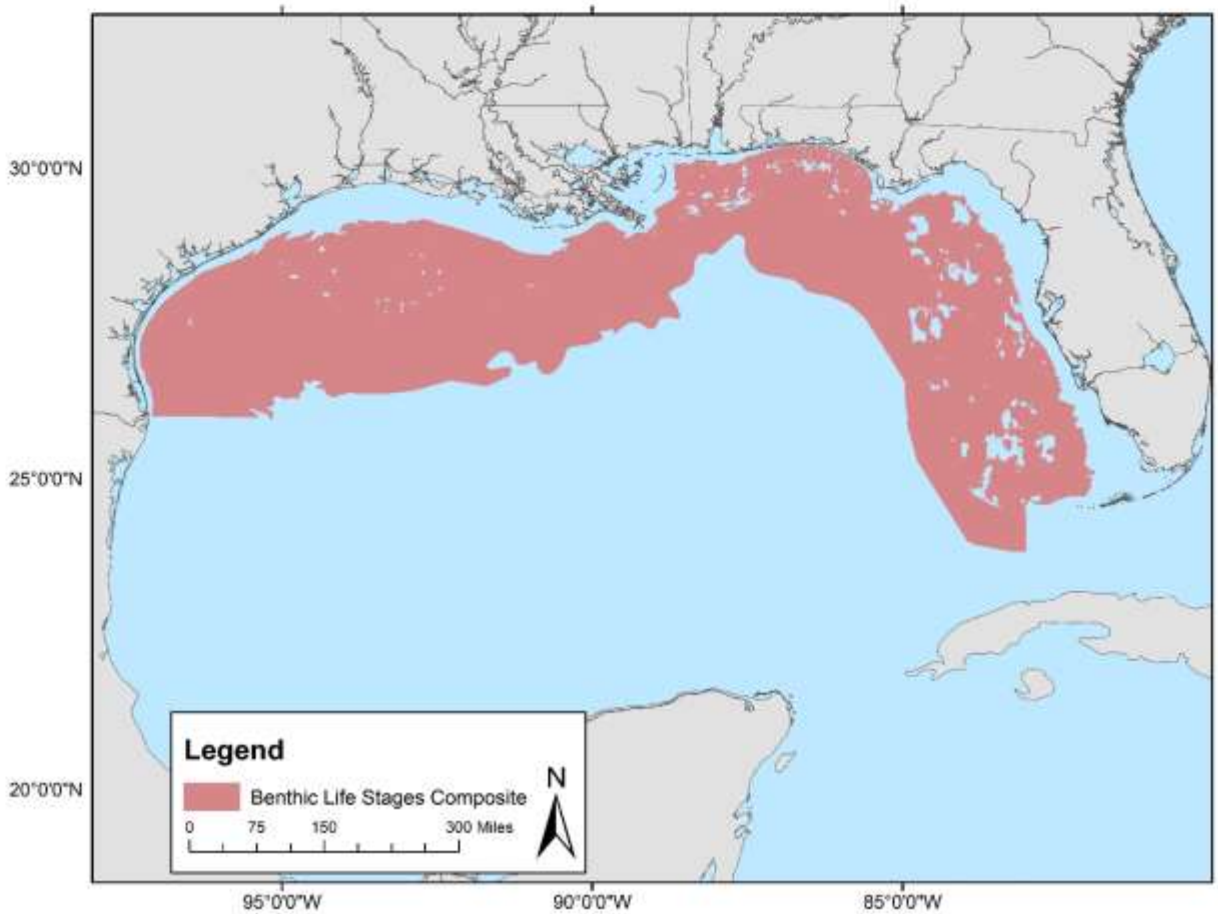

Figure 64. Map of benthic habitat use by all life stages of royal red shrimp.

3.1.6 Spiny Lobster

Spiny Lobster (*Panulirus argus*)

Distribution

The principal habitat used by spiny lobster is offshore coral reefs and seagrasses (GMFMC and SAFMC 1989) to depths of 80 m or more. The Florida Platform is fronted by shelf-edge reef complexes of the Cretaceous Era. The Southwest Florida Reef Tract appears to be the most important feature for spiny lobster (GMFMC 2004).

Areas of high relief on the continental shelf serve as spiny lobster habitat and include coral reefs, artificial reefs, rocky hard bottom substrates, ledges and caves, sloping soft-bottom areas, and limestone outcroppings (GMFMC 2004).

Reproductive adults are primarily found along the oceanic (eastward) and gulfward (west) reef and hard substrate fringes of the Florida Keys and Florida Bay. Some individuals may move back and forth to the bay during non-reproductive periods. Juveniles above 20 mm carapace length (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 (GMFMC 2004).

Summary of new literature review

No new literature was found that vastly reinforms or adds to current information on spiny lobster habitat use.

Habitat information by life stage (see Habitat Association Tables in appendix A for references)

Phyllosome Larvae:

Phyllosome larvae can be found throughout the Gulf of Mexico (Gulf) in offshore waters. They are water column associated (WCA) and found year-round off the Florida Keys and the southeastern coast of Florida and from June through November in the northeastern Gulf. They occupy waters with depths of 1-100 m (based on adult distributions) and temperatures greater than 24°C. Prey items include plankton, and predators are pelagic fish. During this life stage, spiny lobster experience about 11 molts over 9-12 months and have a 0.5-12 mm CL. There is some genetic evidence that suggests a pan-Caribbean stock, and their occurrence in the Gulf may be associated with the loop current.

Puerulus Postlarvae:

Puerulus postlarvae are found in eco-region (ER) one and are WCA until they settle into the benthos on submerged aquatic vegetation (SAV). They can be found in estuarine, nearshore, or offshore waters year-round, peaking in spring, with a secondary peak in the fall. They've been collected at temperatures from 18-33°C and occupy depths of 1-100 m (based on adult distributions). This life stage is presumed to be nonfeeding and its predators include nocturnally active, water column feeding fish. Spiny lobster puerulus postlarvae are subject to mortality via predation and physiological stress from temperatures and salinity extremes. Their abundance in south Florida is associated with wind-forcing, dynamics of ocean gyres, and by Caribbean-wide spawning activity. This life stage experiences metamorphosis into first benthic instar at 7-21 days post-settlement.

Juveniles:

Juvenile spiny lobster are found in ER-1 and are associated with SAV, reefs, and hard bottom habitats. They can be found year-round and are thought to occupy depths from 1-100 m (based on adult distributions) at salinities of 32-36 parts per thousand (ppt). They feed on invertebrates, especially mollusks and crustaceans and their predators include elasmobranchs, boney fish, octopods, and portunid crabs. Juvenile spiny lobster are subject to approximately 95% mortality primarily due to predation and the commercial fishery, and they experience a growth rate of 3-4 mm CL/month during the first year. This rate can be influenced by temperature, diet, and injuries.

Adults:

Adult spiny lobster can be found year-round occupying estuarine, nearshore, and offshore waters in ER-1. They use hard bottom, SAV, and reef habitats at depths of 1-100 m and salinities of 32-36 ppt. Their prey items include mollusks and arthropods and their predators are elasmobranchs, boney fish, dolphins, and loggerhead turtles. Spiny lobster face a mortality of about 90% from fishery exploitation, though this mortality is decreasing as the number of lobster traps in the Florida fishery has been reduced. Growth rates for adult spiny lobster in south Florida are about 0.6 mm CL/month, this rate is affected by temperature and injuries.

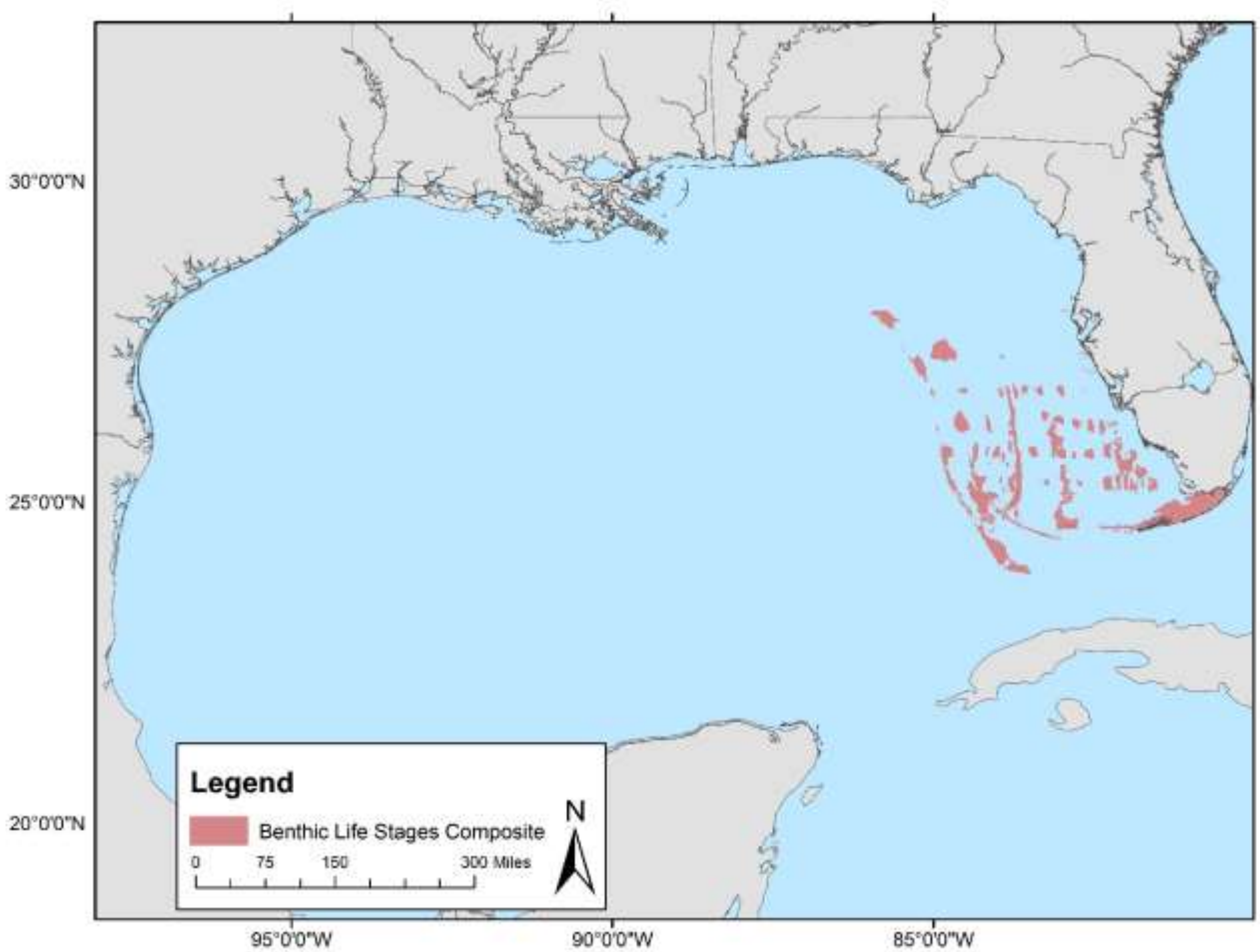

Figure 65. Map of benthic habitat use by all life stages of spiny lobster.

3.2 Fishing and Non-fishing Impacts

3.2.1 Fishing Impacts

A review of scientific literature regarding the habitat impacts of fishing did not produce any new information on how current fisheries in the Gulf are impacting habitat. An exhaustive list of fishing threats to habitat can be found in GMFMC (2004) section 2.1.5. Potential fishing impacts to habitat can also be found in the environmental assessment (EA) or environmental impact statement (EIS) of amendments to fishery management plans. In these documents, specific threats to habitat are evaluated based on the types of fishing gear used for a particular species or species complex.

3.2.2 Non-Fishing Impacts

This review encompasses assessment of any changes or new information that has become available since the 2010 EFH 5-year review (GMFMC 2010). The 2010 review outlined non-fishing activities that can negatively impact EFH, which were analyzed in detail in the Council's 2004 EFH EIS document (GMFMC 2004). In 2008, NOAA produced a Technical Memorandum (NOAA 2008) aimed at providing assistance to the Northeast and Mid-Atlantic Councils in updating their non-fishing impacts analysis within their FMPs. Additionally this memorandum discussed invasive lionfish and offshore aquaculture. Since the 2010 review, several important non-fishing related impacts have occurred in the Gulf of Mexico. For example, the range and abundance of the invasive lionfish has continued to expand (Figure 66). In 2010, *Deepwater Horizon* oil spill occurred releasing 210 million gallons of oil over 87 days and including the release of dispersant with unknown effects. Also, NOAA published a final rule in 2016 implementing the nation's first regional regulatory program for offshore aquaculture in federal waters of the Gulf of Mexico.

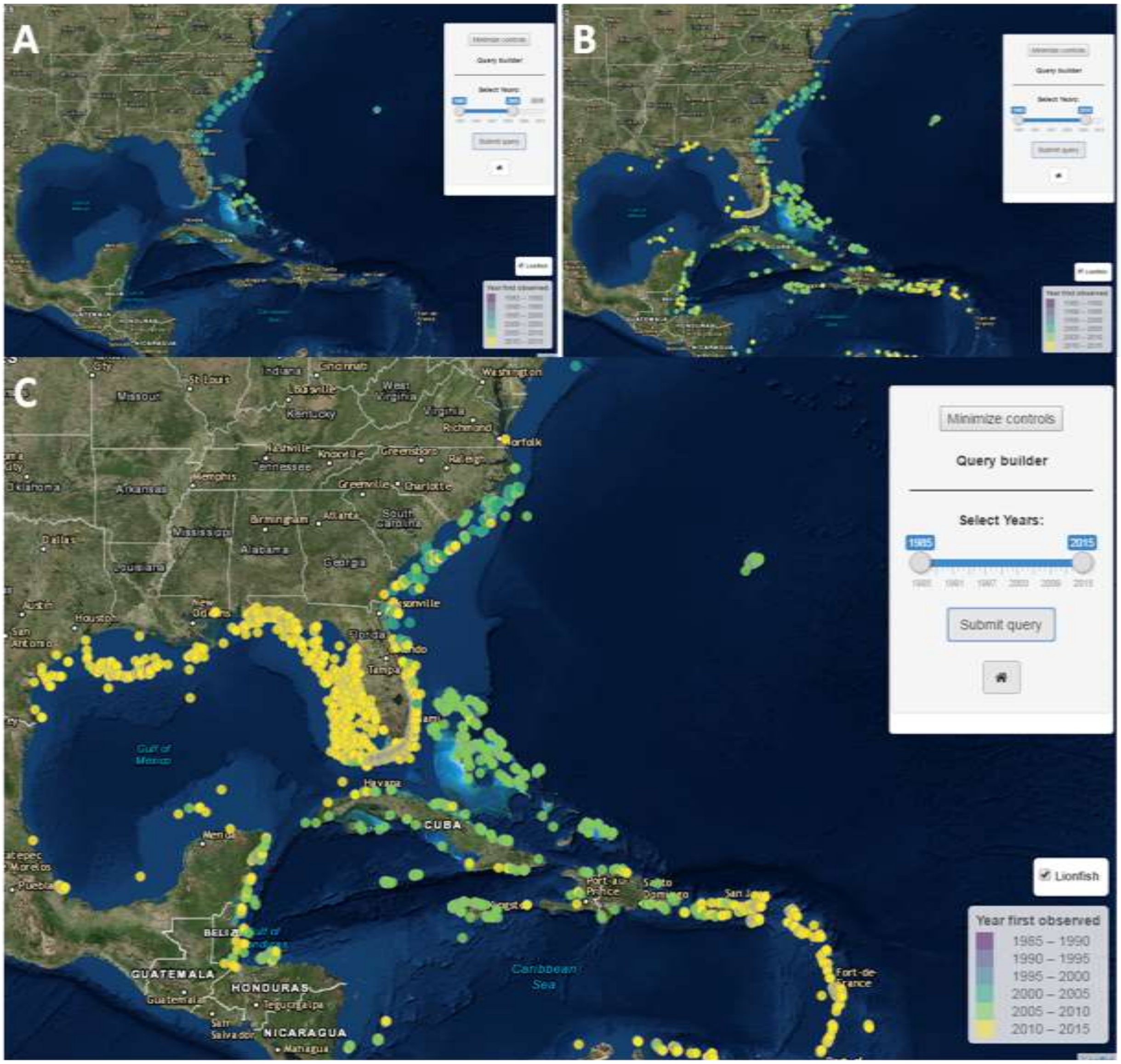

Figure 66. Distribution of invasive lionfish in 2005 (A), 2010 (B), and 2015 (C). Lionfish are now well established in a variety of habitats throughout the western Atlantic, Caribbean, and Gulf of Mexico. Data source: USGS.

3.2.2.1 Deepwater Horizon Oil Spill

On April 20, 2010 an explosion occurred on the *Deepwater Horizon* semi-submersible oil rig approximately 36 nautical miles (41 statute miles) off the Louisiana coast. Two days later the rig sank. An uncontrolled oil leak from the damaged well continued for 87 days until the well was successfully capped by British Petroleum on July 15, 2010. The *Deepwater Horizon* MC252 oil spill affected at least one-third of the Gulf area from western Louisiana east to the Florida Panhandle and south to the Campeche Bank in Mexico. This disaster led to concern regarding the impacts of oil on aquatic biota, and since the spill, extensive research has been done to examine effects or potential effects on many organisms. This section discusses the ramifications or potential effects of this oil spill on various habitats in the Gulf.

Deepwater corals are particularly vulnerable to episodic mortality events such as oil spills, since corals are immobile. Severe health declines (determined based on the percentage of live polyps on a coral fragment) have been observed in three deepwater corals in response to dispersant alone (2.3-3.4 fold) and the oil-dispersant mixtures (1.1-4.4 fold) compared to oil-only treatments (DeLeo et al. 2015). Increased dispersant concentrations appeared to exacerbate these results. As hundreds of thousands of gallons of dispersant were applied near the wellhead during the Deepwater Horizon MC252 oil spill, the possibility exists that deepwater corals may have been negatively impacted by the oil spill and subsequent spill remediation activities.

Several studies have documented declines in coral health or coral death in the presence of oil from the *Deepwater Horizon* MC252 oil spill (White et al. 2012; Hsing et al. 2013; Fisher et al. 2014). Sites as far as 11 km southwest of the spill were documented to have > 45% of the coral colonies affected by oil (White et al. 2012; Hsing et al. 2013), and, though less affected, a site 22 km in 1,900 m of water had coral damage caused by oil (Fisher et al. 2014). Coral colonies from several areas around the wellhead had damage to colonies that seemed to be representative of microdroplets as all colonies were not affected, and colonies that were affected had patchy distributions of damaged areas (Fisher et al. 2014). Because locations of deep-sea corals are still being discovered, it is likely that the extent of damage to deep-sea communities will remain undefined.

Also under threat from numerous anthropogenic sources are wetlands/marshes. DeLaune and Wright (2011) examined greenhouse and field studies conducted primarily in coastal Louisiana to assess the potential impacts of oil on marsh vegetation. The authors concluded that intensive remediation is not necessary, and that wetlands will recover naturally. They stated that fish species dependent on this habitat type will likely relocate to unimpacted vegetation until the oil dissipates. They also recognize that shifts in microbial communities will probably occur, but suspect that, as with vegetation, they will recover. The primary reason they cite for drawing these conclusions is that impacted soils possess microorganisms capable of degrading oil given suitable environmental conditions. They provide field observations of new shoots appearing in oiled marshes a year after the spill as evidence to support their conclusions. Also studying marsh/wetlands impacted by the oil spill, Silliman et al. (2012) investigated cordgrass (*Spartina alterniflora*) dominated marshes in Barataria Bay, LA, where the authors conducted work on oil impacted and reference sites. The sites were surveyed in October 2010, April 2011, October 2011 and January 2012. 'Interior' marsh regions (> 15 m from marsh edge) were intact at the impacted sites, but marsh shoreline vegetation (< 15 m from marsh edge) had both seemingly healthy and severely degraded regions. Polycyclic aromatic hydrocarbons found in surface sediments were > 100 times higher at impacted sites than at reference marshes. At impacted sites, there was almost a complete loss of standing aboveground plant cover extending 5-10 m from the shoreline and this area was also negatively impacted beneath the waterline with about 95% of rhizomes were dead. In addition to loss of marsh regions stemming from the oil spill, the authors found that erosion on the steep edges of marsh platforms at impacted sites was occurring twice as fast as at reference sites between October 2010 and October 2011, however after this time period, erosion rates were not different between types of sites. This increased erosion is likely due to death of root systems stabilizing the marsh sediments. Despite these deleterious effects, this study also showed marsh recovery at impacted sites in April 2011, with full recovery of plant cover occurring between October 2011 and January 2012 (Silliman et al. 2012).

Soft bottom is another habitat type potentially impacted by the oil spill. Montagna et al. (2013) sampled deep-sea sediments following the spill at distances of 0.5 km to 125 km from the wellhead and depths of 76 to 2767 m. Collections occurred on two vessels from September through October 2010. This study showed the greatest decrease in macro and meiofaunal diversity within 3 km of the wellhead and moderate impacts were seen up to 17 km southeast and 8.5 km northeast of the wellhead. The recovery time for these communities is unknown though expected to be slow due to the time it would take for contaminants to degrade or bury at the depths and temperatures of the deep-sea environment, and the subsequent natural succession process.

Drifting algae is a challenging habitat to monitor due to its transient nature though it is of concern during oiling events, particularly those with a substantial surface slick. Additionally, it serves as a habitat to vulnerable larval and juvenile life stages of several of the Gulf Council managed species. Aerial surveys following the spill document the co-occurrence of oil and *Sargassum*, and also showed *Sargassum* exposed to dispersant. Surveys conducted in 2011 and 2012 indicated a four-fold increase in *Sargassum* abundance since the initial surveys in 2010 (Powers et al. 2013). Mesocosm experiments were conducted to test if oiling impacted the buoyancy and sink time of *Sargassum*. The control *Sargassum* sank slowest, followed by oil, dispersant, and dispersed-oil treatments. The experiments also showed significant differences in dissolved oxygen (DO) concentrations based on treatment. The dispersed-oil treatment had the least DO, followed by dispersant, oil, and lastly the control. Given the lack of baseline data, the authors cannot conclusively confirm that the increase of *Sargassum* in aerial surveys conducted in 2011 and 2012 was due to a recovery event following the oil spill. The mesocosm experiments suggest that contaminated *Sargassum* poses two main threats to the aquatic environment, (1) exposure of organisms attracted to the *Sargassum* mats remaining afloat to oil, and (2) upon sinking, contaminated *Sargassum* can transport oil and dispersants to benthic and mesopelagic fauna (Powers et al. 2013).

3.2.2.2 Invasive Species

The threat of invasive species to essential fish habitat was discussed briefly in the 2010 5-year EFH review, with an emphasis on the Indo-Pacific lionfish (*Pterois volitans* and *P. miles*). At that time, lionfish were considered established off the Atlantic coast of the United States, Bermuda Island, the Bahamas, Turks and Caicos Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Mexico, Honduras, and Costa Rica, and present but not established in US Virgin Islands, Gulf of Mexico, Belize, Panama, and Colombia (GMFMC 2010). Since 2010, the lionfish invasion has continued, and research on them and their impacts on native species and the environment has increased (Figure 66).

In the northern Gulf, the first lionfish was reported during the summer of 2010. Dahl and Patterson III (2014) studied habitat densities and diet of lionfish in the northern Gulf from fall 2010 to fall 2013. They reported an exponential increase in lionfish density over the course of the study, and that lionfish densities on artificial reefs were two order of magnitude higher than on natural reefs (14.7 fish 100 m^{-2} vs. 0.49 fish 100 m^{-2}).

Another study in the northern Gulf examined reproductive life history of lionfish (Fogg et al. 2015), their results suggest that lionfish spawning may occur from May - October (based on gonadosomatic index values). They also estimated relative batch fecundity as 83.8 ± 6.5 eggs/g gonad free body weight. Fogg et al. (2013) reported on the distribution and length frequency of lionfish in the northern Gulf collected from March to December 2012, most of which were collected from spearfishers and commercial trawl operations. At this point, the furthest westward collection location occurred about 100 km south of High Island, Texas in 22.9 m of water. The authors suggest further research should be focused on dispersal mechanisms for lionfish in the northern Gulf, so as to understand population dynamics, but also to address how dispersal may occur for other potentially invasive species.

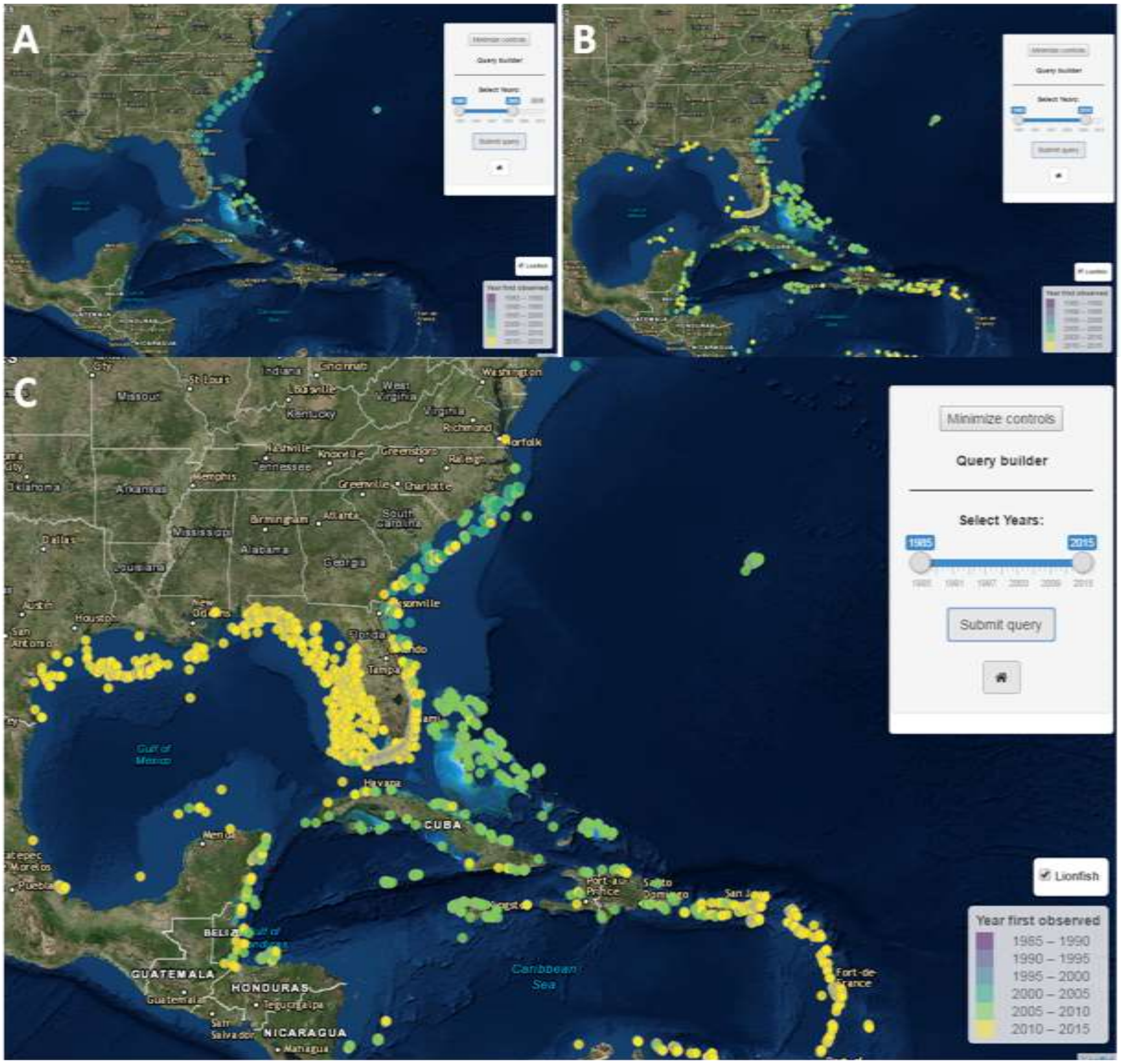

Figure 67. Maps showing the spread of the lionfish invasion over the years. A) lionfish observations from 1985 to 2005, B) lionfish observations from 1985 to 2010, C) lionfish observations from 1985 to 2015.

Another invasive species that was mentioned in literature obtained during this review is the Asian tiger shrimp (*Penaeus monodon*; Figure 28.). Fuller et al. (2014) suggested three potential mechanisms by which Asian tiger shrimp made their way to the Gulf: discharged ballast water from somewhere in their established range, larval transport from non-native populations in the Caribbean or South America, or escape from aquaculture facilities in the western Atlantic and migration to the Gulf. As with most shrimp species, estuarine habitats (SAV, emergent marsh, mangroves, sand/shell, soft bottom) serve as nurseries grounds for larvae, juveniles, and young sub-adults (Mohamed 1967; Chaudhari and Jalihal 1993). Sub-adults move offshore as they mature, and are usually found in depths up to 70 m (Motoh 1981). They have a high salinity, 0-

38 psu (Motoh 1981; Chaudhari and Jalihal 1993) and thermotolerance, 10-39°C (Motoh 1981; Jintoni 2003). The primary impact of concern stated by Fuller et al. (2014) regarding the introduction of Asian tiger shrimp outside of its native range is its potential to compete with, or prey on native shrimp species.

The first collection of Asian tiger shrimp appears to have occurred in the Gulf in 2006 off of Alabama. There has been an increase in the number of sightings (primarily by commercial shrimp fishermen), though it appears there are a greater number of the invasive shrimp in the South Atlantic Bight than in the Gulf and there may be breeding populations in either or both areas. The impacts on native fauna by an Asian tiger shrimp invasion are largely unknown, their feeding ecology suggest direct predation on other penaids, crabs, bivalves, and gastropods may be a concern. Additionally, they reach larger sizes than native shrimp, potentially providing them a competitive advantage over native species. As with other aquacultured species, there is a risk of disease transmission from escaped cultured individuals into the invasive wild population, then to native species (Fuller et al. 2014).

One sessile invasive species that is well established in the Gulf is the orange cup coral (*Tubastraea coccinea*). The primary concern stemming from the *T. coccinea* invasion is its ability to displace native corals. It reproduces at a young age and uses chemical defenses to prevent other benthic invertebrates from settling around it[1] (Lages et al. 2010). Additionally, they do not depend upon zooxanthellae, allowing for growth in areas with suboptimal light penetration. Orange cup coral are prolific on artificial reefs, and according to Sammarco et al. (2010), there can be hundreds of thousands of colonies on a single oil platform. Likely due to their proximity to many oil platforms in the Gulf, reefs located within the Flower Garden Banks National Marine Sanctuary have begun experiencing this invasion. Currently, the response to presence of orange cup coral within the Sanctuary has been physical removal. Further information on the orange cup coral invasion is available at:
http://flowergarden.noaa.gov/education/invasivecupcoral.html

3.2.2.3 Offshore Aquaculture

On February 12 2016, NOAA issued a Final Rule[2] that implements a permitting process to manage the development of aquaculture in federal waters of the Gulf. This legislation was passed in an effort to increase the U.S. seafood supply, which is currently being met by imports (approximately 90%). Currently, there are no commercial finfish or shellfish aquaculture operations in U.S. federal waters. Some states have finfish aquaculture permits within their

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[1] Source: http://flowergarden.noaa.gov/education/invasivecupcoral.html

[2] Final Rule:
http://sero.nmfs.noaa.gov/sustainable_fisheries/gulf_fisheries/aquaculture/documents/pdfs/gulf_aquaculture_fmp_fr.pdf

waters, including Hawaii, Maine and Washington, and most states have nearshore shellfish aquaculture operations[3].

In an effort to reduce a number of threats posed by offshore aquaculture, non-native and genetically engineered species are prohibited from culture. Allowable species are all those managed by the Council, except shrimp and corals. Because no offshore aquaculture operations are currently occurring in the Gulf EEZ, the potential environmental impacts can only be estimated by looking to other regions, and making comparisons to coastal aquaculture facilities. Examples of the environmental problems with coastal aquaculture include a variety of pollution threats (visual, water column, benthic substrate), spread of disease from cultured to wild populations, and antibiotic feed impacts on nontarget bacteria (Stickney 1997). Some of these are inherently mitigated by moving the operations offshore. In order to decrease the impacts of wave energy and surface storms, along with minimizing biofouling and corrosion, submerged growout cages have been proposed, effectively eliminating the visual pollution component (Dahle and Oltedal 1990; Dahle 1991; Stickney 1997).

Directly related to habitat are the potential benthic and water column pollution impacts from offshore aquaculture. Regarding benthic impacts, the sedimentation of feed and fecal matter may result in anoxic environments, decreased biodiversity, and loss of secondary production (Hargrave et al. 2008). It's expected that these impacts would be less extreme in offshore aquaculture due to increased water flow and dispersal. Conversely, several studied have showed positive impacts from increased organic loading. Kutti et al. (2007a) examined organic waste production from a salmon from in Norway located in 230 m of water. Sedimentation rates were high and variable within 250 m of the farm, and sedimentation decreased between 550 and 3000 m away from the farm. Interestingly, the sediments did not experience changes in content of organic matter. Additionally several other studies (Kutti et al. 2007b; Kutti et al. 2008) conducted in the same region found the highest abundance and biomass in the benthos during peak production from the farm. Another potential threat to benthic habitats stems from anchoring of offshore aquaculture pens. Proposed anchoring options are extensive, and won't be covered in depth here. Both of the aforementioned threats to the benthos and essential fish habitat can be avoided with proper siting of the offshore aquaculture facility. Specifically, to prevent or minimize habitat degradation, facilities would be properly sited to ensure adverse effects do not occur to essential fish habitat and other ecologically important areas (50 CFR Parts 600 and 622). NOAA Fisheries Service is required to review a proposed marine aquaculture facility site on a case-by-case basis. Aquaculture operations would also be prohibited in specific areas, such as marine reserves, artificial reef zones, SMZs, MPAs, HAPCs, and coral areas. Additional criteria may also be required by other federal agencies. These criteria are intended to prevent, or minimize to the extent practicable, impact to EFH and bottom habitat in general (50 CFR Parts 600 and 622).

[3] Source: http://sero.nmfs.noaa.gov/sustainable_fisheries/gulf_fisheries/aquaculture/documents/pdfs/aquaculture_gulf_fmp_faqs_jan2016.pdf

Impacts to the water column from offshore aquaculture could be detrimental, particularly to species with life stages that are water column associated. However, studies suggest that water quality affected by offshore aquaculture. An example in the U.S. was a study conducted by Grizzle et al. (2003), from which the authors reported the results of monitoring efforts from 1997-2000 on longline suspension culture of bivalve mollusks and two grow-out fish cages. The site of this aquaculture operations was 10 km offshore Portsmouth, New Hampshire in water about 55 m deep. Prior to deployment of stocks, water quality and sediment characteristics were quantified to obtain background information. These measurements were taken for two years prior to stocking. In 1999, mussels and 3000 summer flounder were stocked in cages and longlines. Further environmental sampling took place and results were compared the background data. The authors concluded that there were no detectable changes related to the aquaculture operations, though they acknowledge that there was a relatively low biomass of animals being cultured in this experiment. Similarly, studies conducted in the Mediterranean and Adriatic Seas, and off of Chile found no impact to water quality from offshore aquaculture operations (Basaran et al. 2007; Matijević et al. 2006; Soto and Norambuena 2004; Maldonado et al. 2005).

Other potential impacts will not be addressed here as they are not directly related to habitat, further information about the costs and benefits surrounding offshore aquaculture can be found in the Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf of Mexico (2009).

Figure 68. Asian tiger shrimp (*Penaeus monodon*).

3.3 Addition or removal of HAPCs and Changes in Regulations

There were no additions, removals, or changes in regulations pertaining to habitat areas of particular concern (HAPCs) between the five-year review completed in 2010 and the current review.

3.4 HAPC Recommendations

In the Gulf of Mexico, all of the current Habitat Areas of Particular Concern (HAPC) protect coral areas. While conducting this 5-year review, an amendment process has been initiated to identify and designate more coral HAPC locations. In 2014, the Council convened a group of scientists that identified 47 areas (including existing HAPCs) that need protection. In August 2016, these areas were revisited by the Council's Coral Scientific and Statistical Committee, Coral and Shrimp Advisory Panels, and longline fishermen met to narrow down the 47 areas to a list of 15 priority areas. The group also recognized seven deep water areas that are important but don't require fishing restrictions. Further information about these recommendations can be found in the Deep Sea Coral Amendment 7 Scoping Guide (**http://gulfcouncil.org/docs/Public%20Hearing%20Guides/Amendment%207%20Scoping%20Guide_09_2016.pdf**). These areas have also been added to the Coral HAPC Viewer found here: **http://portal.gulfcouncil.org/coralhapc.html**.

Other regional Fishery Management Councils use HAPCs to designate areas beyond corals. For example, in the New England region, inshore juvenile cod habitats are designated as HAPCs. In the Pacific region, focus is placed on habitat types used by Pacific salmon, including complex channels and floodplain habitat, thermal refugia, spawning habitat, estuaries, and marine and estuarine submerged aquatic vegetation are considered HAPC. If the Gulf Council was interested in extending HAPC designation beyond their current coral focus, areas could be designated by overlaying the various benthic habitat use maps generated during this review to create a heatmap that would reflect the locations used by the most species and life stages.

3.5 Artificial Reefs

Artificial structures are prominent features of Gulf of Mexico (Gulf) ecosystems, having been placed there either for fishing enhancement (such as artificial reefs) or intended for other uses (e.g., petroleum production), but also indirectly serve as fish aggregating structures. The role of artificial structures in fishing enhancement has long been recognized and was included in the National Fishing Enhancement Act of 1984 (98th Congress 1984). The value of artificial reefs as habitat in the Gulf has been discussed extensively (GMFMC 1998). In the Gulf of Mexico, two types of artificial reefs are recognized: 1) structures intentionally placed as artificial reefs and 2) structures such as oil and gas platforms that are intended for other purpose but do provide fish habitat. Petroleum platforms have been in place since the 1940's and have increased in number to approximately 3,228 platforms as of 2012 (Figure 67). A variety of other structures in the Gulf also serve as artificial reefs including pipelines, and sunken vessels.

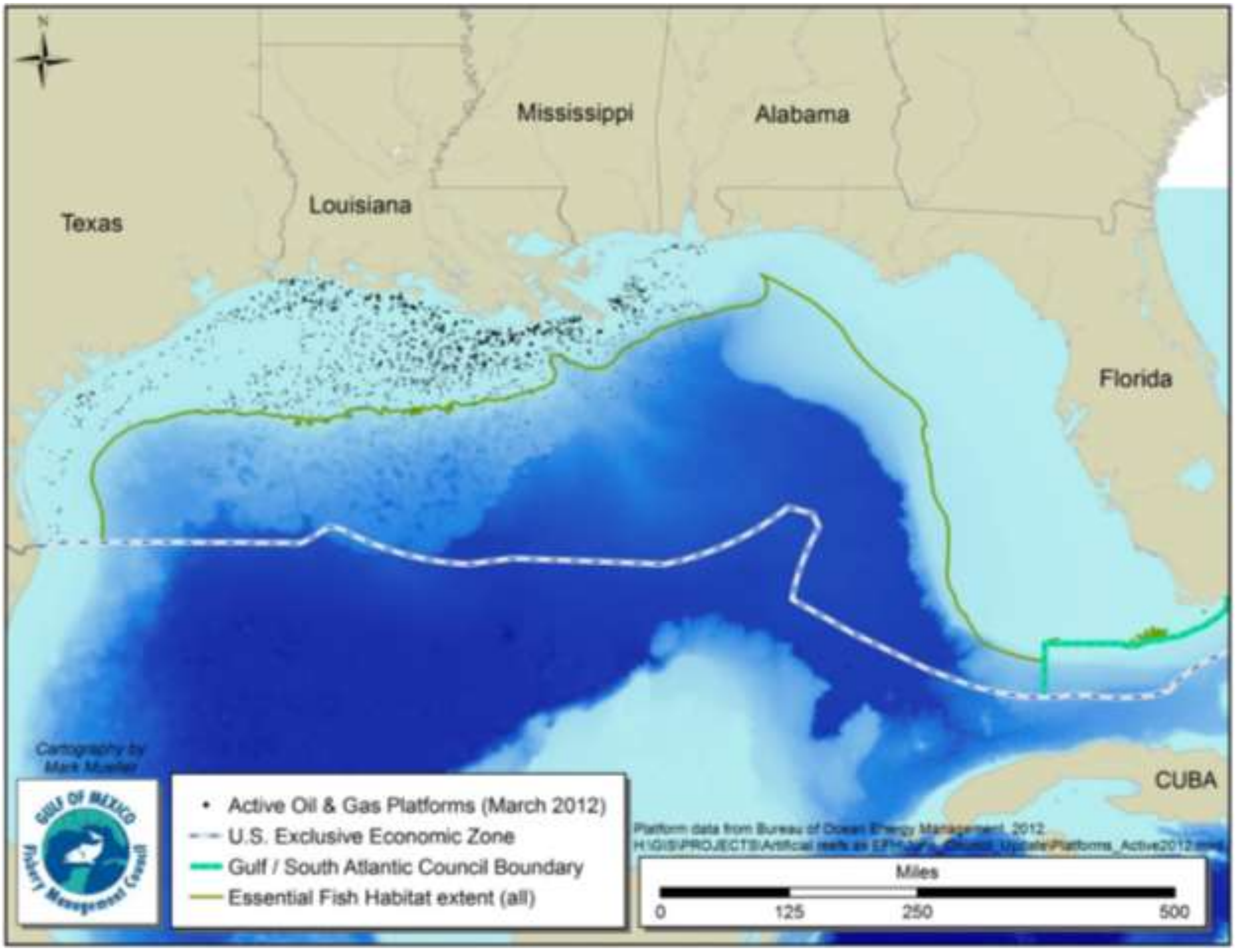

Figure 69. Active oil and natural gas platforms (n = 3,228), as of March, 2012.

Artificial reefs are not currently used as part of any fishery management plan in the Gulf, and though they are numerous, they occupy only a small fraction of total hard-bottom habitat (Table 1). However, evidence suggesting detectable impacts from the presence of artificial reefs on managed fisheries exists (South Korea: Kim et al. 2011). Kim et al. (2011) found that artificial habitat could play an important role in the enhancement of sandfish (*Arctoscopus japonicus*) stocks.

Table 2. Summary of estimated areas (sq. km and acres) of known artificial structures and naturally-occurring rocky substrate in the Gulf of Mexico.

CATEGORY	AREA (sq. km)	AREA (acres)
INSIDE EEZ (Gulf Council Jurisdiction)	626,830.81	154,892,652
Oil & Gas platforms (3,701 active--2009 BOEM data)	20.49	5,062
State-Permitted Artificial Reef	0.09	22
Shipwrecks/Obstructions	0.25	61
All Artificial Structures combined area*	20.82	5,145
*Total area not additive—some areas overlap		
Substrate: rock dominant (>66%):	20,144.99	4,977,918
Substrate: rock subdominant (>33%):	6,790.12	1,677,868
Substrate: rock dominant or subdominant:	26,935.12	6,655,786
INSIDE EFH (including state waters)	349,136.46	86,273,155
Oil & gas platforms (3,701 active--2009 BOEM data)	20.23	5,000
State-Permitted Artificial Reef	0.13	32
Shipwrecks/Obstructions	.74	183
All Artificial Structures combined area*	21.10	5,214
*Total area not additive—some areas overlap		
Substrate: rock dominant (>66%):	5,553.60	1,372,318
Substrate: rock subdominant (>33%):	6,664.27	1,646,769
Substrate: rock dominant or subdominant:	12,217.86	3,019,087

A common thread in discussions concerning the use of artificial reefs as fishery management tools has been the "attraction versus production" argument, debating whether artificial reefs merely attract and concentrate fish from nearby habitats or actually augment fish production with new biomass in areas where artificial habitats are located (suggesting reef habitat is a limiting factor). The attraction versus production issue has been addressed in research and literature by several scientists and research managers, but the relative levels of each component, and the factors affecting them, have yet to be unequivocally resolved (Broughton 2012 and references therein). This debate has also been considered "un-resolvable" by several Gulf fisheries researchers (Shipp 1999; Shipp and Bortone 2009; Cowan et al. 2010) with respect to reef-associated species. Recent investigations of this topic note that attraction and production are not mutually exclusive, and artificial reefs likely serve both roles with the degree of each dependent upon location, oceanographic conditions, and the species composition and abundance. The benefits of artificial reefs with respect to fisheries management may include of fishing pressure on and mitigation of lost natural hard bottom habitat. However, for overfished stocks (or stocks that are not limited by available hard bottom habitat), artificial reefs may provide negative impacts, as remaining biomass is concentrated around artificial reefs where vulnerability to fishing is increased.

Artificial structures (including petroleum related structures) have not been recognized as a habitat type that is necessary for the identification and description of essential fish habitat (EFH). While artificial structures may provide similar functions to defined habitat types (e.g., hard bottom), the identification and description of artificial structures as EFH could be problematic (GMFMC 2013). For example, if artificial structures were identified as EFH, the Council is required to consider actions to minimize the adverse impacts of fishing activities on such EFH. Additionally, Federal agencies would be required to consult on their actions that may adversely affect the quantity or quality of the newly designated EFH. Federal agencies are required to respond to NOAA Fisheries Service recommendations in writing with a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on such habitat. However, NOAA Fisheries Service's EFH conservation recommendations are advisory in nature and do not preempt the jurisdiction and regulatory oversight of other agencies on these structures.

The NOAA Fisheries Service currently consults with the Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) programmatically on the installation and removal of oil and gas structures in the Gulf of Mexico. The NOAA Fisheries Service Southeast Region first completed a programmatic EFH consultation with BOEM/BSEE (formerly the Minerals Management Service or MMS) Gulf of Mexico Region in 1999. In 2012, a new programmatic EFH consultation was completed for the Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017 in the Western and Central Planning Areas of the Gulf of Mexico (Figures 29 and 30). These consultations cover a variety of oil and gas development activities including pipeline rights-of way, plans for exploration and production, and platform removal in the Gulf of Mexico. EFH conservation recommendations addressed avoidance and minimization measures to protect natural fish habitats from adverse effects of sighting, construction, and removal operations authorized by BOEM/BSEE.

4.0 WEB RESOURCES

One of the objectives of this review was to develop web resources for essential fish habitat (EFH) in the Gulf of Mexico (Gulf). This web application will be hosted on the Gulf Council data portal (**http://portal.gulfcouncil.org/**). These each element of this resource is discussed in more detail below.

4.1 Searchable References

All of the references used to inform the habitat association tables found in Appendix A will be available in a format that allows the user to query the references based on species, Fishery Management Plan (FMP), authors, and year. Each reference will include a URL, if available, to either a pdf, or to the abstract on the publisher's website.

4.2 Interactive Essential Fish Habitat Maps

The interactive EFH map will allow users to toggle between different species and turn on and off life stage layers for each species. These layers will include benthic use maps as depicted in this document and will include layers that describe water column habitat use. If the National Marine Fisheries Service (NMFS) deems these maps appropriate for use, they could ultimately replace the current maps used to identify and describe EFH in the Gulf.

4.3 Interactive Habitat Areas of Particular Concern Map

This is a simple tool to explore current and proposed Habitat Areas of Particular Concern (HAPC) in the Gulf of Mexico. The Gulf of Mexico Fishery Management Council is considering changes to current HAPC designations to take advantage of recent research (primarily from the BOEM/NOAA/USGS Lophelia I & II Research Programs, more information about these can be found here: http://oceanexplorer.noaa.gov/) that has identified additional regions supporting deepwater coral formations. Consideration of new areas has been the subject of on-going discussion of the Council working with their Coral Advisory Panel and Special Coral Scientific and Statistical Committee, the meeting summary can be found **here**. This habitat supports many important fish and invertebrate species and is among the most biologically diverse habitats in the Gulf of Mexico

The objective of this tool is to permit viewing of current and proposed areas in this region using the interactive mapping (Map) tab. The mapper contains several 'layers' including (1) designated HAPCs with one of more HAPC specific fishing regulations, (2) designated HAPCs without specific HAPC fishing regulations, and (3) areas that have been recommended for HAPC designation. Recommendations were based largely on area-specific knowledge of habitats and research identifying and describing corals and coral reefs by the scientific community. For reference, we have included an aggregated database of known locations supporting deep or shallow water corals.

In total, there are four query able layers that can be turned on or off using the check box in the bottom left corner. The various types of corals recorded at each location are noted in the coral locations legend. The various HAPC types are discernible by color, and identified in the legend in the bottom right of the viewer. Geographic coordinates can identified by clicking on the map (Results displayed below map).

4.4 Habitat Association Tables

The habitat association tables found in Appendix A will be available on the EFH web application. Similarly to the references, these will be query able with search criteria including species, FMP, life stage, eco-region, habitat zone, and habitat type.

4.5 Species Profiles

All species profiles will also be available in the EFH application. These will include the textual description of EFH for each species and life stage, interactive length at age plots and interactive recent landings history plots.

5.0 RECOMMENDATIONS ON UPDATING EFH INFORMATION

The exercise of creating habitat maps by species and life stage identified a variety of issues with the current method of identifying and describing essential fish habitat (EFH) for species managed by the Gulf of Mexico Fishery Management Council (Gulf Council). Suggestions for updating EFH information are described below based on the problems identified in this review. Each suggestion states the overarching problem, provides a species specific example that highlights this problem (when available) and, where appropriate, provides a potential solution to the identified problem.

- Problem: The way eco-regions are currently described and illustrated, they extend to 183 m yet some species commonly inhabit depths greater than 183 m.

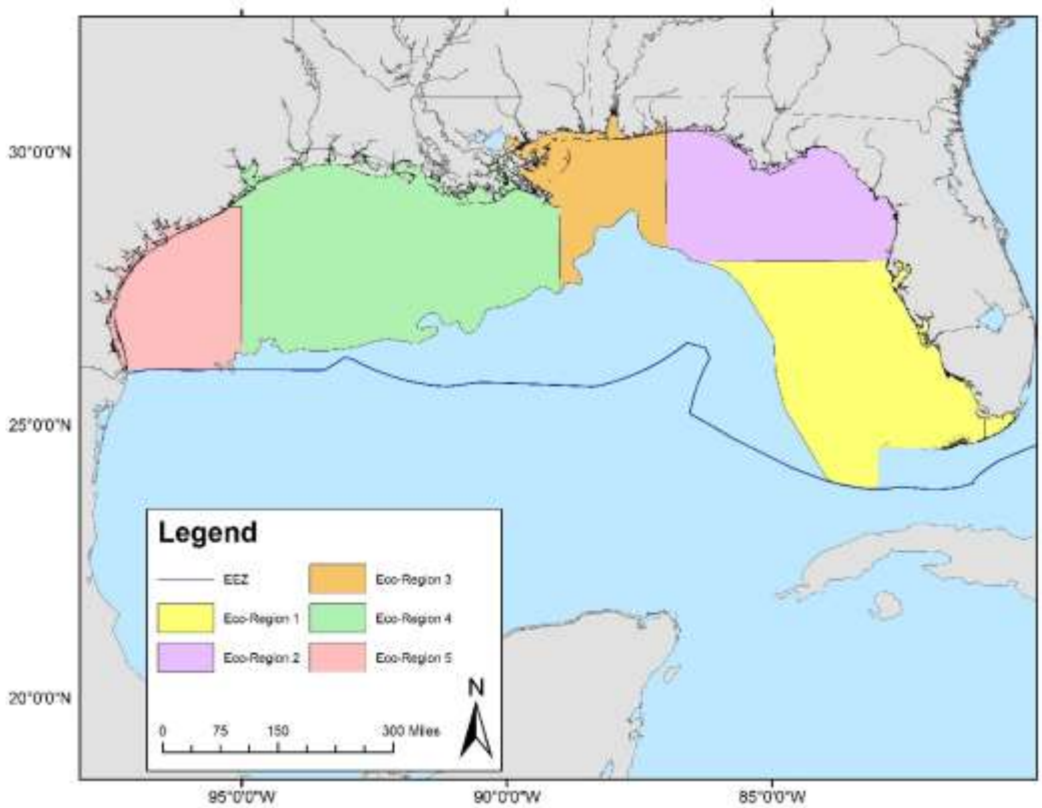

Figure 70. Map showing each eco-region and the EEZ boundary.

   – Example Species: Queen snapper occupy depths from 95-680 m and royal red shrimp occupy depths of 140-750 m. The maximum depth for these two species fall well outside the eco-region demarcations.

- Potential solution: Create an eco-region six that covers the area between the outermost boundary of eco-regions one through five and the EEZ.

- Problem: As currently described, habitat zones are: estuarine (inside barrier islands and estuaries), nearshore (60 ft (18 m) or less in depth), and offshore (greater than 60 ft (18 m) in depth; GMFMC 2004). These zones are vague and challenging to define in shallower water and the offshore zone encompasses a very wide depth range (from 19-183 m).

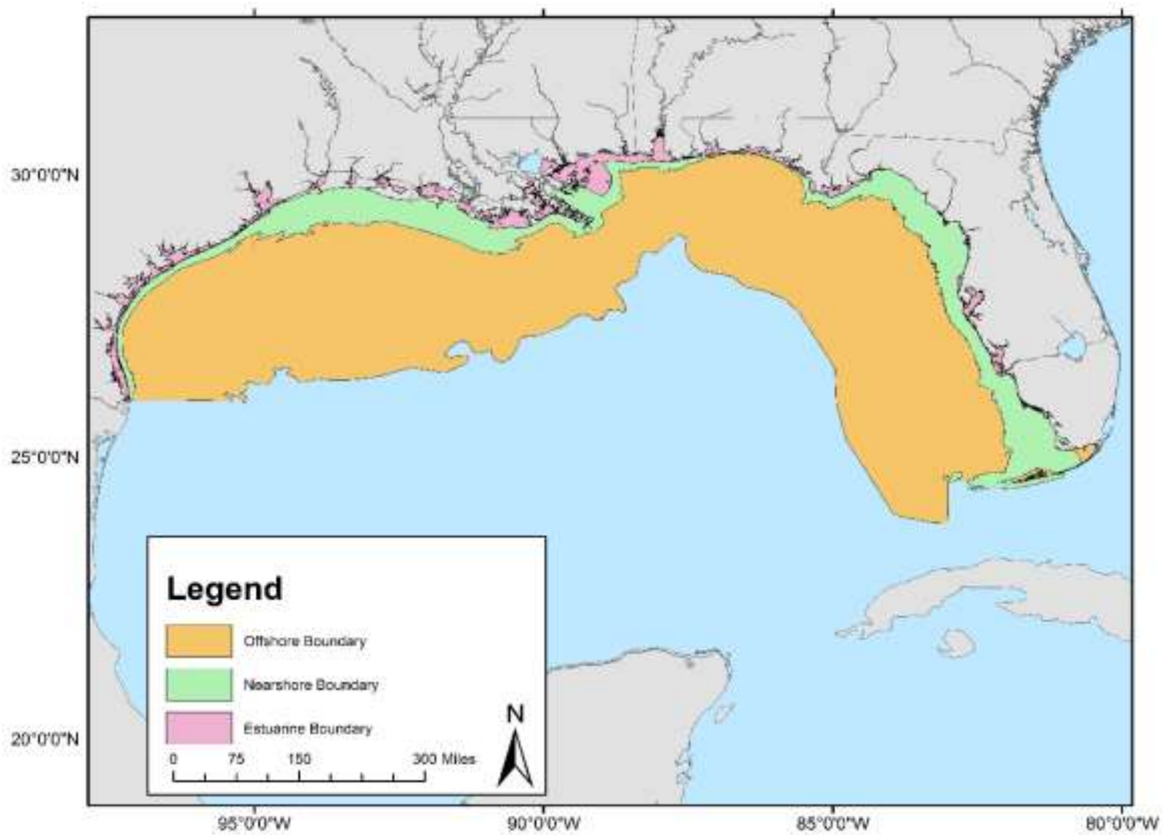

Figure 71. Map showing the three habitat zones used to inform depth preferences for the species in the 5-year review.

  – Examples Species: White shrimp occupy depths from 1-34 m. Under the current system this means they can occupy habitats in the estuarine, nearshore, and offshore habitat zones, though it's unlikely that their EFH extends to the outer limit of the offshore boundary at 183 m.

    - Potential solution: Convene a panel of experts to reassess the habitat zone designations.

- Problem: Some of the habitat types are poorly defined, have convoluted definitions, or are unmappable. Specifically, banks/shoals are defined as "…represented in the GIS as the actual substrate, or habitat of which they are composed i.e., if a bank or shoal is composed of sand, then in the GIS it is shown as sand" (GMFMC 2004). This habitat type was not mapped in the EFH environmental impact statement document and it has not been mapped in this document. Reef and hard bottom habitat types are currently defined as being separate, however biologically speaking they are not mutually exclusive.

  - Example Species: Gray triggerfish spawning adults use reef type habitat but have not been described as using hard bottom. They likely use both, but due to the separation of these habitat types, it appears as though spawning only occurs on the very small distribution of "reefs" throughout the Gulf.

    - Potential solution: Convene a panel of experts to reassess how habitat types are described in the Gulf.

- Problem: Similar to the above problem with hard bottom and reef habitat types, the GIS data used to describe reef habitat in the Gulf for this review is poor, due in part to the required separation of hard bottom from reef types. Much better GIS data are available for point observations of corals in the Gulf. Should these data be incorporated into the GIS layer used to describe reef habitats?

- Problem: There is no criteria to decide if habitat types identified in studies occurring outside GMFMC jurisdiction should be used to create mapped depictions of EFH.

  - Example Species: Spawning adult blueline tilefish were collected on shelf edge/slope habitat in a study conducted outside GMFMC jurisdiction. There is no information available regarding the habitat types used by spawning blueline tilefish from studies conducted inside GMFMC jurisdiction.

    - Potential solution: Develop criteria to determine if habitat types identified in studies occurring outside GMFMC jurisdiction should be used to create mapped depictions of EFH.

- Problem: Inland boundaries are poorly defined, causing challenges for NOAA during the consultation process.

  - Potential solution: Work with interested stakeholders to establish an appropriate inland boundary that is more explicit for consultation and mapping purposes.

- Problem: There are discrepancies within the habitat association tables that were identified while creating habitat use maps.

  - Example Species: Red drum spawning adults use submerged aquatic vegetation (SAV) as a habitat type, but their depth distribution (40-70 m) falls well outside depths where SAV occurs.

    - Potential solution: Work with species experts to further identify gaps and discrepancies with habitat information in habitat association tables.

- Problem: Identification of best available GIS data. There were challenges while gathering GIS data for this review surrounding the question of what qualifies as best available data. For some habitat types (i.e. hard bottom, reefs), there is high confidence with data because of the biologically static nature of the habitat. With other types, such as seagrass, there can be drastic changes in spatial footprint over the course of a decade or less.

- Potential solution: Convene a panel of regional GIS experts to assess and compile what they consider to be best available GIS data describing each habitat type in the Gulf.

- Problem: Essential Fish Habitat for Goliath grouper is only identified in Ecoregion 1. Recent fishery independent data from the Florida Fish and Wildlife Conservation Commission has documented the goliath grouper occur often in Ecoregion 2.

  - Potential solution: revised description of goliath grouper EFH.

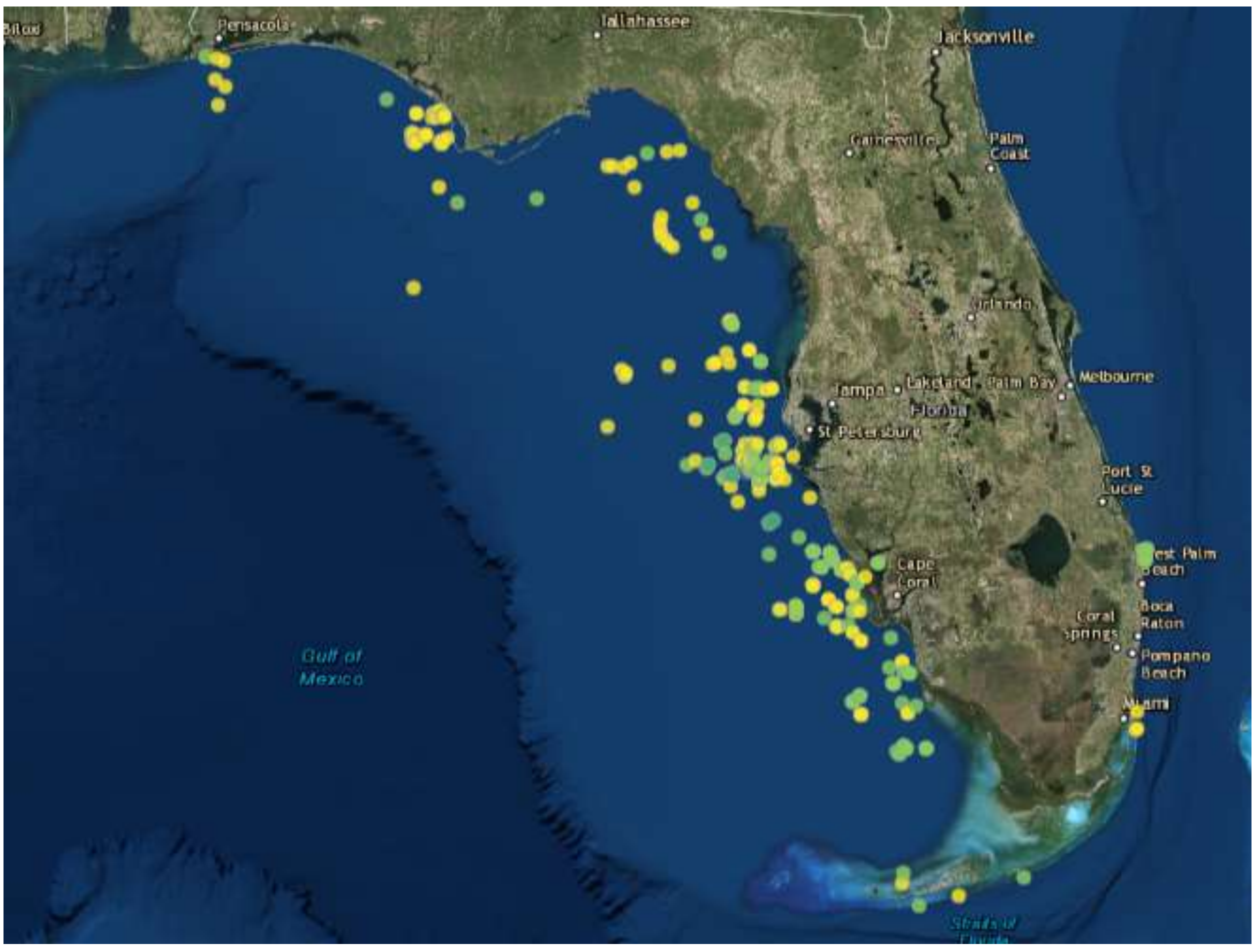

Figure 72. Map showing distribution of goliath grouper from fishery independent monitoring from 2006 through 2015. Interactive map is available at: **http://portal.gulfcouncil.org/GoliathGrouper.html**

- Problem: Address suggested revisions based on 2010 EFH 5-year review.

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10/14/2016

APPENDIX A

INFORMATION ON SPECIES DISTRIBUTION AND HABITAT ASSOCIATIONS

FOR:

Draft Report

5-Year Review of Essential Fish Habitat Requirements

Including Review Of Habitat Areas Of Particular Concern And Adverse Effects Of Fishing And Non-Fishing In The Fishery Management Plans Of The Gulf Of Mexico

October 2016

This is a publication of the Gulf of Mexico Fishery Management Council Pursuant to National Oceanic and Atmospheric Administration Award No. NA15NMF4410011.

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COVER SHEET

Name of Action

Essential Fish Habitat

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Type of Action

( ) Administrative ( ) Legislative

(X) Draft ( ) Final

LIST OF TABLES

Appendix A. HABITAT ASSOCIATION TABLES

The overall goal of habitat association table refinement was to consolidate the tables from the essential fish habitat environmental impact statement (EFH EIS) 2004 document into an easier to read format with descriptions that can be geo-referenced by life stage for each species based on our habitat GIS layers, and regional and depth boundaries. Several columns were removed (oxygen, salinity, and production) because in most cases this information is either unknown, or the species use waters with oceanic parameters which are fairly static in nature. With species for which these variable are known, this data was incorporated in a notes section at the bottom of each table. The location and habitat selection columns have been reclassified as eco-region (1-5), habitat zone (estuarine, nearshore, offshore), and habitat type. These categories are defined in the EFH EIS 2004 document, and are the variables of interest for mapped representations of species and life stage distributions.

Eco-region Name	Bounds	NOAA Stat Grids
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

Habitat zone comprised 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). Habitat type was subdivided into 12 categories distributed amongst the three zones. These 12 types were based on a combination of substrate and biogenic structure descriptions that was considered to provide the best overall categorization of fish habitats in the Gulf of Mexico. The table below presents this consolidated list of standard habitat types.

Habitat Type	Related Terms
Submerged Aquatic Vegetation (SAV)	Seagrasses, benthic algae
Mangroves	
Drifting algae	Sargassum
Emergent marshes	Tidal wetlands, salt marshes, tidal creeks, rives/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	
Banks/shoals	
Reefs	Reefs, reef halos, patch reefs, deep reefs
Shelf edge/slope	Shelf edge, shelf slope
Water Column Associated (WCA)	Pelagic, planktonic, coastal pelagic

Note: low-relief irregular bottoms include low ledges, caves, crevices, and burrows; high-relief irregular bottoms include high ledges & cliffs, boulders, and pinnacles.

Table A-1. King Mackerel (*Scomberomorus cavalla*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4, 9, 17, 18]	ER-3, ER-4, ER-5	offshore	WCA	spring, summer	hatch = 18-21 hrs at 27	35-180				
larvae[4, 9, 11, 12, 13, 14, 18]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	May-Oct	20-31	***35-180***	larval fish (carangids, clupeids, engraulids)	young pelagics (tuna, dolphin)	predation, starvation	enhanced in n.c. Gulf and n.w. Gulf, associated with MS River plume
post-larvae[4, 9, 11, 12, 13, 14, 18]	ER-1, ER-2, ER-3, ER-4, ER-5									
early juveniles[5, 8, 11, 12, 13, 20]	ER-3, ER-4, ER-5	nearshore	WCA	May-Oct peak: Jul, Oct		≤ 9	fish, some squid	larger pelagic fish	bycatch (shrimp fishery), sport fishery	enhanced in n.c. Gulf and n.w. Gulf, associated with MS River plume
late juveniles[1, 5, 12, 13, 16, 20]	ER-3, ER-4, ER-5	nearshore	WCA				estuarine-dependent fish, some squid	larger pelagic fish	bycatch (shrimp fishery), commercial and recreational fisheries	enhanced in n.c. Gulf and n.w. Gulf, associated with MS River plume

adults[1, 2, 3, 6, 7, 12, 15, 16, 17, 19, 21, 22, 23, 26, 27]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA		> 20	0-200	fish, squid, shrimp; feeding sometimes associated with *Sargassum*	larger fish, sharks, dolphin, tuna	fishing mortality, *M* = 0.174	highest growth occurs in eastern Gulf; L_{inf} = 1154.1 mm FL, *k* = 0.19, t_0 = -2.60; max. age = 24 yrs
spawning adults[1, 5, 10, 12, 16, 18]	ER-3, ER-4, ER-5	offshore	WCA	May-Oct	> 20	35-180				

Notes: Adults migrate to northern Gulf in spring, and return to south Florida in eastern Gulf and Mexico in western Gulf in fall[19,22]

n.c. = north central

n.w. = north western

Bold and italicized font indicates proxy data

Table A-2. Spanish Mackerel (*Scomberomorus maculatus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 3, 5, 14, 20, 21]	ER-2, ER-3	nearshore, offshore	WCA	spring, summer	hatch in 25 hours at 26	< 50				
larvae[3, 5, 7, 8, 14, 20, 24, 25, 28]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA	May-Oct	20-32	9-84	larval fish, some crustaceans	other immature fish, dolphin, tuna		
post-larvae[3, 5, 7, 8, 14, 20, 24, 25, 28]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA	May-Oct	20-33	9-84	larval fish, some crustaceans	other immature fish, dolphin, tuna		
early juveniles[4, 7, 8, 16, 20, 24, 28, 29]	ER-2, ER-3	estuarine, nearshore	WCA	Mar-Nov	15.5-34.0	1.8-9.0	mostly fish, some crustaceans, gastropods, shrimp	pelagic fishes	bycatch in shrimp trawl fishery	
late juveniles[4, 8, 10, 13, 16, 17, 20, 28, 29]	ER-2, ER-3	estuarine, nearshore, offshore	WCA	Mar-Nov	15.5-34.0	1.8-50	fish, squid	pelagic fishes	bycatch in shrimp trawl fishery, vulnerable to recreational fishery	

adults[1, 2, 8, 9, 10, 12, 13, 15, 19, 20, 22, 23, 26, 29, 31]	ER-1, ER-2, ER-3	estuarine, nearshore, offshore	WCA	n. Gulf in spring, s. Florida and Mexico in fall	15.5-34.0	3-75	fish, crustaceans, squid	larger pelagics	fishing mortality, impacted by baitfish harvest; M = 0.37/yr	females grow faster, live longer than males; t_0 = -0.5, k = 0.61, L_{inf} = 560 mm FL; max. age = 11 yrs
spawning adults[3, 5, 6, 11, 14, 18, 20]	ER-2, ER-3	nearshore, offshore	WCA	May-Sep	> 25	< 50				

Notes: juveniles and adults: salinity = 0-31 ppt

DO = 2.8-10.8mg/L[29]

Northeastern and northcentral Gulf considered important spawning areas[5,14]

Larvae and juveniles collected from artificial reefs[28]

Table A-3. Cobia (*Rachycentron canadum*) life history for the Gulf of Mexico**.** Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 2, 9, 25, 26, 27, 28, 35]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore	WCA	summer	28.1-29.7	top meter of water column				hatch within 36 hrs
larvae[1, 2, 3, 4, 9, 28, 29]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	WCA	May-Sep	24.2-32	3.1-300, in surface waters	In lab: zooplankton, primarily copepods			22 mm SL in 22 days (lab)
post-larvae[1, 2, 4, 9, 28, 30, 31]	ER-3, ER-4, ER-5	nearshore, offshore	WCA	May-Jul	25.9-30.3	11-53 * in or near surface waters*	In lab: zooplankton, primarily copepods			25 mm SL in 25 days (lab)
early juveniles[1, 4, 9, 28, 30, 31, 32]	ER-3, ER-4, ER-5	nearshore, offshore	WCA	Apr-Jul	*16.8-25.2*	5-300 * in or near surface waters*	In lab: *Gambusia*, shrimp and fish parts			~ 55 mm SL by 50 days (lab)
late juveniles[1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 26, 28, 37]	ER-3, ER-4, ER-5	nearshore, offshore	WCA	May-Oct		***1-70***	fish, shrimp, squid	*Coryphaena hippurus*		231 mm SL by 130 days (lab)
adults[1–29, 34, 36, 38, 39]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA, banks/shoals, hard bottom	Mar-Oct (n. Gulf), Nov-Mar (s. Gulf, s. FL)	23.0-28.0	1-70	crustaceans and fish		M = 0.38/yr	rapid growth for first two yrs; Linf = 1281.5 mm FL, k = 0.42, t_0 = -0.53, max. age = 11 yrs

spawning adults[1, 10, 16–18, 26–28, 35, 39]	ER-3, ER-4, ER-5	nearshore, offshore		Apr-Sep (n. Gulf)	23.0-28.0	***1-70***				50% maturity at age 2

Notes:

Eggs:	salinity = 30.5-34.1 ppt[2, 9, 28]
Larvae:	salinity = 18.9-37.7 ppt[2, 9, 28]
Post-larvae:	salinity = 28.9-30.2 ppt[1, 2, 30, 31]
Early Juveniles:	salinity = *30.0-36.4 ppt*[1, 30, 32]
Adults:	migrate seasonally[1, 2, 11, 13, 15, 16] salinity = 24.6-30.0 ppt[1, 3, 7, 22]

Spawning Adults: salinity = 24.6-30.0+ ppt[1, 18]

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Table A-4. Red Drum (*Sciaenops ocellatus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[5, 6, 7, 10, 14, 16, 17, 18, 19, 20]	ER-1, ER-2, ER-3, ER-4, ER-5		WCA	summer, fall	20-30	**20-30**			high early in spawning	
larvae[5, 7, 10, 17, 18, 19, 20]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine	SAV, soft bottom, WCA	late summer, fall	18.3-31		copepods	larger piscivorous fish	Higher at 20-24°C than 25-30°C	0.5 mm/day. Faster at 25-30°C. 3-6 mm at 2 weeks. peak settlement from 6-8 mm TL
postlarvae[17, 18, 20]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine	SAV, emergent marsh, soft bottom, sand/shell	late summer, fall	18.3-31.0		copepods	larger piscivorous fish		Increased with increasing salinity (up to 30 ppt)

early juveniles[3, 5, 7, 9, 16, 17, 18, 19, 20, 21, 22, 25]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore	SAV, soft bottom, emergent marsh	Sep-Dec	> 5-32.2	0-3	copepods, mysids, amphipods, shrimp, polychaetes, insects, fish, isopods, bivalves, decapod crabs	larger piscivorous fish	rapid decline in water temp. can cause mortality	higher in backwater than seagrass beds. 15-20 mm/month
late juveniles[1, 3, 4, 5, 7, 11, 12, 15, 16, 17, 18, 19, 21]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore	SAV, soft bottom, hard bottom, sand/shell	fall	> 5-30	0-5	mysids, amphipods, shrimp, polychaetes, insects, crabs, fish	amberjack, sharks, larger piscivorous fish	changes in environment, disease, parasites, rapid decline in water temp.	15-20 mm/month
adults[4, 7, 9, 12, 15, 16, 17, 20, 23, 26, 27]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	SAV, emergent marsh, soft bottom, hard bottom, sand/shell, WCA		2-33	1-70	crabs, shrimp, fish	sharks	*M* (age-constant) = 0.07-0.13	L_{inf} = 881 mm FL, *k* = 0.32, t_0 = -1.29, max. age = 42 yrs
spawning adults[1, 2, 3, 7, 9, 10, 14, 15, 16, 17, 20]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	SAV, soft bottom, hard bottom, sand/shell	mid Aug - Oct	20-30	40-70		sharks		L_{50} (male) = 529 mm FL, L_{50} (female) = 825-900 mm FL

Notes:
eggs: salinity = 10-40 ppt[5, 7, 16, 17, 18]
larvae, post-larvae: salinity = 8-36.4 ppt[5, 7, 17, 18, 19]
early juveniles: salinity = 0-45; primarily 20-40 ppt[7, 18, 19]

DO > 0.6 ppm[17]

late juveniles: salinity = 0-45; primarily 20-40 ppt[7, 18, 19]

DO = 5.2-8.4 ppm[18]

adults: salinity = 0-45 ppt; primarily 20-40 ppt[7, 17]

spawning adults: mean batch fecundity = 1.54 million ova[24]

salinity = 25-34 ppt[7, 16, 17]

Bold and italicized font indicates proxy data

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Table A-5. Queen Snapper (*Etelis oculatus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	**Eco-region**	**Habitat Zone**	**Habitat Type**	**Season**	**Temp (°C)**	**Depth (m)**	**Prey**	**Predators**	**Mortality**	**Growth**
eggs[3]	ER-1	offshore	WCA			***95-680***				
larvae[3, 7]	ER-1	offshore	WCA	*Sep-Nov*		*0-100*			*Z = -0.113 ± 0.023 (SE)*	*SL-age curve = 0.113, *K* = 0.040 ± 0.003 (SE), PLD ≤ 36 d*
postlarvae[7]	ER-1	offshore	*WCA*	*Sep-Nov*		*0-100*			*Z = -0.113 ± 0.023 (SE)*	*SL-age curve = 0.113, *K* = 0.040 ± 0.003 (SE), PLD ≤ 36 d*
early juveniles[1, 8, 9]	ER-1	offshore	WCA			***95-680***	*crustaceans*	*beardfish (*Polymixia lowei*)*		
late juveniles[9]	ER-1	offshore				***95-680***	*crustaceans*			
adults[1, 2, 3, 4, 5, 8, 9]	ER-1	offshore	hard bottom, *shelf edge/slope*		16-18	95-680	*squid, small fish*		**Z/K* = 3.73*	Up to 1000 mm TL; at least 30 yrs; *L_{inf} = 905.7 mm FL, females larger than males*

spawning adults[5, 6, 10]	ER-1	offshore		*year-round peak: Oct-Nov*		95-680				*50% maturity = 310 mm FL (females), 220 mm FL (males);100% maturity = 370 mm FL*

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Table A-6. Mutton Snapper (*Lutjanus analis*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 9]	ER-1		WCA	Late spring-summer						
larvae[6, 7, 12]	ER-1		WCA	early summer						PLD = 31 d
postlarvae[6, 7, 12]	ER-1		WCA	early-mid summer						PLD = 31 d
early juveniles[6, 7]	ER-1	estuarine, nearshore	SAV	summer						
late juveniles[6, 7]	ER-1	estuarine, nearshore	SAV, reefs	late summer						
adults[1, 2, 3, 4, 5, 8, 13]	ER-1	estuarine, nearshore	SAV, reefs	year-round			crustaceans, fish, gastropods		*M* = 0.17	Linf = 861 mm TL, *K* = 0.165, t_0 = -1.23, max. age = 40
spawning adults[1, 10, 11, 14]	ER-1	offshore	reefs, bank/shoals, hard bottom, shelf edge/slope	Mar-Jul		25-95			heavy fishing pressure at spawning aggregations	

Notes:

Table A-7. Blackfin Snapper (*Lutjanus bucanella*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[3, 4]	ER-1, ER-2	offshore	WCA	year-round		***40-300***				
larvae	ER-1, ER-2					***40-300***				
postlarvae	ER-1, ER-2					***40-300***				
early juveniles[2, 6, 7]	ER-1, ER-2	nearshore, offshore	hard bottom	*spring*		*7*-40				
late juveniles[2, 6, 7]	ER-1, ER-2	nearshore, offshore	hard bottom	*spring*		*7*-40				
adults[1, 2, 6]	ER-1, ER-2	offshore	shelf edge/slope, hard bottom	year-round		40-300	fish, crustaceans			
spawning adults[2, 3, 4]	ER-1, ER-2	offshore	shelf edge/slope, hard bottom	year-round peak: spring, fall		40-300				

Notes:
Never reported in significant numbers by recreational or commercial fishery[5]
Juveniles and adults present on artificial reefs off southeastern FL[7, 8]
Unspecified life stages (likely adults) present on Sonnier Bank (ER-4/5)[9]
Information in asterisks comes from studies conducted outside GMFMC jurisdiction
Bold and italicized font indicates proxy data

Table A-8. Red Snapper (*Lutjanus campechanus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 2, 6, 17]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	Apr-Oct		**18-126**				50% hatch in 20-27 hrs
larvae[5, 13, 20]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	Jul-Nov	17.3-29.7	**18-126**	alga, rotifers (in lab)			PLD = 28 d
postlarvae[5, 17, 20]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	Jul-Nov	17.3-29.7	**18-126**				settle at 16-19 mm TL; PLD = 28d
early juveniles[2, 5, 8, 16, 20, 21, 24]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reefs, hard bottom, banks/shoals, soft bottom, sand/shell	Jul-Nov	17.3-29.7	17-183	zooplankton, shrimp, chaetognaths, squid, copepods		shrimp trawl bycatch; *M* (age 0) = 2.0/yr	0.817-1.01 mm/d
late juveniles[2, 3, 8, 10, 12, 16, 17, 20, 21, 24]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reefs, hard bottom, banks/shoals, soft bottom, sand/shell	year-round	20-28	18-55	fish, squid, crabs, shrimp		shrimp trawl bycatch; *M* (age 1) = 1.2/yr	0.817-1.01 mm/d
adults[2, 3, 4, 7, 9, 10, 11, 12, 14, 15, 17, 18, 24]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reefs, hard bottom, banks/shoals	year-round	14-30	7-146	fish, shrimp, squid, octopus, crabs	sharks	enter fishery at age 2; *M* = 0.094/yr	L_{inf} = 856.4 mm TL, *K* = 0.19, t_0 = -0.39, max. age = 48 yrs

spawning adults[1, 2, 6, 19, 25]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	sand/shell, banks/shoals	Apr-Oct	16-29	18-126				50% mature (female) at age 3-5, 400-450 mm TL; 100% mature (female) at age 8, 700 mm TL

Notes: larvae and post-larvae: 32.8-37.5 ppt[5]

juveniles: salinity = 30-35ppt[21]
DO > 0.4 mg/L[22]

adults: 33-37 ppt[10]

spawning adults: batch fecundity = 27-142 egg/g fish weight[24]

Bold and italicized font indicates proxy data

red snapper use artificial reefs as juveniles and adults[17]

Table A-9. Cubera Snapper (*Lutjanus cyanopterus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1]	ER-1	nearshore, offshore	WCA	summer		***10-85***				
larvae	ER-1	nearshore, offshore				***10-85***				
postlarvae	ER-1	nearshore, offshore				***10-85***				
early juveniles[4, 5, 6, 7]	ER-1	estuarine, nearshore, offshore	SAV, mangrove, emergent marsh		24.5-31.0	***0-85***				
late juveniles[4, 5, 6, 7]	ER-1	estuarine, nearshore, offshore	SAV, mangrove, emergent marsh		24.5-31.0	***0-85***				
adults[1, 2, 3, 4]	ER-1	estuarine, nearshore, offshore	mangrove, reef			0-85				
spawning adults[1, 8, 9]	ER-1	nearshore, offshore	*reef, shelf edge/slope, hard bottom, bank/shoal*	*Apr-Jul, peak: May*	*> 26.9*	10-85				

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Juveniles: salinity = 3.7-37 ppt[5]

Spawning adults: transient spawners[10]

Bold and italicized font indicates proxy data

Table A-10. Gray Snapper (*Lutjanus griseus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[5, 13, 16, 23, 32, 33, 34]	ER-1, ER-2	offshore	WCA	Jun-Sep		***0-180***				pre-settlement duration: 25-33 d
larvae[4, 6, 12, 13, 16, 32, 33, 34]	ER-1, ER-2	offshore	WCA	Apr-Nov peak: Jun-Aug	15.6-27.2	***0-180***	lab: zooplankton	carnivorous fish		pre-settlement duration: 25-33 d
postlarvae[6, 12, 15, 19, 23, 24, 28, 32, 33, 34]	ER-1, ER-2	estuarine	SAV				copepods, amphipods	carnivorous fish		pre-settlement duration: 25-33 d
early juveniles[1, 6, 12, 16, 18, 19, 23, 24, 28, 31, 32, 33, 34]	ER-1, ER-2	estuarine	SAV, mangrove, emergent marsh		12.8-36.0	1-3	amphipods	carnivorous fish		growth rate = 0.60-1.02 mm/d; *SAV residents ~ 8 months; settle Sep-Oct (at 78 mm TL)*
late juveniles[1, 3, 12, 18, 19, 21, 22, 23, 25, 28, 34]	ER-1, ER-2	estuarine, nearshore	SAV, mangrove, emergent marsh		12.8-36.0	***0-180***	penaeid shrimp, crabs, fish, mollusks, polychaetes	carnivorous fish		growth rate = 0.60-1.02 mm/d; *SAV residents ~ 8 months; occupy mangroves from 100-120+ mm TL*

adults[1, 2, 6, 7, 8, 9, 10, 11, 14, 17, 18, 20, 21, 22, 23, 25, 27, 29, 30]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	hard bottom, soft bottom, reef, sand/shell, banks/shoals, emergent marsh		13.4-32.5	0-180	fish, shrimp, crabs		*Z*=0.17-0.22, *M*=0.15	recruit to fishery @ age 4; max. age = 28 yrs; L_{inf} = 656.4 mm TL, *k* = 0.22, t_0 = 0
spawning adults[5, 23, 26]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	reef, hard bottom	year-round (S. FL), summer elsewhere		0-180				maturation at 185 mm TL for males and 200 mm TL for females

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Table A-11. Lane Snapper (*Lutjanus synagris*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[3, 9]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	Mar-Sep, peak: Jul-Aug		***4-132***				
larvae[2, 10, 11]	ER-1, ER-2, ER-3, ER-4, ER-5	*estuarine, nearshore, offshore*	*WCA*	*Jun-Aug*	28 (in lab); *28.4-30.4*	*0-50*	plankton and rotifers (in lab)		death by day 10 at 25°C in lab; * *Z* = -0.429± 0.053(SE), subject to size-selective mortality*	*SL-age curve = 0.032, *K* = 0.047 ± 0.008 (SE; W. Straits of FL), *K* = 0.042 ± 0.008 (SE; E. Straits of FL), PLD = 25.6 d*
postlarvae[10, 11]	ER-1, ER-2, ER-3, ER-4, ER-5	*estuarine, nearshore, offshore*	*WCA*, SAV	*Jun-Aug*	*28.4-30.4*	*0-50*			death by day 10 at 25°C in lab; * *Z* = -0.429± 0.053(SE), subject to size-selective mortality*	*SL-age curve = 0.032, *K* = 0.047 ± 0.008 (SE; W. Straits of FL), *K* = 0.042 ± 0.008 (SE; E. Straits of FL), PLD = 25.6 d*

early juveniles[5, 8, 11, 13, 14]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	SAV, sand/shell, reefs, soft bottom, banks/shoals, *mangrove*	late summer-early fall	28-29.5	0-24	copepods, grass shrimp, small inverts		*subject to growth-selective mortality*, daily *Z* = 0.097-0.165	settle Jul-Aug, min. settle length = 15.1 mm SL, min. settle age = 25 d, growth rate = 0.9-1.3 mm/d
late juveniles[5, 8, 11, 13, 14]	ER-1, ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	SAV, reefs, sand/shell, soft bottom, banks/shoals, *mangrove*	late summer-early fall	28-29.5	0-24	copepods, grass shrimp, small inverts		*subject to growth-selective mortality*, daily *Z* = 0.097-0.165	growth rate = 0.9-1.3 mm/d
adults[1, 6, 9, 15]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reef, sand/shell, banks/shoals, hard bottom		16-29	4-132	fish, crustaceans, annelids, mollusks, algae		*Z* = 0.38-0.58; *M* = 0.11-0.24	max. length = 673 mm TL. Males grow faster, and larger at age than females; L_{inf} = 449 mm FL, *k* = 0.17, t_0 = -2.59, max. age = 19 yrs

spawning adults[5, 7, 11, 13]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	*reef, shelf edge/slope*	May-Aug		*30-70m*					*50% maturity = 230 mm (females), 242 mm (males); 100% maturity > 350 mm TL (females), > 377 mm TL (males)*

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Juveniles:
salinity = 30-35.5 ppt[13]
can be found at lower salinities < 15 ppt[4]
DO = 4.4-5.7 mg/L[13]

Adults:
occupy artificial reef habitat
always found at high (> 30 ppt) salinities[4]

Spawning adults:
fecundity < 104,749 oocytes/female (255 mm TL) and 568,400 oocytes/female (560 mm TL)[12]

Table A-12. Silk Snapper (*Lutjanus vivanus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 2]	ER-1	offshore		year-round		**90-200**				
larvae[1, 2]	ER-1	offshore		year-round		**90-200**				
postlarvae[1, 2]	ER-1	offshore		year-round		**90-200**				
early juveniles[1, 2, 4]	ER-1	offshore		year-round		*30-40*				
late juveniles[4]	ER-1	offshore				*30-40*	fishes, shrimp, crabs	sharks, grouper, barracuda		
adults[3, 4, 5, 6, 9, 10]	ER-1	offshore	shelf edge/slope, *soft bottom, hard bottom*		*13-27*	90-200	fish, shrimp, crabs, gastropods, cephalopods, tunicates, urochordates	sharks, grouper, barracuda	*M* = 0.230	L_{inf} = 781.1 mm TL, *K* = 0.092, t_0 = -2.309, max. age = 9 yrs
spawning adults[1, 2, 4, 7, 8]	ER-1	offshore		year-round, peak: Jul-Aug		**90-200**	fishes, shrimp, crabs	sharks, grouper, barracuda		*50% maturity = 500-550 mm FL (females), 380-600 mm FL (males)*

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Table A-13. Yellowtail Snapper (*Ocyurus chrysurus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 7]	ER-1, ER-2	nearshore, offshore	WCA	Feb-Oct		***1-183***				
larvae[12, 13]	ER-1, ER-2	nearshore, offshore	WCA			***1-183***				**K* = 0.048 ± 0.007 (west Straits of FL), *K* = 0.041 ± 0.007 (east Straits of FL)*; avg. PLD = 25.3 d
postlarvae[12, 13]	ER-1, ER-2	nearshore, offshore	WCA			***1-183***				**K* = 0.048 ± 0.007 (west Straits of FL), *K* = 0.041 ± 0.007 (east Straits of FL)*; avg. PLD = 25.3 d
early juveniles[1, 7, 8, 11]	ER-1, ER-2	estuarine, nearshore	SAV, mangrove	fall	24-30	*0.3-1.2 *	zooplankton			
late juveniles[1, 7, 8, 16]	ER-1, ER-2	estuarine, nearshore, offshore	reefs, *hard bottom*		24-30	***1-183***	zooplankton			

adults[1, 2, 3, 4, 5, 6, 7, 10, 14]	ER-1, ER-2	nearshore, offshore	reefs, hard bottom		18-34	1-183	benthic and pelagic reef fish, crustaceans, mollusks		*F* = 0.22-0.25; *M* = 0.194	max. age = 23 years; L_{inf} = 618.0 mm TL, *K* = 0.133, t_0 = -3.132
spawning adults[1, 14a, 14b, 15]	ER-1, ER-2	nearshore, offshore		Apr-Aug		***1-183***				50% maturity = 232 mm TL and 1.7 yrs (female), *194 mm FL (male)*

Notes: Spawning adults: females with hydrated oocytes found May-Sep[9]

Bold and italicized font indicates proxy data

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Table A-14. Wenchman (*Pristopomoides aquilonaris*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1,3,4]	ER-3, ER-4, ER-5	offshore	WCA	summer	20	***80-200***				
larvae[1,4]	ER-3, ER-4, ER-5	offshore	WCA	summer		***80-200***				
postlarvae[1]	ER-3, ER-4, ER-5	offshore		summer		***80-200***				
early juveniles	ER-3, ER-4, ER-5	offshore				***19-481***				
late juveniles	ER-3, ER-4, ER-5	offshore				***19-481***				
adults[2,3,4,5,6]	ER-3, ER-4, ER-5	offshore	hard bottom, shelf edge/slope	year-round	9.1-28.7	19-481	small fish			L_{inf} = 240 mm FL, *K* = 0.18, t_0 = -4.75, max. age (# otolith increments) = 14
spawning adults[1,3]	ER-3, ER-4, ER-5	offshore	shelf edge/slope	summer	20	80-200				

Notes: adults: salinity = 28.2-36.6 ppt[6]

DO = 3.4-8.0 mg/L[6]

Bold and italicized font indicates proxy data

Table A-15. Vermilion Snapper (*Rhomboplites aurorubens*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***18-100***				
larvae[1]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	*Jun-Nov*		*30-40*				
postlarvae[1]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	*Jun-Nov*		*30-40*				
early juveniles[3, 11]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom, reefs			***18-100***	*copepods, nematodes*	lionfish		
late juveniles[3, 11]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom, reefs			***18-100***	*fish scales, copepods, small pelagic crustacea, cephalopods*	lionfish		
adults[2, 4, 5, 6, 8, 9, 11]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	banks/shoals, reef, hard bottom	*year-round*	*16.4-26.2*	18-100	benthic tunicates, amphipods, juvenile vermilion (rare), *cephalopods*		Z = 0.39 ± 0.05	L_{inf} = 344 mm FL, k = 0.3254, t_0 = -0.7953, max. age = 26 yrs
spawning adults[7]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore		May-Sep		***18-100***				

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Notes cont: Deeper sites had older fish[8]

Adults: *salinity = 32.7-36.3 PSU[2]*

Spawning adults: *fecundity = 8,168-1,789,998 ova/female[10]*

Table A-16. Speckled Hind (*Epinephelus drummondhayi*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[8]	ER-1, ER-2	offshore	WCA			***44*-183***				
larvae[8]	ER-1, ER-2	offshore	WCA			***44*-184***				
postlarvae[8]	ER-1, ER-2	offshore	WCA			***44*-185***				
early juveniles[13]	ER-1, ER-2	offshore	*reef*			***25-183***				
late juveniles[13]	ER-1, ER-2	offshore	*reef*			***25-183***				
adults[1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15]	ER-1, ER-2	offshore	hard bottom		17-24	25-183	fish, cephalopods, other inverts		overfishing; *M=0.13, F=1.14, Z=1.27*	recruit to fishery at 6-7 yrs; * max. length = 973 mm TL*; L_{inf} = 888 mm TL, K = 0.12, t_0 = -1.8, max. age = 45 yrs
spawning adults[2, 4, 5, 6, 9, 11, 14]	ER-1, ER-2	offshore	shelf edge/slope	Apr-May, Jul-Sep		*44*-183			fishing affects sex ratio and spawning biomass; males rare	protogynous hermaphrodites; *50% maturity = 532 mm TL and 6.6 yrs (females); 50% transition = 627 mm TL and 6.9 yrs*

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Notes cont: Juveniles: young more common in shallower portion of depth range[1]

have been reported on artificial reefs in southeast FL (occurances, not common)[12]

Spawning adults: females can produce up to 2 million eggs in one spawning[2]

Table A-17. Goliath Grouper (*Epinephelus itajara*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 2, 13]	ER-1, ER-5	offshore	WCA	late summer, early fall		***36-46***				
larvae[1, 13, 20]	ER-1, ER-5	offshore	WCA	late summer, early fall		***36-46***				pelagic larval duration: 30-80 d
postlarvae[5, 20]	ER-1, ER-5		mangroves							pelagic larval duration: 30-80 d
early juveniles[1, 2, 6, 7, 8, 11, 16, 19]	ER-1, ER-5	estuarine, nearshore	SAV, mangroves, emergent marsh	Nov-Jan		0-5	crustaceans			growth rate ~ 0.300 mm/d
late juveniles[1, 2, 15, 16, 19]	ER-1, ER-5	estuarine, nearshore	SAV, mangroves, emergent marsh, reefs, hard bottom			0-5	crustaceans			emigrate from mangroves btwn age 5 and 6 (1000 mm TL); growth rate ~ 0.300 mm/d
adults[1, 2, 3, 6, 10, 12, 14, 16, 17, 18, 21]	ER-1, ER-5	nearshore, offshore	reefs, hard bottom, banks/shoals		20-25	0-95	crustaceans (esp. lobster), fish, molluscs (cephalopods)		Z = 0.85, F = 0.70, M = 0.15 Vulnerable to overfishing	L_{inf} = 2221 mm TL, K = 0.0937, t_o = -0.6842, max. age = 37 yrs;

										Slow growth rate
spawning adults[1, 2, 4, 16]	ER-1, ER-5	offshore	reefs, hard bottom	Jun-Dec peak: Jul-Sep	25-26	36-46				

Notes: adults, spawning adults: use artificial reefs (esp. wrecks) as habitat[2, 4]

Bold and italicized font indicates proxy data

Table A-18. Red Grouper (*Epinephelus morio*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[10, 11, 17, 22]	ER-1, ER-2	offshore	WCA	Apr-May		20-100			**M* = 194.93*	hatch in 30 hrs at 24°C
larvae[7, 10, 11, 17, 22]	ER-1, ER-2	offshore	WCA	May-Jun	optimum: 27.4-28.5	20-100	zooplankton		**M*= 13.03-153.10 (depending on age)*	stage lasts 30-40 days post-hatch
postlarvae[1, 17, 22]	ER-1, ER-2		WCA	May-Jul					**M* = 13.03-153.10 (depending on age)*	stage lasts 35-50 days post-hatch, leave plankton at about 20 mm SL
early juveniles[2, 4, 5, 9, 10, 11, 16, 22]	ER-1, ER-2	estuarine, nearshore	SAV, hard bottom		16.1-31.2	0-15	demersal crustaceans	larger fishes	**M* = 2.52-5.73 (depending on age)*; low DO (3.9-4.7 mg/L) has caused mortality	
late juveniles[5, 8, 10, 11, 16, 19, 20, 22]	ER-1, ER-2	estuarine, nearshore, offshore	hard bottom			0-50	demersal crustaceans, fishes	larger demersal fishes	catch/ release when caught from > 44 m; **M* = 2.52-5.73	influenced by food availability, population density

									(depending on age)*	
adults[3, 5, 8, 10, 11, 12, 13, 14, 15, 16, 18, 24, 25, 27]	ER-1, ER-2	nearshore, offshore	hard bottom, reefs		15-30	3-190	fish, crustaceans, cephalopods	top predators (ex: sharks, barracudas)	competition for food, shelter; predation; catch/ release mortality; red tide; sudden temp. decreases; Z = 0.39; M (> age 2) = 0.1194-0.2583	influenced by fishing pressure, food availability, population density; max. age 29; L_{inf} = 829 ± 5.50 mm FL, k = 0.1251 ± 2.0 x 10^{-3}, t_0 = -1.2022 ± 3.4x10^{-2}

spawning adults[6, 7, 10, 11, 17, 19, 21, 23, 25, 26]	ER-1, ER-2	offshore	shelf edge/slope, hard bottom	Mar-Jun	*16.97-24.08*	20-100				population density and environmental stress may influence sexual transition; 50% maturity = 2.8 yrs, 292 mm FL; 50% transition = 11.2 yrs, 707 mm FL

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Early juveniles: salinity = 20.7-35.5 ppt[2, 9]

Adults: more abundant in fishery during summer months, move offshore during winter[8, 11, 12]
can be found on artificial reefs

Spawning Adults: protogynous hermaphrodites[6, 7, 11, 19]

eggs require at least 32 ppt for buoyancy[17]

Table A-19. Yellowedge Grouper (*Hyporthodus flavolimbatus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[9]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***35-370***				
larvae[9]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***35-370***				
postlarvae [16]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	*Jul-Oct*		***35-370***				
early juveniles [19]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore				9-110				
late juveniles[12, 19]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom			9-110				
adults[1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	hard bottom, soft bottom, *shelf edge/slope*		10.7-27.0	35-370	brachyuran crabs, fish, other inverts		Z = 0.128, M = 0.048-0.090, F = 0.038-0.080	max. age = 85 yrs, max. length = 1228 mm TL; L_{inf} = 1005 mm TL, K = 0.059, t_0 = -4.75

spawning adults[7, 9, 11, 17, 18]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	*shelf edge/slope, reefs*	Feb-Sep, Nov peak: Mar-Sep	*14.47*	35-370				Protogynous hermaphrodites; 50% maturity = 547 mm TL and 8 yrs (females), 50% transition = 815 mm TL and 22 yrs

Notes: ***Bold and italicized font indicates proxy data***

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Adults: salinity = 25.3-38.0 ppt [15]

DO = 2.1-9.6 mg/L [15]

Spawning Adults: form local spawning aggregations[14]

Table A-20. Warsaw Grouper (*Epinephelus nigritus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4, 6]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***40-525***				
larvae[4, 6]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***40-525***				
postlarvae[4, 6]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***40-525***				
early juveniles	ER-1, ER-2, ER-3, ER-4, ER-5	offshore				***20-30***				
late juveniles[2, 9]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	reefs			20-30				
adults[1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, hard bottom		12-25	40-525	crabs, shrimp, lobsters, fish		vulnerable to overfishing; overfishing affects size structure; *M = 0.10*	*L_{inf} = 2394 mm TL, K = 0.0544, t_0 = -3.616; max. age = 41 yrs, max. length = 2300 mm*
spawning adults[5, 6, 7]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, hard bottom, reef	late summer		40-525				protogynous hermaphrodite; mature at 9 yrs

Notes: Early Juveniles: collected at 29 ppt[9]

Bold and italicized font indicates proxy data

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Table A-21. Snowy Grouper (*Epinephelus niveatus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4]	ER-1	offshore	WCA			***30-525***				
larvae[4, 6, 9]	ER-1	offshore	WCA	Jun, Oct	28	***30-525***				
postlarvae[4, 6, 9]	ER-1	offshore	WCA	Jun, Oct	28	***30-525***				
early juveniles[2, 4, 7, 9]	ER-1	nearshore	reefs			> 1				
late juveniles[2, 4, 5, 7, 9, 10]	ER-1	nearshore, offshore	reefs		*15-29*	17-60	fish, gastropods, cephalopods, other inverts		trawl bycatch	
adults[1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 20]	ER-1, ER-2	offshore	hard bottom, reef, *shelf edge/slope*		12-26	30-525	fish, crabs, crustaceans, cephalopods, gastropods		vulnerable to fishing pressure; *M = 0.12*	max. size = 1200 mm, max. weight = 30 kg; recruit to fishery at age 8; L_{inf} = 1064.62 mm TL, K = 0.094, t_0 = -2.884, max. age = 35 yrs

spawning adults[2, 4, 7, 9, 13, 14, 16, 18]	ER-1, ER-2	offshore	*reef, shelf edge/slope*	Apr-Jul (FL Keys), May-Aug (w. FL)		30-525			overfishing causes sex ratio imbalance	protogynous hermaphrodites; 50% maturity = 541 mm TL and 4.92 yrs; 40% of fish ≥ 8 yrs (700 mm) are male; transition = 6-7 yrs and 475 mm FL

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction
Bold and italicized font indicates proxy data

larvae/ postlarvae: salinity = 37 ppt[6]

juveniles: on artificial reefs in ER-2 (occurrences, not common)[15]

Table A-22. Black Grouper (*Mycteroperca bonaci*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4]	ER-1, ER-2	offshore	WCA			***18-28***				
larvae[4]	ER-1, ER-2	offshore	WCA			***10-150***				
post-larvae[4]	ER-1, ER-2	offshore	WCA			***10-150***				
early juveniles[5, 11, 12, 13, 17, 18]	ER-1, ER-2	estuarine, nearshore	SAV	year-round	31	*1-10*	crustaceans, fish			
late juveniles[1, 2, 5, 11, 13, 16, 17, 18]	ER-1, ER-2	estuarine, nearshore, offshore	reefs, hard bottom, mangrove	year-round		*1*-19	crustaceans, fish			
adults[1, 2, 3, 5, 6, 7, 9, 10, 11, 13, 21]	ER-1, ER-2	nearshore, offshore	reefs, hard bottom		16-28	10-150	fish	sharks, larger groupers	overfishing; M = 0.136	rapid first 3-4 yrs; L_{inf} = 1334 mm TL, k = 0.1432/yr, t_0 = -0.9028/yr; max. age = 33 yrs

spawning adults[5, 6, 8, 10, 14, 15, 19, 20, 21]	ER-1, ER-2	offshore	reefs, hard bottom, *shelf edge/slope*	Feb-Mar	*24-27*	18-28			spawning aggregations vulnerable to overfishing	*females range from 570-1235 mm, males from 860-1320 mm; females change sex between 855-1250 mm*

Notes:

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Not considered EFH, but late juveniles have been document on artificial reefs[18]

Bold and italicized font indicates proxy data

Table A-23. Yellowmouth Grouper (*Mycteroperca interstitialis*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[3]	ER-1, ER-5	offshore	WCA			***20-189***				
larvae[3, 13]	ER-1, ER-5	offshore	WCA			***20-189***				
postlarvae[3, 13]	ER-1, ER-5	offshore	WCA			***20-189***				
early juveniles[1, 5]	ER-1, ER-5	estuarine	mangrove							
late juveniles[1, 7, 13]	ER-1, ER-5	estuarine	mangrove				*fish*			
adults[1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 14, 15]	ER-1, ER-2, ER-4, ER-5	offshore	hard bottom, reef, banks/shoals		19-24	20-189	fish, crustaceans, other inverts	sharks, large fish	vulnerable to overfishing; *Z* = 0.25-0.28; **M* = 0.14*	long-lived, slow growing, fastest growth in first two year; maximum age/length = 28 yrs/830 mm TL; L_{inf} = 828 mm TL, *K* = 0.076, t_0 = -7.5

spawning adults[4, 7, 8]	ER-1, ER-2, ER-5	offshore		year-round peak: Apr-May (in FL)		20-189				protogynous; females mature at 400-450 mm TL (age 2-4); transition to males at 505-643 mm TL (age 5-14)

Notes: ***Bold and italicized font indicates proxy data***

Information in asterisks comes from studies outside GMFMC jurisdiction

Table A-24. Gag (*Mycteroperca microlepis*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4,5,7,9,13,19,24]	ER-1, ER-2	offshore	WCA	Dec-Apr		***50-120***				hatch in 45h at 21°C
larvae[13, 19, 21, 24, 31]	ER-1, ER-2	offshore	WCA	early spring		***50-120***				pelagic larval duration = 29-52 d
postlarvae[10, 13, 21, 31]	ER-1, ER-2	offshore	WCA			***50-120***				pelagic larval duration = 29-52 d
early juveniles[1, 2, 3, 6, 7, 13, 21, 23, 24, 28, 32]	ER-1, ER-2	estuarine, nearshore	SAV, mangroves	late spring-early fall	22-32	0-12	crustaceans (amphipods, copepods, grass shrimp)		minimal while in SAV	rapid during association with SAV
late juveniles[2, 3, 7, 11, 13, 15, 21, 23, 24, 26, 28, 32]	ER-1, ER-2	estuarine, nearshore, offshore	SAV, hard bottom, reefs, mangroves	recruit to reefs offshore in fall	22-32	1-50	decapod crustaceans and fish	cannibalistic, larger fishes	recreational fishery, shrimp fishery bycatch	
adults[2, 6, 9, 13, 15, 16, 18, 20, 22, 23, 24, 29, 34, 35]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom, reefs	year-round	14-24	13-100	fish, crustaceans, cephalopods	sharks	sudden low temps, fishing mortality; M = 0.1342	L_{inf} = 1277.95 mm FL, k = 0.1342, t_0 = -0.6687, max. age = 31 yrs
spawning adults[2, 4, 8, 9, 13, 14, 18, 19, 25, 27, 30]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, hard bottom	Dec-May peak: Feb-Mar	21-30	50-120			spawning aggregations vulnerable to fishery	

Notes: Adults occupy artificial reefs in ER-2 and ER-3[33, 34]

Late juveniles: occupy artificial reefs in ER-2[34]

salinity = 28.8-37.6 ppt[3, 11, 13]

Postlarvae: successful larval transport into estuaries is dependent on oceanographic conditions[10]

Early Juveniles: salinity = 25.9-35.5 ppt[3, 13]

Early Juveniles: salinity = 25.9-35.5 ppt[3, 13] availability of estuarine habitat is critical to survival and growth[10]

Spawning adults: annual fecundity estimated at 0.065 to 61.4 million eggs/female/year[27]

Bold and italicized font indicates proxy data

Table A-25. Scamp (*Mycteroperca phenax*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 9]	ER-1, ER-2	offshore	WCA	spring		***60-189***				
larvae[1, 9]	ER-1, ER-2	offshore	WCA	spring		***60-189***				
postlarvae[1, 9]	ER-1, ER-2	offshore	WCA	spring		***60-189***				
early juveniles[5, 11, 14]	ER-1, ER-2, ER-4	nearshore, offshore	hard bottom, reef, banks/shoals			12-33				
late juveniles[5, 11, 14]	ER-1, ER-2, ER-4	nearshore, offshore	hard bottom, reef, banks/shoals			12-33				
adults[1, 3, 4, 5, 6, 7, 8, 10]	ER-1, ER-2	nearshore, offshore	hard bottom, reef		14-28	12-189	fish, crustaceans, cephalopods	sharks	catch and release mortality > 44m	reach maximum size slowly
spawning adults[1, 2, 4, 12]	ER-1, ER-2	offshore	shelf edge/slope, reef, hard bottom	Feb-June	> 8.6	60-189			fishing pressure may reduce proportion of males in population	

Notes: ***Bold and italicized font indicates proxy data***

adults: use artificial reefs in the western Atlantic[13]

spawning adults: protogynous hermaphrodite[1, 2]

Table A-26. Yellowfin Grouper (*Mycteroperca venenosa*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs	ER-1	offshore				**_*25-30*_**				
larvae	ER-1	offshore				**_*25-30*_**				
postlarvae	ER-1	offshore				**_*25-30*_**				
early juveniles[2, 5, 7]	ER-1	estuarine, nearshore	SAV			2-4				
late juveniles[2, 5, 6, 7, 16]	ER-1	estuarine, nearshore	SAV, hard bottom			**2-4**	*fish, squid, shrimp*			
adults[1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 13]	ER-1	nearshore, offshore	reefs, hard bottom		15-26	2-214	*fish, squid, shrimp*	sharks	vulnerable to fishing pressure	max. length = 900 mm TL, *max. age = 13 yrs, L_{inf} = 977 mm TL, *K* = 0.14, t_0 = -1.50*
spawning adults[2, 5, 7, 9, 11, 12, 13, 14, 15]	ER-1	offshore	*shelf edge/slope, reef, hard bottom, banks/shoals*	Mar-Aug		*25-30*			fishing may affect sex ratios	protogynous; smallest males found at 540 mm TL; *50% maturity = 561 mm TL and 4.66 yrs (female); 50% transition = 716-871 mm TL and 8-9 yrs*

Notes: ***Bold and italicized font indicates proxy data***
Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Table A-27. Goldface Tilefish (*Caulolatilus chrysops*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs			WCA							
larvae[2]			WCA							
postlarvae[2]			WCA							
early juveniles[2]										
late juveniles[2]										
adults[1, 2, 3]	ER-2, ER-3	offshore	shelf edge/slope, soft bottom			291 ± 54	*bivalves, urchins, worms, crabs*			
spawning adults[2]				*Sep*						

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction
Habitat information for blueline tilefish is likely applicable to goldface tilefish.
Reference blueline tilefish habitat association table for more information.

Table A-28. Blueline Tilefish (*Caulolatilus microps*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[7]	ER-1, ER-2	offshore	WCA			***46-256***				
larvae[2, 7]	ER-1, ER-2	offshore	WCA			***46-256***				
postlarvae[2, 7]	ER-1, ER-2	offshore	WCA			***46-256***				
early juveniles	ER-1, ER-2	offshore				***60-256***				
late juveniles	ER-1, ER-2	offshore				***60-256***				
adults[1-6, 8-11, 13]	ER-1, ER-2	offshore	hard bottom, sand/shell, soft bottom, shelf edge/slope		13.8-18	60-256, burrows at 91-150	benthic inverts, demersal fishes		fishing; *M = 0.1*	rapid growth in first two years; *L_{inf} = 600.3 mm FL, k = 0.33, t_0 = -0.5 yr, max. age = 43 yrs*
spawning adults[7, 11, 12]	ER-1, ER-2	offshore	*shelf edge/slope*	*Feb-Oct, peak: Mar-Sep*	*8.87-16.28*	*46-256*				females mature at 420-450 mm TL, males mature at 500 mm TL

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Bold and italicized font indicates proxy data

Table A-29. Golden Tilefish (*Lopholatilus chamaeleonticeps*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[5, 6, 7, 10]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	late spring-summer	hatched in 40 hrs at 22.0-24.6 (lab)	***80-450***				
larvae[6, 7, 13]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	summer		***80-450***				
postlarvae[6, 7, 13]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	summer		***80-450***				
early juveniles[6]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA			***80-450***				settlement at 9.0-15.5 mm SL
late juveniles[1, 8]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, soft bottom			***80-450***		larger tilefish, other fish		
adults[1, 2, 3, 4, 8, 9, 11, 12, 13, 14, 15, 16]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, soft bottom		9-14.4	80-450	bivalve mollusks, squids, polychaetes, holothurians, decapod crustaceans, elasmobranchs, and ray-finned fishes	sharks, other tilefish	over-exploitation; mass mortality from cold water intrusion events; M = 0.137	max. length = 1000 mm SL; males grow faster, reach larger size; L_{inf} = 830 mm TL, k = 0.13, t_0 = -2.14, max. age = 40 years

spawning adults[5, 8, 10, 13, 15]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, soft bottom	Jan-Jun peak: Apr		80-450				Fishing pressure may cause males to spawn at smaller sizes; maturity < 1 yr and 150 mm FL (male); 2.5 yrs and 331 mm FL (female); protogynous hermaphrodites

Notes: ***Bold and italicized font indicates proxy data***

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Table A-30. Greater Amberjack (*Seriola dumerili*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[16]	ER-1, ER-2, ER-3, ER-4, ER-5		WCA							hatch in 2 days
larvae[1, 16, 17]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	year-round						
postlarvae[15, 22]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA, drifting algae	summer						
early juveniles[2, 8, 14, 16, 18, 20, 22, 29]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA, drifting algae	summer-fall			invertebrates		Z=0.0045	1.65-2.00 mm/d
late juveniles[2, 8, 14, 16, 18, 20, 22, 25]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA, drifting algae, hard bottom	summer-fall			invertebrates		Z=0.0045	1.65-2.00 mm/d
adults[4, 5, 19, 22, 23, 25, 30, 31, 35]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA, hard bottom, banks/shoals, *reefs*	year-round	14.25	4.6-187	fish, crustaceans, cephalopods		males (7-8 yrs) have shorter life span than females (10-15 yrs)	females usually larger than males; L_{inf} = 1436 mm FL, k = 0.175, t_0 = -0.954, max. age = 15 yrs

spawning adults[17, 27, 28, 31, 34]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA, *reef*	Feb-May						50% maturity at *644 mm FL (males)*; 900 mm FL & age 4 (females)

Notes: Salinity = 30-36 ppt (open gulf)[22, 33]

Fecundity: 25,472,100-47,194,300 eggs/female ages 3-7 (data from SE US)[27]

Adults: use artificial reefs in ER-2, ER-3[24, 32]

DO = 2.99 mg/L[33]

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Table A-31. Lesser Amberjack (*Seriola fasciata*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs	ER-1, ER-2, ER-3, ER-4, ER-5									
larvae	ER-1, ER-2, ER-3, ER-4, ER-5									
postlarvae	ER-1, ER-2, ER-3, ER-4, ER-5									
early juveniles[17, 18, 22]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	drifting algae	late summer-fall		***55-348***				
late juveniles[17, 18, 22, 23, 25]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	drifting algae, hard bottom, reef	late summer-fall		*55-348*				
adults[4, 22, 23, 25]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	hard bottom, reef	year-round		*55-348*	squid			females slightly larger than males (408.8 vs 396.2 mm FL)
spawning adults[22]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	hard bottom	Sep-Dec, Feb-Mar		***55-348***				

Notes: Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Adults: can be found on artificial reefs in ER-2, ER-3[24]

Table A-32. Almaco Jack (*Seriola rivoliana*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[12, 14, 17]	ER-1, ER-2, ER-5		WCA	spring-fall						
larvae	ER-1, ER-2, ER-5									
post-larvae	ER-1, ER-2, ER-5									
early juveniles[5, 17, 22, 23, 28]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	drifting algae, WCA	Aug-Jan, Jul-Oct	23.3-31.7	6.7-16.8	*fish, shrimp, copepods*			
late juveniles[5, 17, 22, 23, 28]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	WCA, drifting algae	Aug-Jan, Jul-Oct	23.3-31.7	6.7-16.8	*fish, shrimp, copepods*			
adults[4, 5, 20, 22, 24, 25, 26]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, hard bottom, banks/shoals, *reefs*	Summer (N. Gulf), year-round (S.Gulf)		21-*179*	fish			
spawning adults[14, 17, 22]	ER-1, ER-2, ER-5			spring-fall						

Notes: N. Gulf likely not an important spawning area[22]
Information in asterisks comes from studies conducted outside GMFMC jurisdiction
While not considered EFH, almaco jack have been collected from artificial reefs

Table A-33. Banded Rudderfish (*Seriola zonata*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs	ER-1, ER-2	nearshore, offshore				***10-130***				
larvae[1]	ER-1, ER-2	nearshore, offshore	WCA	all months except Feb, Apr, Sep, Dec		***10-130***				
post-larvae[1]	ER-1, ER-2	nearshore, offshore	WCA	all months except Feb, Apr, Sep, Dec		***10-130***				
early juveniles[1, 18, 19, 22]	ER-1, ER-2	nearshore, offshore	WCA, drifting algae	year-round		***10-130***				
late juveniles[1, 18, 19, 22]	ER-1, ER-2	nearshore, offshore	WCA, drifting algae	year-round		***10-130***				
adults[4, 10, 22]	ER-1, ER-2	nearshore, offshore	WCA	year-round		10-130	fish and shrimp			
spawning adults	ER-1, ER-2	nearshore, offshore	WCA	continuous, or two seasons: winter-spring and fall		10-130				

Notes: ***Bold and italicized font indicates proxy data***

Table A-34. Gray Triggerfish (*Balistes capriscus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[2, 4, 10, 17, 19, 21, 24, 27, 28]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reefs	late spring, summer		***10-100***		wrasses, *Lutjanus campechanus*		hatch in 48-55 hrs
larvae[11, 21, 31]	ER-1, ER-2, ER-3, ER-4, ER-5		WCA, drifting algae							spend 4-7 months in pelagic zone
postlarvae[1, 5, 18, 31]	ER-1, ER-2, ER-3, ER-4, ER-5		WCA, drifting algae					tuna		spend 4-7 months in pelagic zone
early juveniles[1, 5, 6, 7, 18, 31]	ER-1, ER-2, ER-3, ER-4, ER-5		drifting algae, mangrove				algae, hydroids, barnacles, polychaetes	tuna, blue marlin, dolphinfish, sailfish, sharks		spend 4-7 months in pelagic zone
late juveniles[1, 5, 6, 7, 18, 29]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	drifting algae, mangrove, reefs			***10-100***	algae, hydroids, barnacles, polychaetes		*Z = 0.95, M = 0.28*	

adults[1, 3, 6, 7, 8, 9, 15, 16, 20, 23, 25, 26, 27, 29, 33, 34]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom, reefs			10-100	bivalves, barnacles, polychaetes, decapod crabs, gastropods, sea stars, sea cucumbers, brittle stars, sea urchins, sand dollars	greater amberjack, sharks, groupers	predation, recreational fishery (age 3), commercial fishery (age 4). *Z = 0.95, M=0.28*	rapid in year one, then slows. Relatively long lived. L_{inf} = 589.7 mm FL, K = 0.0.14, t_0 = -1.66, max. age = 15 yrs
spawning adults[1, 3, 6, 7, 8, 9, 15, 16, 20, 23, 25, 26, 27, 30]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	reefs	late spring, summer	20.9-30.0	10-100	bivalves, barnacles, polychaetes, decapod crabs, gastropods, sea stars, sea cucumbers, brittle stars, sea urchins, sand dollars	greater amberjack, sharks, groupers.	predation, recreational fishery (age 3), commercial fishery (age 4)	rapid in year one, then slows. Relatively long lived. Males larger than females

Notes: Fecundity estimates: 300 mm = 49,000; 410 mm = 66,000; 560 mm > 90,000

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Late juveniles, adults: occupy artificial reefs[30]

Spawning adults:
- salinity = 29.8-35.6 ppt[30]
- DO = 4.9-6.8 mg/L[30]
- harem spawners[32]
- occupy artificial reefs[30]

Bold and italicized font indicates proxy data

Table A-35. Hogfish (*Lachnolaimus maximus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[5]	ER-1, ER-2		WCA	Apr-Dec	25.5			yellowtail snapper		hatch in ~ 23hrs
larvae[5]	ER-1, ER-2		WCA							23 hrs-13 d
postlarvae[5]	ER-1, ER-2		WCA							13 d-34 d
early juveniles[7]	ER-1, ER-2	estuarine, nearshore	SAV	Dec-Apr						
late juveniles[7]	ER-1, ER-2	estuarine nearshore	SAV	Dec-Apr						
adults[1,2,3,4,6,8]	ER-1, ER-2	nearshore, offshore	hard bottom, reefs	year-round	15.7-31.2	< 30	benthic inverts		*M*/yr = 0.16-1.47 depending on estimation method	max. age = 25; L_{inf} = 849 mm FL, *k* = 0.106, t_o = -1.33
spawning adults[3,9]	ER-1, ER-2	nearshore, offshore	reef, sand/shell, hard bottom	Dec-Jul peak: Mar-Apr		1-69	sand-dwelling mollusks, sea urchins			50% maturity = 169.0 mm FL and 1.1 yrs (female), 426 mm FL and 6.5 yrs (males)

Notes: After 34 d, postlarvae "oriented strongly to the bottom"[5]

Adults: occupy artificial reefs
29-36 PSU[1]
6.0-9.60 mg/L[1]
commonly found along reef edges and gorgonian areas[3]

Spawning adults: spawn in harems[3]
batch fecundity= $839.0*wt(g)^{0.48}$; $7773.0*age^{0.78}$[8]

Table A-36. Brown Shrimp (*Penaeus aztecus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
fertilized eggs (0.26 mm diameter)[1, 5, 12, 13, 24]	ER-3, ER-4, ER-5	offshore	soft bottom, sand/shell	fall and spring	>24	***18-110***				hatch 24 hrs after spawning
larvae, pre-settlement postlarvae (< 14 mm)[1, 5, 13, 24, 25, 63, 84, 93, 109]	ER-3, ER-4, ER-5	estuarine, nearshore, offshore	WCA	year-round, peak: spring	28-30	0-82	phytoplankton and zooplankton	fish, some zooplankton		
late postlarvae, juveniles (14-80 mm) [1-3, 6, 8-11, 13-16, 18, 21-24, 27-30, 32-37, 41-50, 54-61, 64-83, 85, 86, 94-98, 106, 110, 116, 118]	ER-3, ER-4, ER-5	estuarine	SAV, emergent marsh, oyster reef, soft bottom, sand/shell	spring-fall	7-35	< 1	benthic algae, polychaete worms, peracarid crustaceans	fish (southern flounder, spotted seatrout, red drum, Atlantic croaker, pinfish, sea catfish)	predation is major cause of mortality, cold temperatures in shallow water	Higher growth rates in salt marsh than soft bottom and with carnivorous feeding; reduced growth in low salinity due to increased metabolic costs and decreased food resources; 0.9 mm/day

sub-adults[1, 3, 4, 8, 9, 13, 24, 27, 34, 37-40, 41, 52, 62, 65-81, 98, 101, 103, 119]	ER-3, ER-4, ER-5	estuarine, nearshore	soft bottom, sand/shell	spring-fall	18-28	1-18	Polychaetes, amphipods, other benthic inverts	fish (southern flounder, spotted seatrout, red drum, Atlantic croaker, pinfish, sea catfish)	cold fronts, hypoxia	
non-spawning adults (females > 140 mm TL[1, 2, 3, 4, 12, 13, 24, 26, 38, 39, 40, 101, 104, 111, 112, 113]	ER-3, ER-4, ER-5	offshore	soft bottom, sand/shell	summer and fall	10-37	14-110	omnivorous, feed at night	larger fish		
spawning adults[1, 4, 5, 12, 13, 24, 38, 39, 40]	ER-3, ER-4, ER-5	offshore	soft bottom, sand/shell	fall and spring, year-round in depths > 64 m		18-110	omnivorous, feed at night	larger fish		

Notes: Larvae, pre-settlement postlarvae: salinity 24-36 ppt[13]

Late postlarvae/ juveniles:

population in shallow water habitats of Galveston Bay estimated at 1.3 billion[114]

salinity = 2-40 ppt[1, 2, 6, 13, 24, 47, 82, 83]

DO > 1 ppm[2, 34, 85, 96-98]

production related to amount of marsh edge and elevation of marsh surface

research following the Deepwater Horizon oil spill showed decreased growth in heavily oil marsh shorelines[118]

	Sub-adults:	salinity = 0.9-30.8 ppt[107]
Notes cont:		DO > 1 ppm[2, 34, 87, 88, 89, 96-98, 102]
		Impoundments of estuarine areas have been shown to decrease production.
		Correlations exist between abundance of sub-adults and landings offshore
	Non-spawning adults:	salinity = 2-35 ppt[2]
		reducing discards from the fishery can affect shrimp productivity[39, 111, 112, 113]
		DO > 2 ppm[2]

Hypoxia affects spatial distribution of brown shrimp[115]
Brown shrimp populations have shown declines with wetland and marsh edge loss[117]
Bold and italicized font indicates proxy data

Table A-37. White Shrimp (*Penaeus setiferus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
fertilized eggs[12, 26, 52, 100, 101]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore		spring-fall		9-34			daily *Z* = 0.373	demersal eggs, hatch 10-12 hrs after spawning; egg/larval stage lasts 16 days
larvae/ pre-settlement postlarvae[1, 25, 26, 52, 84, 100, 101]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore		spring-fall	17.0-28.5	0-82	phytoplankton and zooplankton	fish, some zooplankton		egg/larval stage lasts 16 days
late postlarvae/ juveniles[1-3, 5, 7-11, 14, 18-24, 28-34, 37, 41, 42, 44-47, 50, 52-56, 58-61, 63, 64, 74, 75, 79, 80, 83, 92, 94, 95, 100, 102, 103, 104, 105, 106, 107, 111]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore	emergent marsh, SAV, oyster reefs, soft bottom, mangroves	late spring-fall	postlarvae 13-31; juveniles 9-33	< 1	omnivorous; detritus, annelid worms, pericarid crustaceans, caridean shrimp, diatoms	fish	predation; daily *Z* = 0.014-0.126	growth rates increase with temps 18-32.5°C, but decrease at 35°C; grow slowly at < 18°C; 0.3-1.2 mm/ day; stage duration = 79 days

sub-adults[1, 3, 5, 10, 13, 15, 16, 21, 22, 26, 37, 40, 47, 52, 53, 57, 63, 65-73, 76, 77, 82, 85, 89, 92, 93, 100, 108]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	soft bottom, sand/shell	summer-fall	*> 6 *	1-30	omnivorous, scavengers; annelids, insects, detritus, gastropods, copepods, bryozoans, sponges, corals, fish, filamentous algae, vascular plant stems and roots	fish	daily *Z* = 0.023-0.048	stage duration = 33 days; 0.4-1.5 mm/day
adults[1, 3, 12, 26, 27, 35, 36, 38, 39, 40, 52, 57, 83, 87, 88, 100, 109, 110]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore	soft bottom	late summer and fall	7-38	< 27	omnivorous	larger fish	daily *Z* = 0.004-0.034	adult/spawning adult stage duration is about 237 days; 0.4-1.0 mm/day
spawning adults[1, 3, 5, 12, 17, 38, 39, 40, 47, 52, 92, 100, 109, 110]	ER-2, ER-3, ER-4, ER-5	estuarine, nearshore, offshore		spring-late fall peak: Jun-Jul		9-34	omnivorous	larger fish		adult/spawning adult stage duration is about 237 days; 0.4-1.0 mm/day

Notes: larvae/ pre-settlement postlarve: migrate through passes at night in shallow water, during the day at mid-depths, mainly from May-Nov[1, 26, 84, 90, 91]

Notes cont:	late postlarvae/ juveniles:	salinity = 0.4-37 ppt[1, 2, 52, 83, 86, 96, 97, 98]
		DO > 1.0 ppm[1, 2, 52, 83, 86, 96, 97, 98]
		research suggests greater abundances with increases in temperature, salinity, and turbidity[112]
		kills have occurred in shallow water after cold fronts[2, 10, 11, 37, 47, 52, 53, 63, 83]
		production estimated in emergent marsh habitat in Galveston Bay, TX at 109 kg/ha[107]
		greater densities in oyster reefs and emergent marsh than soft bottom[114]
	late postlarvae/ juveniles:	larger shrimp collected on soft bottom than oyster reefs or emergent marsh[114]
		higher growth rates in oyster reefs than emergent marsh or soft bottom[114]
		higher survival in emergent marsh and soft bottom than oyster reef[114]
	sub-adults:	salinity = 1-21ppt[2]
		migrate from estuaries in late August and September, related to shrimp size and environmental conditions in estuary (e.g. temperature drops)
	adults:	salinity = 2-35 ppt[2]
		DO > 2 ppm[2]
		Trophic models developed for bycatch management indicate that reducing discards from the fishery can affect shrimp productivity[39, 78, 80, 99]
	spawning adults:	salinity ≥ 27 ppt[6]

One study found no relationship between hypoxic zone and white shrimp annual catch[113]

Table A-38. Pink Shrimp (*Penaeus duorarum*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
fertilized eggs (0.31-0.33 mm diameter)[16, 18]	ER-1, ER-2, ER-3, ER-5	offshore	sand/shell	year-round	> 27	***9-48***				
larvae, pre-settlement postlarvae (< 15 mm)[1, 9, 11, 13, 16, 18, 28, 33, 67, 68, 78]	ER-1, ER-2, ER-3, ER-5	estuarine, nearshore, offshore	WCA	year-round	15-35	1-50	phytoplankton, zooplankton	fish, inverts	mortality is higher at 35°C	
late postlarvae, juveniles (> 15 mm)[1, 2, 4, 6, 9, 11, 12, 21, 23-25, 28-30, 35, 36, 40, 42, 45, 47-49, 51, 53, 55, 56, 58, 59, 60, 62, 63, 65, 67, 69, 72, 73, 75, 79]	ER-1, ER-2, ER-3, ER-5	estuarine, nearshore	SAV, soft bottom, sand/shell, mangroves (low densities)	year-round (W. FL); Fall-Spring (TX)	6-38	0-3	seagrass, annelids, small crustaceans, shrimp, bivalves	fish (spotted seatrout, red drum, toadfish, others)	no recorded kills from cold fronts	*0.05-2.08 mm CL/week*

sub-adults[6, 10, 15, 17, 19, 20, 22, 23, 25, 29, 31, 34, 35, 36, 38, 39, 42, 45, 46, 47, 50, 54, 57-59, 62-64, 66, 67, 72, 75, 77, 79]	ER-1, ER-2, ER-3, ER-5	estuarine, nearshore, offshore	SAV, soft bottom, sand/shell, mangroves (low densities), *oyster reefs*	year-round (W. FL); Fall-Spring (TX)	6-38	1-65	annelids, small crustaceans, shrimp, bivalves	fish (spotted seatrout, sand seatrout, gray snapper, mackerels, red drum, grouper)	avoid cold by migrating to deeper water; low predation offshore	*0.05-2.08 mm CL/week*
non-spawning adults (> 75 mm TL[11, 14, 15, 19, 22, 32, 34, 38, 39, 41, 50, 54, 61, 64, 66, 70, 71]	ER-1, ER-2, ER-3, ER-5	nearshore, offshore	sand/shell	year-round	16-31	1-110	carnivores	larger fish, sharks	low predation offshore	
spawning adults (capable at 65-75 mm TL)[8, 11, 14, 15, 22, 32, 33, 34, 37, 41, 43, 50, 66, 72]	ER-1, ER-2, ER-3, ER-5	nearshore, offshore	sand/shell	year-round (W. FL), spring-fall (TX)	16-31	9-48	carnivores	larger fish, sharks	low predation offshore	

Notes: larvae/ pre-settlement postlarvae:

recruit through passes or open shorelines. Primarily on flood tides and at night[1, 5, 9]

wind speed affects larval transport[77]

salinity = 0-43 ppt, optimum 10-22ppt[28, 67, 69] late postlarve/ juveniles:

salinity = 0-65ppt, optimum > 30ppt (SC)[1, 6, 7, 12, 21, 55, 65, 67, 69,74]
DO = 2.5-6.0 mg/L[6, 63, 65, 69]

Notes cont:

production linked positively with freshwater input (W. FL)[5, 26, 27, 34, 61, 64]
areas with high production associated with inshore seagrass beds (E. FL, W. FL, TX)[5, 26, 27, 34, 61, 64]
biomass increases with temperature and decreases at hypersalinities (55) in lab study[80]

sub-adults:

salinity = 10-45 ppt[6, 63, 67, 74]
DO 2.5-5.0 mg/L[6, 63, 67, 74]
catch and effort offshore late in season correlated with subsequent landings[5, 63]
recruitment low after protracted periods of drought[5, 63]

adults/ spawning adults:

salinity 25-45 ppt[5, 26, 27, 61, 67]
production correlated with freshwater (W. FL)[5, 26, 27, 61, 67]
no apparent effect of seagrass mortality inshore[5, 26, 27, 61, 67]

Bold and italicized font indicates proxy data

Table A-39. Royal Red Shrimp (*Pleoticus robustus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[1, 3, 4, 5]		offshore	shelf edge/slope	year-round	9-12	250-550				
larvae						***250-550***				
postlarvae						***250-550***				
early juveniles						***250-550***				
late juveniles						***250-550***				
adults[1, 2, 3, 4, 5, 7, 8]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, soft bottom, sand/shell, *reefs*	year-round	5-15	140-750	small benthic organisms			*max. length = 184 mm (male), 229 mm (female); can live up to 5 years*
spawning adults[1, 3, 7]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope	year-round		250-550				*maturity = 125 mm TL (male), 155 mm TL (female)*

Notes: ***Bold and italicized font indicates proxy data***

Information in asterisks comes from studies conducted outside GMFMC jurisdiction

Adults: salinity = 33.1-36.0 ppt[6]

DO = 3.5-9.0 mg/l[6]

Table A-40. Spiny Lobster (*Panulirus argus*) life history for the Gulf of Mexico. Associations and interactions with environmental and habitat variables are listed with citations as footnotes.

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
phyllosome larvae[1, 2, 7, 8, 12-14, 33, 34, 37, 51]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	WCA	year-round (FL Keys; SE FL), Jun-Nov (NE Gulf)	> 24	***1-100***	plankton	pelagic fish		about 11 molts over 9-12 month larval cycle. Size: 0.5-12 mm carapace length
puerulus postlarvae[3, 4, 9-11, 14, 16-25]	ER-1	estuarine, nearshore, offshore	WCA, SAV	year-round, peak: spring, secondary peak: fall	18-33	***1-100***	non-feeding	nocturnally active, water column feeding fish	predation, physiological stress from temp and salinity extremes	metamorphose into first benthic instar 7-21 d post-settlement
juveniles[9, 15, 17, 19-22, 25, 27-32, 36, 42, 43, 48, 52]	ER-1	estuarine, nearshore, offshore	SAV, reefs, hard bottom	year-round		***1-100***	inverts (esp. mollusks, crustaceans)	elasmobranchs, boney fish, octopods, portunid crabs	mortality ~ 95% primarily via predation, commercial fishery	3-4 mm CL/month during first year, influenced by temp, diet, and injuries
adults[8, 28, 30, 38-40, 43, 45-47, 53-55, 57]	ER-1	estuarine, nearshore, offshore	hard bottom, SAV, reefs	year-round		1-100	mollusks, arthropods	elasmobranchs, boney fish, dolphins, loggerhead turtles	fishery exploitation, estimated to be 90%	S.FL = 0.6 mm CL/month, affected by temp and injuries

Notes: phyllosome larvae:

Genetic evidence suggests a pan-Caribbean stock[7, 35, 36]
Occurrence in Gulf may be associated with loop currents[7, 35, 36]

Notes cont:	puerulus postlarvae:	abundance in S. FL associated with wind-forcing, dynamics of ocean gyres, and by Caribbean-wide spawning activity[3, 24]
	juveniles:	salinity = 32-36 ppt[56]
		abundance dependent on larval influx and availability of suitable settlement and post-settlement habitat[37, 41, 49, 50]
	adults:	salinity = 32-36 ppt[56]
		fishing mortality has decreased as the number of lobster traps in FL fishery have been reduced[58]

Bold and italicized font indicates proxy data

Tab N, No. 4

10/14/2016

APPENDIX B
BENTHIC HABITAT USE MAPS
FOR

Draft Report
5-Year Review of Essential Fish Habitat Requirements

Including Review Of Habitat Areas Of Particular Concern And Adverse Effects Of Fishing And Non-Fishing In The Fishery Management Plans Of The Gulf Of Mexico

October 2016

This is a publication of the Gulf of Mexico Fishery Management Council Pursuant to National Oceanic and Atmospheric Administration Award No. NA15NMF4410011.

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COVER SHEET

Name of Action

Essential Fish Habitat

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http://sero.nmfs.noaa.gov

Type of Action

( ) Administrative ( ) Legislative

(X) Draft ( ) Final

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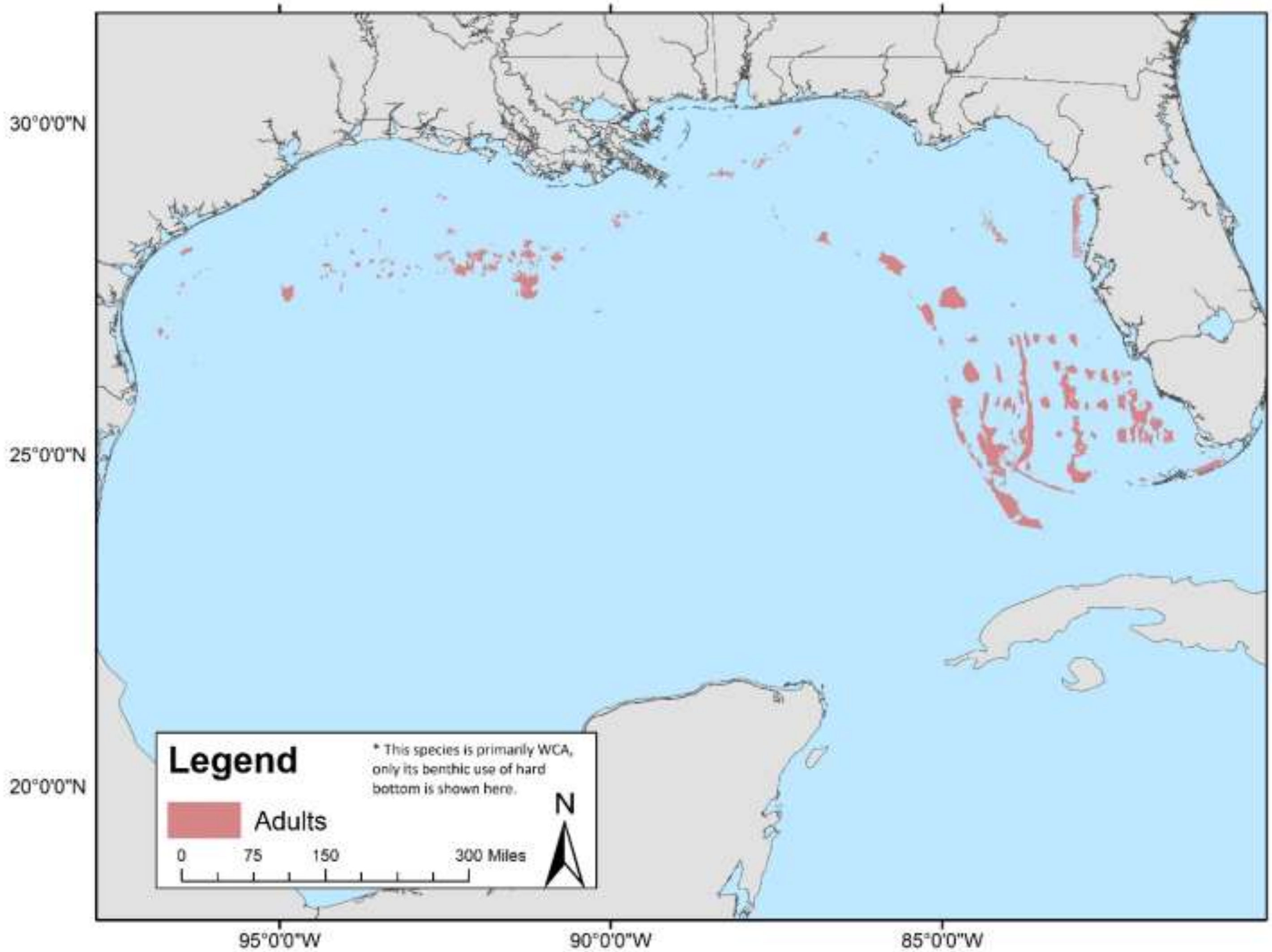

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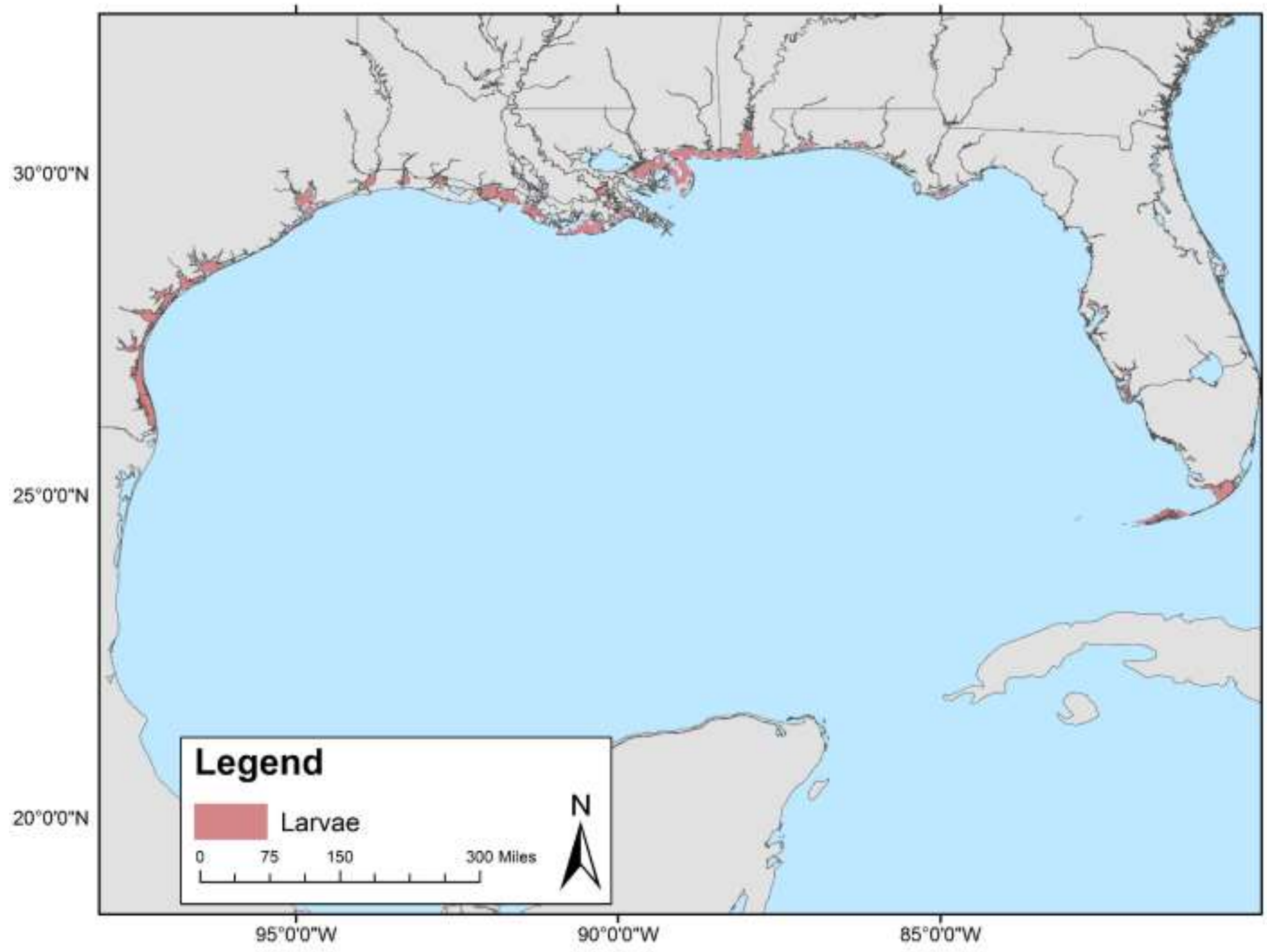
Red Drum (*Sciaenops ocellatus*) Benthic Habitat Use Maps



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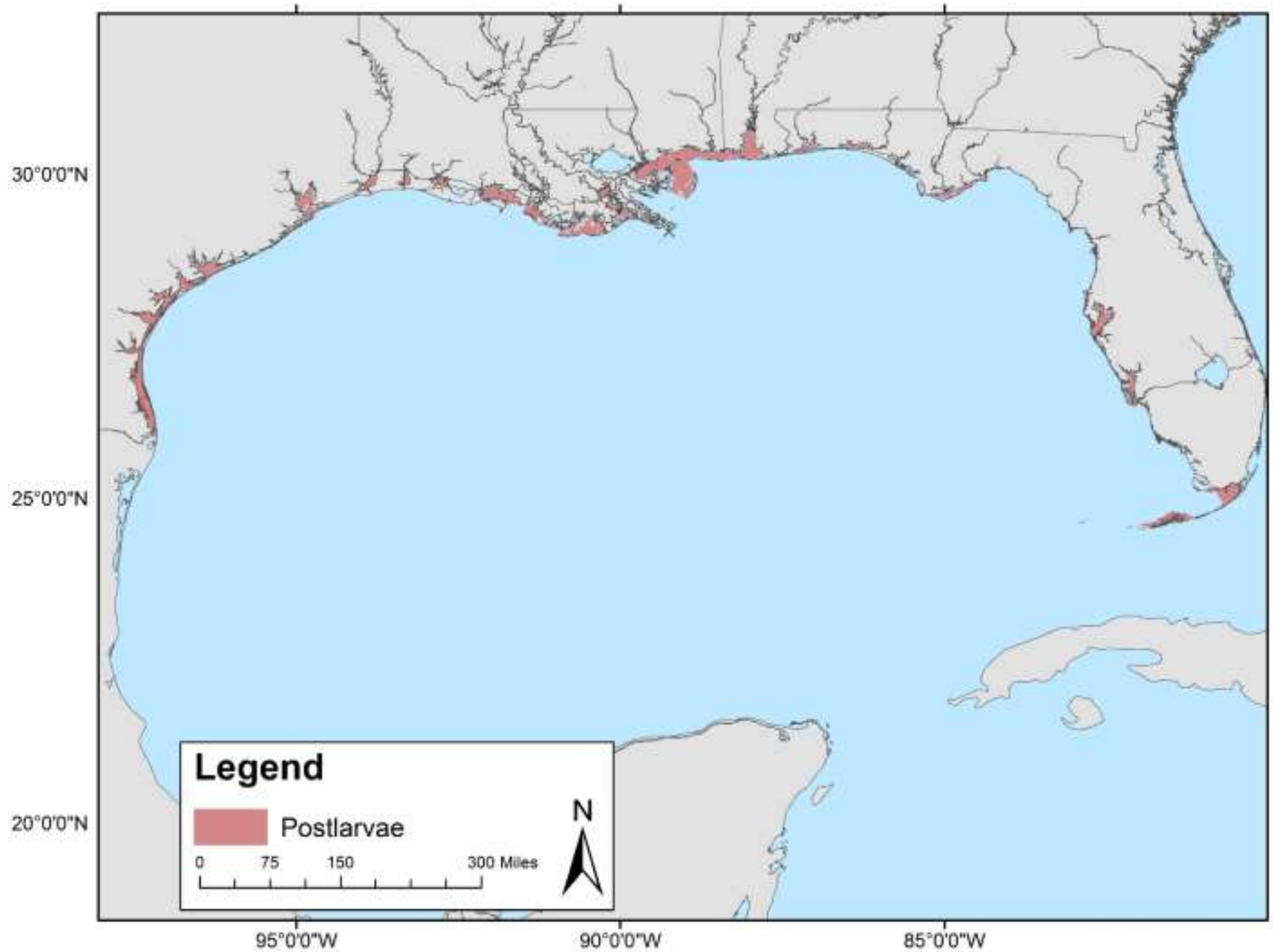

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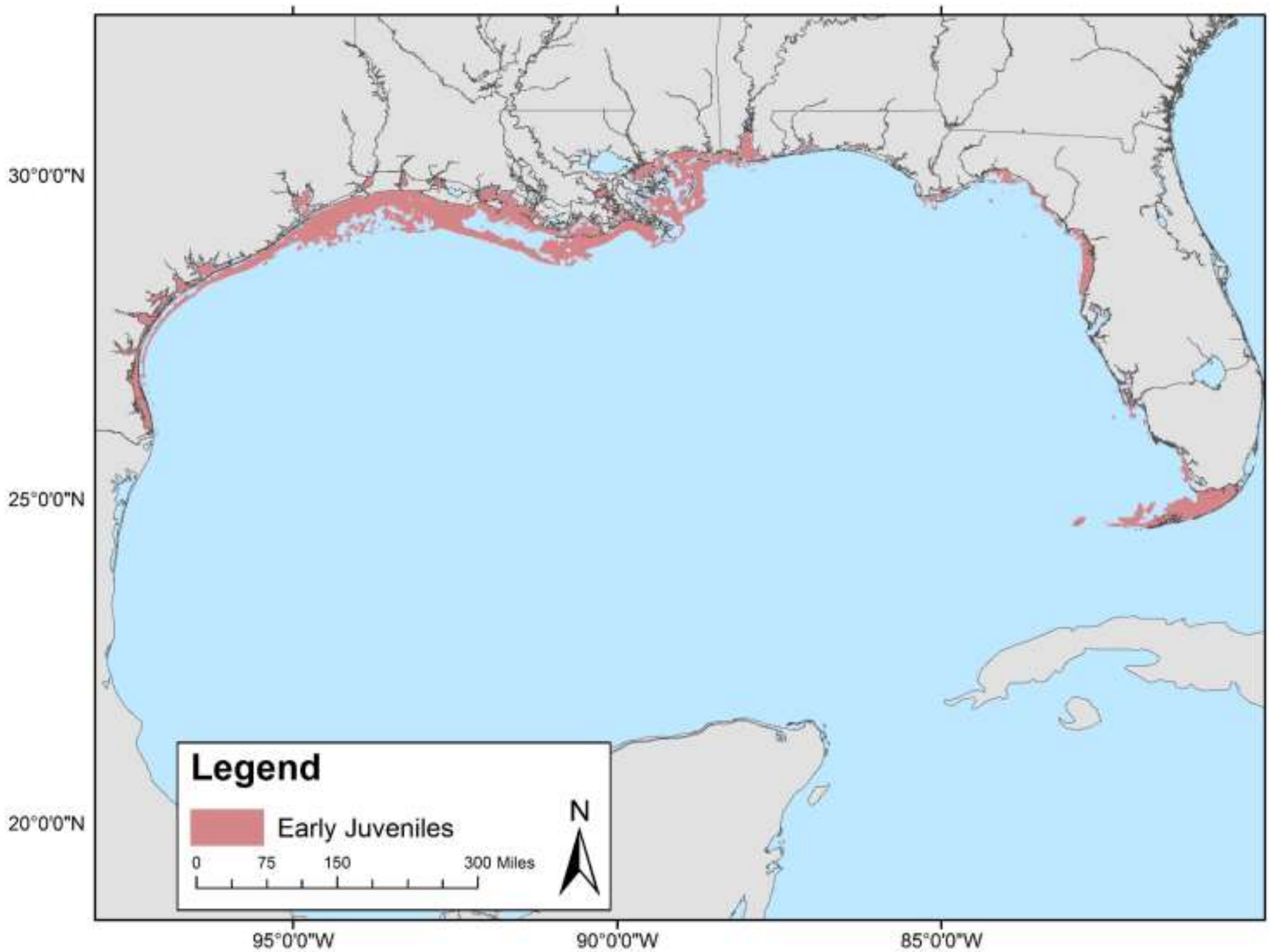

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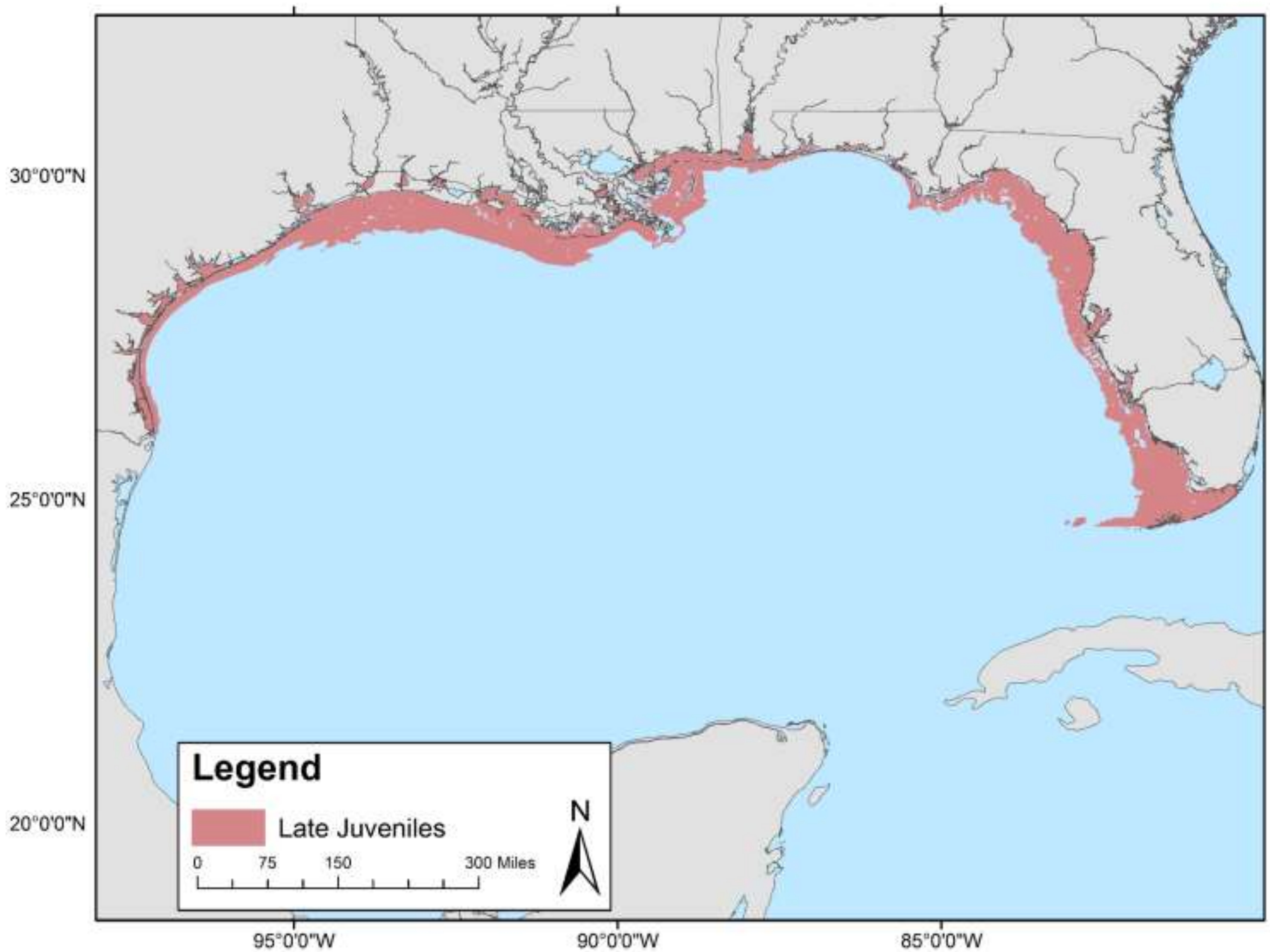

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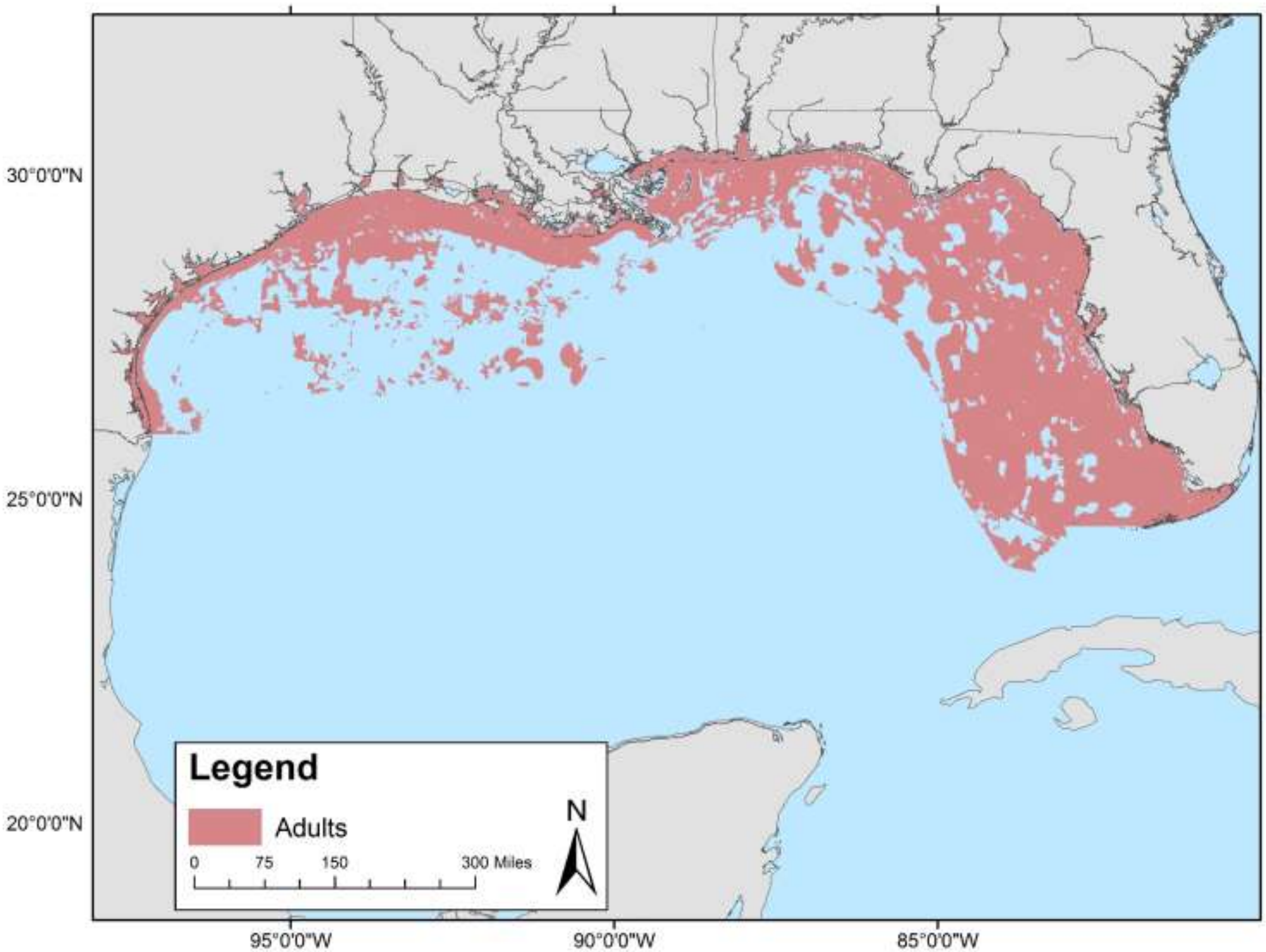

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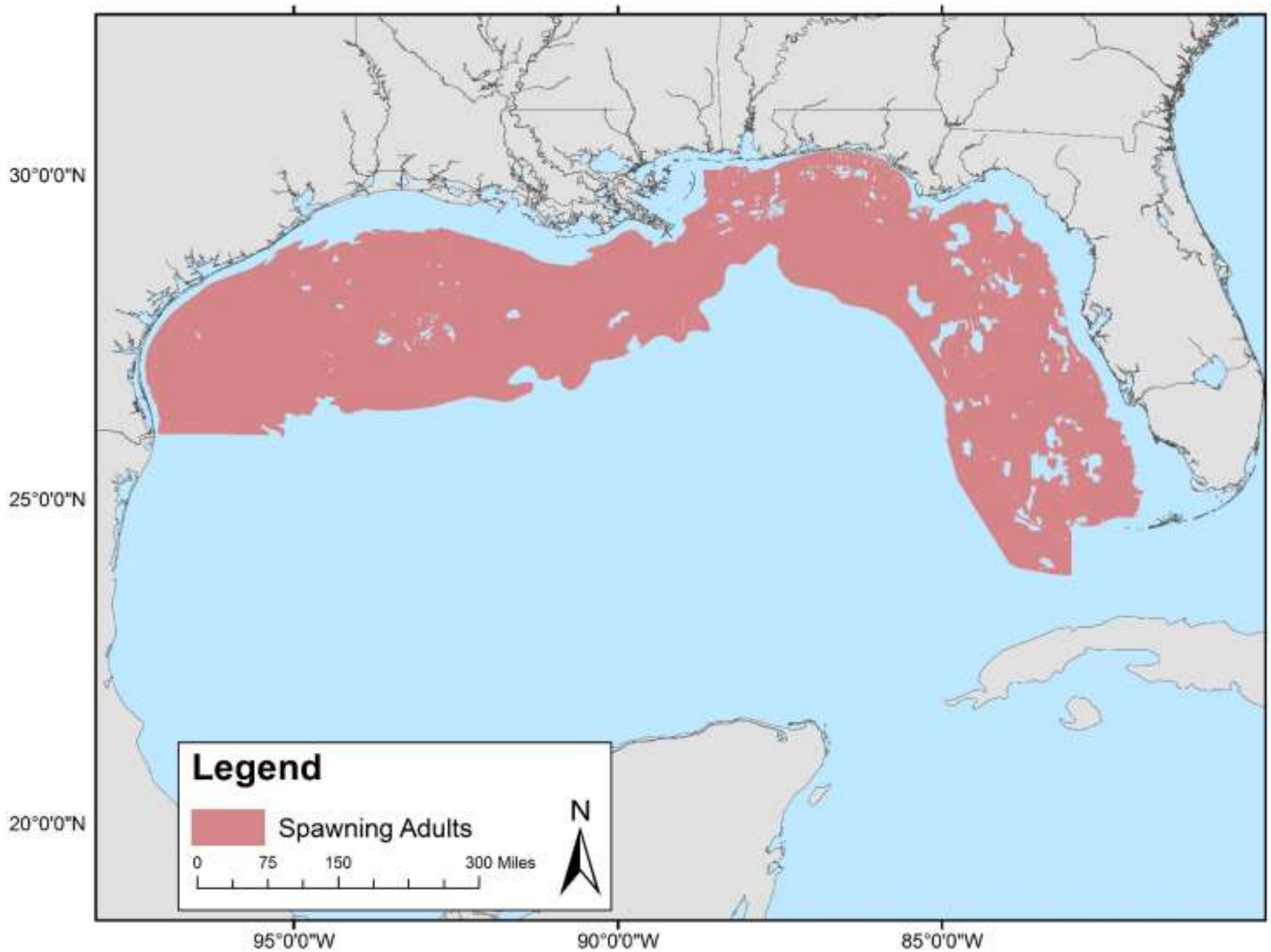
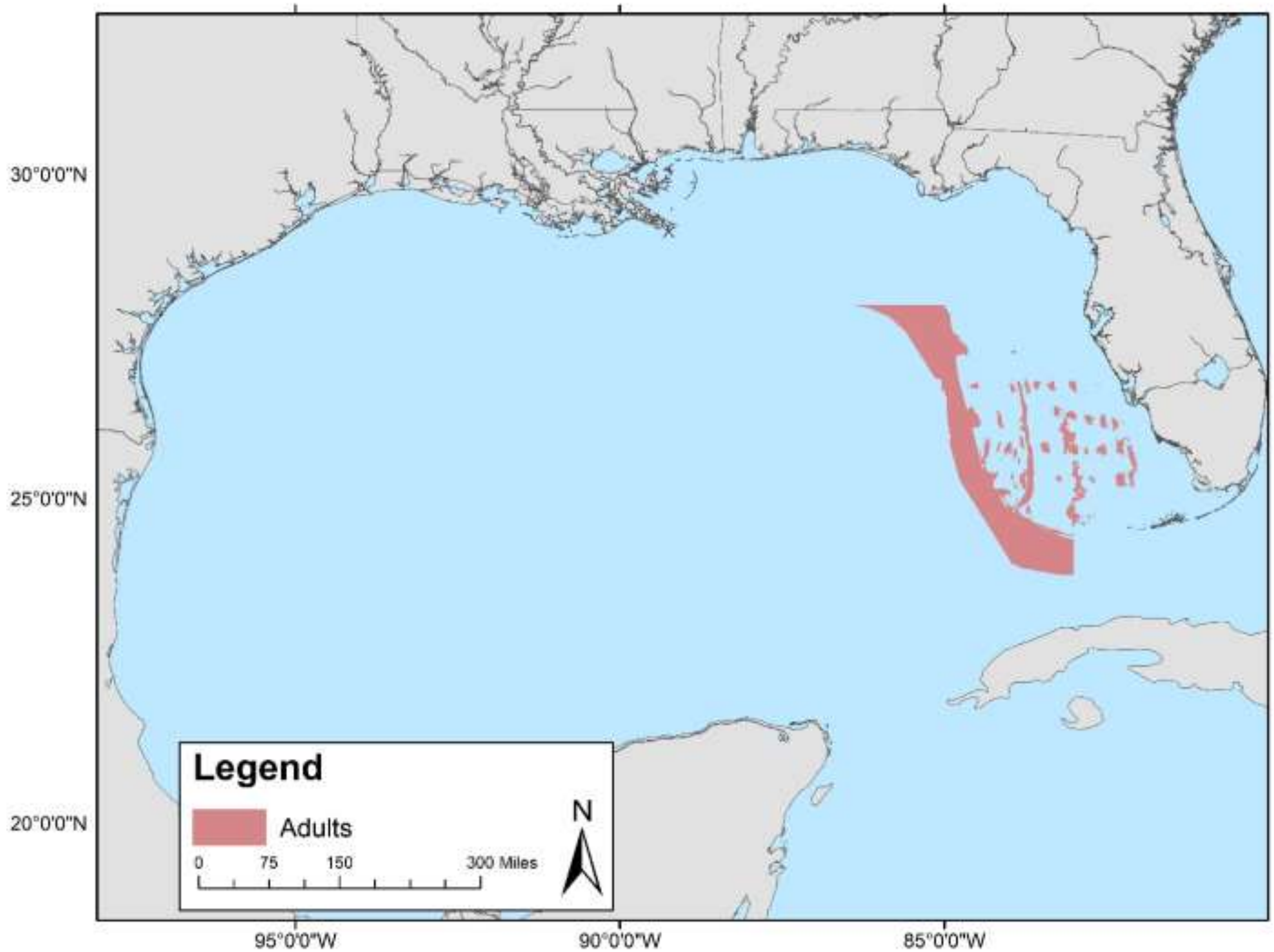


Figure B- 7. Map of benthic habitat use by spawning adult red drum.

Queen Snapper (*Etelis oculatus*) Benthic Habitat Use Maps



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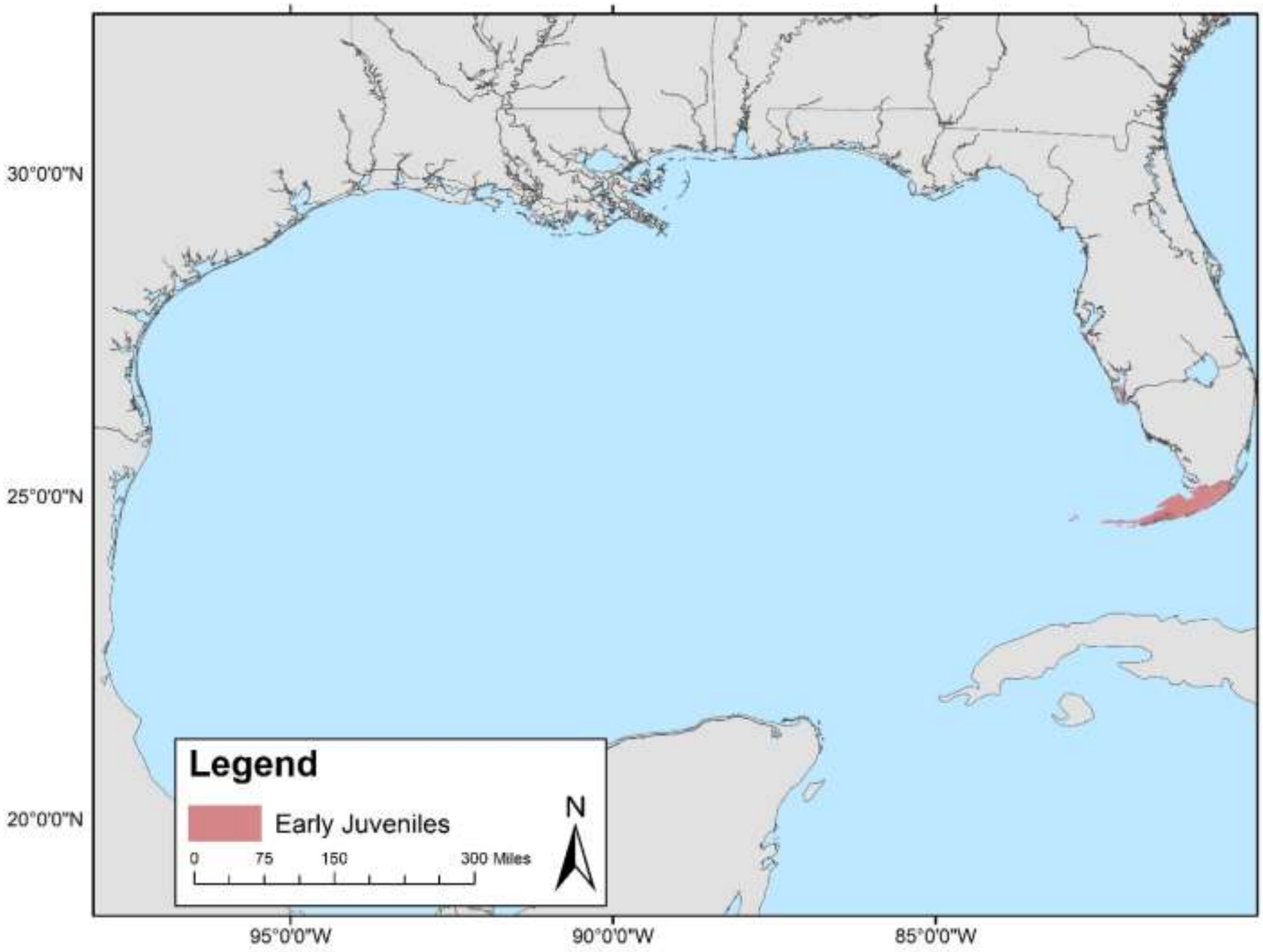
Mutton Snapper (*Lutjanus analis*) Benthic Habitat Use Maps



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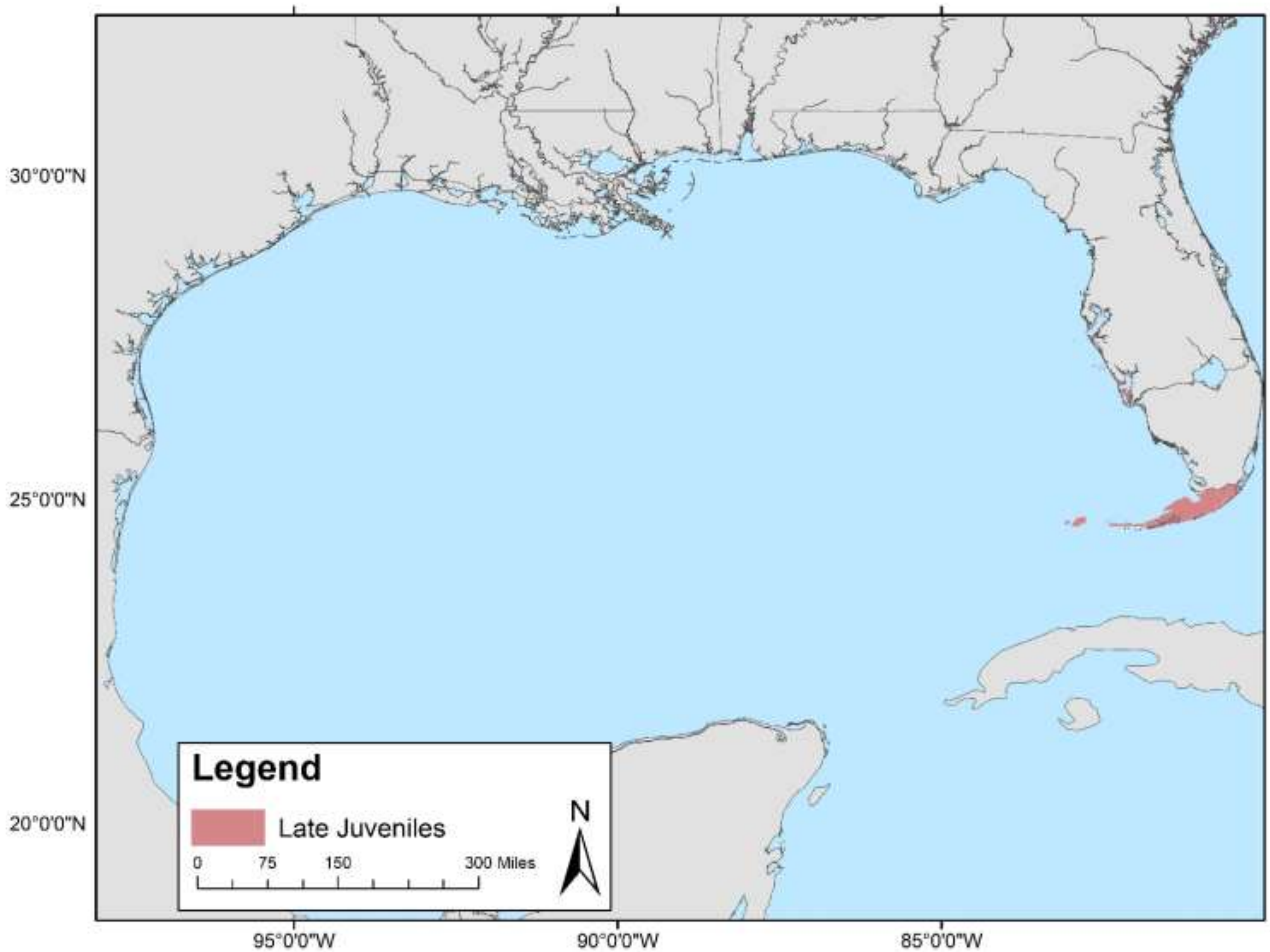

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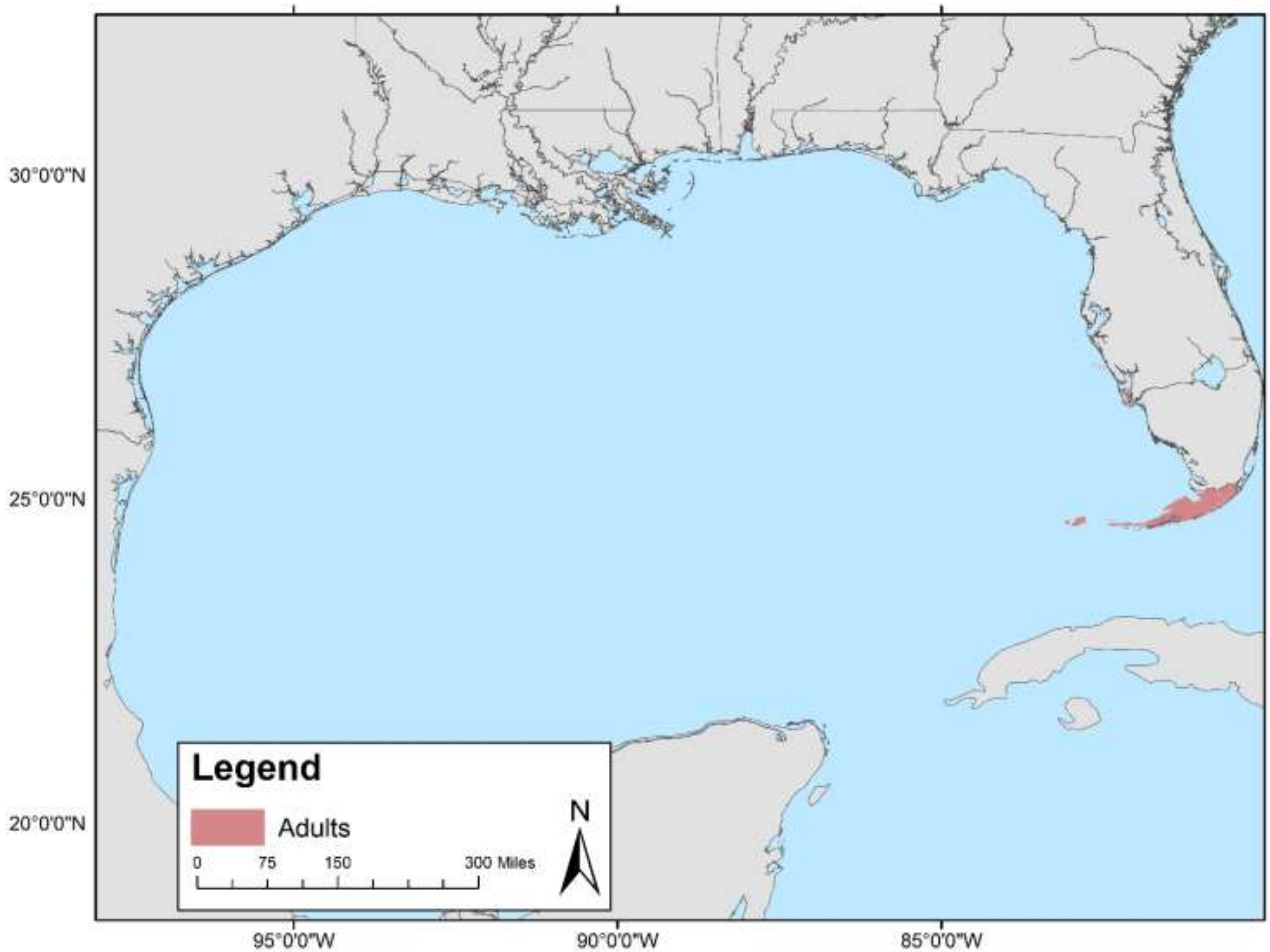

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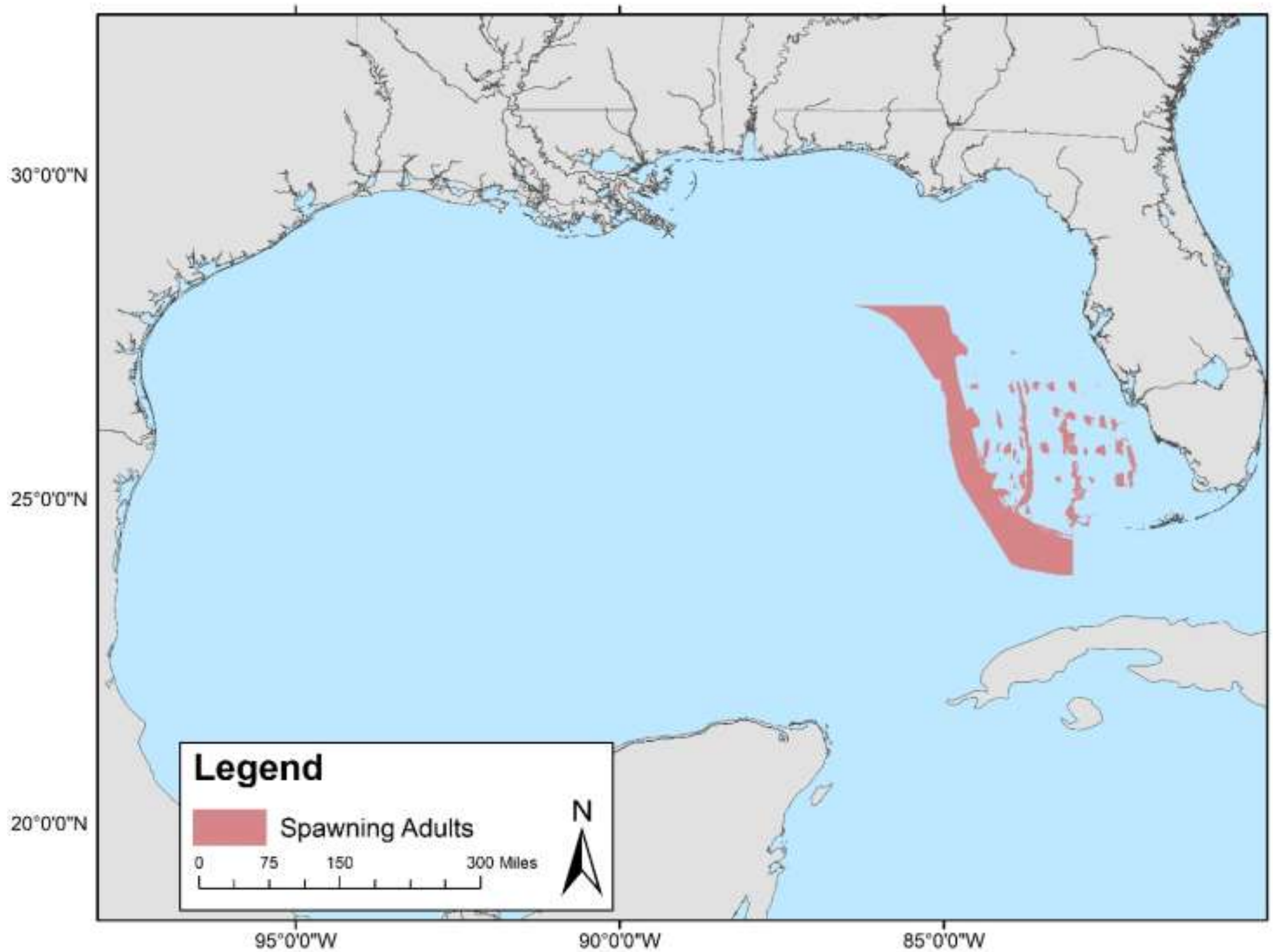

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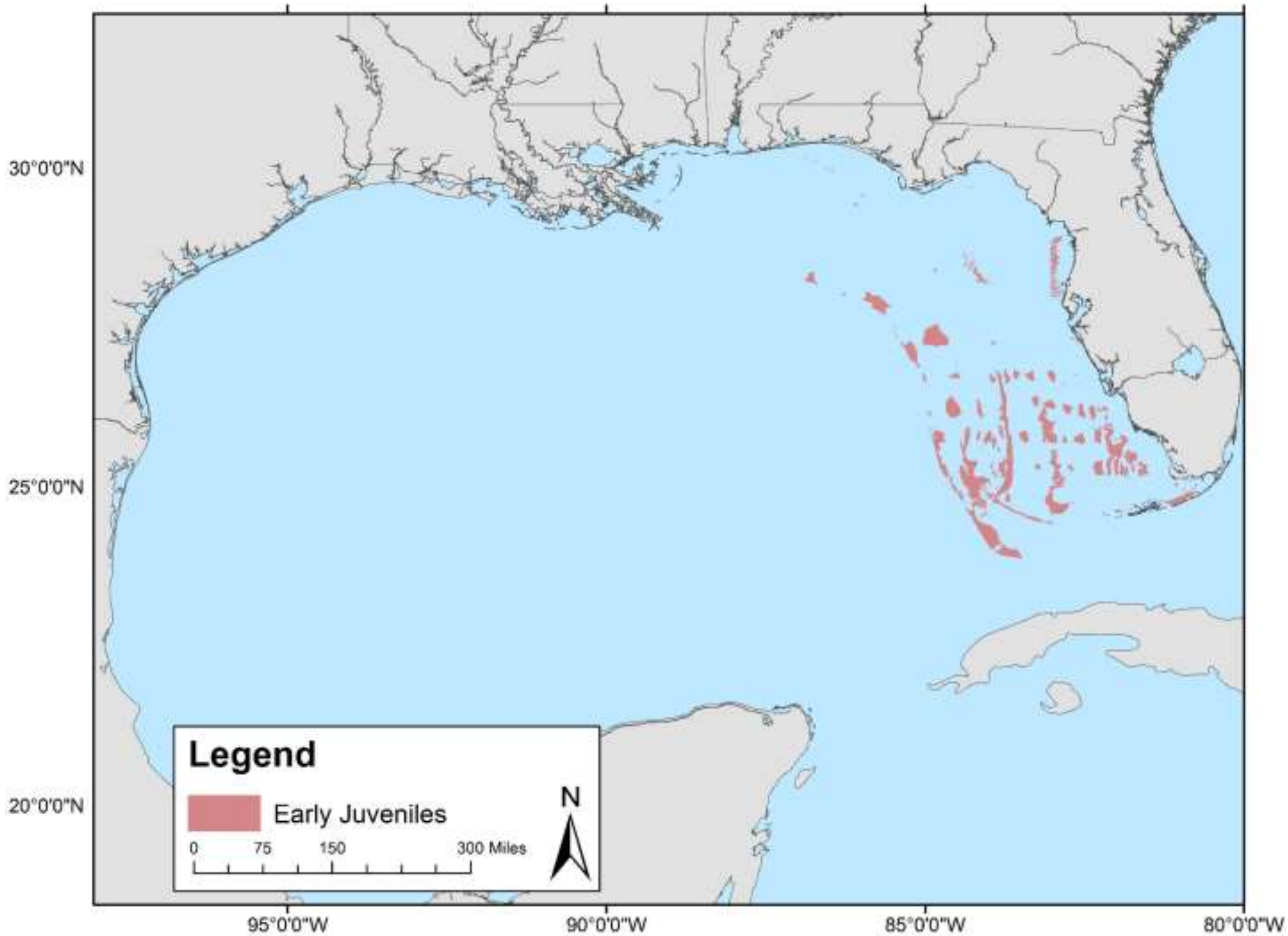

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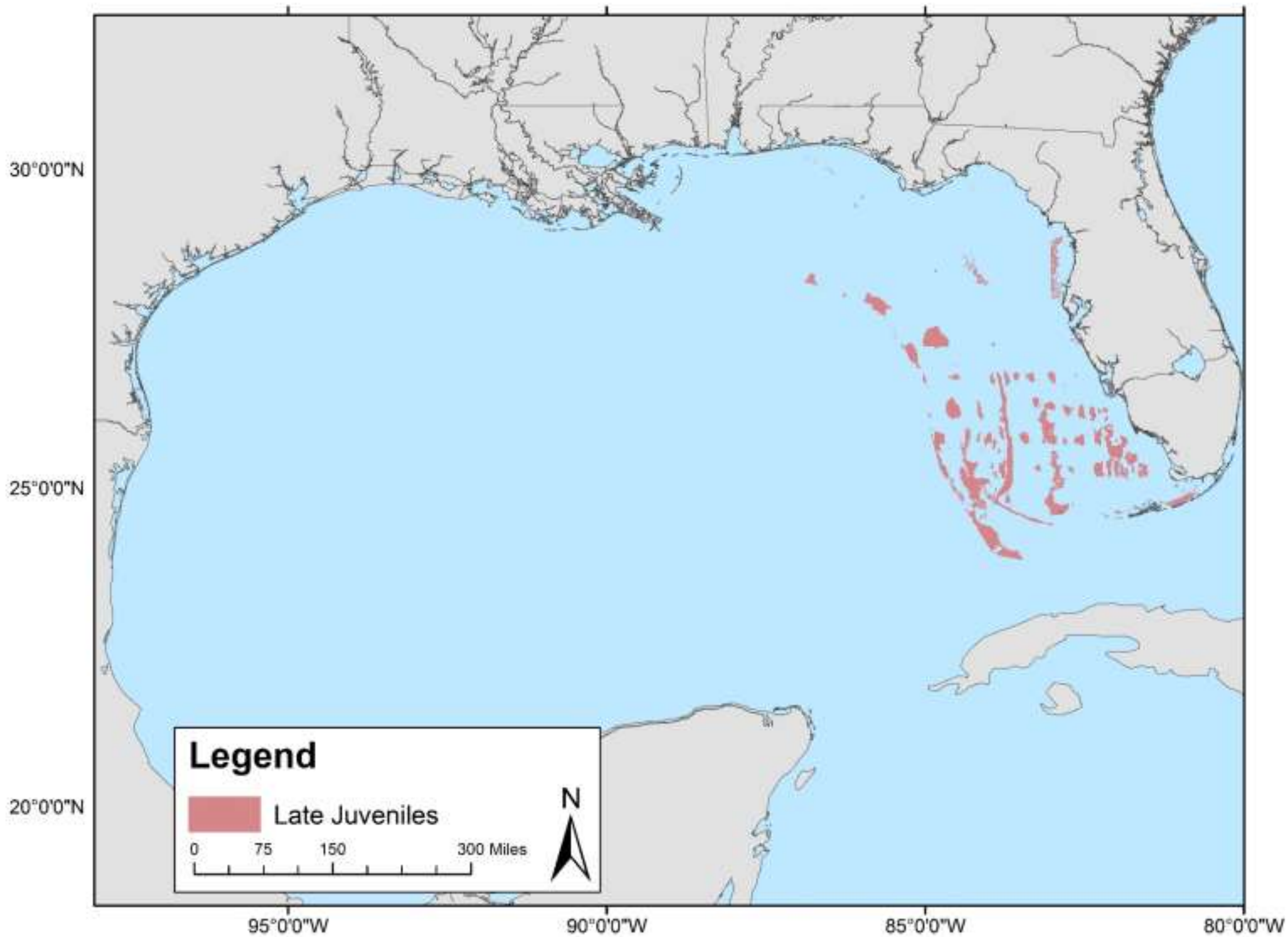

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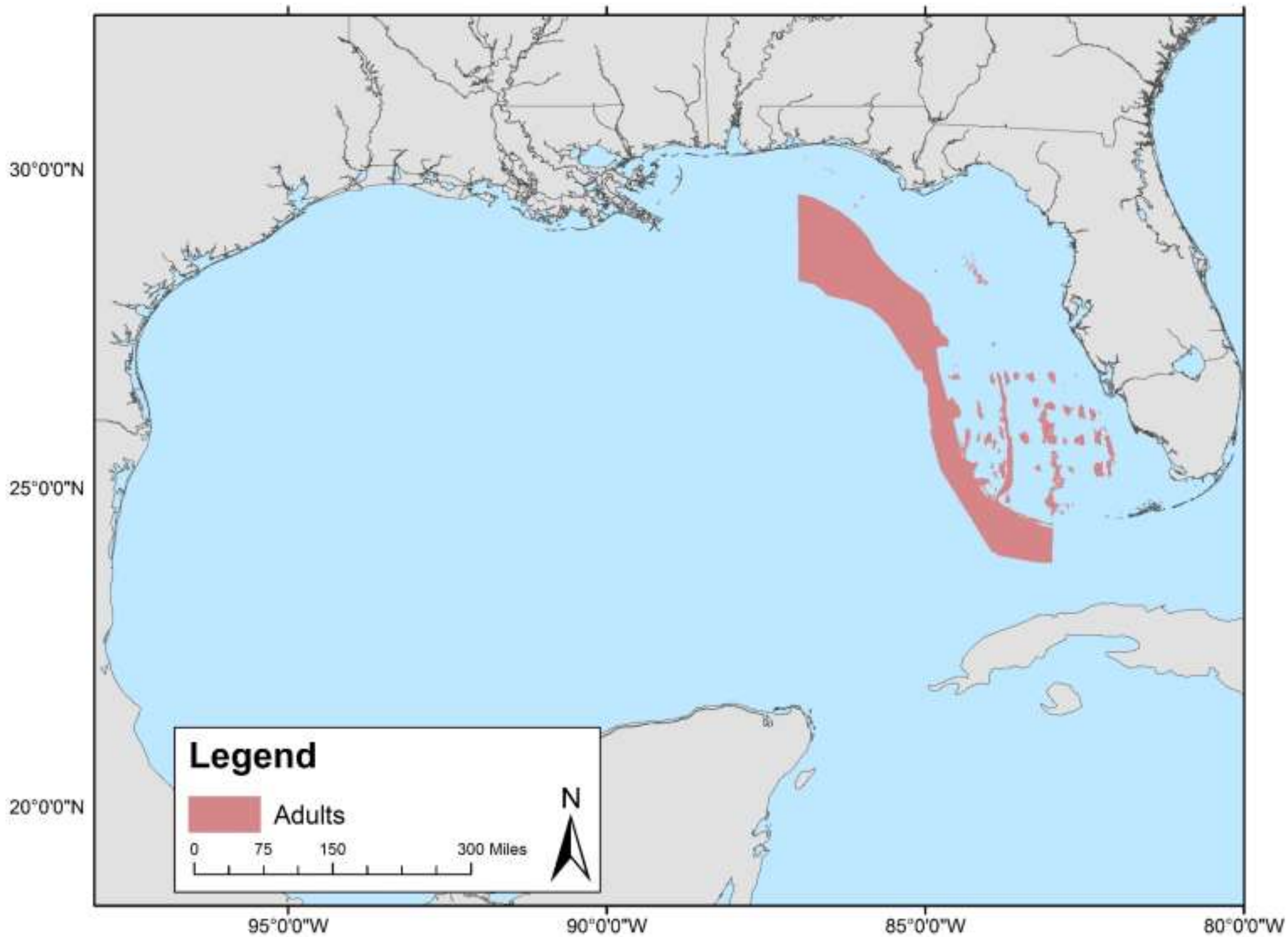

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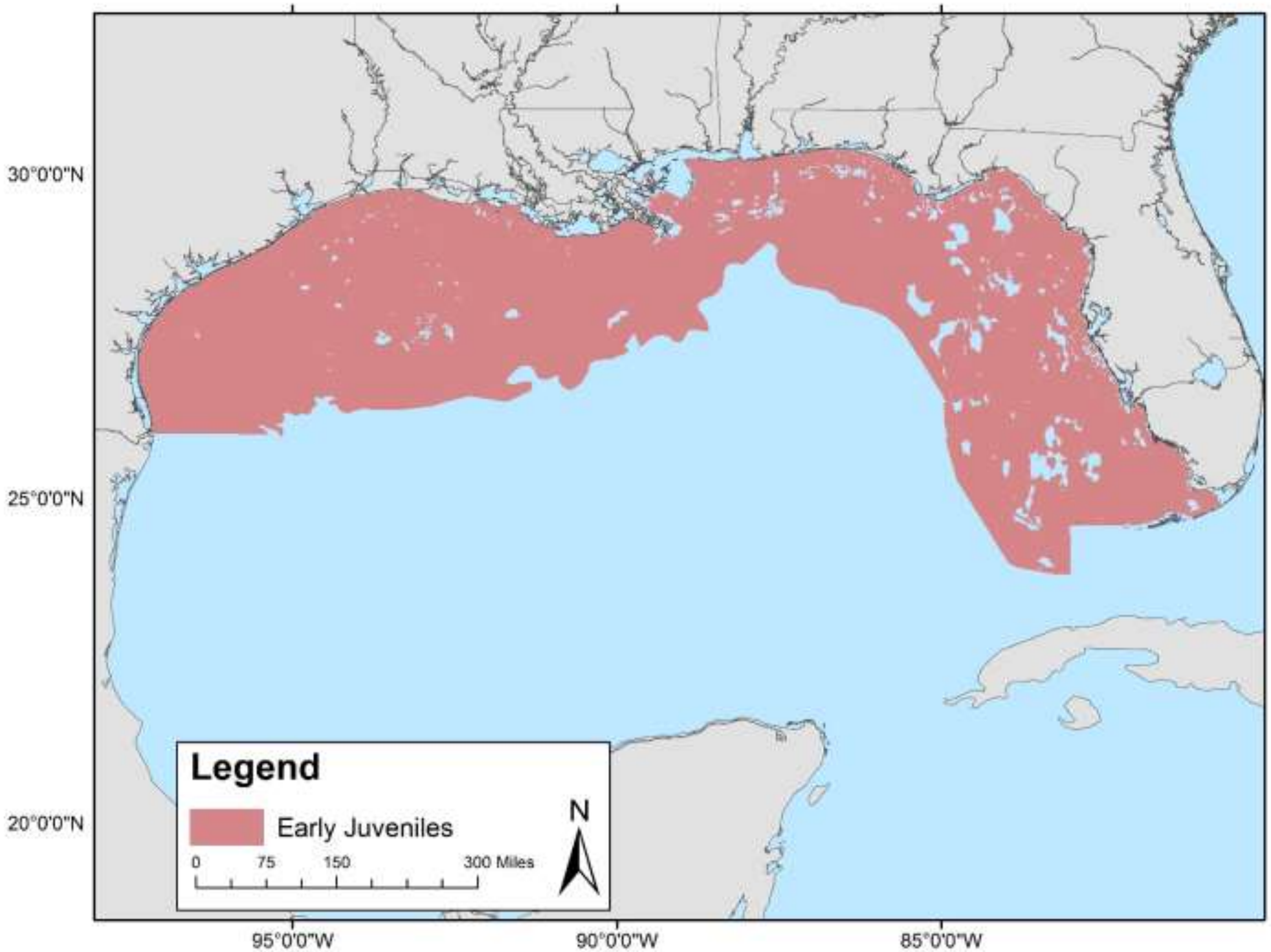
Red Snapper (*Lutjanus campechanus*) Benthic Habitat Use Maps



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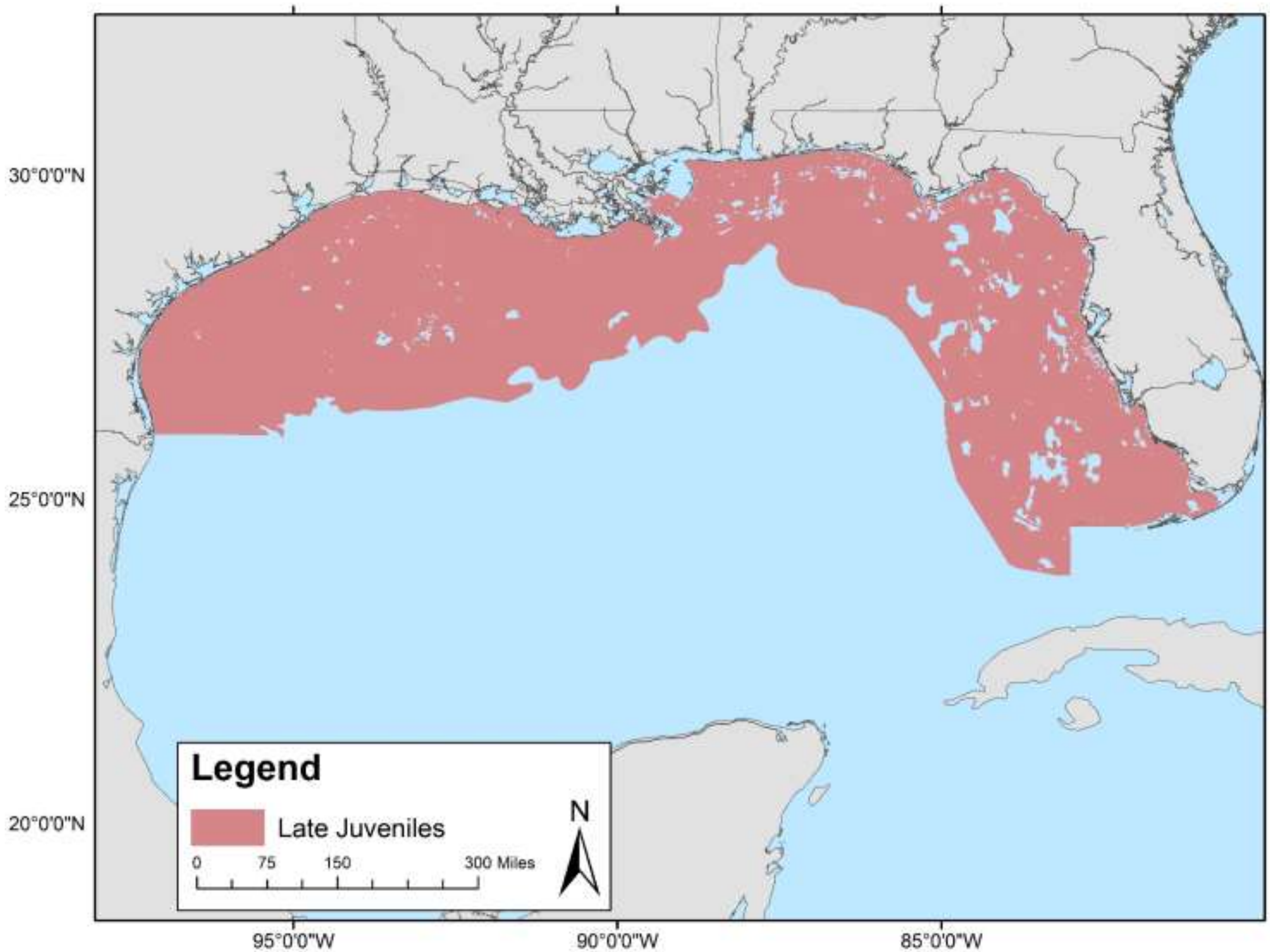

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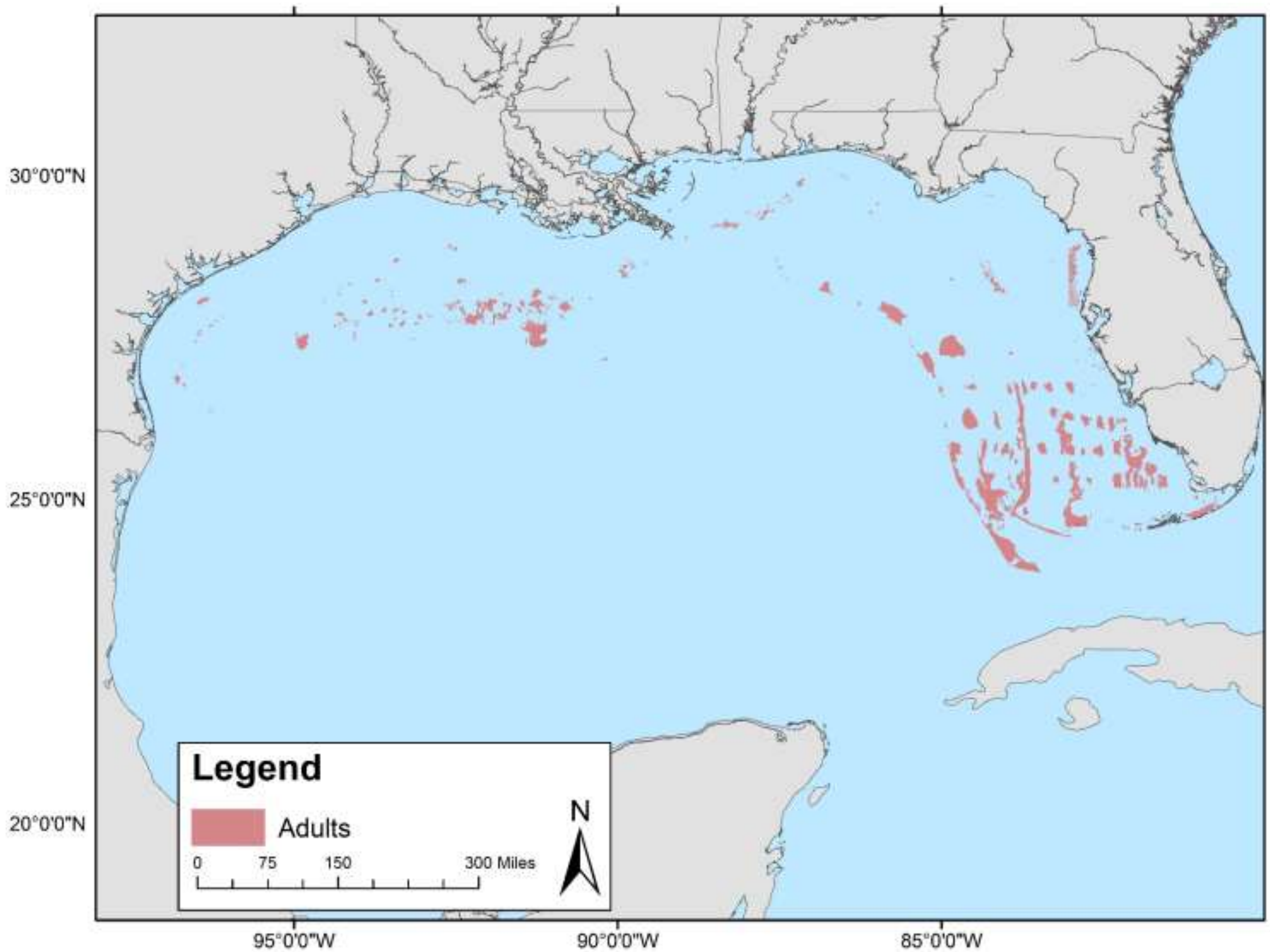

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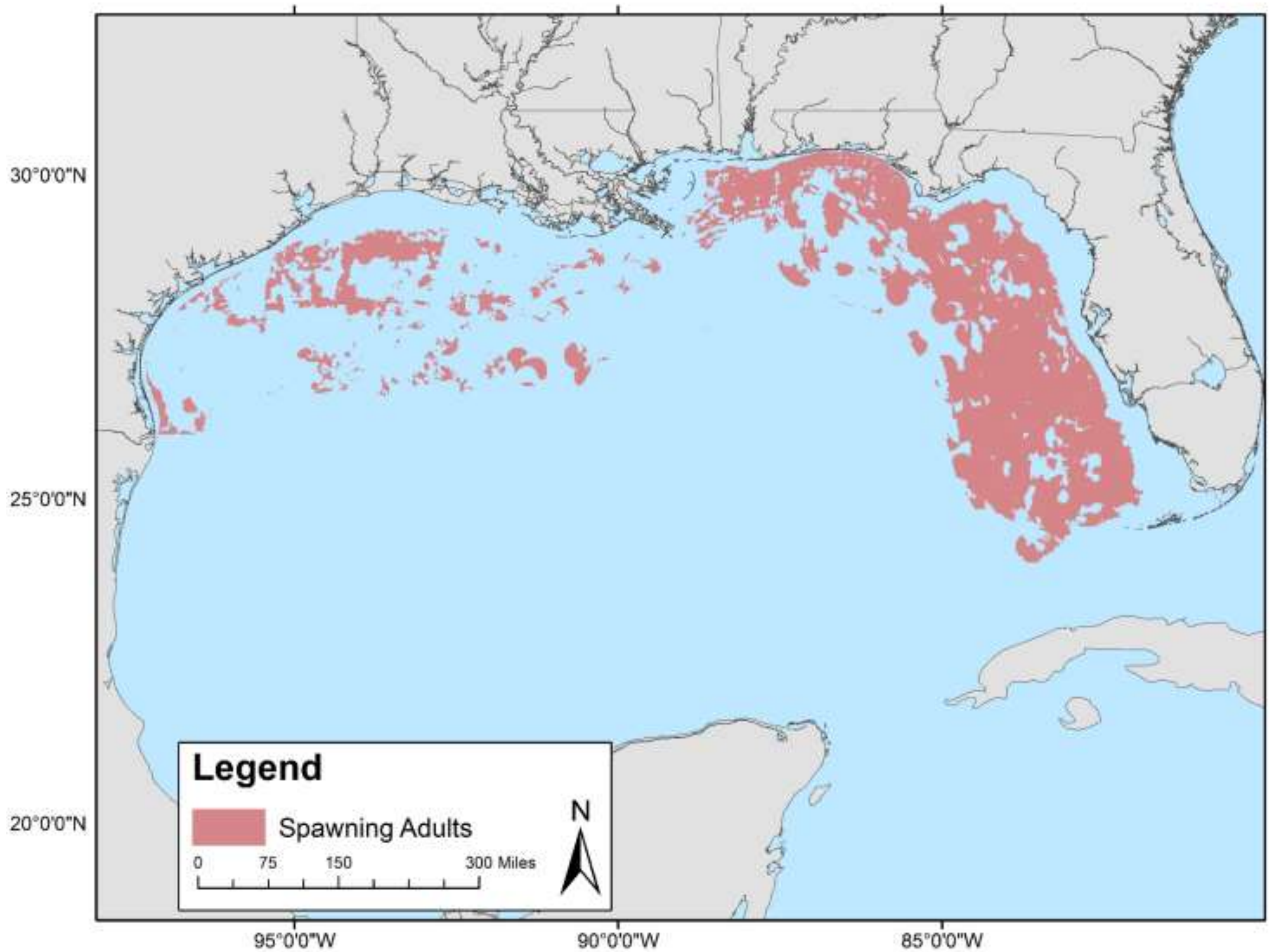

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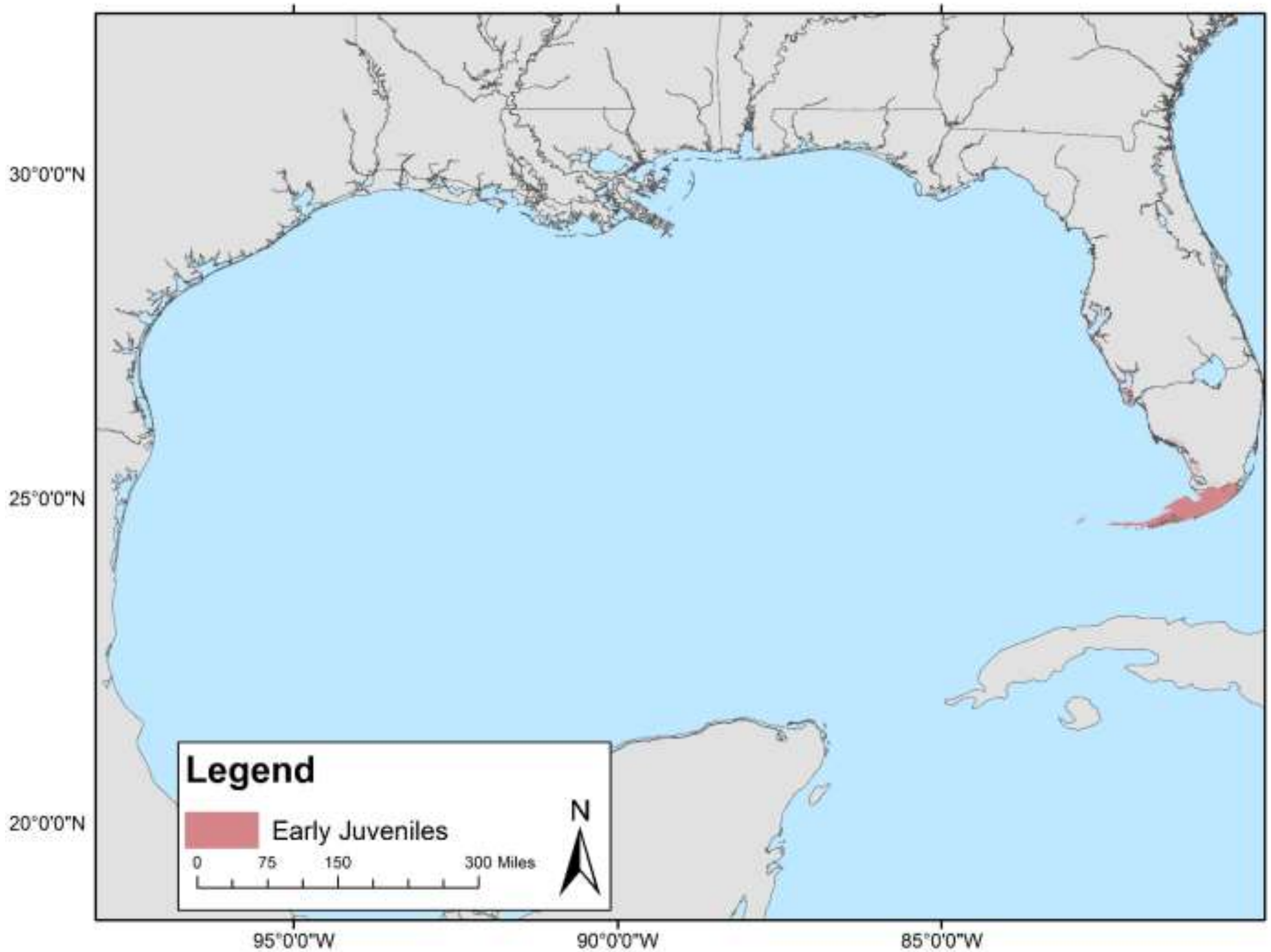
Cubera Snapper (*Lutjanus cyanopterus*) Benthic Habitat Use Maps



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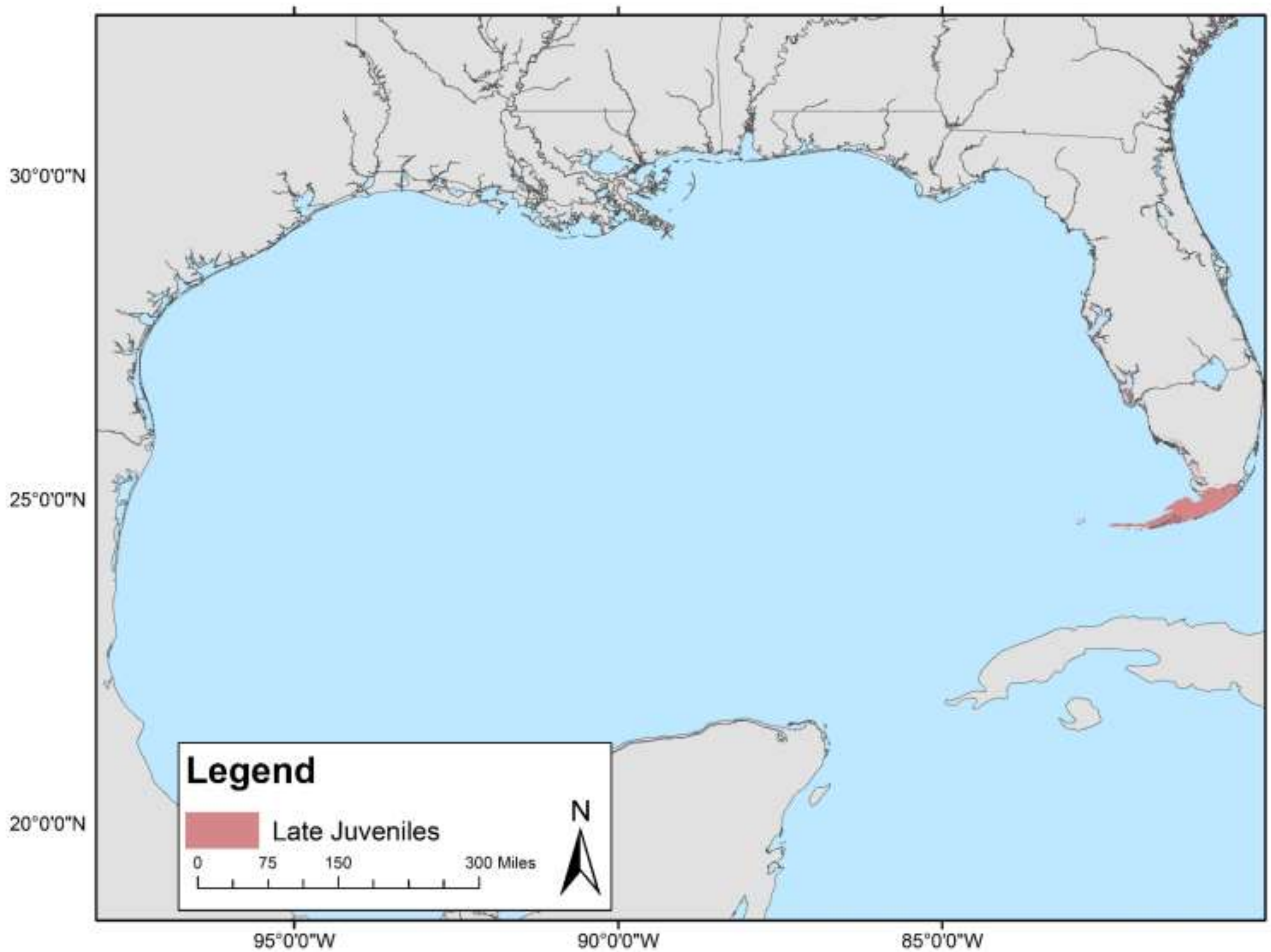

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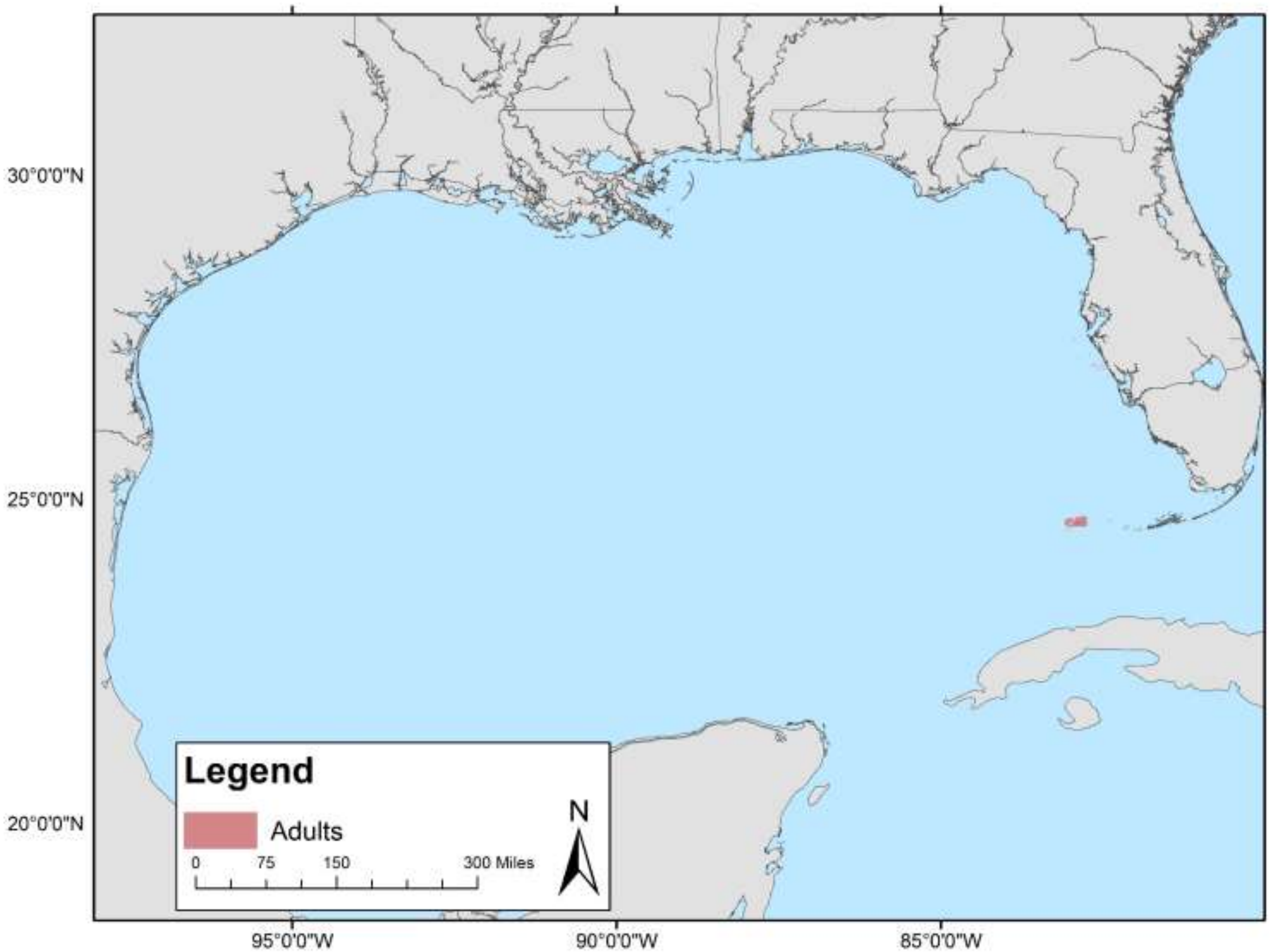

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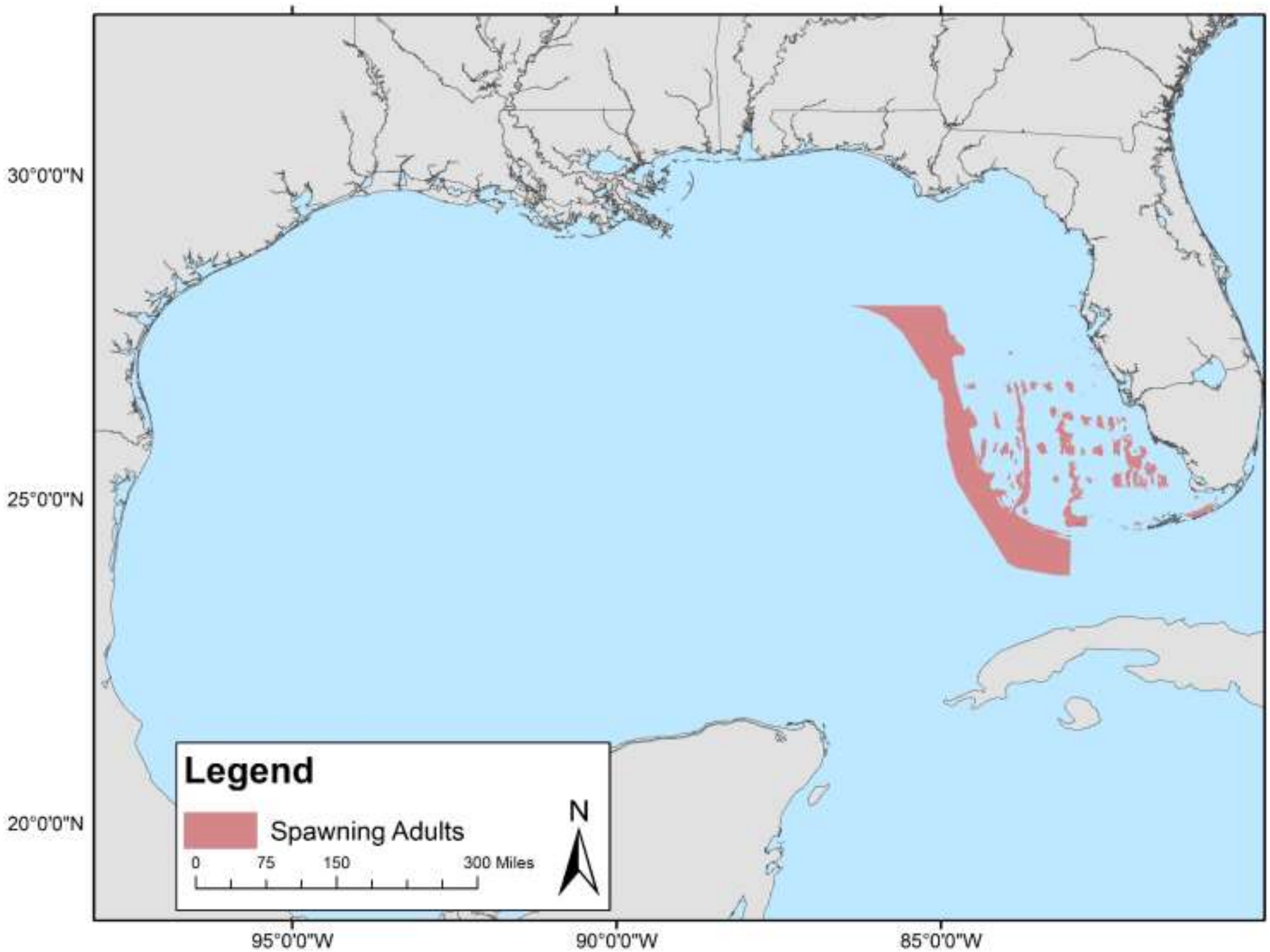

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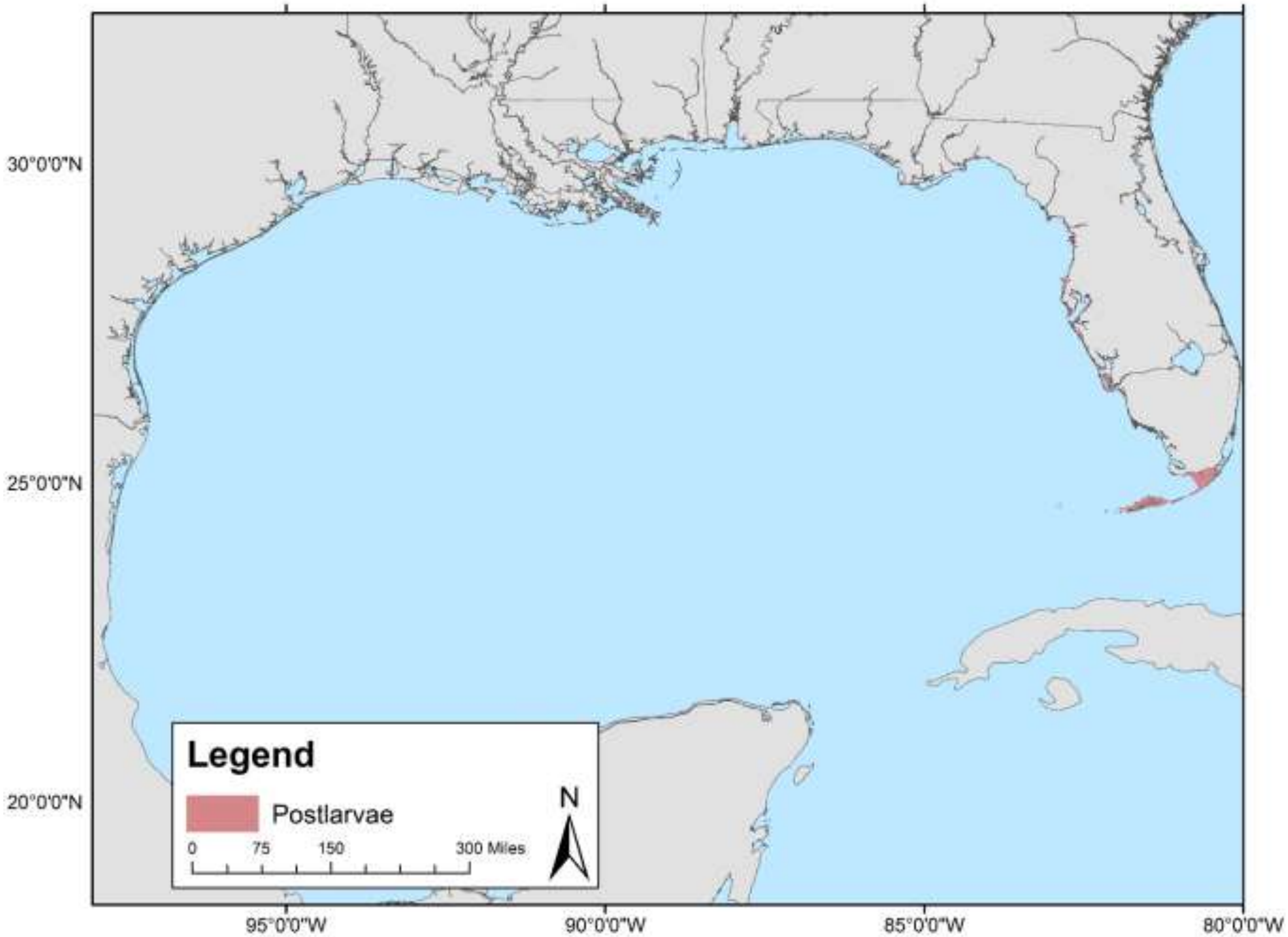
Gray Snapper (*Lutjanus griseus*) Benthic Habitat Use Maps



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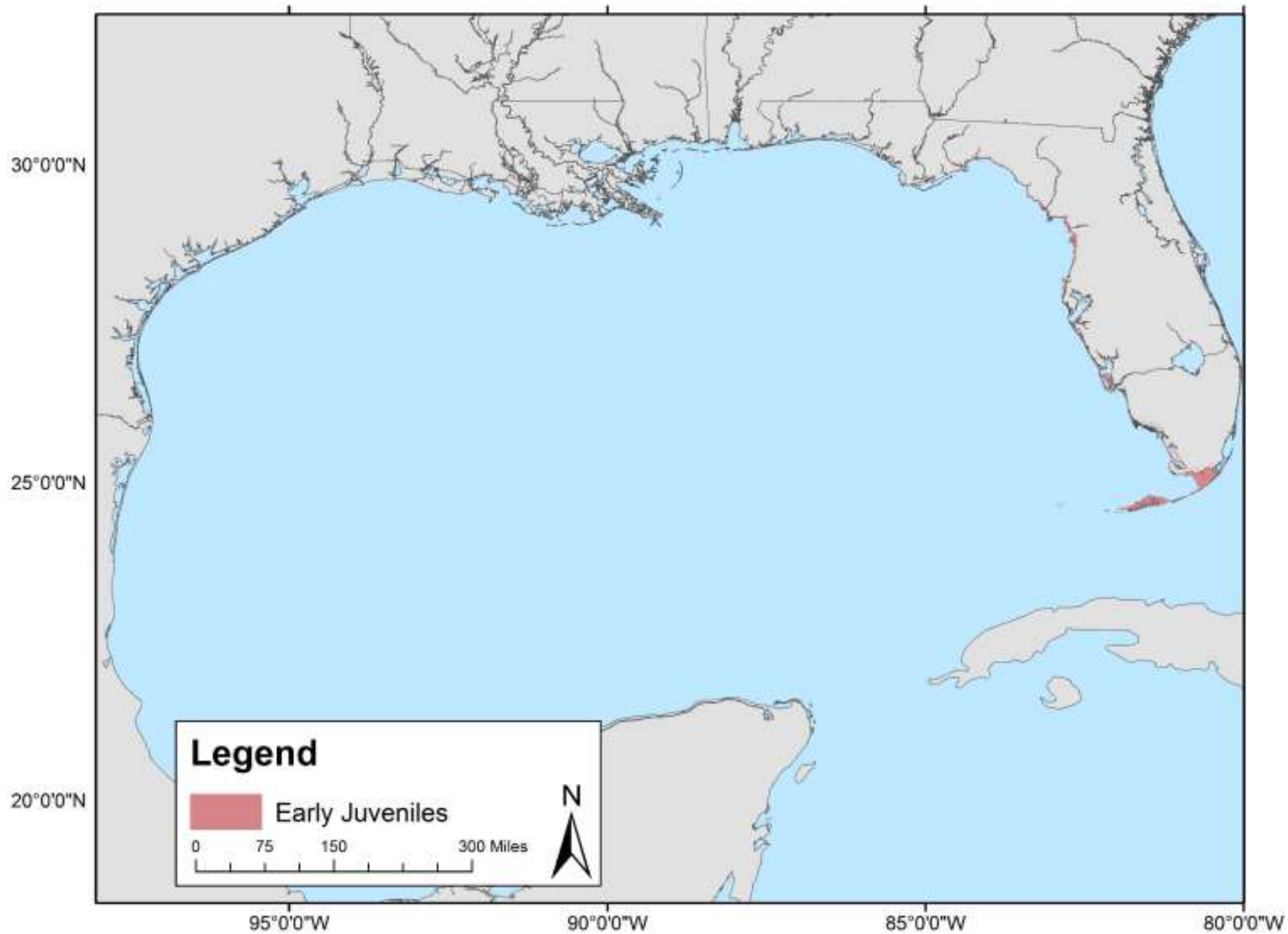

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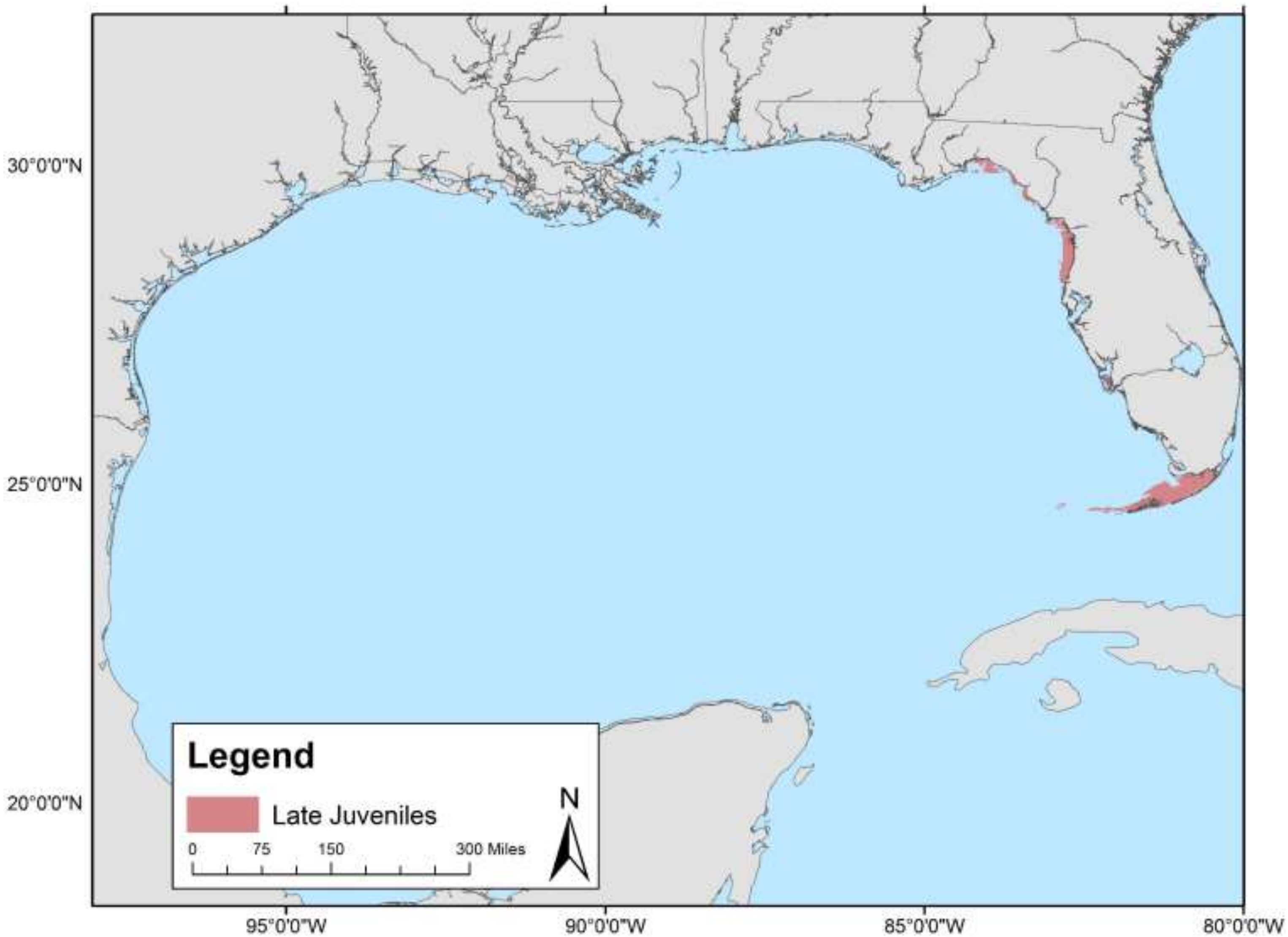

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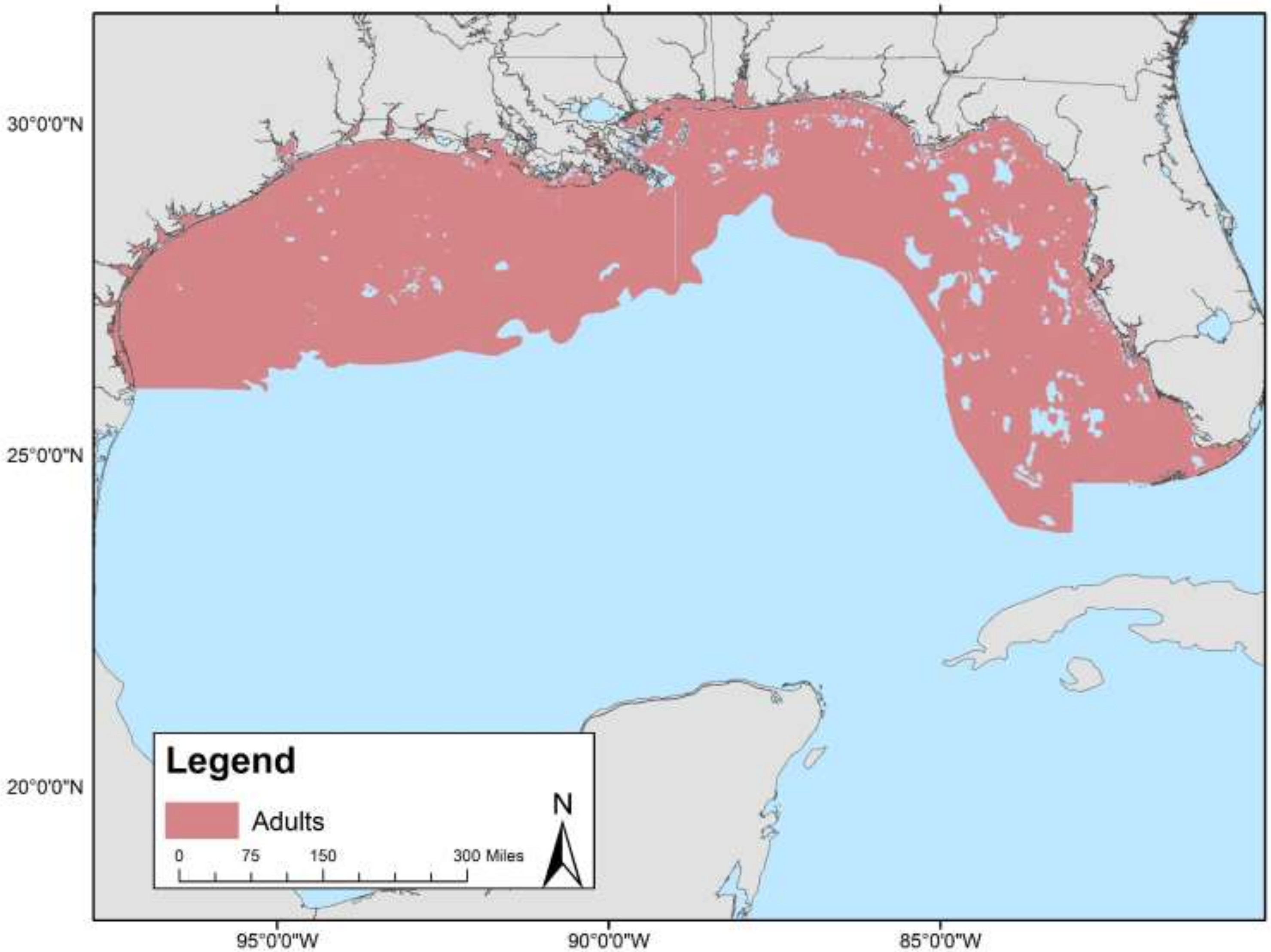

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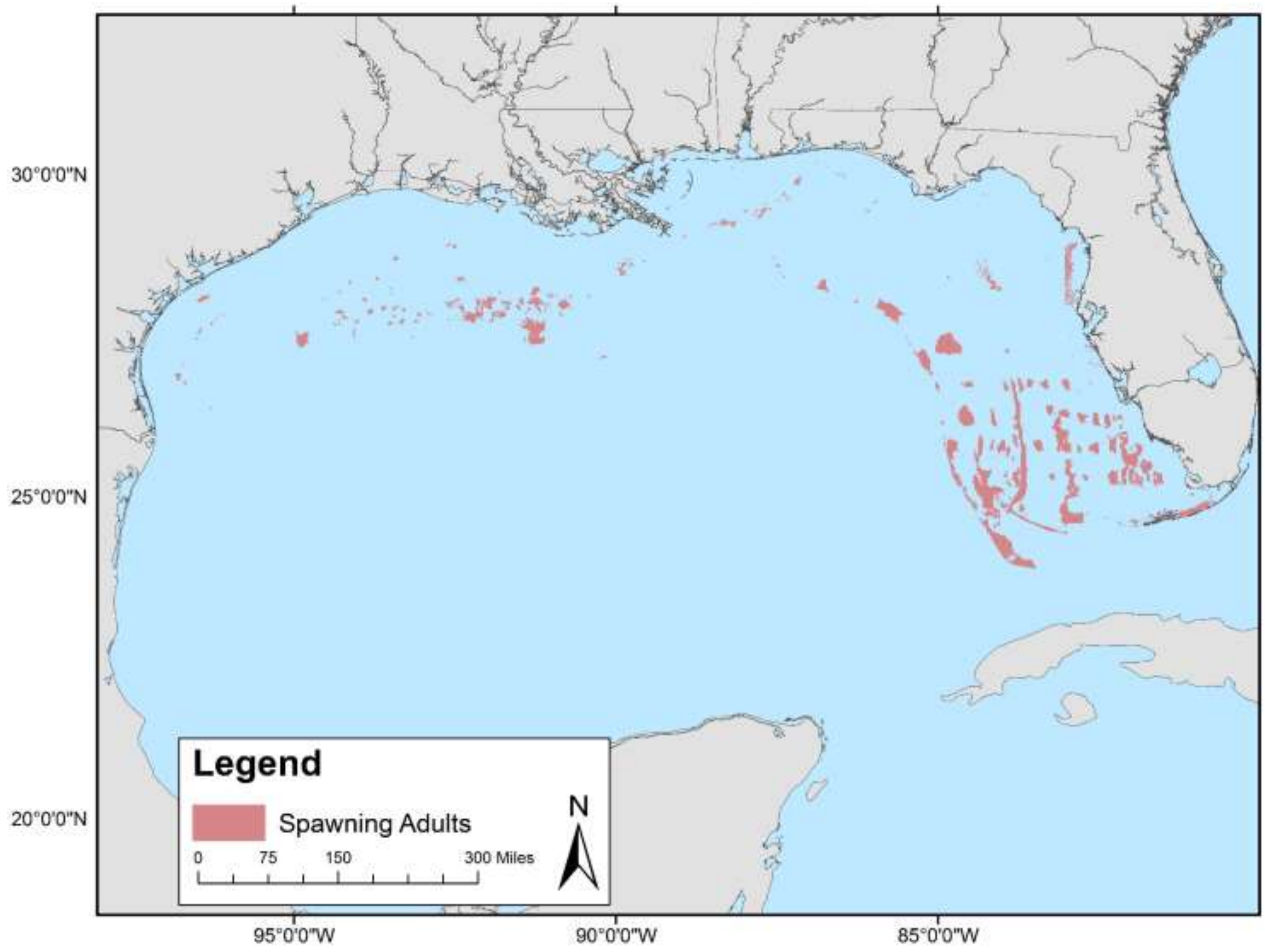

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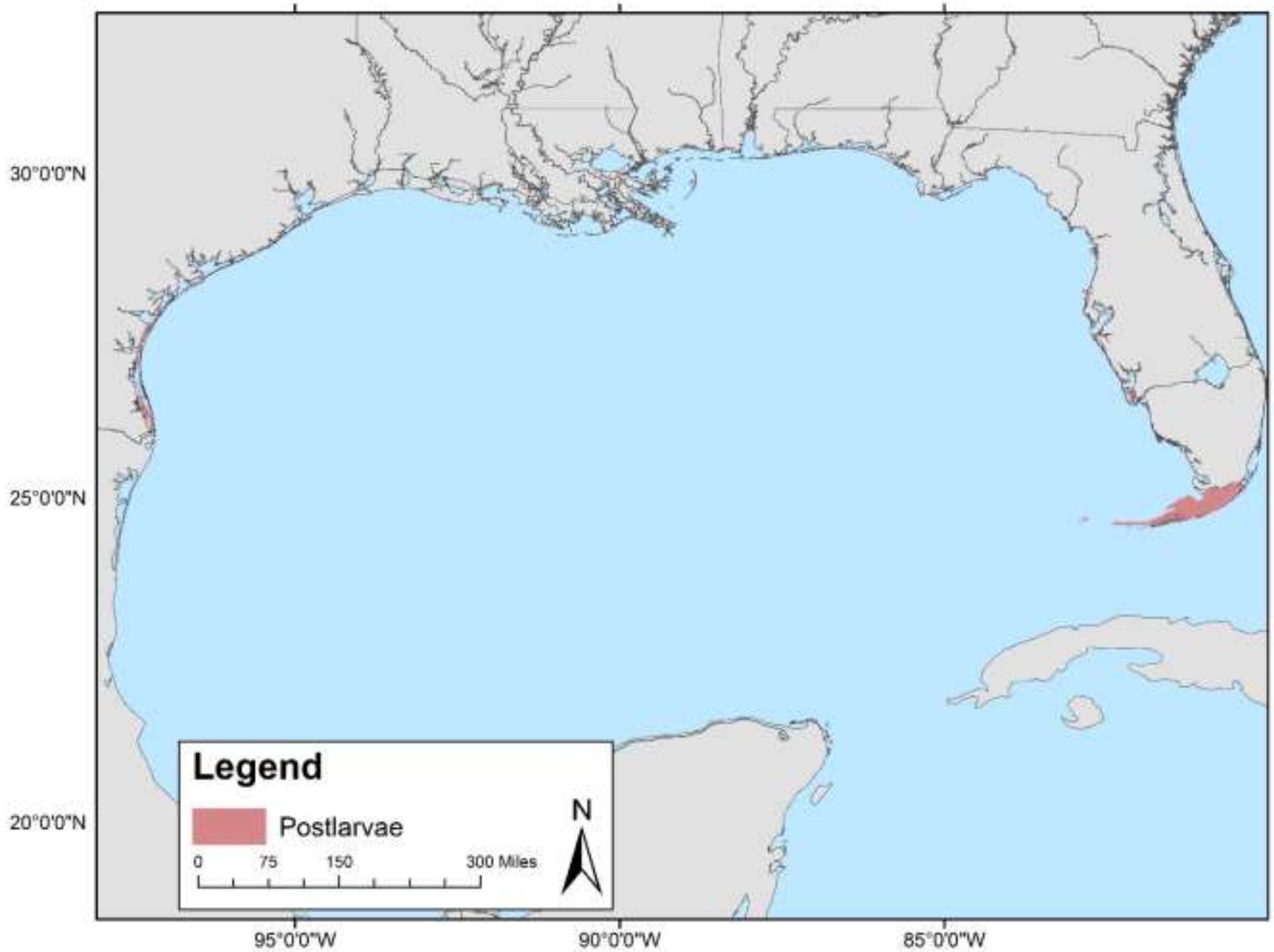

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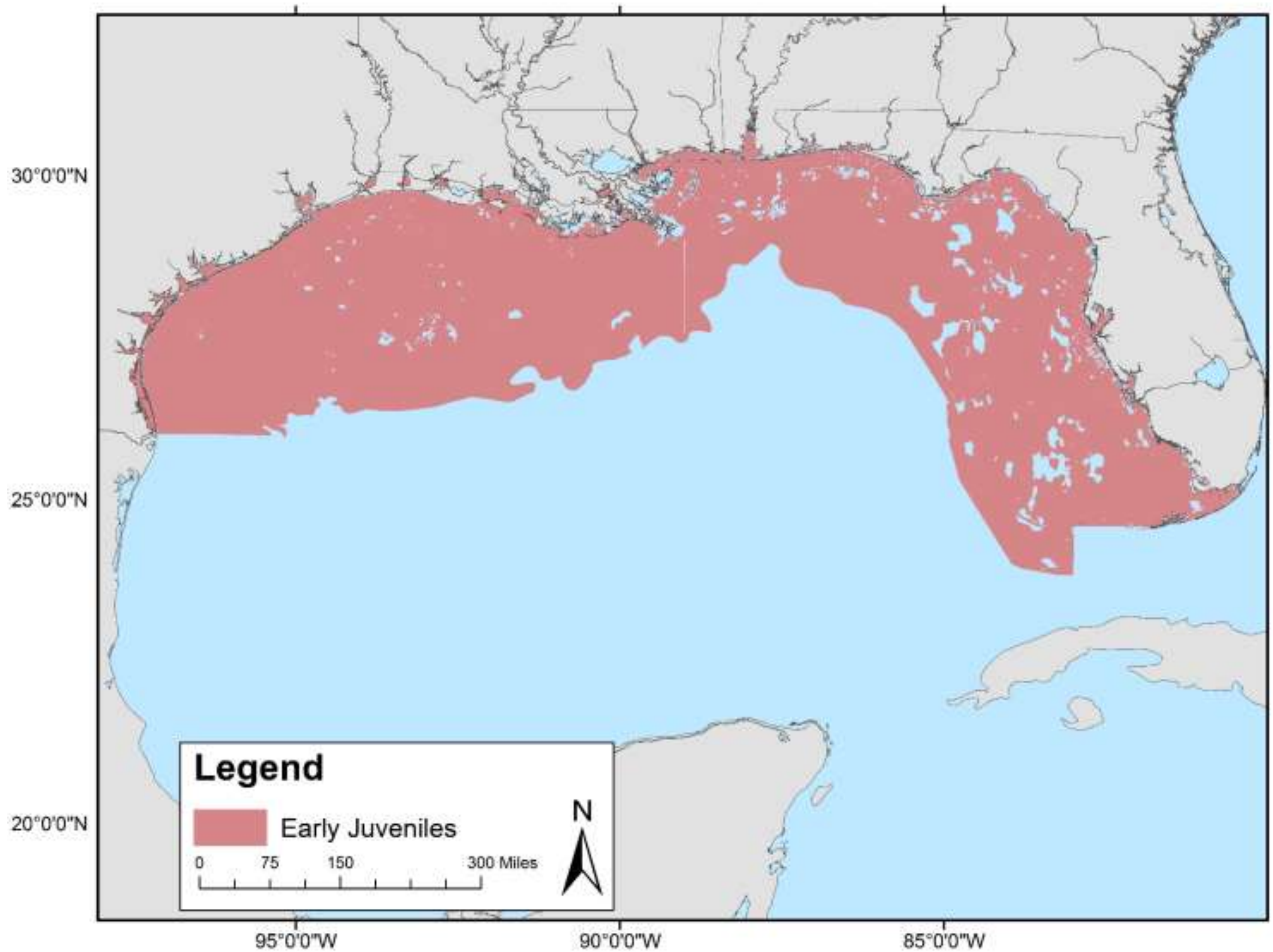

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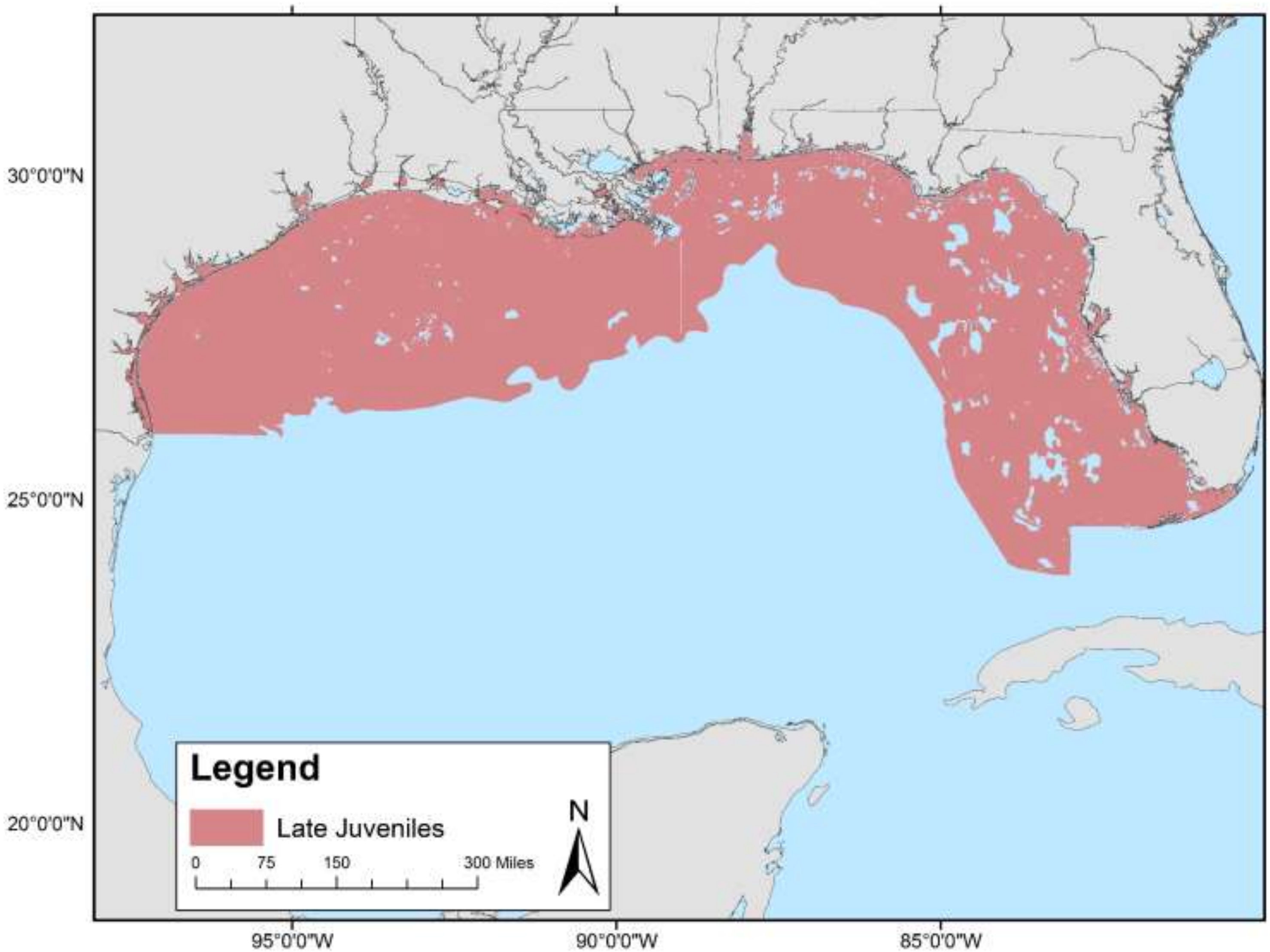

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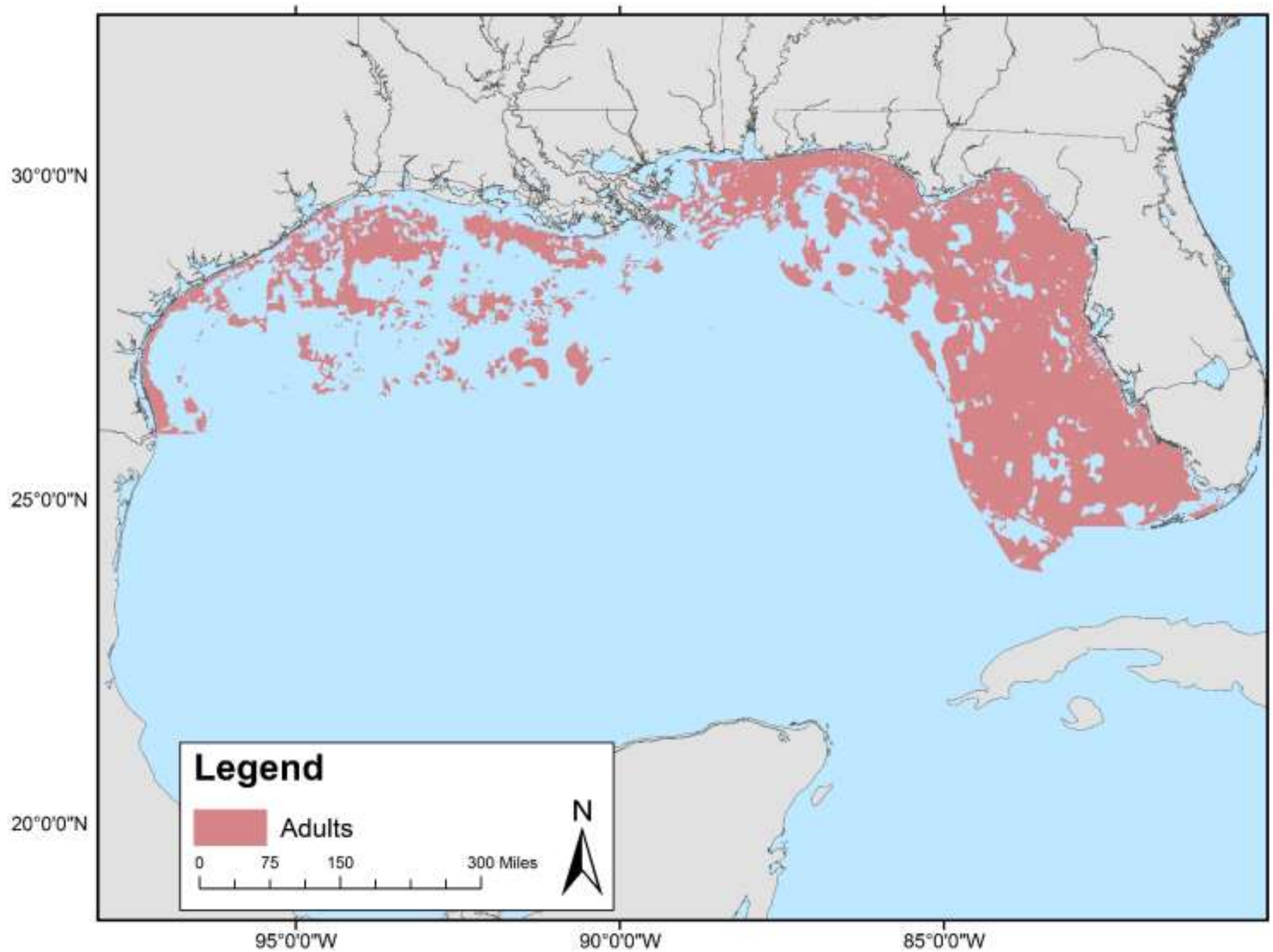

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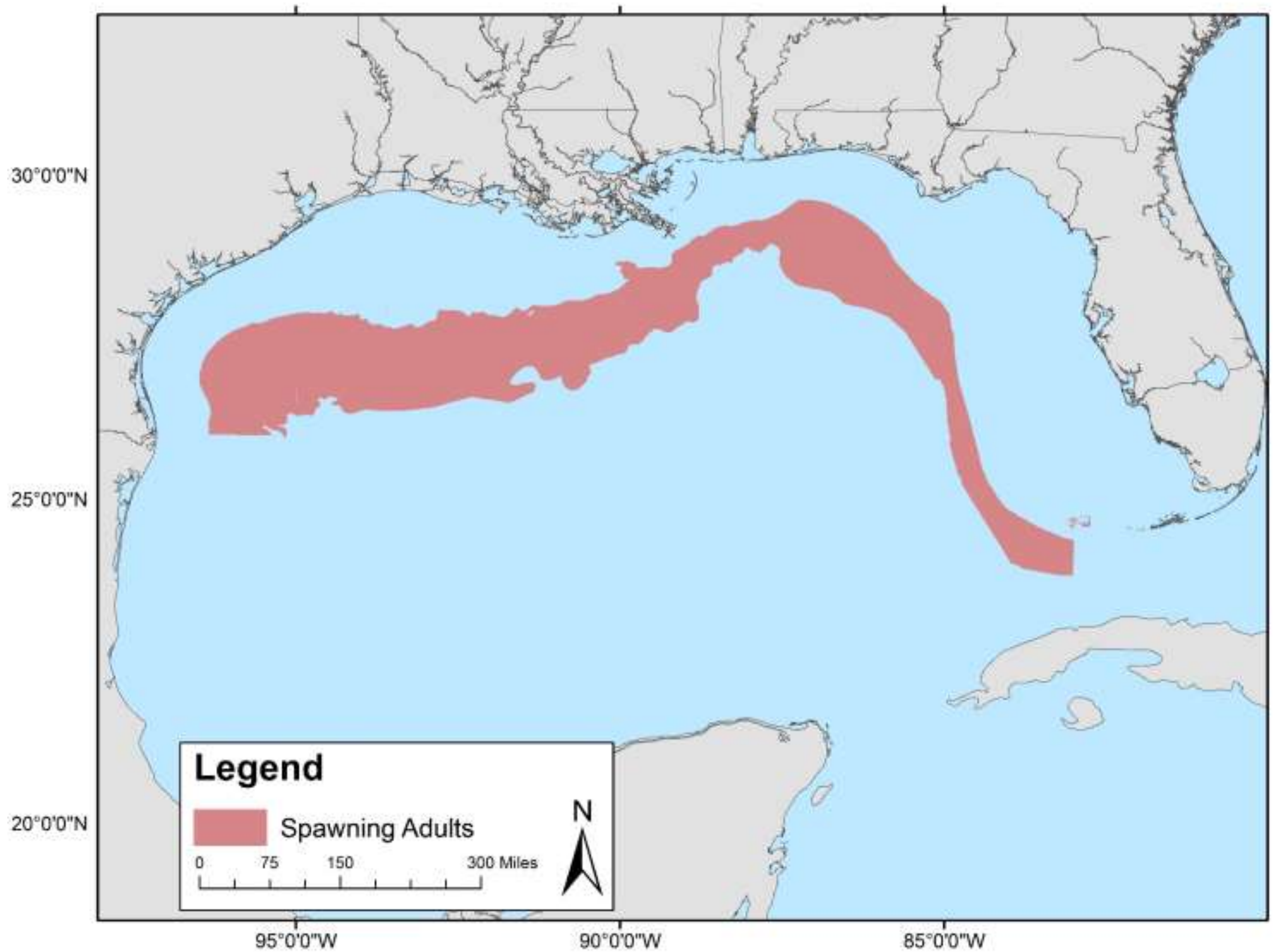

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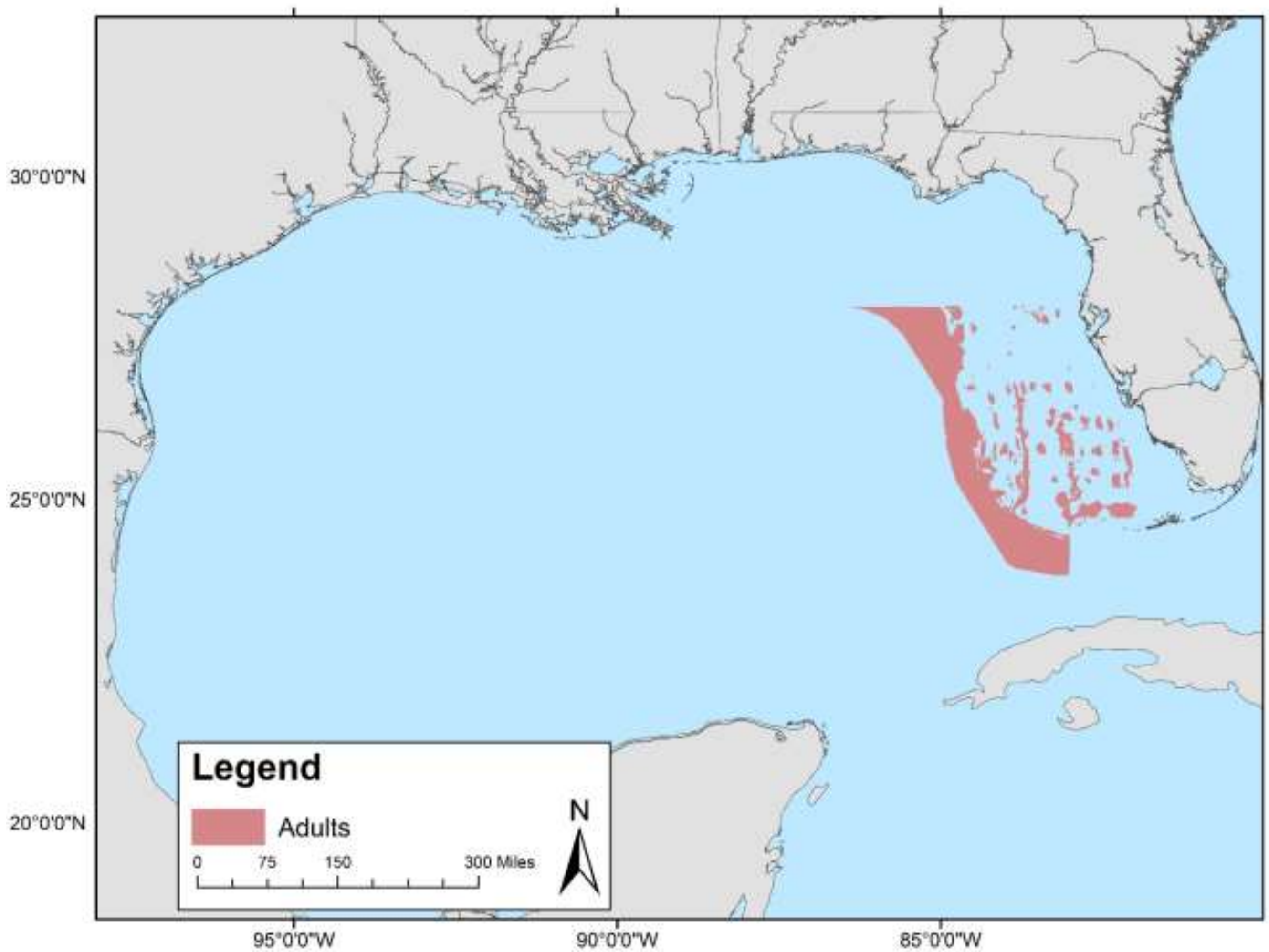
Silk Snapper (*Lutjanus vivanus*) Benthic Habitat Use Maps



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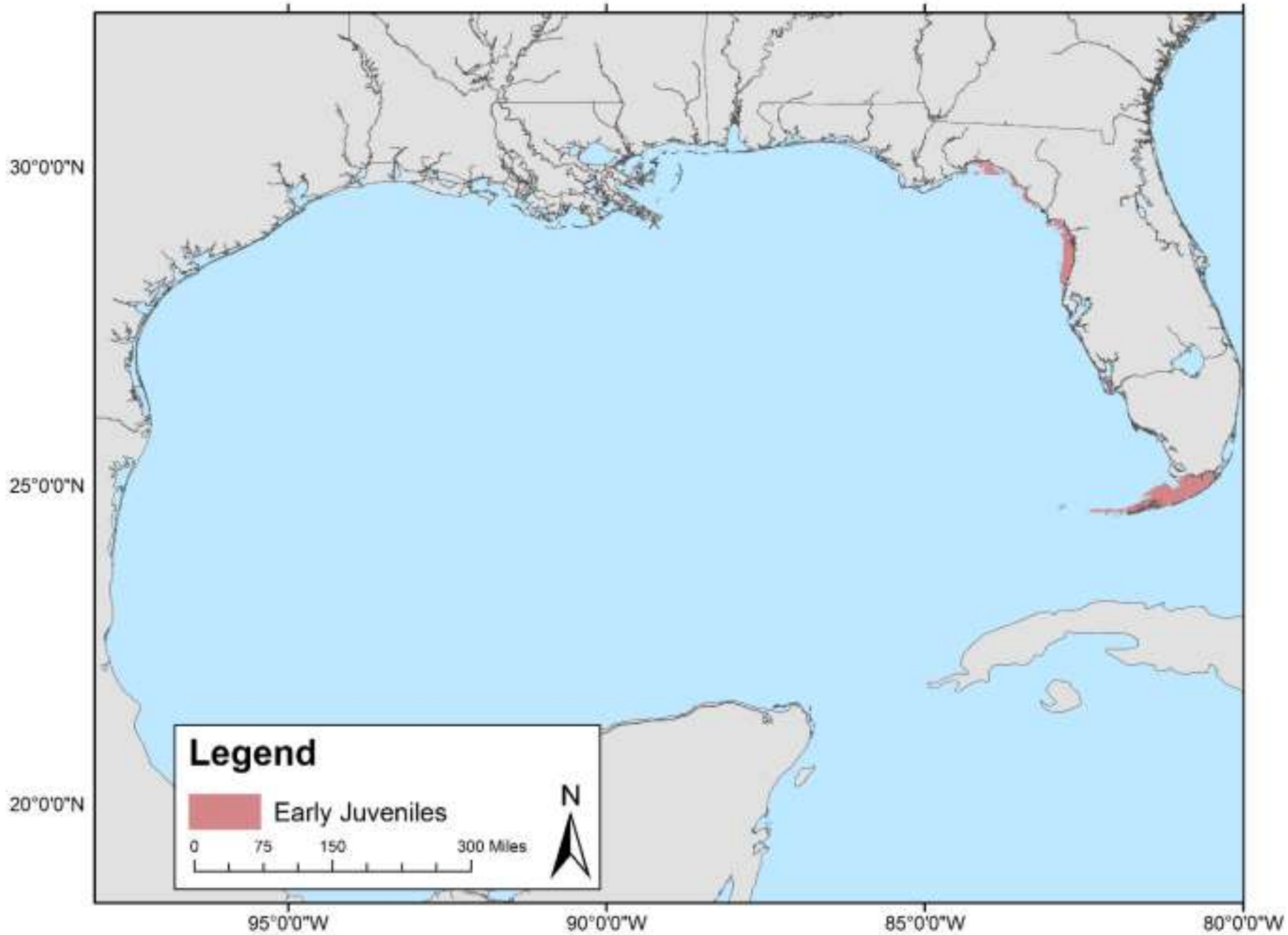
Yellowtail Snapper (*Ocyurus chrysurus*) Benthic Habitat Use Maps



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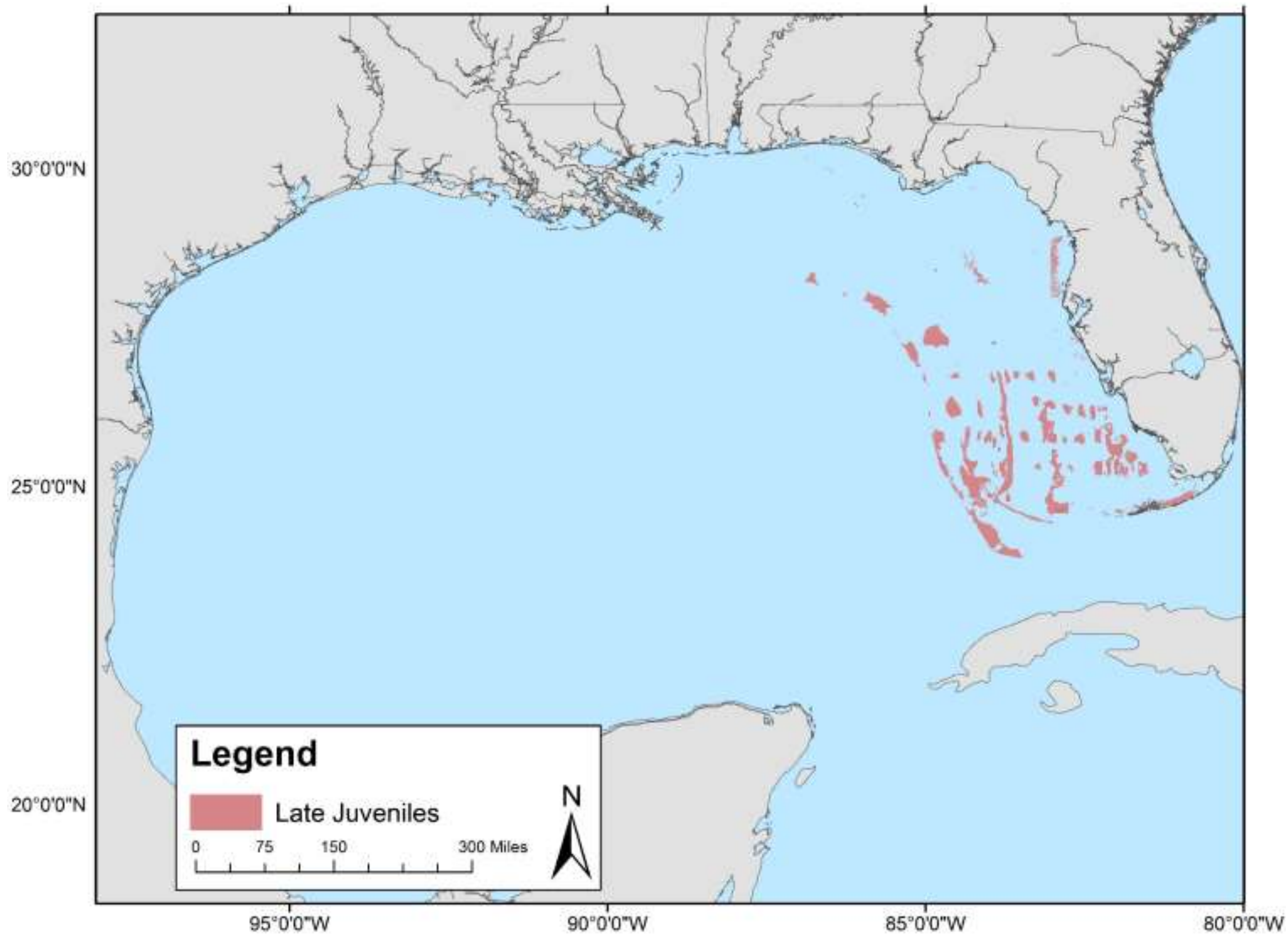

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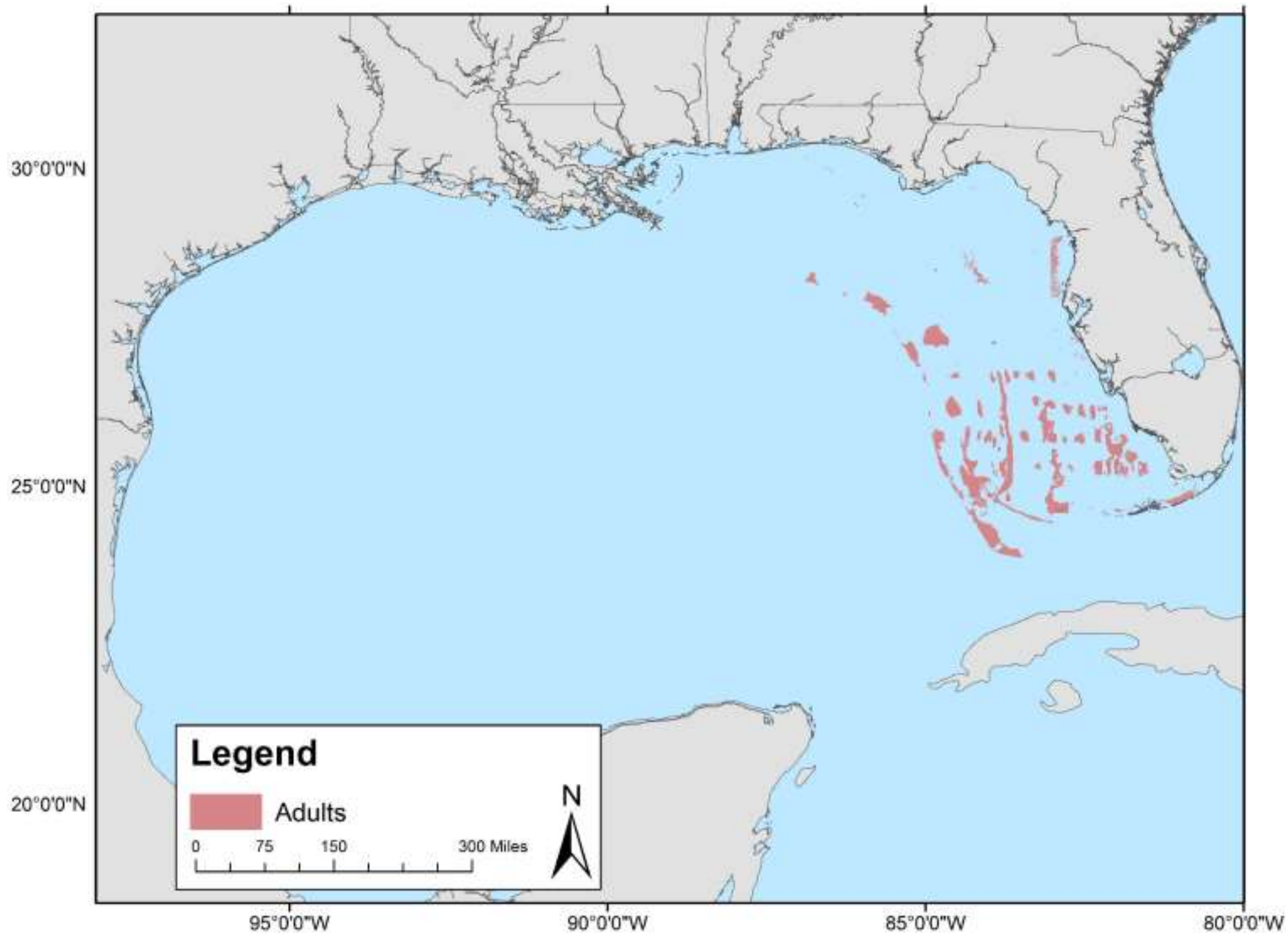

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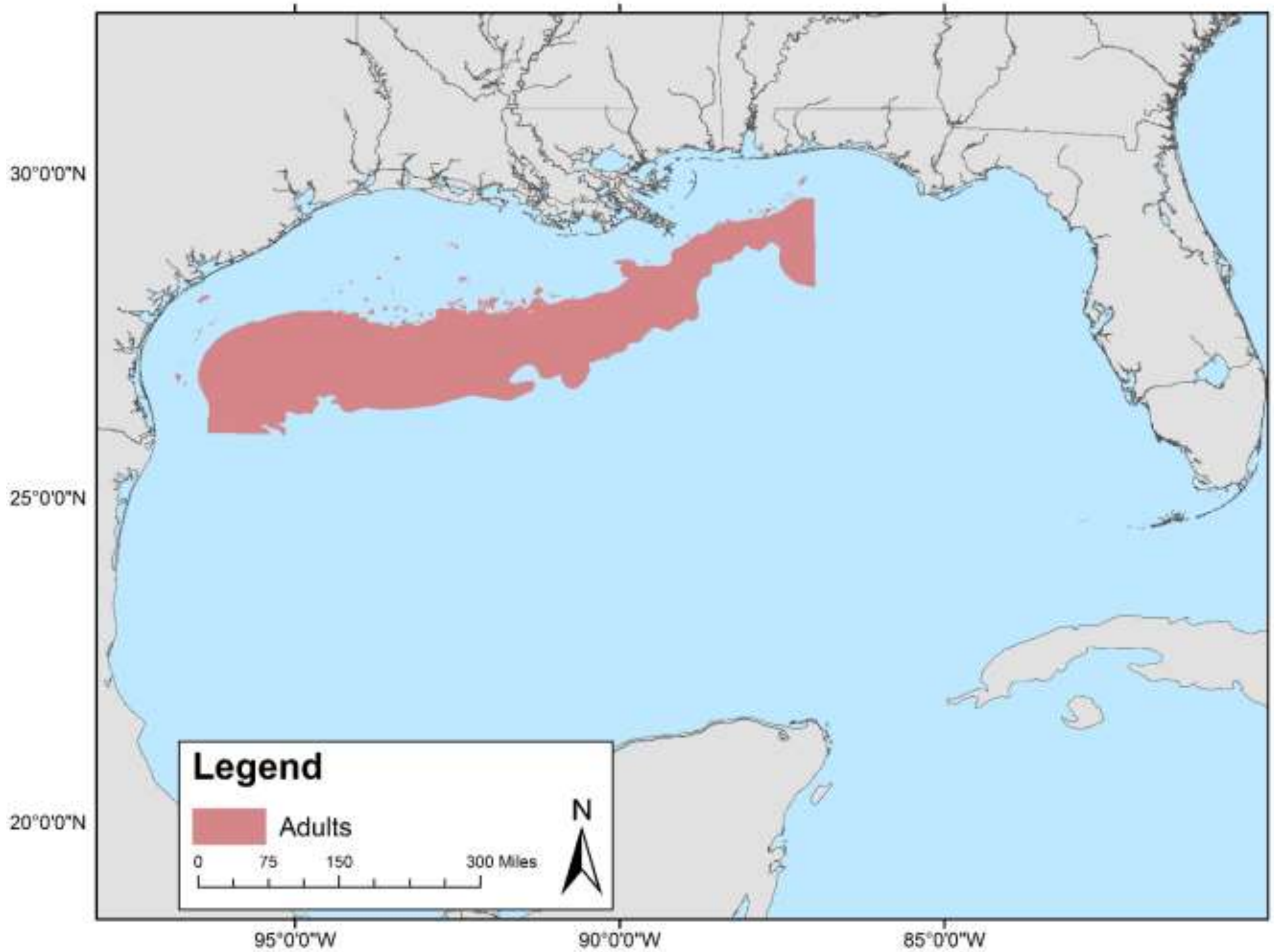
Wenchman (*Pristipomoides aquilonaris*) Benthic Habitat Use Maps



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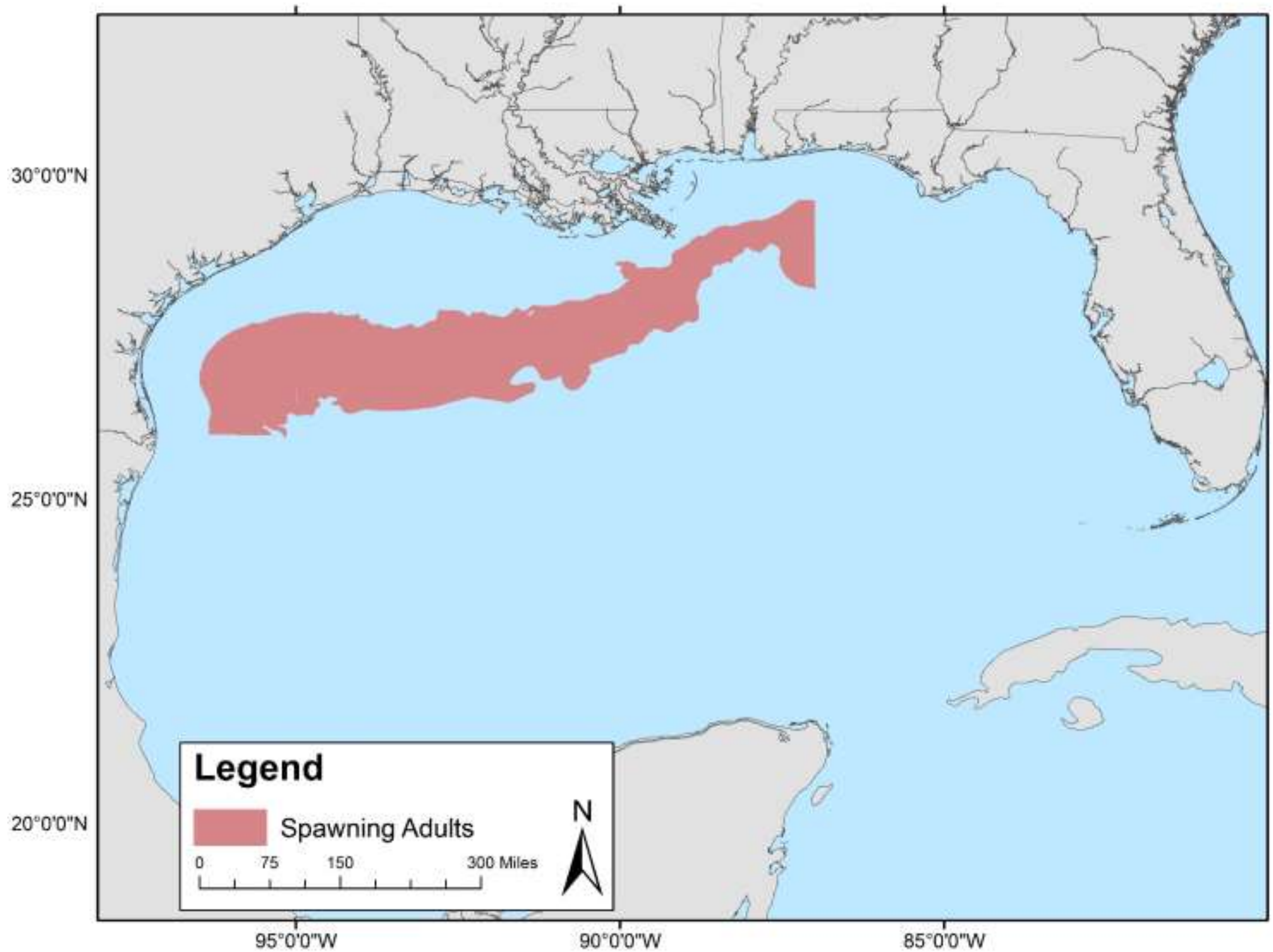

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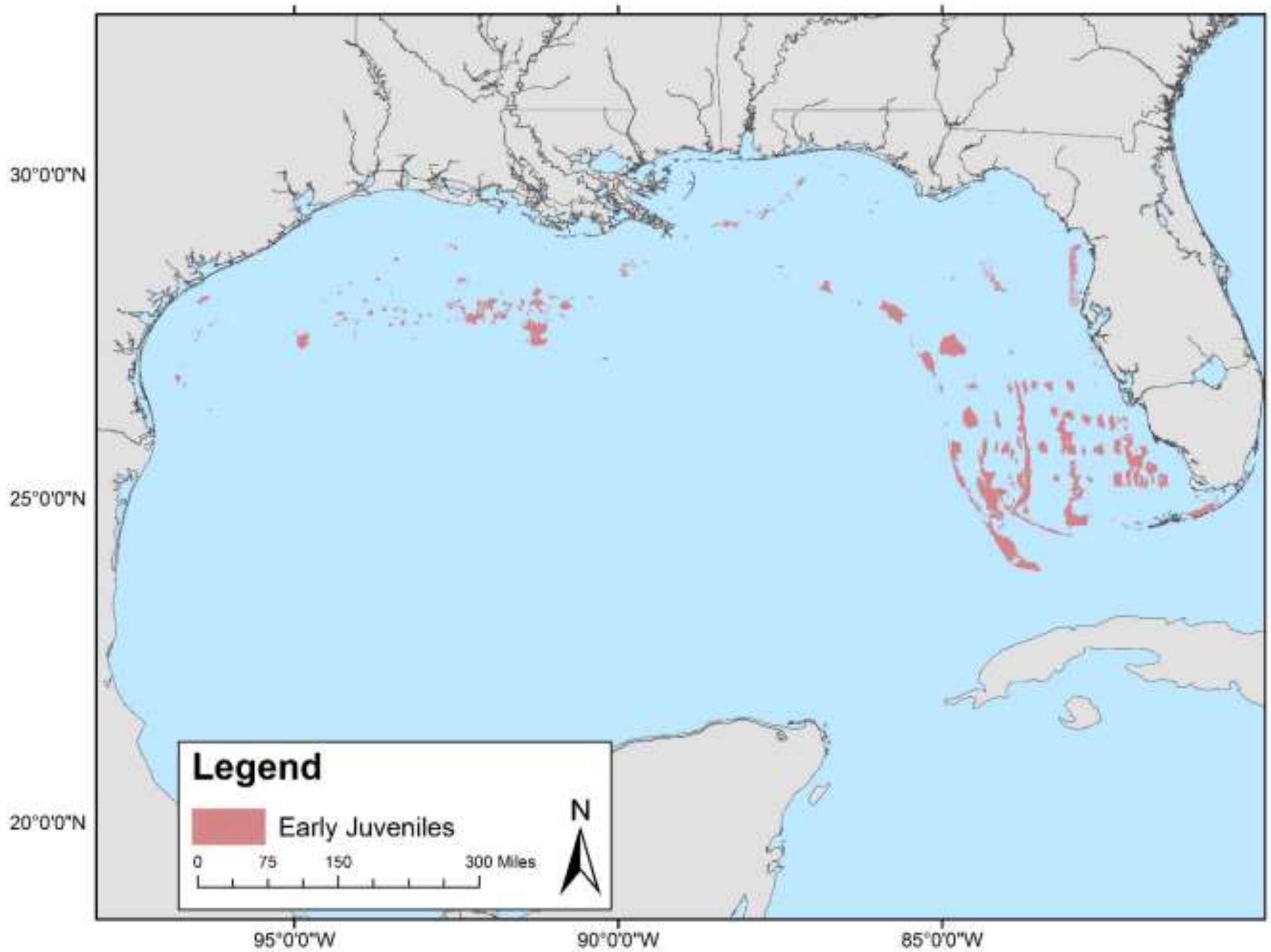

Figure B- 41. Map of benthic habitat use by early juvenile vermilion snapper.

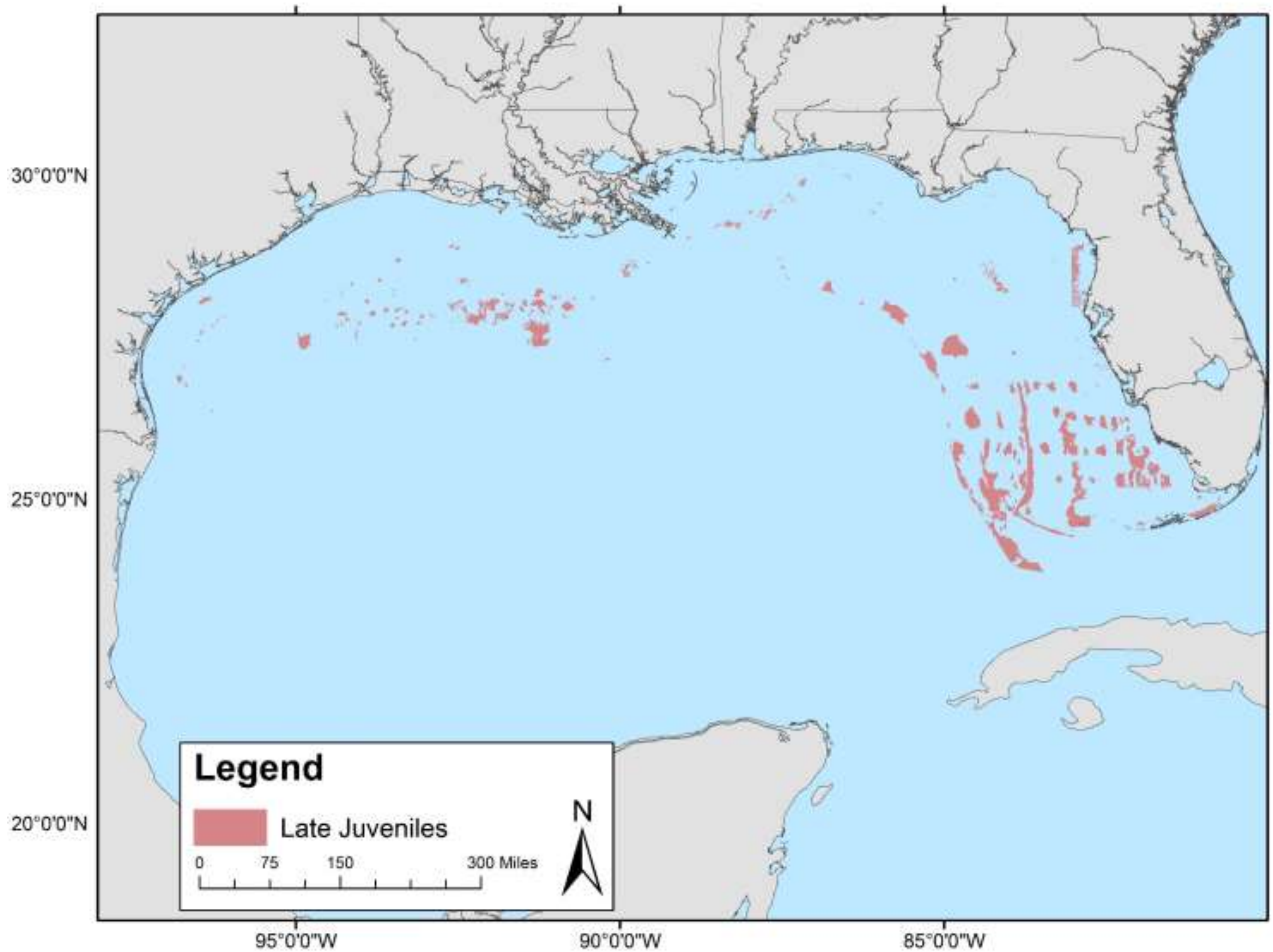

Figure B- 42. Map of benthic habitat use by late juvenile vermilion snapper.

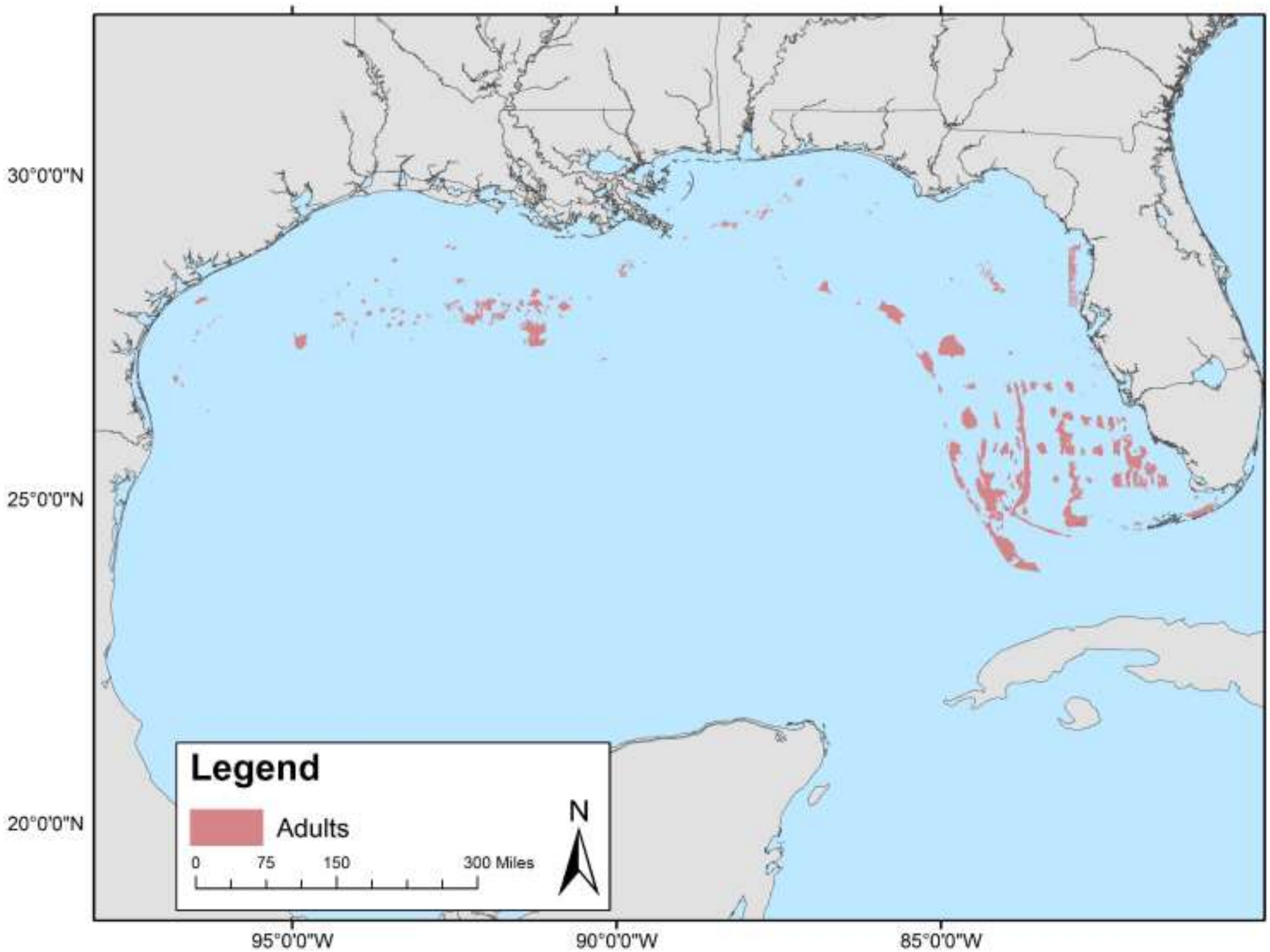

Figure B- 43. Map of benthic habitat use by adult vermilion snapper.

Speckled Hind (*Epinephelus drummondhayi*) Benthic Habitat Use Maps

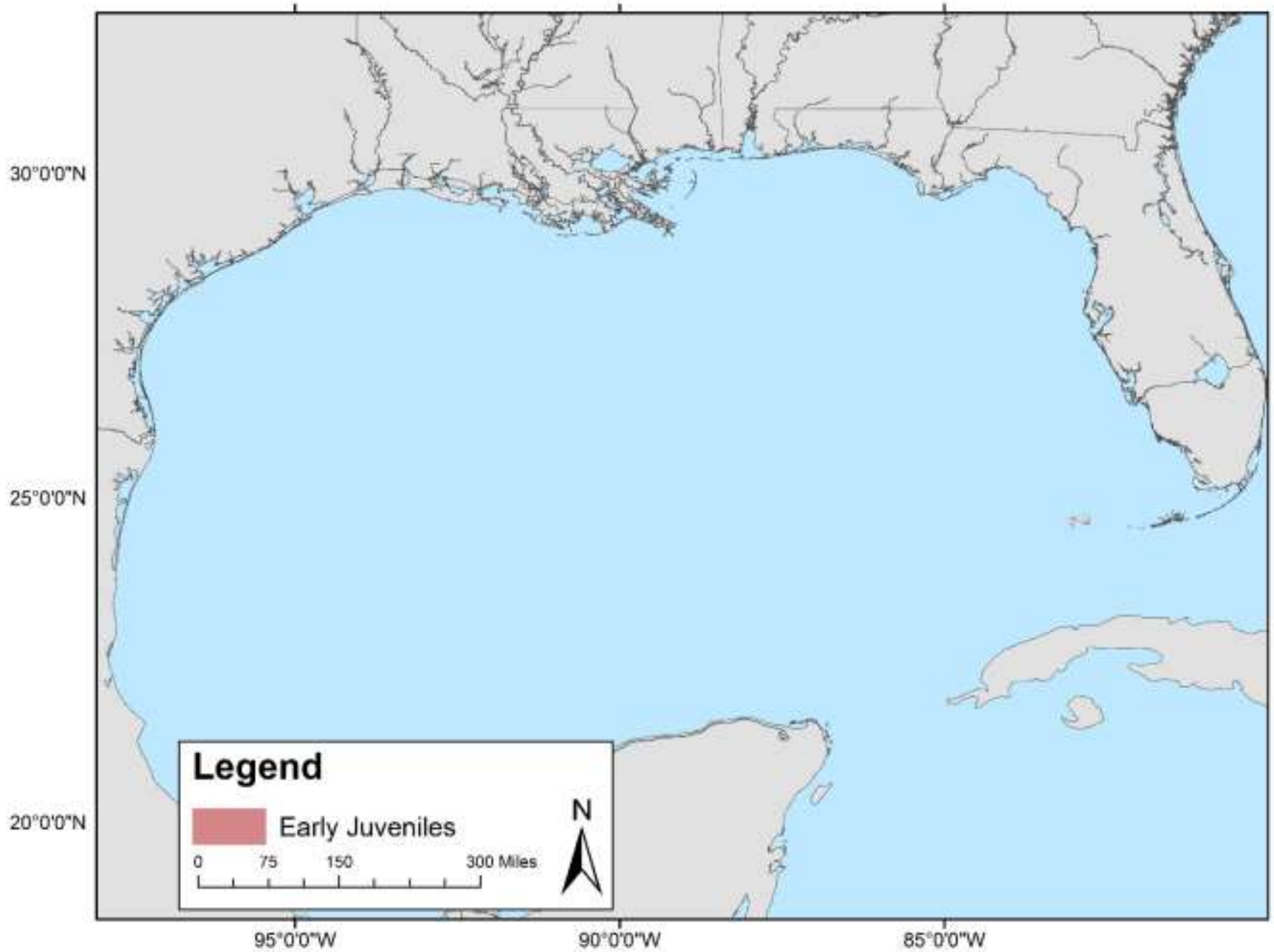

Figure B- 44. Map of benthic habitat use by early juvenile speckled hind.

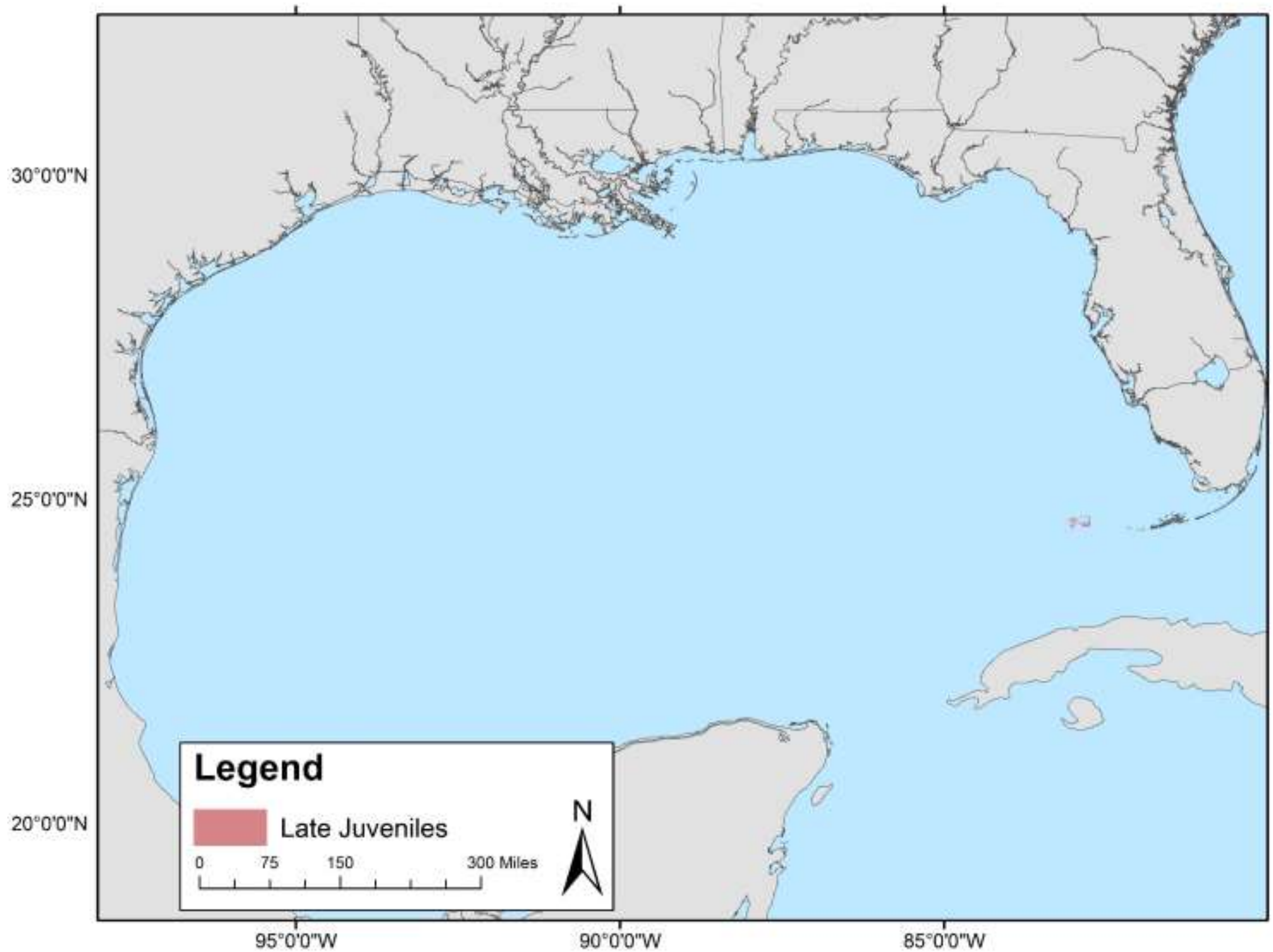

Figure B- 45. Map of benthic habitat use by late juvenile speckled hind.

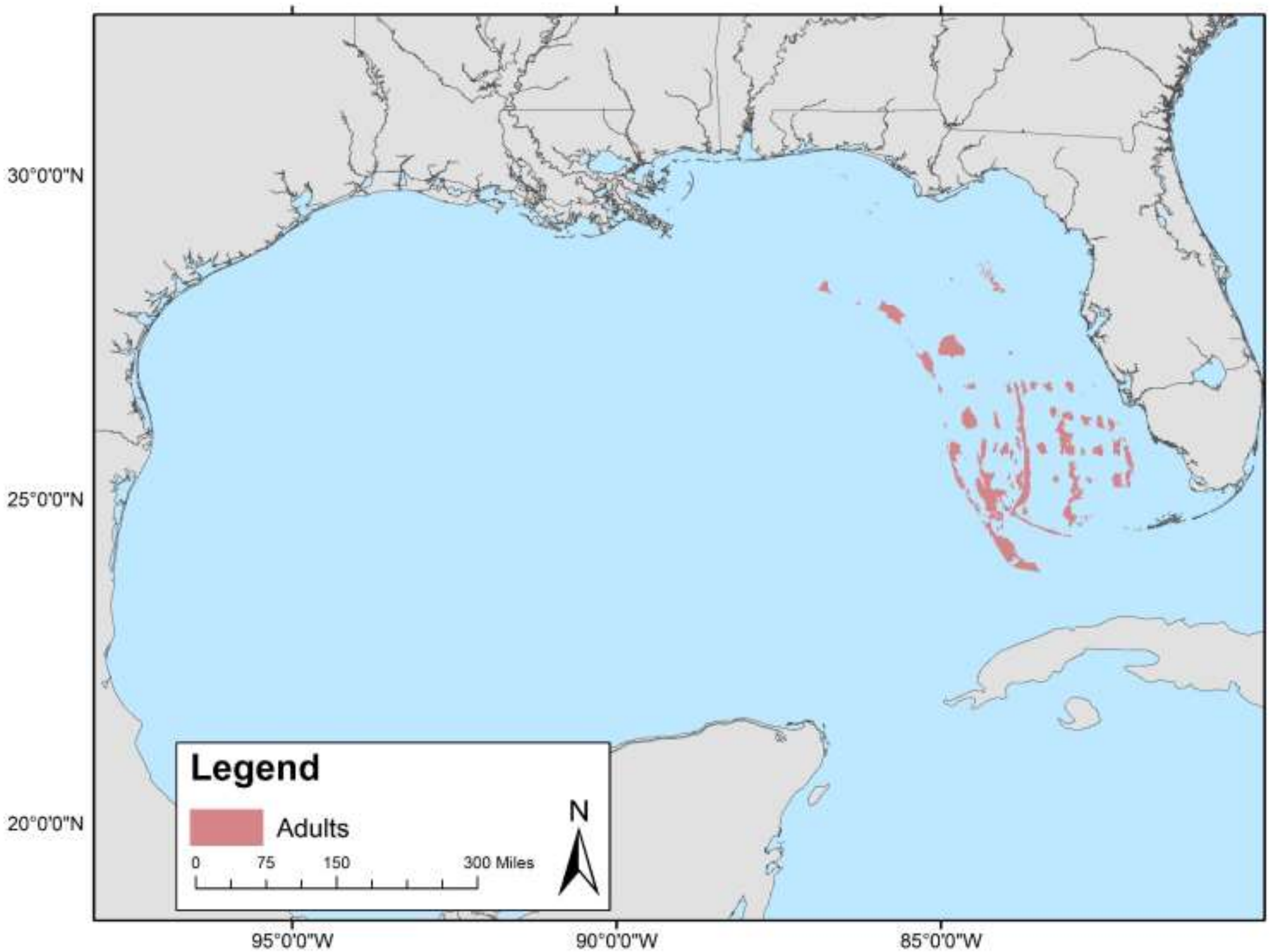

Figure B- 46. Map of benthic habitat use by adult speckled hind.

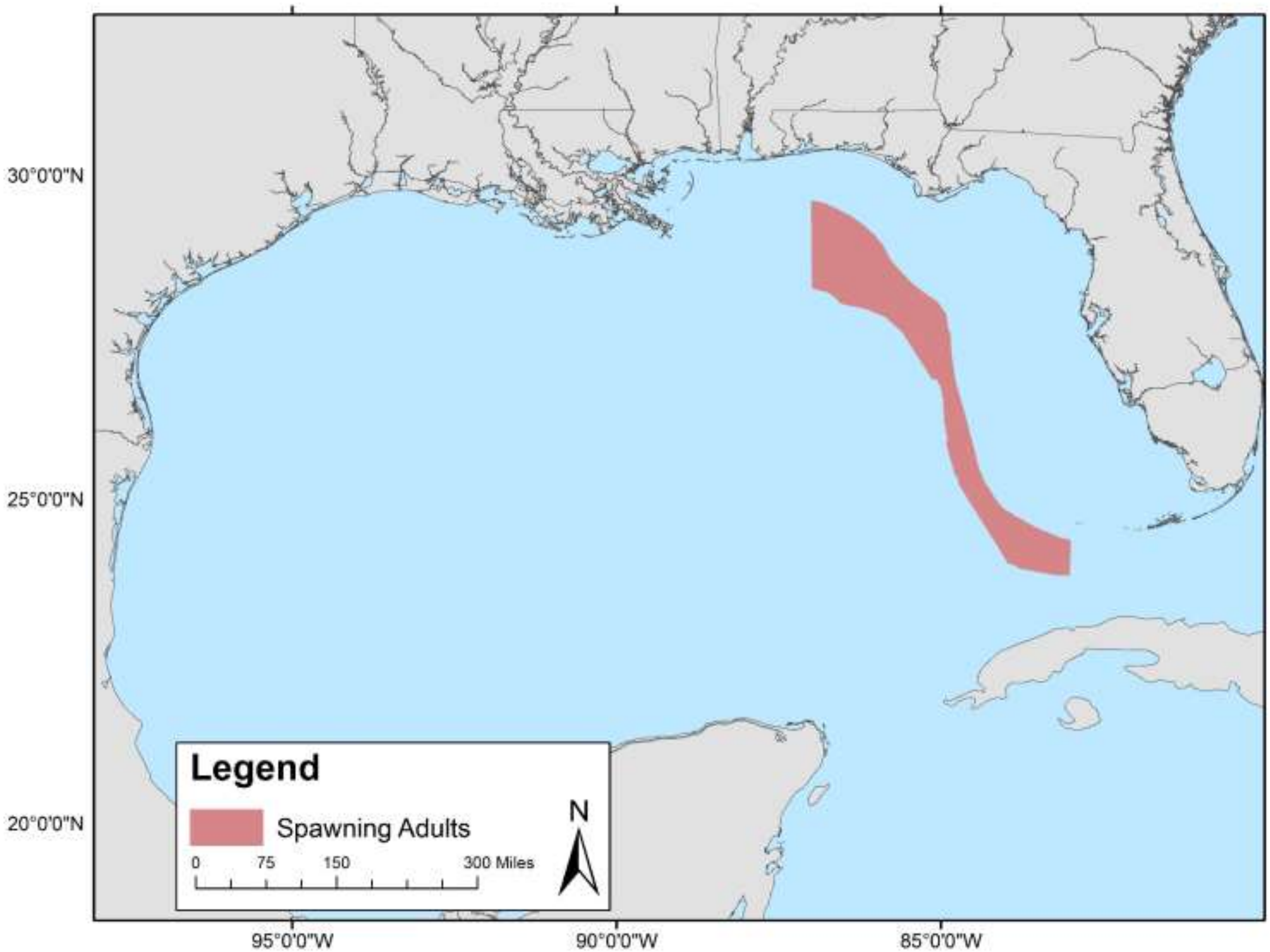

Figure B- 47. Map of benthic habitat use by spawning adult speckled hind.

Goliath Grouper (*Epinephelus itajara*) Benthic Habitat Use Maps

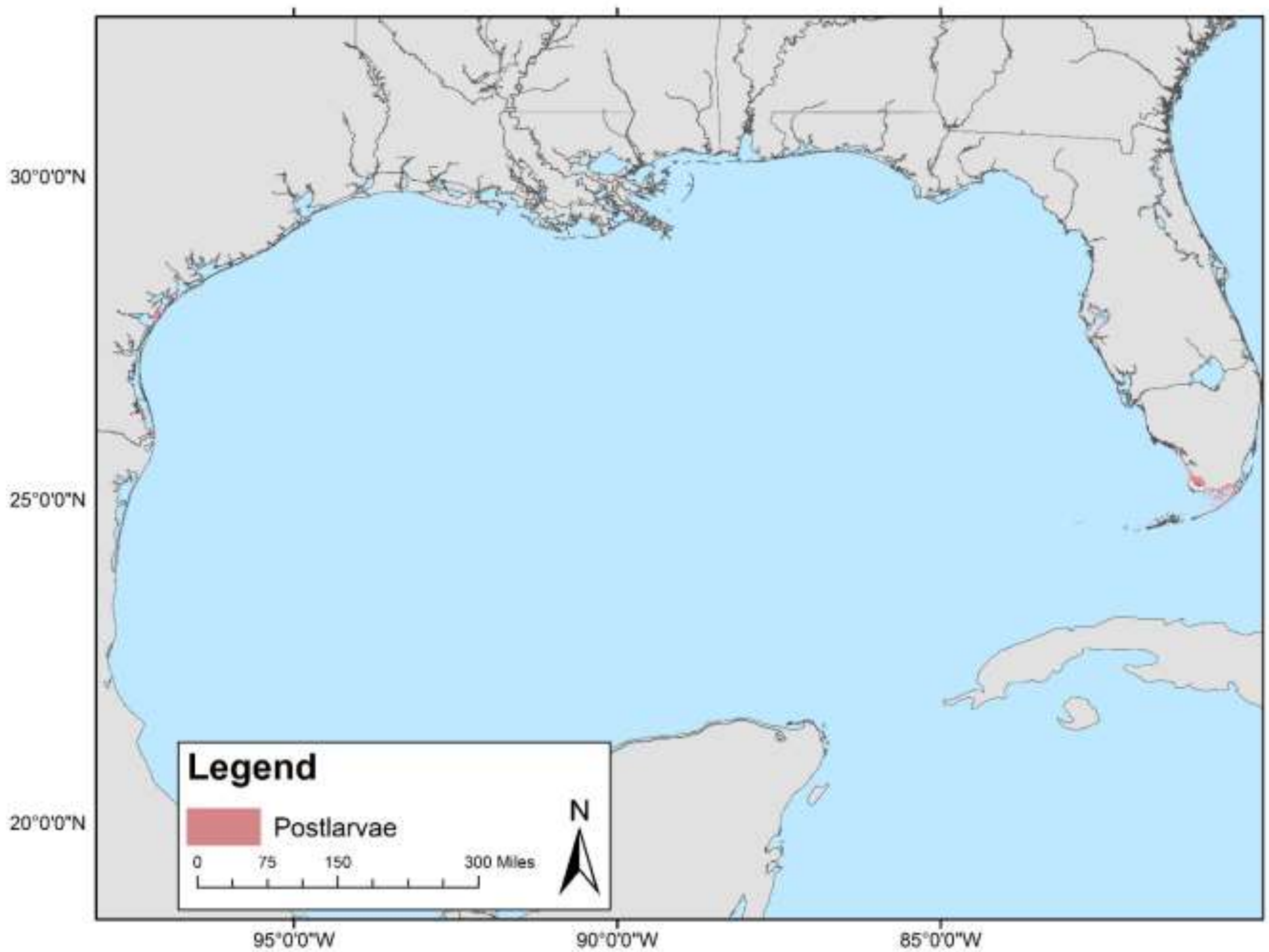

Figure B- 48. Map of benthic habitat use by postlarval goliath grouper.

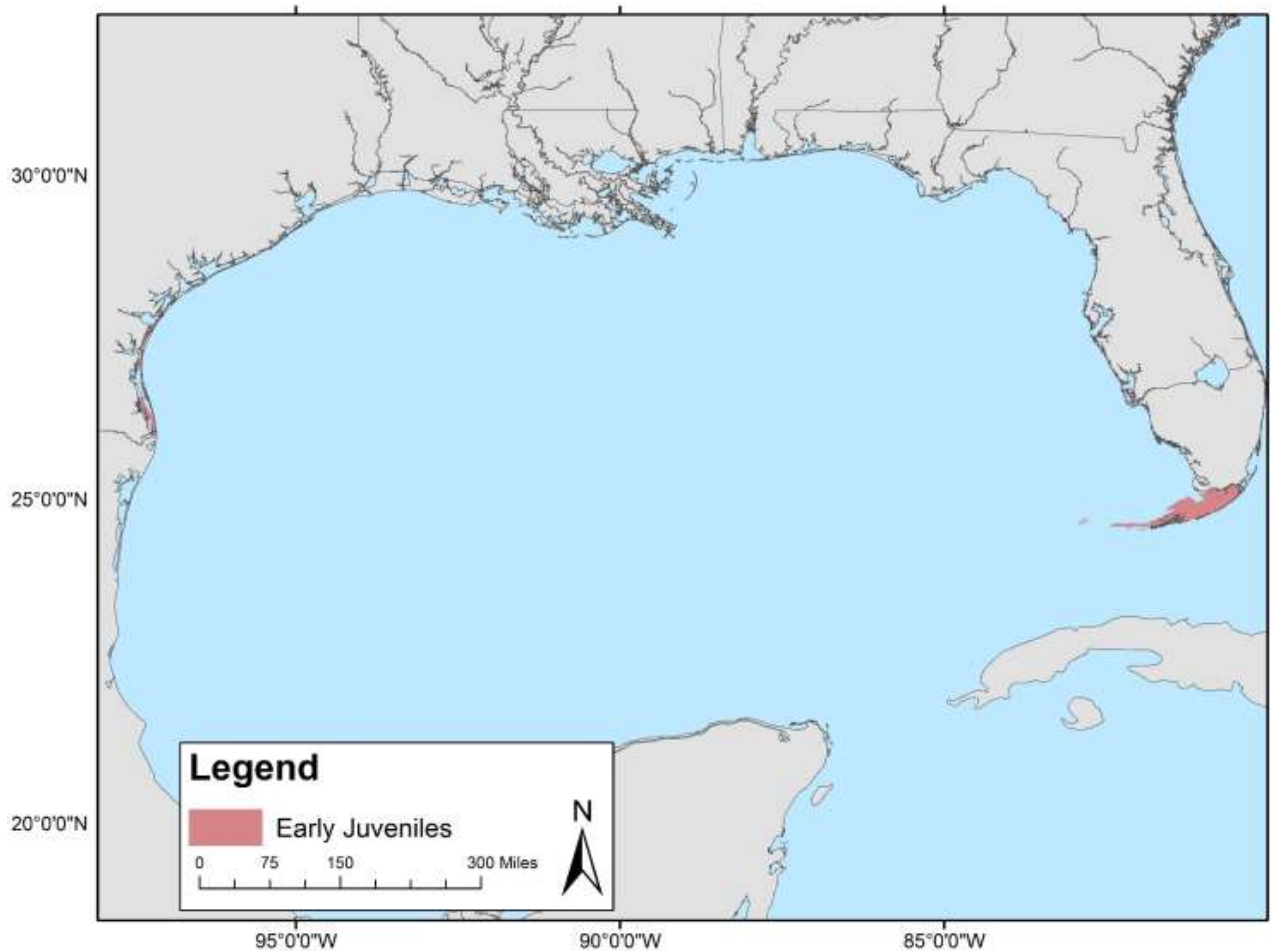

Figure B- 49. Map of benthic habitat use by early juvenile goliath grouper.

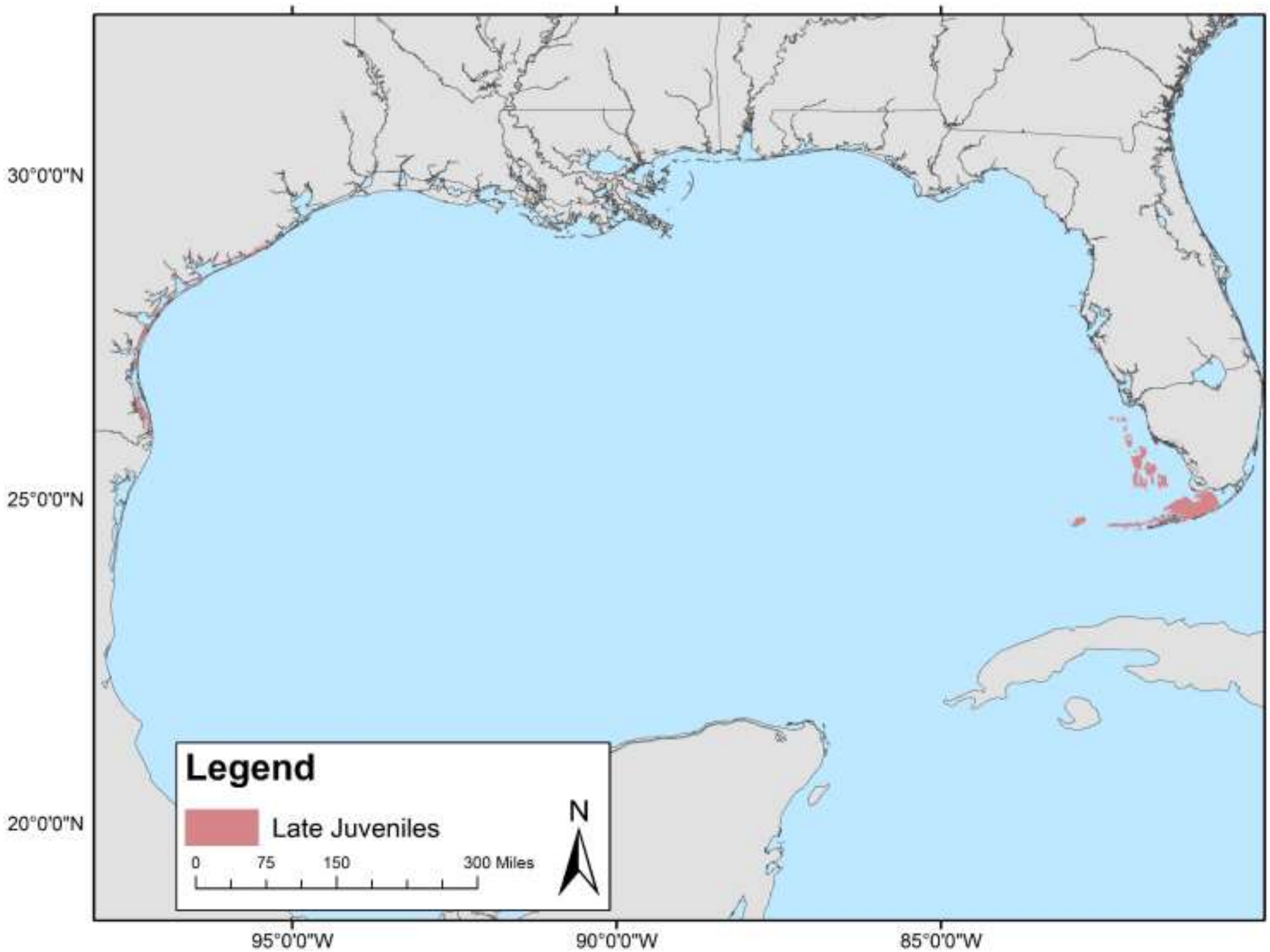

Figure B- 50. Map of benthic habitat use by late juvenile goliath grouper.

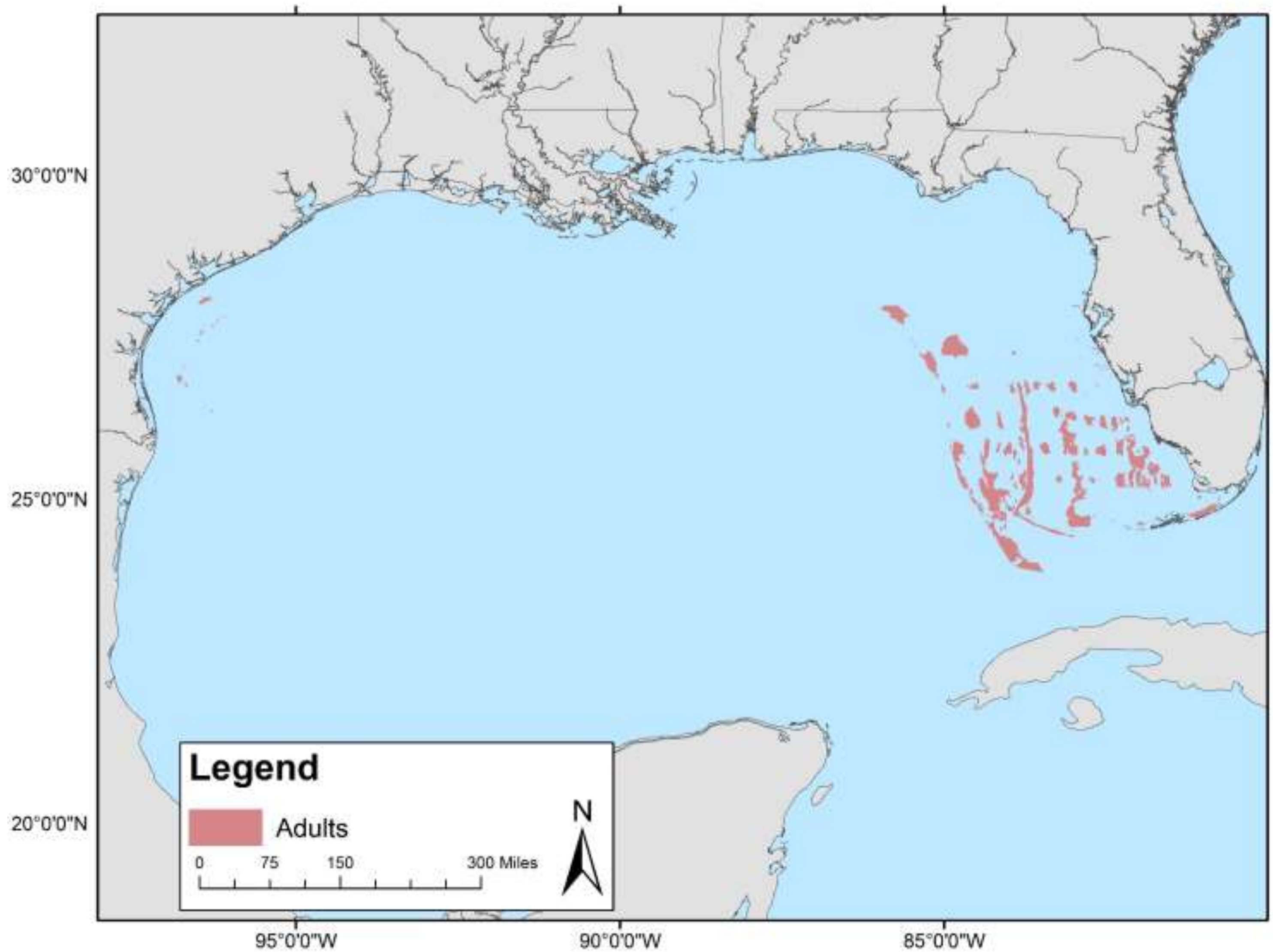

Figure B- 51. Map of benthic habitat use by adult goliath grouper

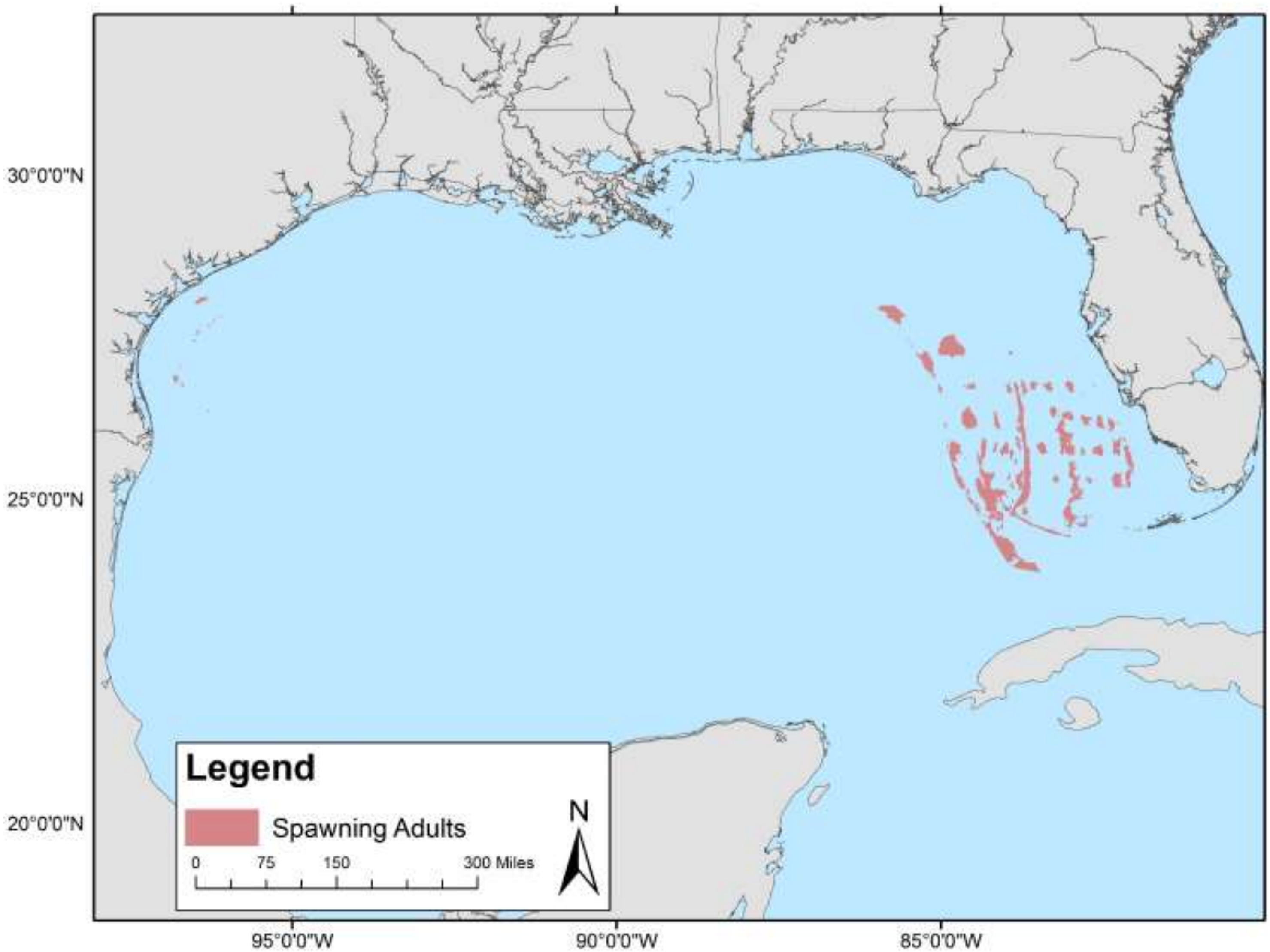

Figure B- 52. Map of benthic habitat use by spawning adult goliath grouper.

Red Grouper (*Epinephelus morio*) Benthic Habitat Use Maps

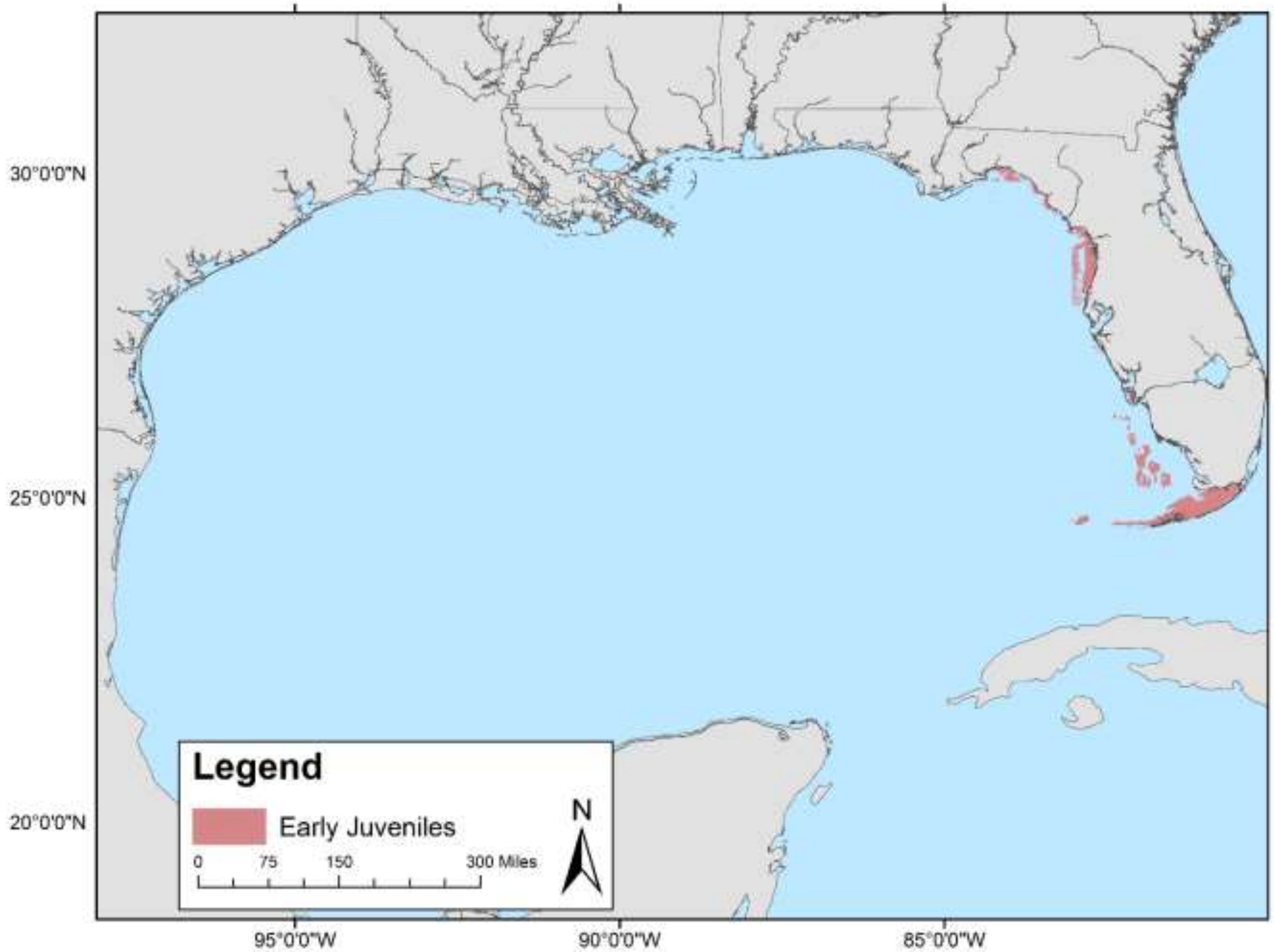

Figure B- 53. Map of benthic habitat use by early juvenile red grouper.

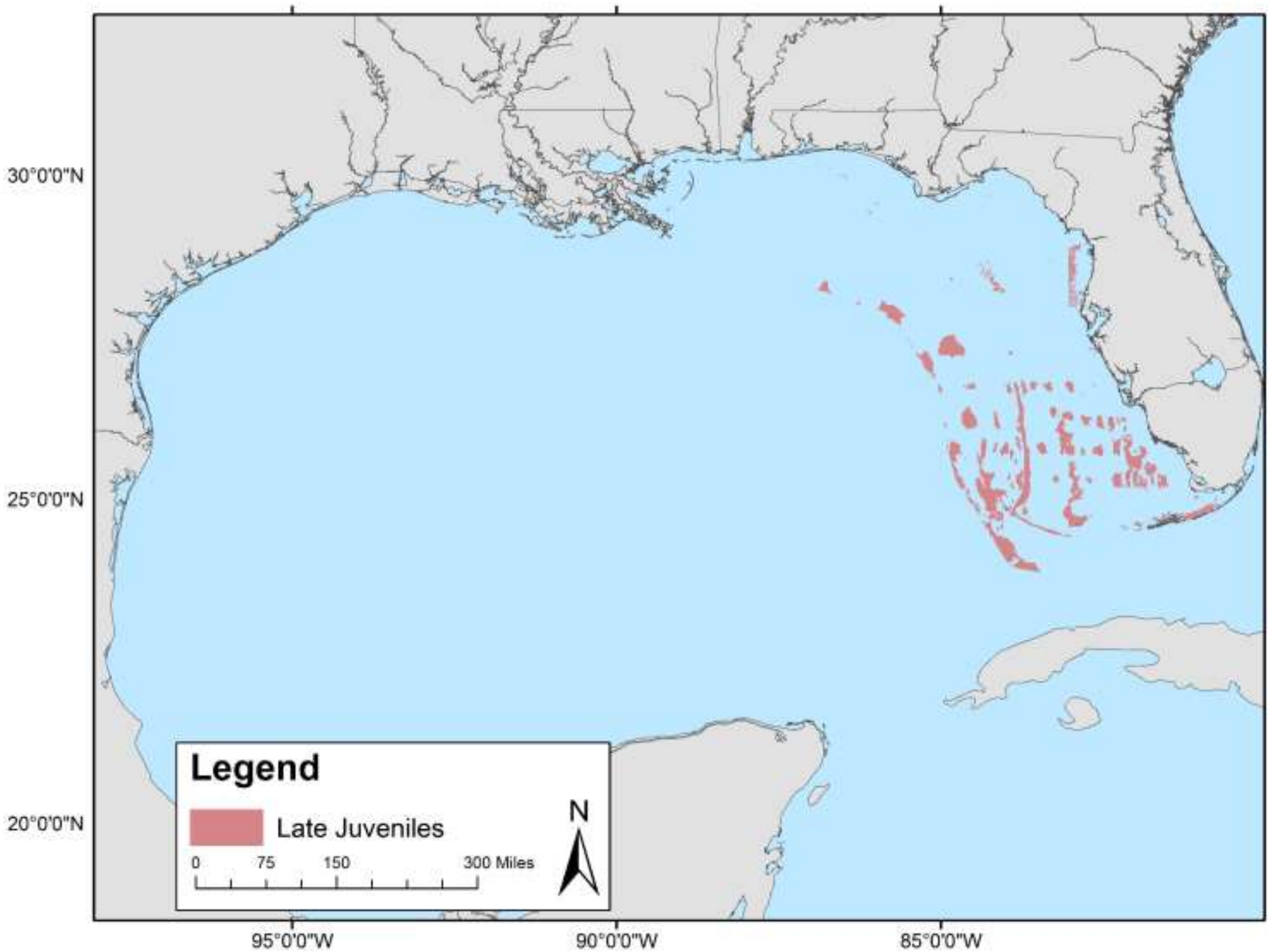

Figure B- 54. Map of benthic habitat use by late juvenile red grouper.

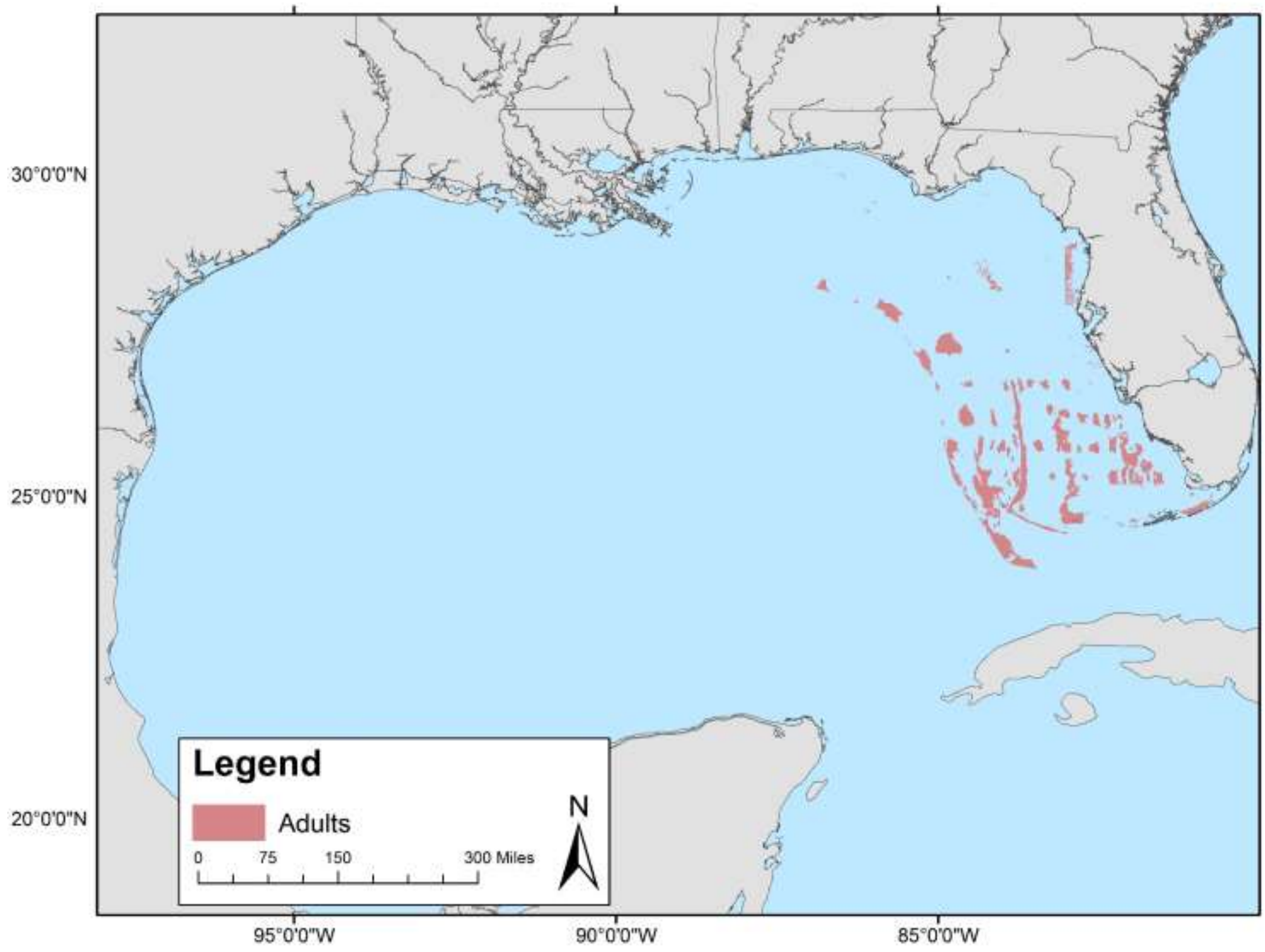

Figure B- 55. Map of benthic habitat use by adult red grouper.

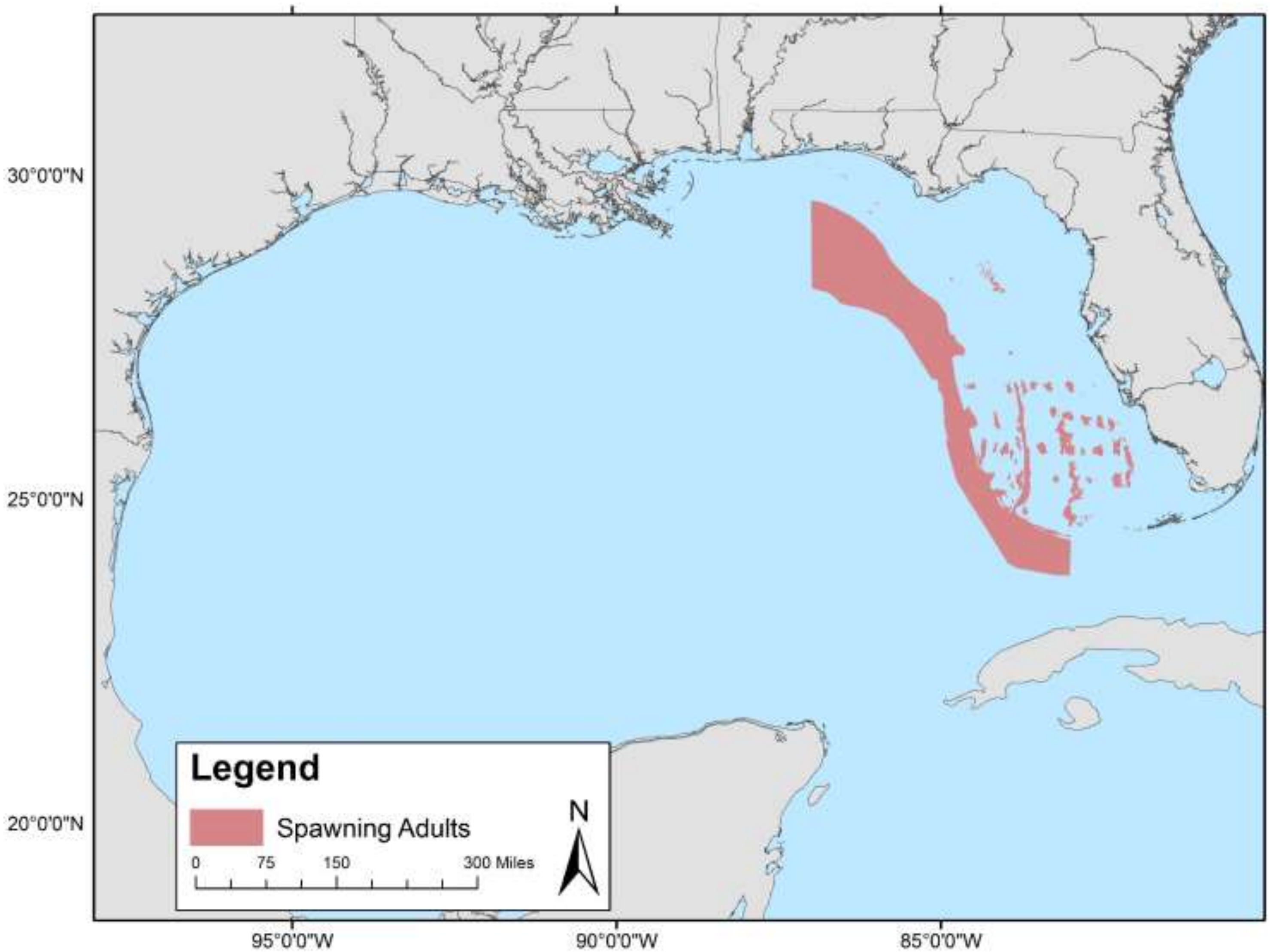

Figure B- 56. Map of benthic habitat use by spawning adult red grouper.

Yellowedge Grouper (*Hyporthodus flavolimbatus*) Benthic Habitat Use Maps

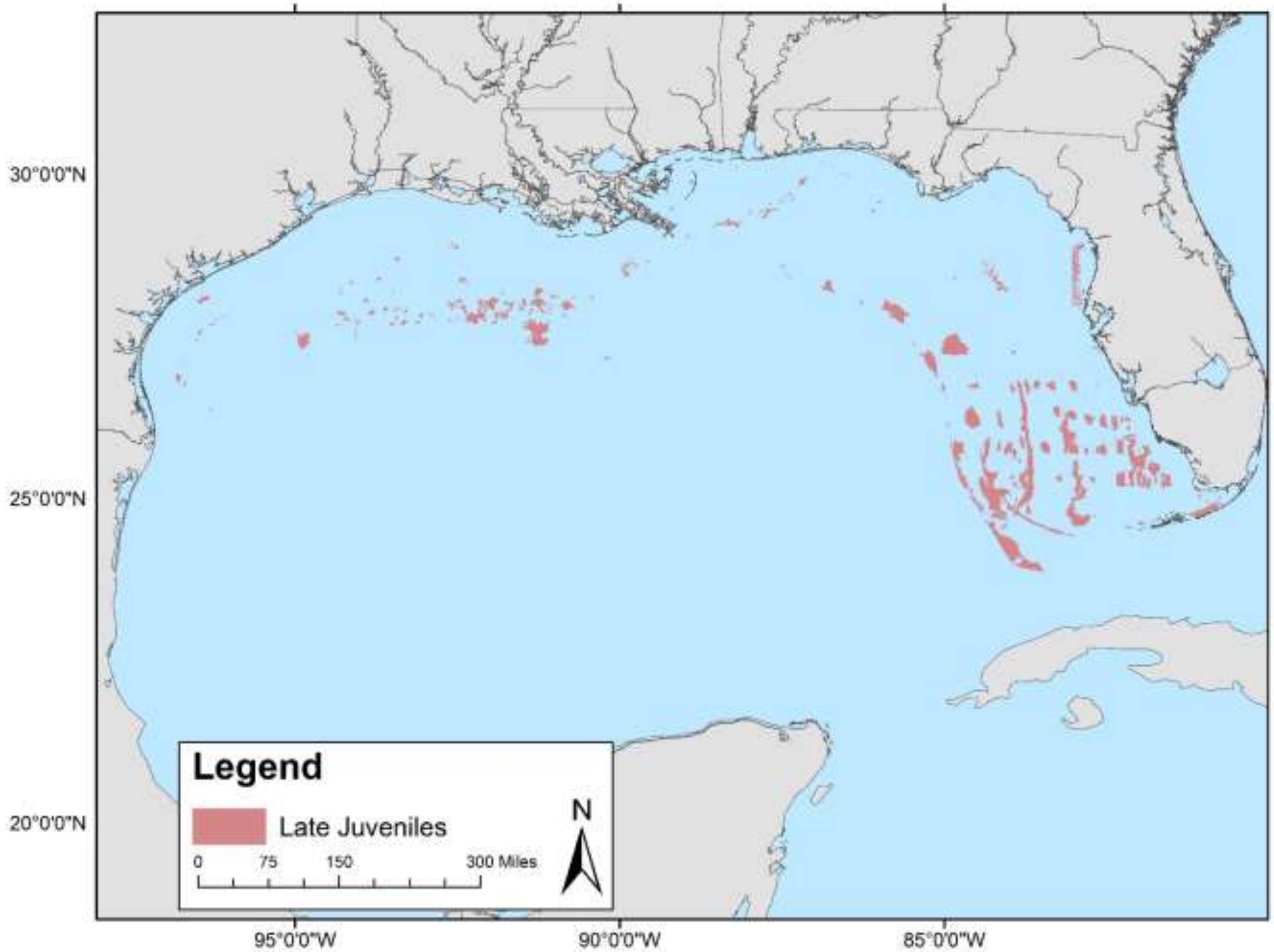

Figure B- 57. Map of benthic habitat use by late juvenile yellowedge grouper.

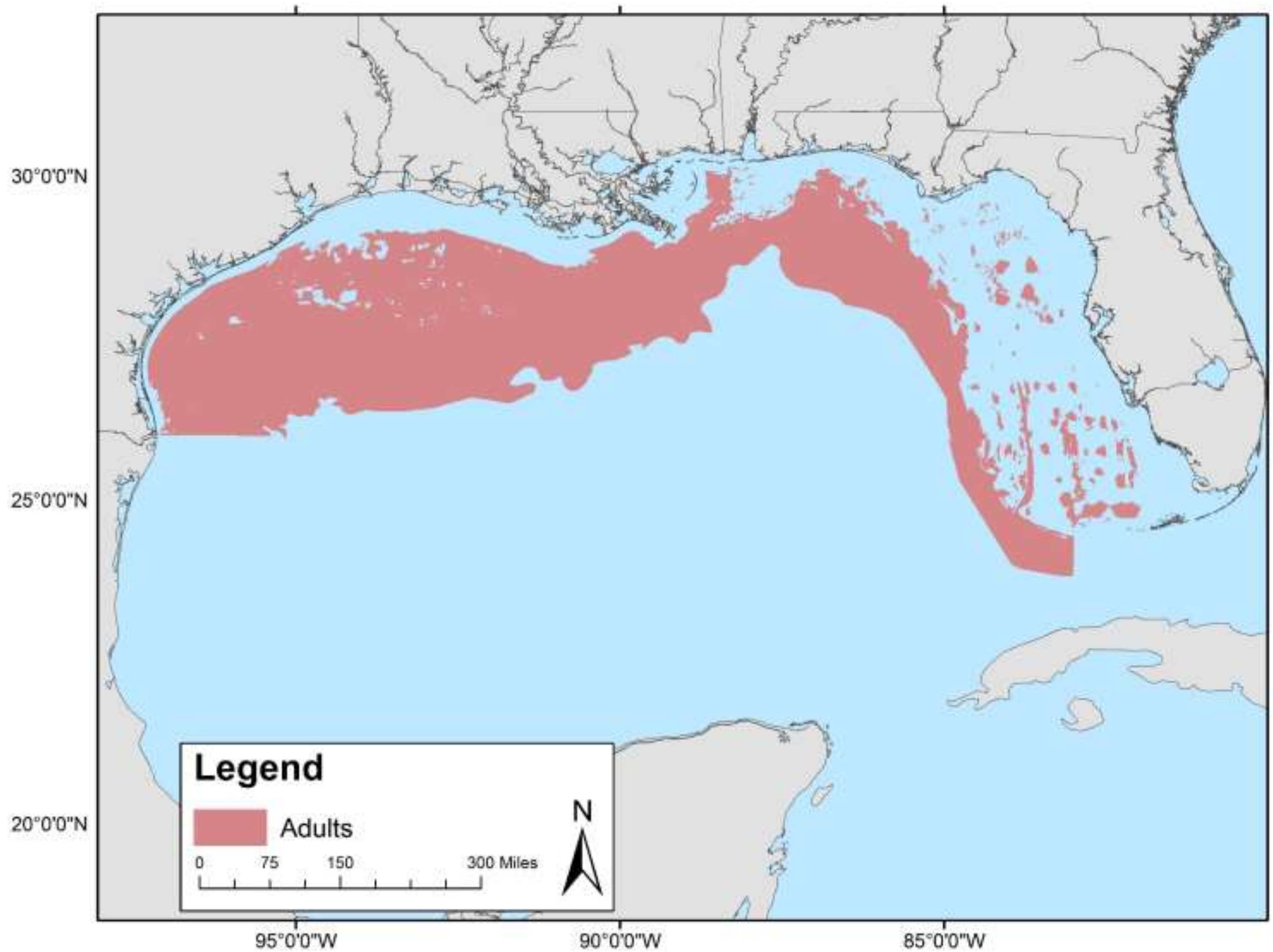

Figure B- 58. Map of benthic habitat use by adult yellowedge grouper.

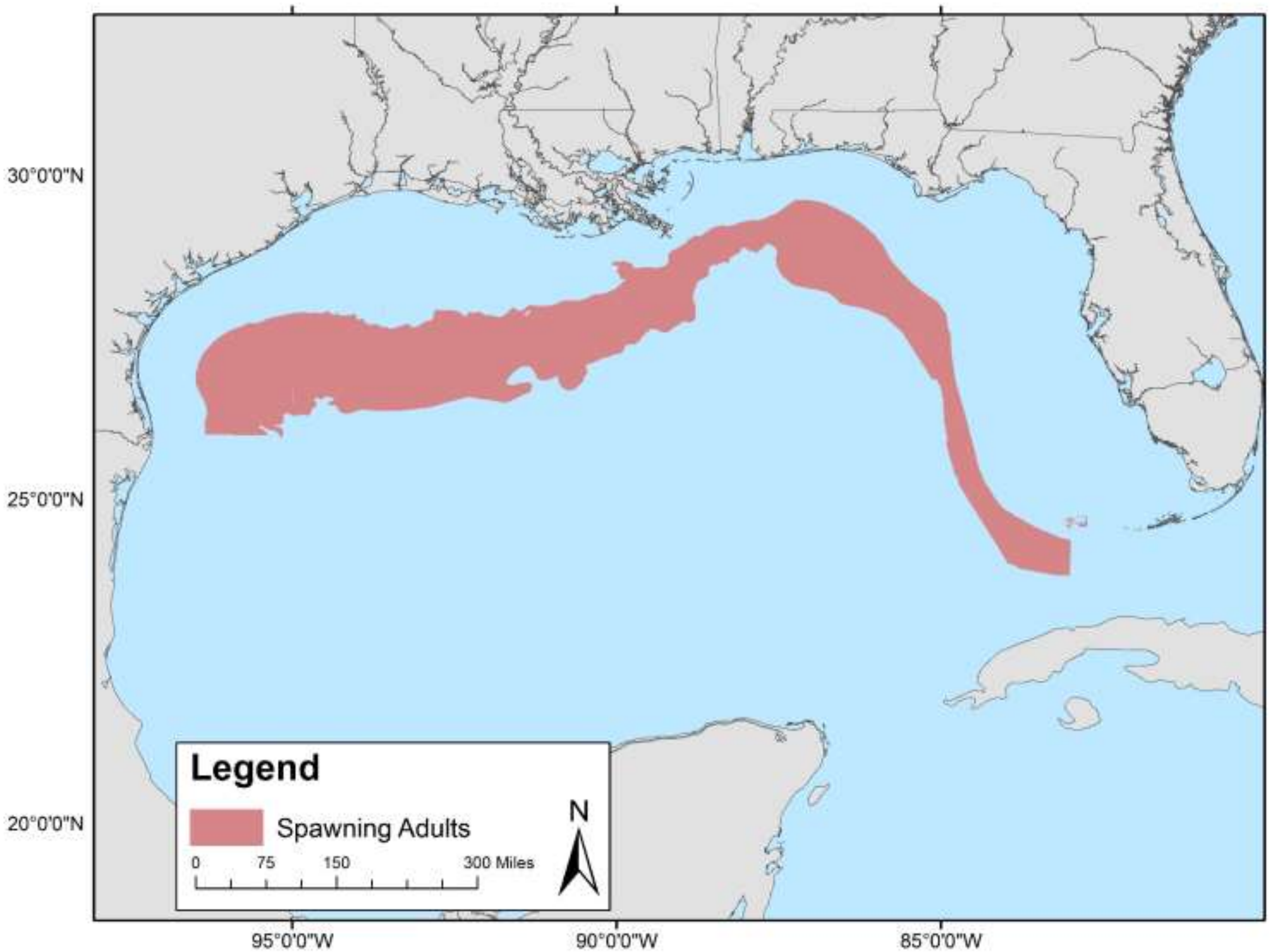

Figure B- 59. Map of benthic habitat use by spawning adult yellowedge grouper.

Warsaw Grouper (*Hyporthodus nigritus*) Benthic Habitat Use Maps

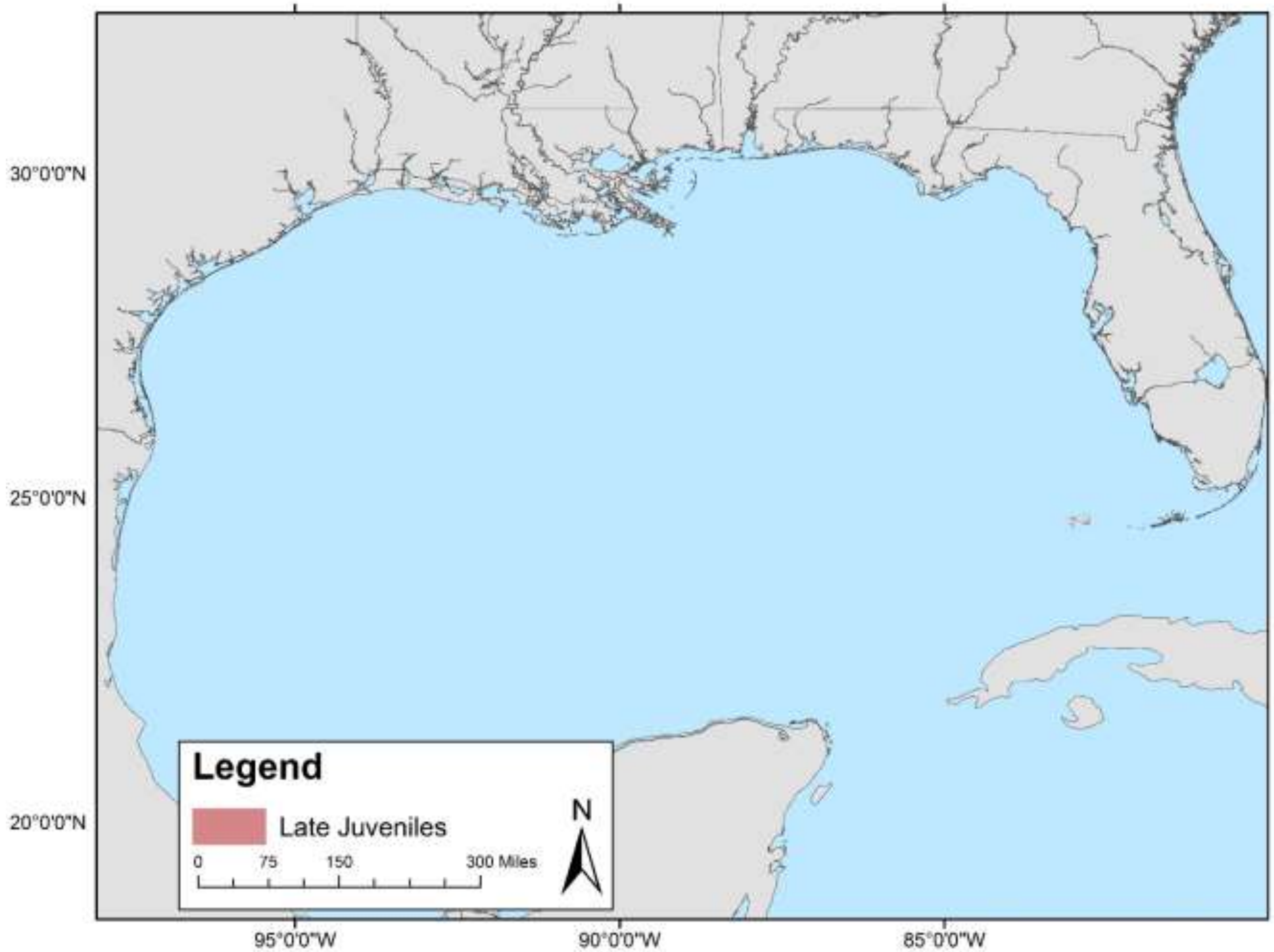

Figure B- 60. Map of benthic habitat use by late juvenile warsaw grouper.

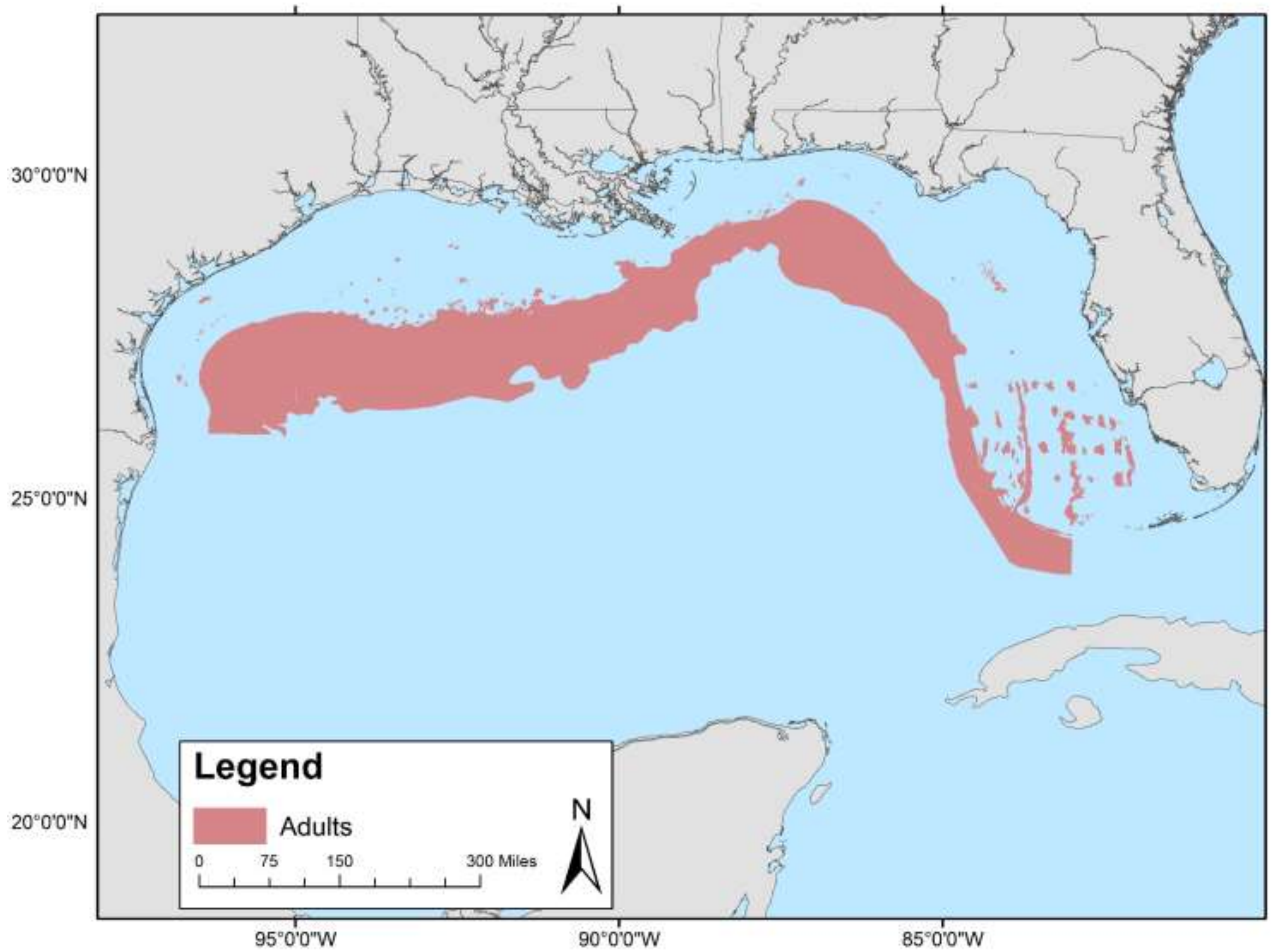

Figure B- 61. Map of benthic habitat use by adult warsaw grouper.

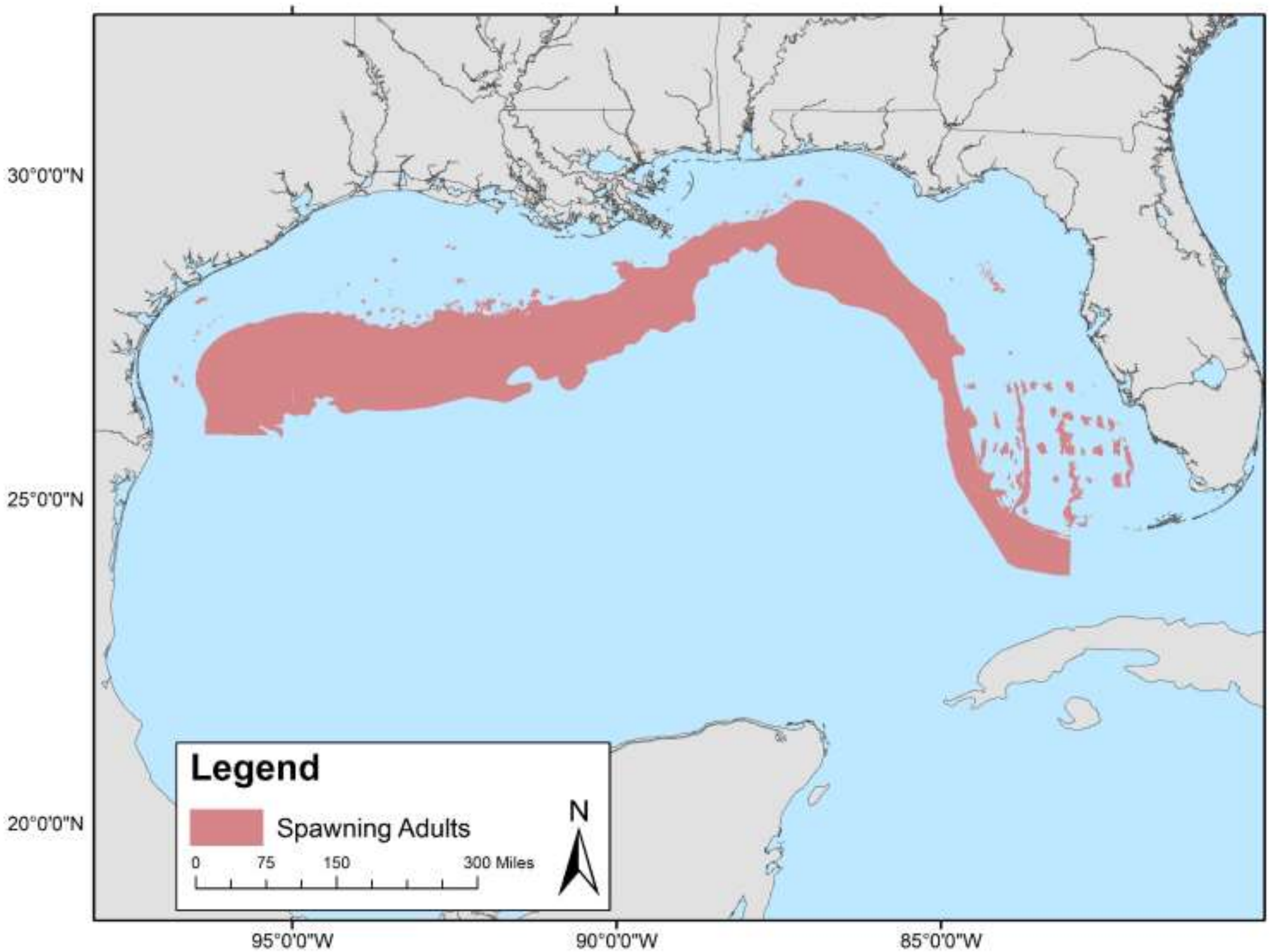

Figure B- 62. Map of benthic habitat use by spawning adult warsaw grouper.

Snowy Grouper (*Hyporthodus niveatus*) Benthic Habitat Use Maps

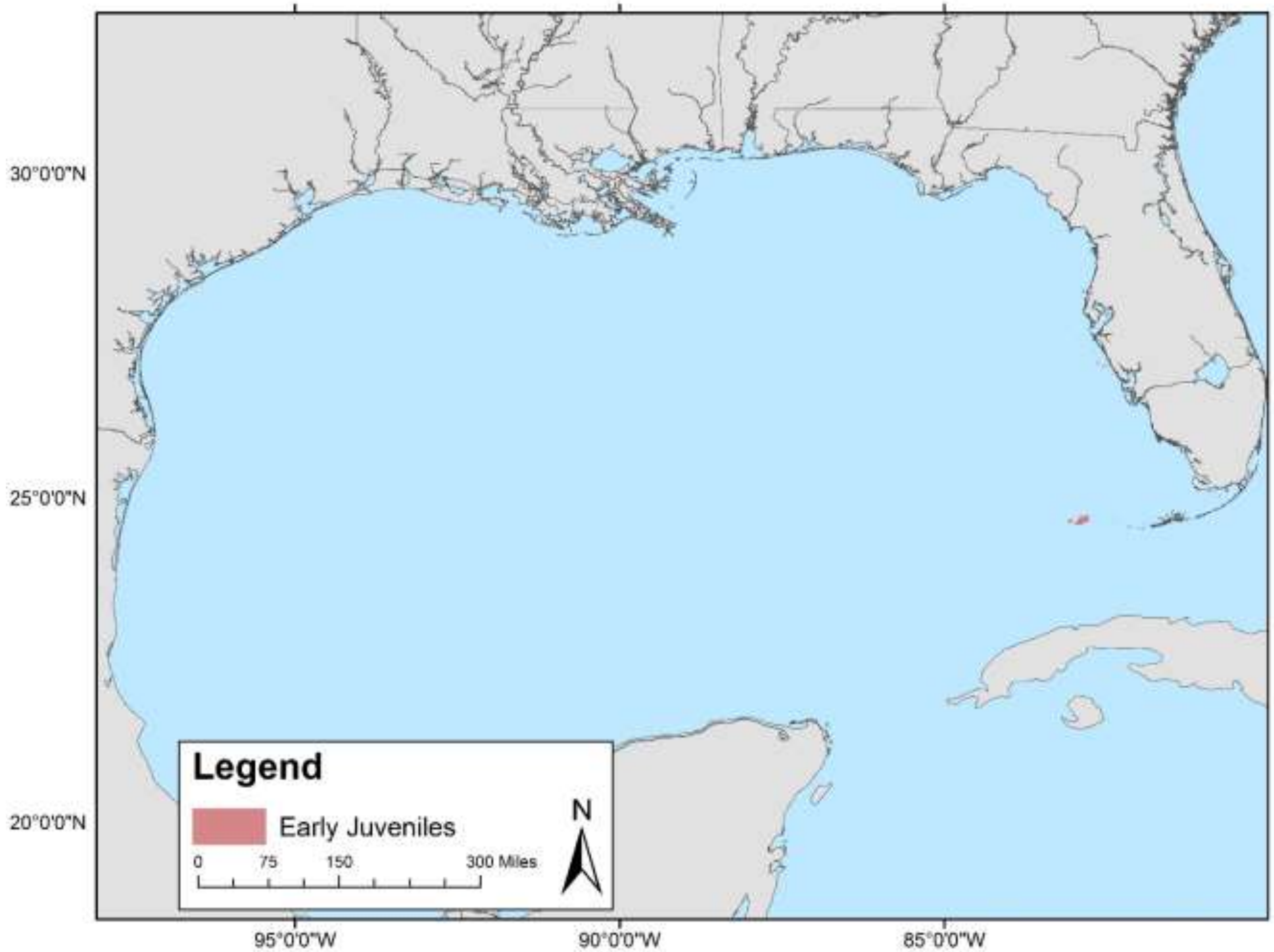

Figure B- 63. Map of benthic habitat use by early juvenile snowy grouper.

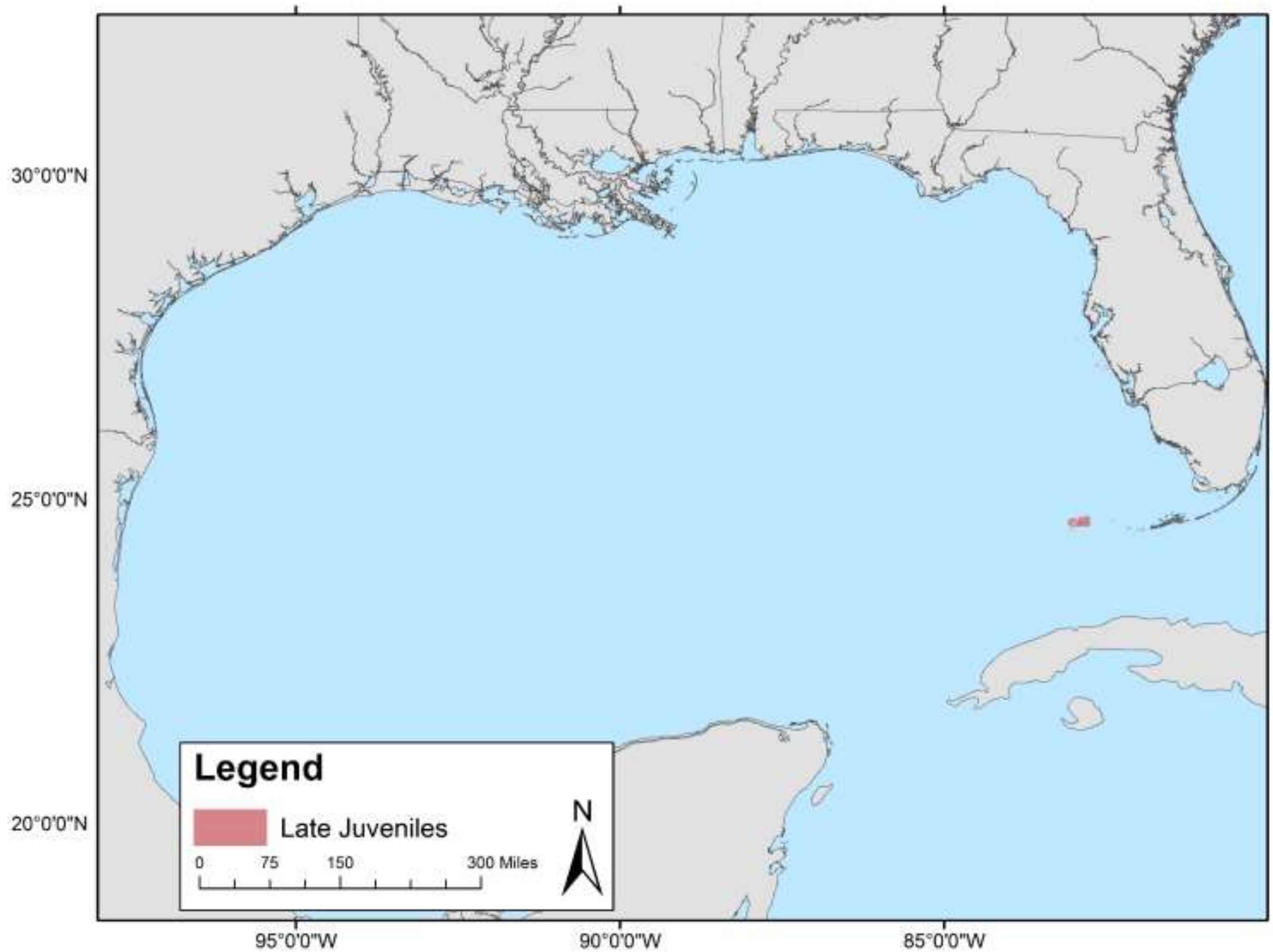

Figure B- 64. Map of benthic habitat use by late juvenile snowy grouper.

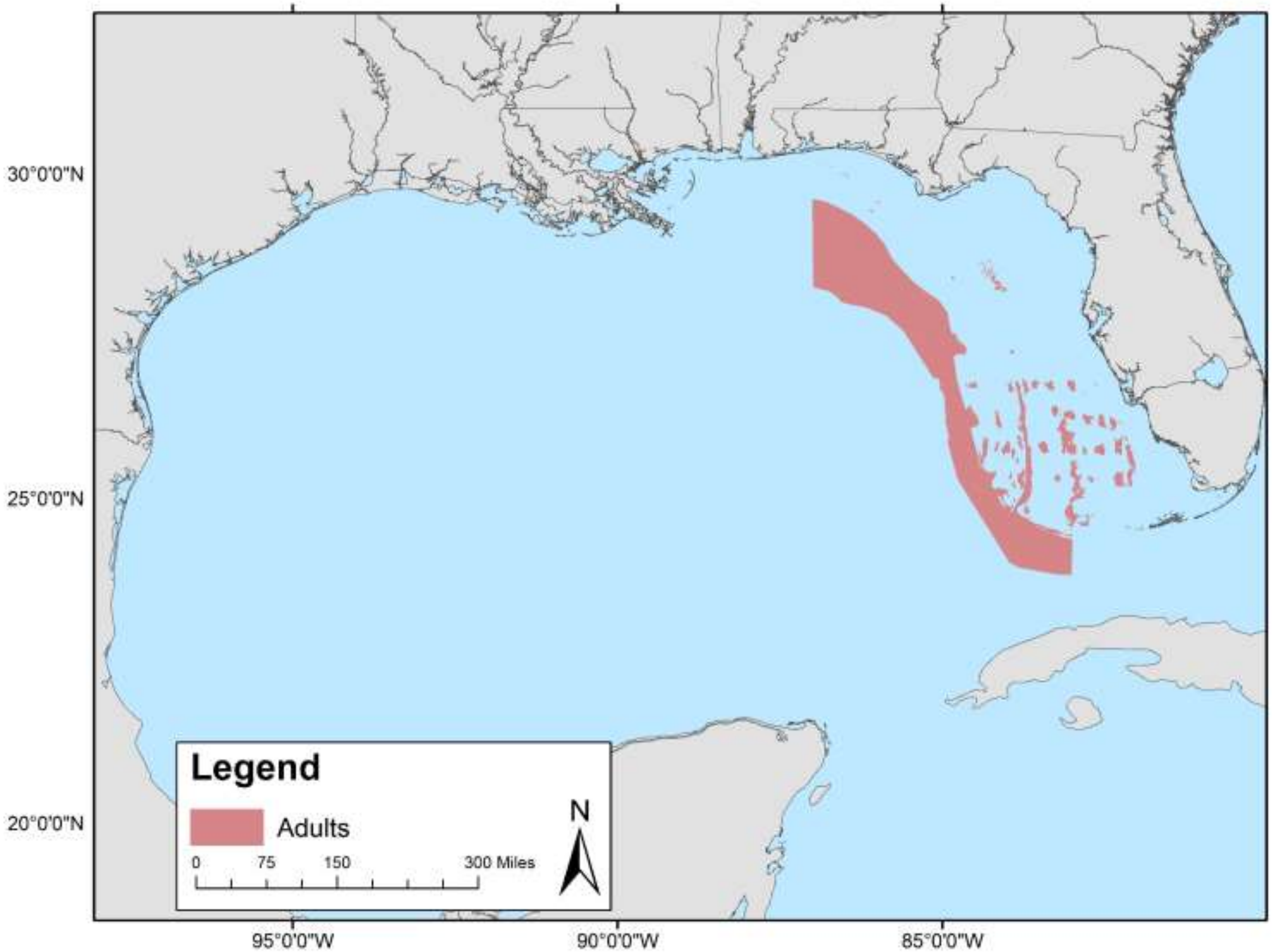

Figure B- 65. Map of benthic habitat use by adult snowy grouper.

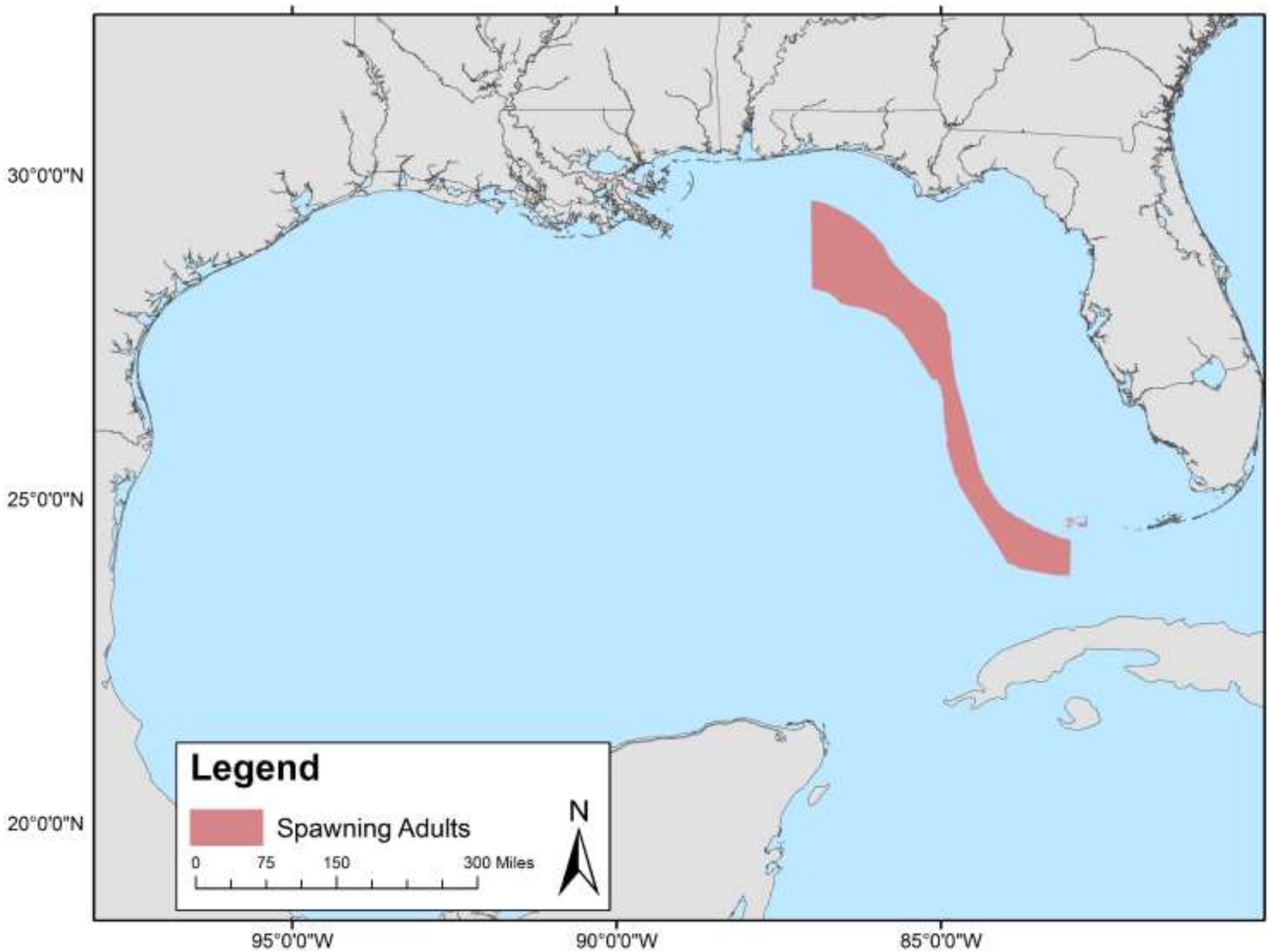

Figure B- 66. Map of benthic habitat use by spawning adult snowy grouper.

Black Grouper (*Mycteroperca bonaci*) Benthic Habitat Use Maps

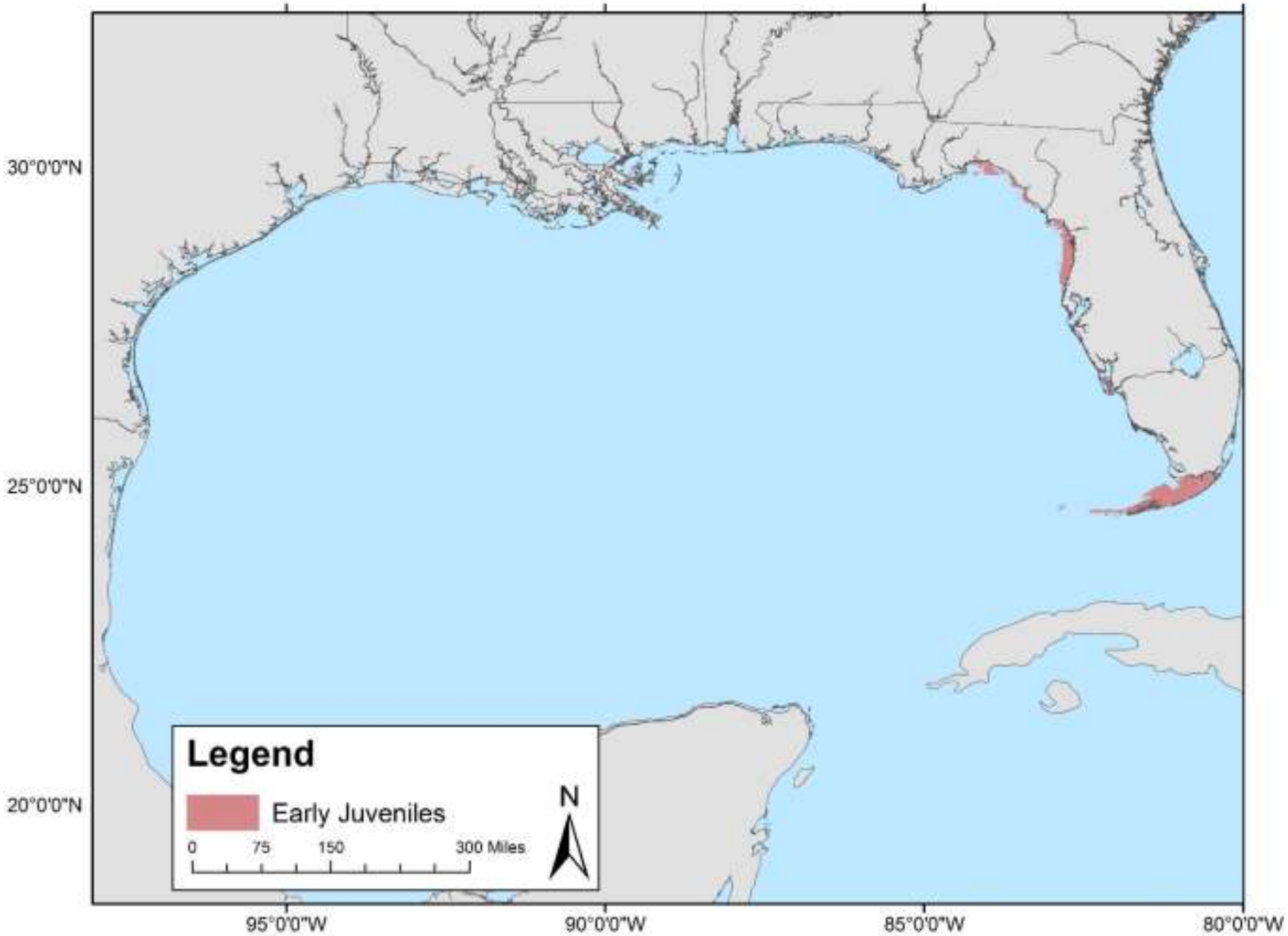

Figure B- 67. Map of benthic habitat use by early juvenile black grouper.

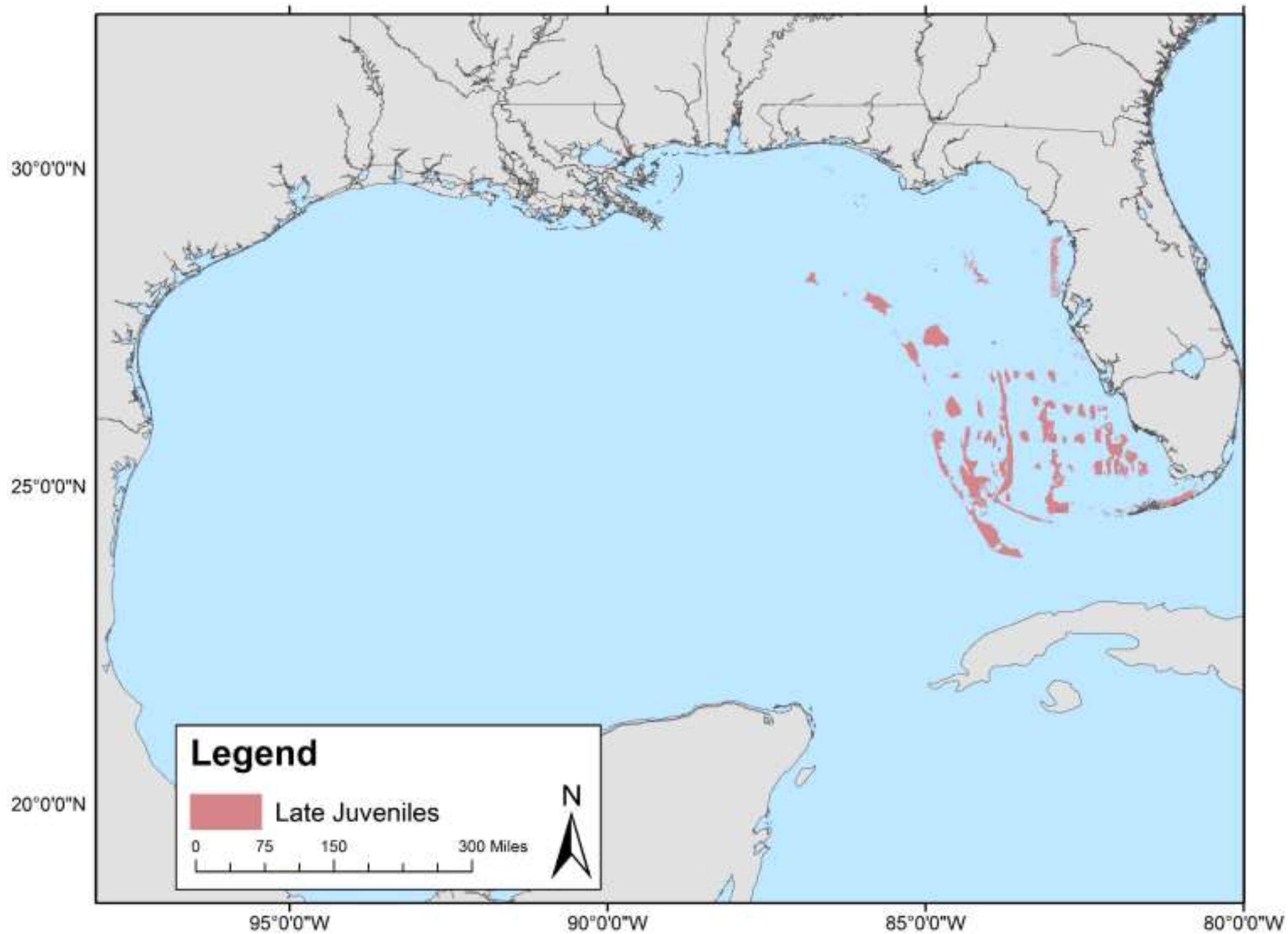

Figure B- 68. Map of benthic habitat use by late juvenile black grouper.

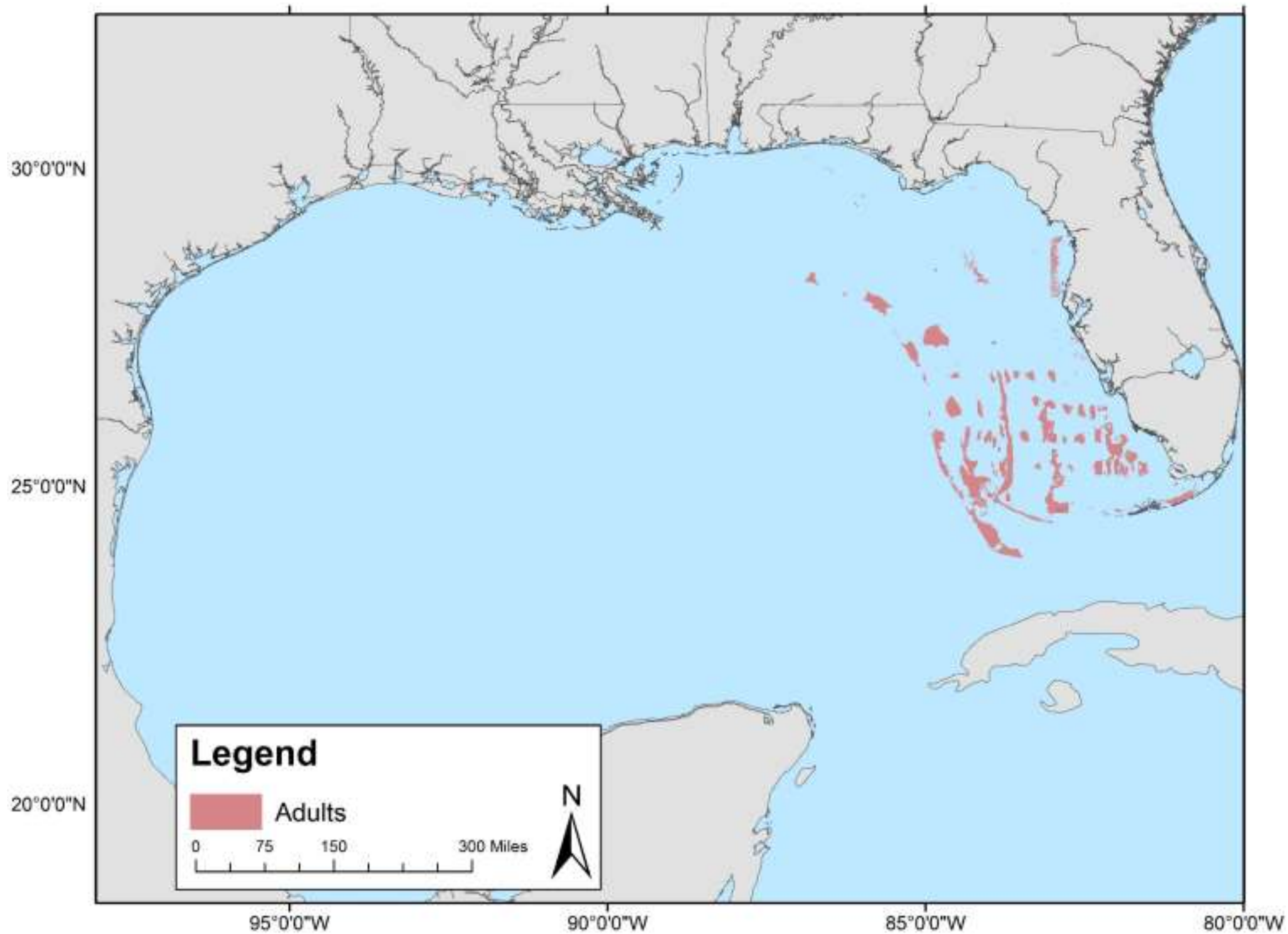

Figure B- 69. Map of benthic habitat use by adult black grouper.

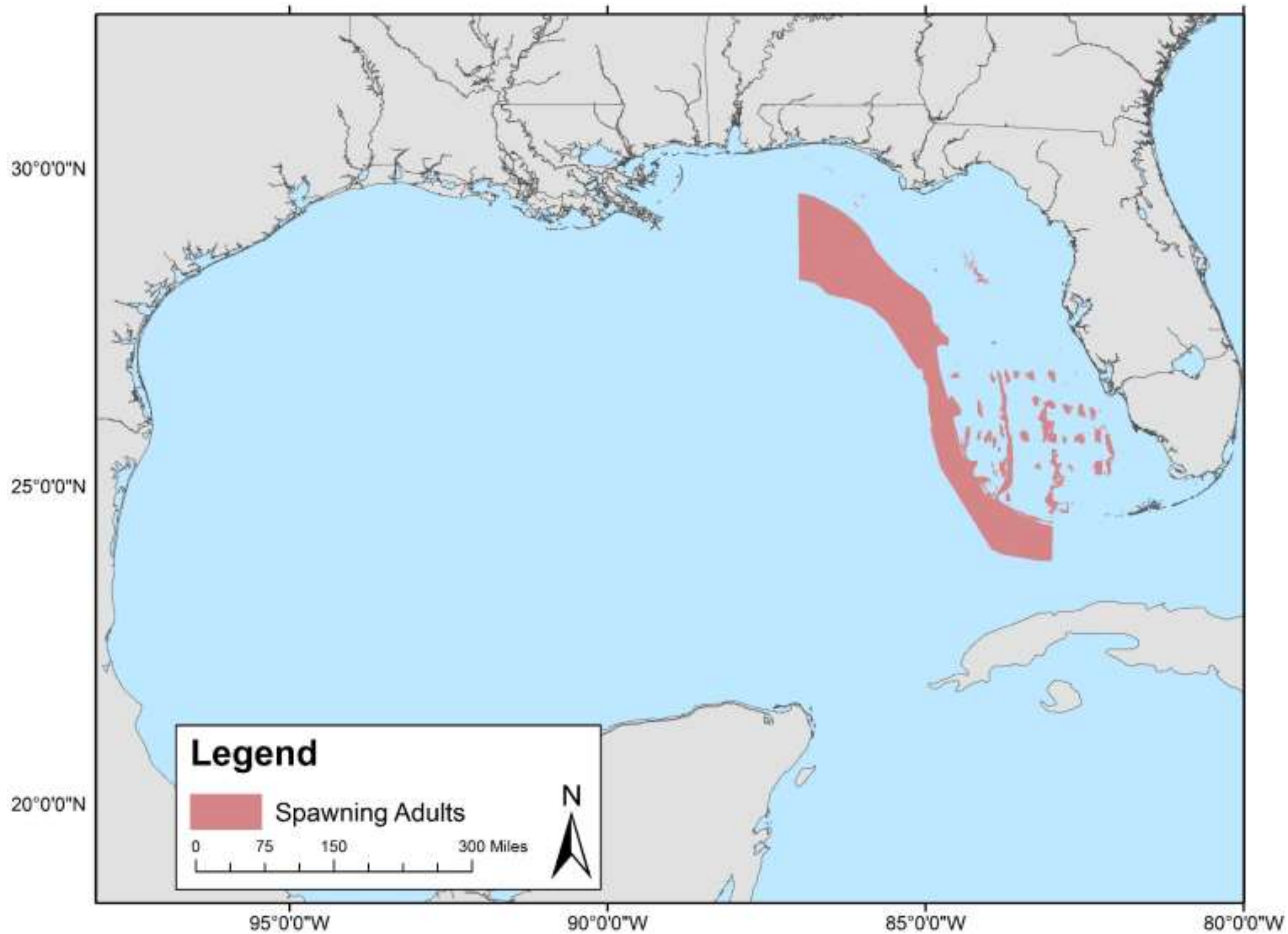

Figure B- 70. Map of benthic habitat use by spawning adult black grouper.

Yellowmouth Grouper (*Mycteroperca interstitialis*) Benthic Habitat Use Maps

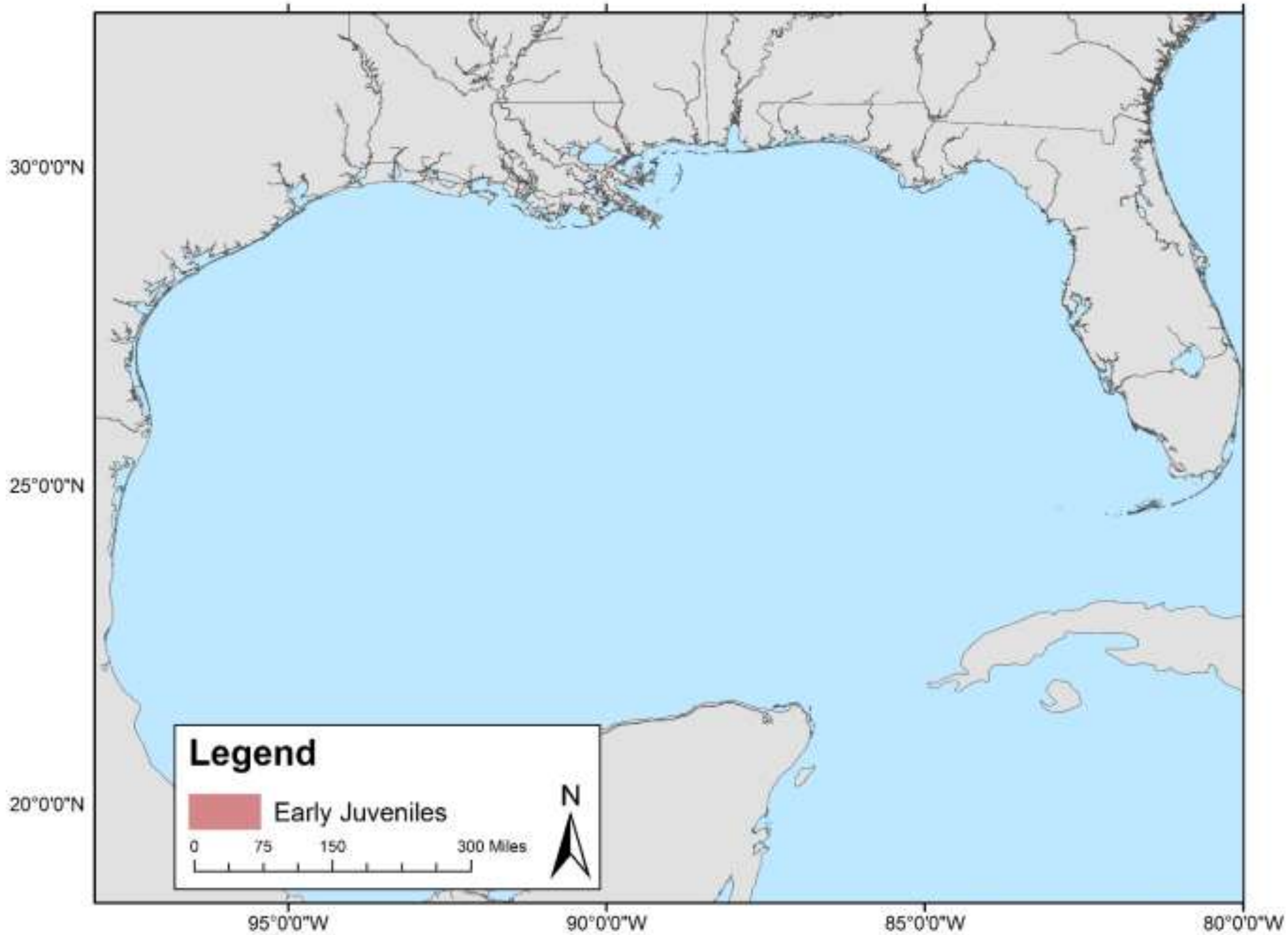

Figure B- 71. Map of benthic habitat use by early juvenile yellowmouth grouper.

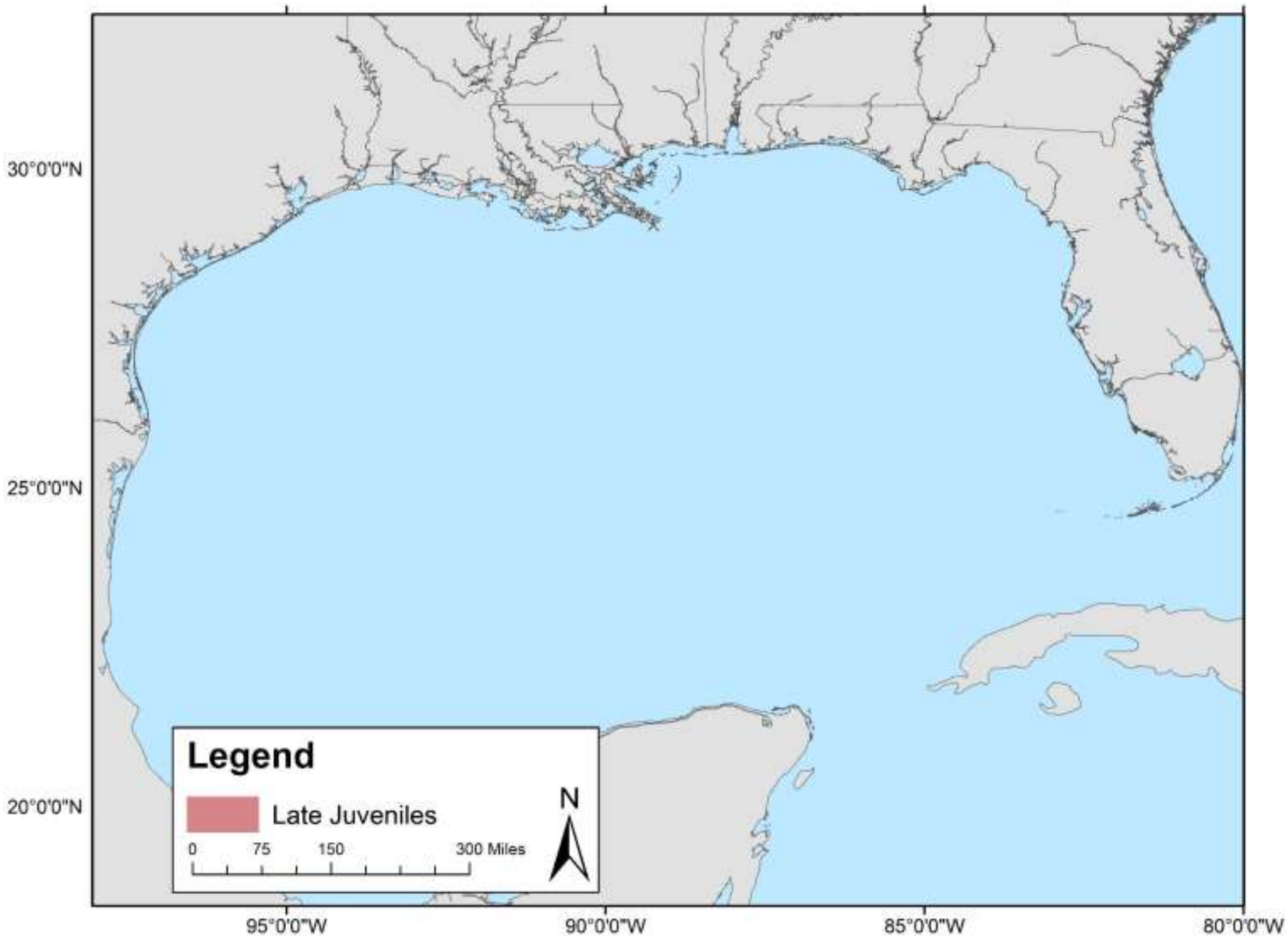

Figure B- 72. Map of benthic habitat use by late juvenile yellowmouth grouper.

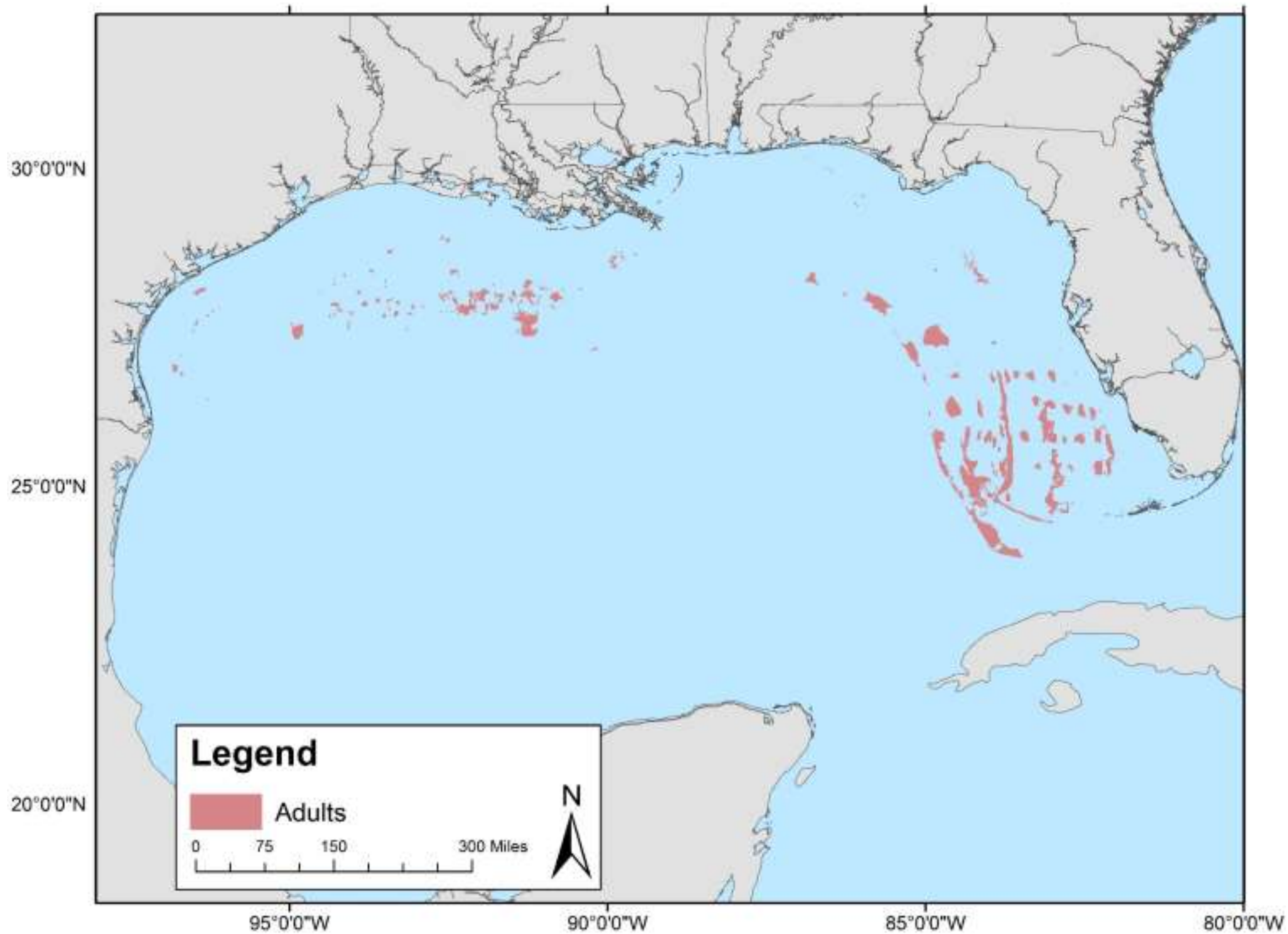

Figure B- 73. Map of benthic habitat use by adult yellowmouth grouper.

Gag (*Mycteroperca microlepis*) Benthic Habitat Use Maps

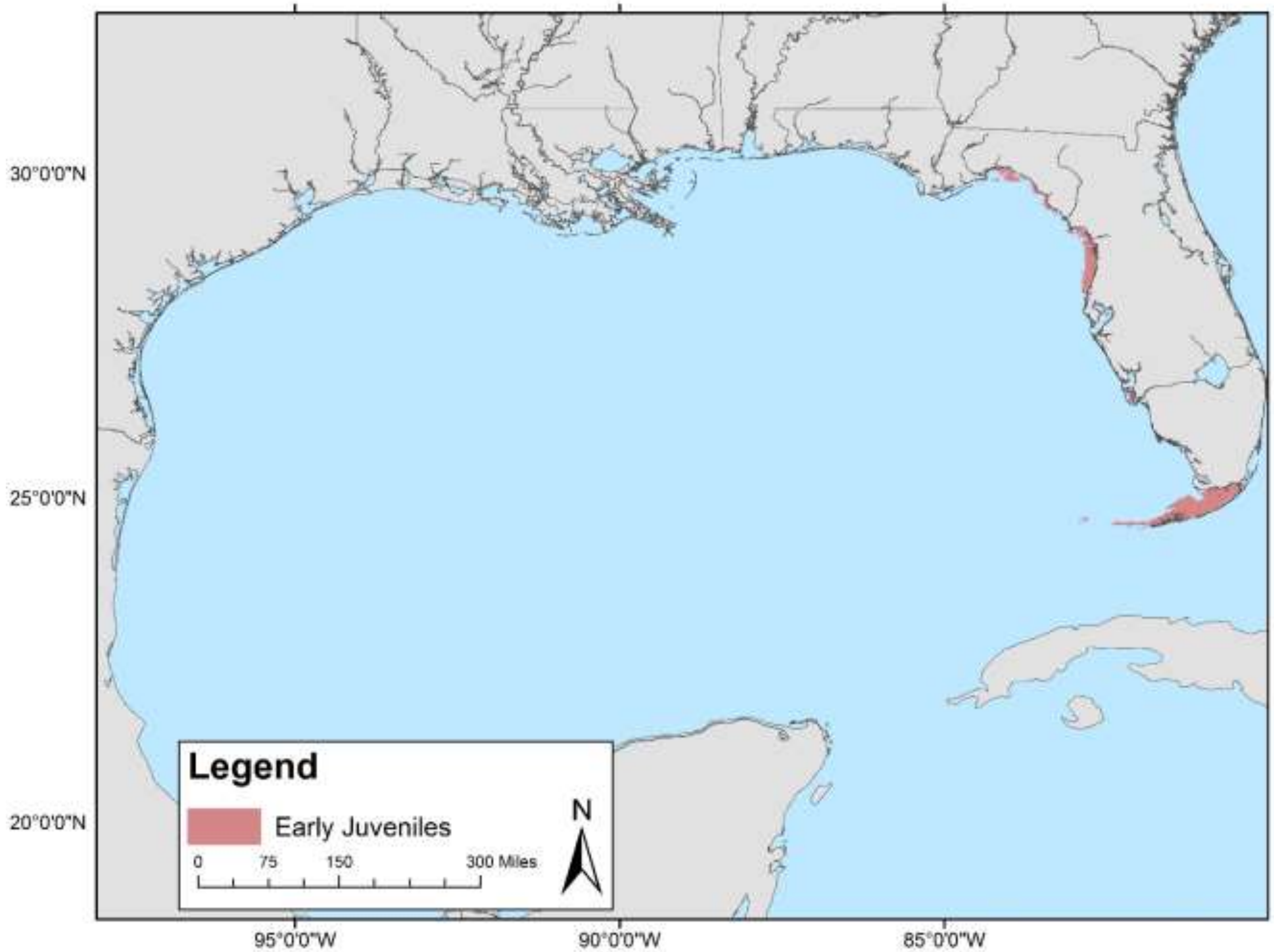

Figure B- 74. Map of benthic habitat use by early juvenile gag.

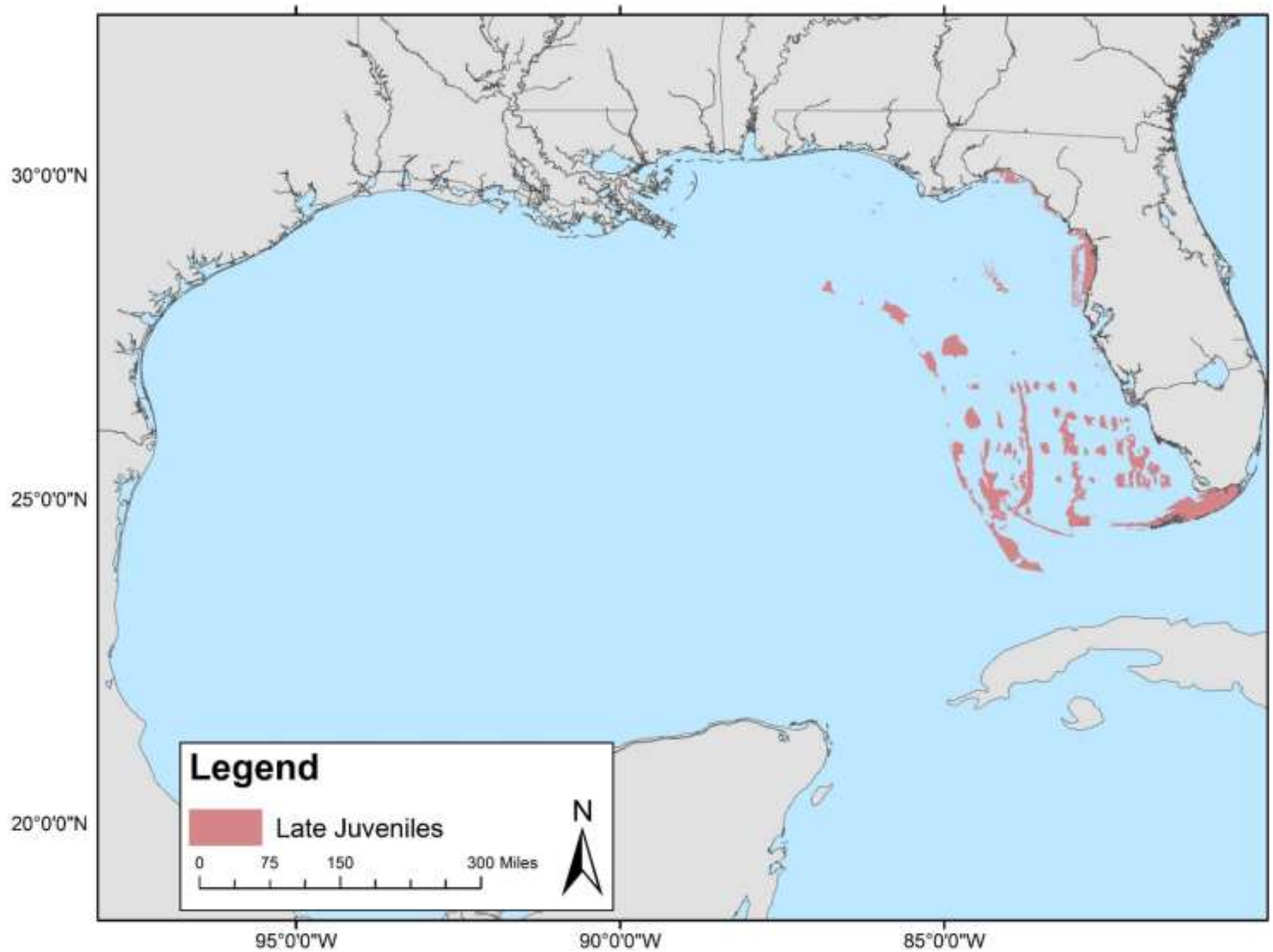

Figure B- 75. Map of benthic habitat use by late juvenile gag.

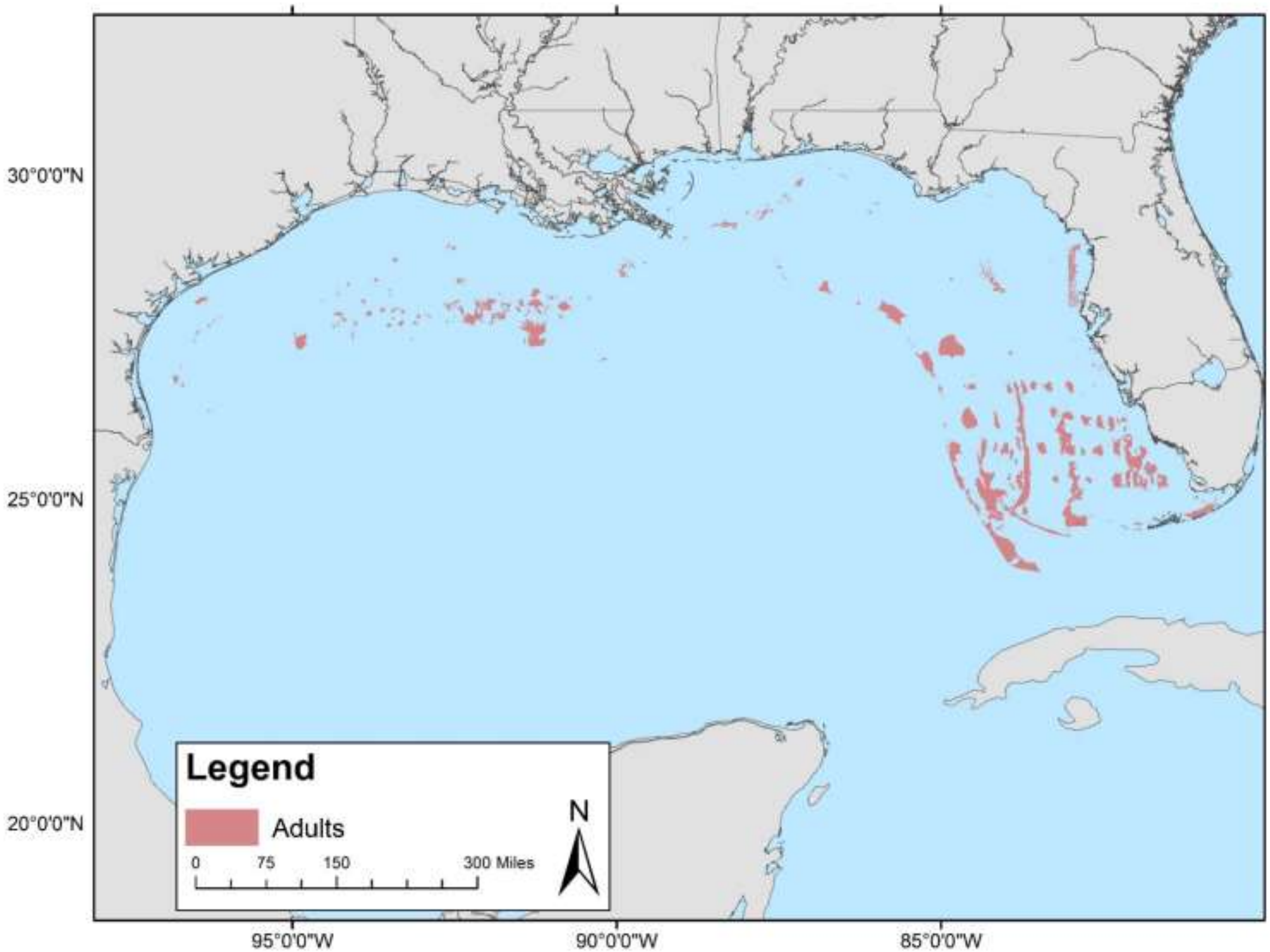

Figure B- 76. Map of benthic habitat use by adult gag.

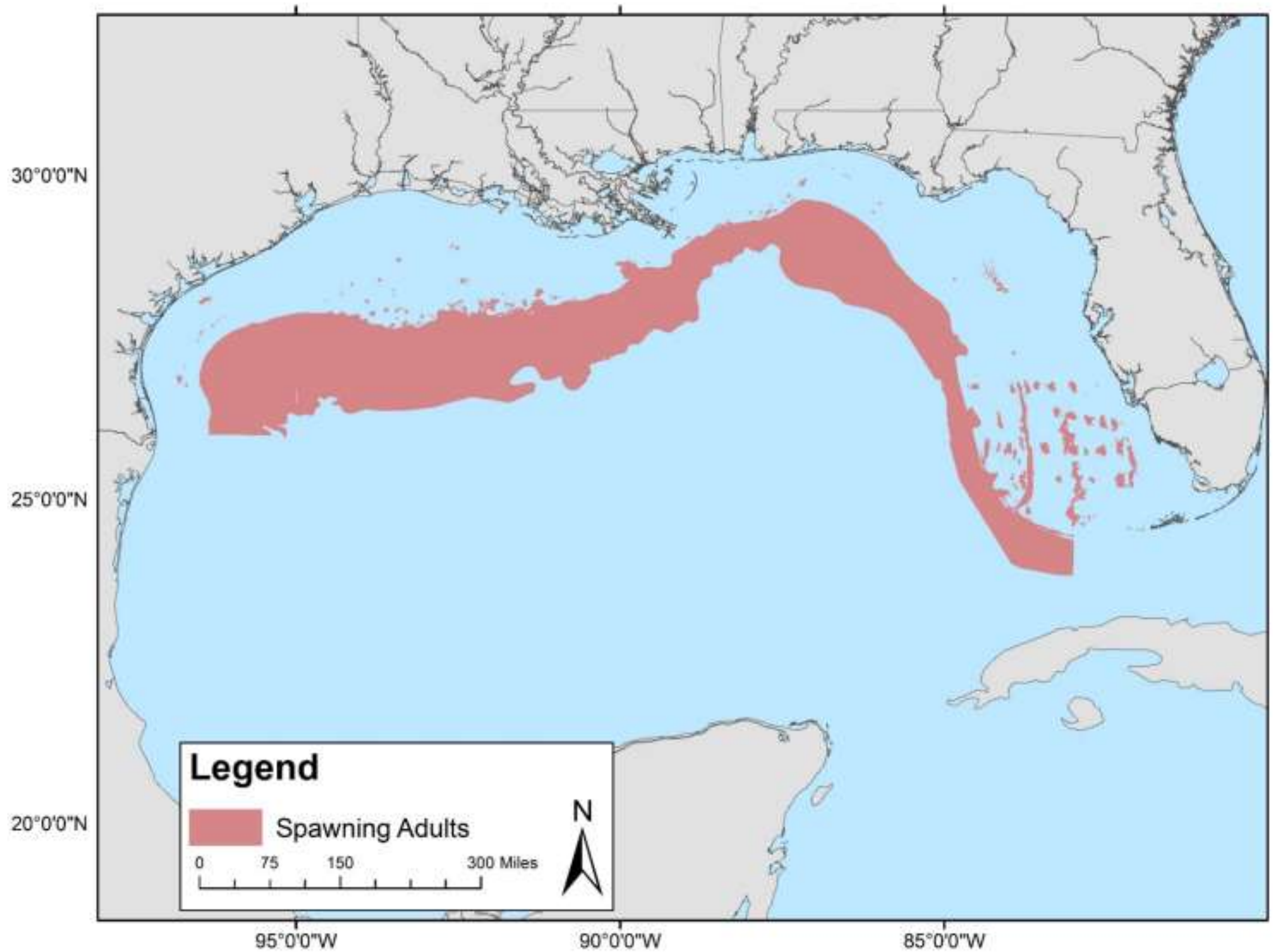

Figure B- 77. Map of benthic habitat use by spawning adult gag.

Scamp (*Mycteroperca phenax*) Benthic Habitat Use Maps

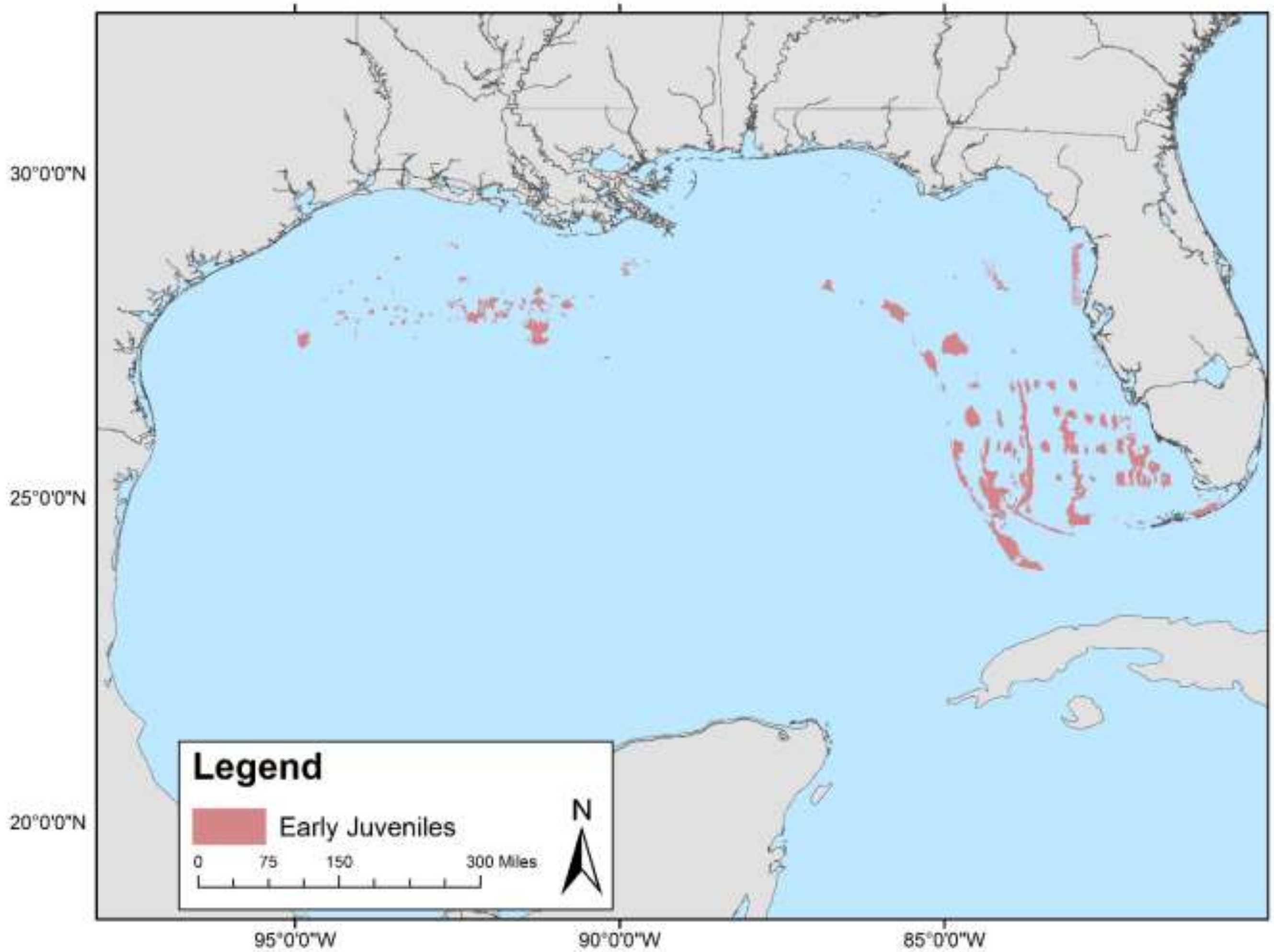

Figure B- 78. Map of benthic habitat use by early juvenile scamp.

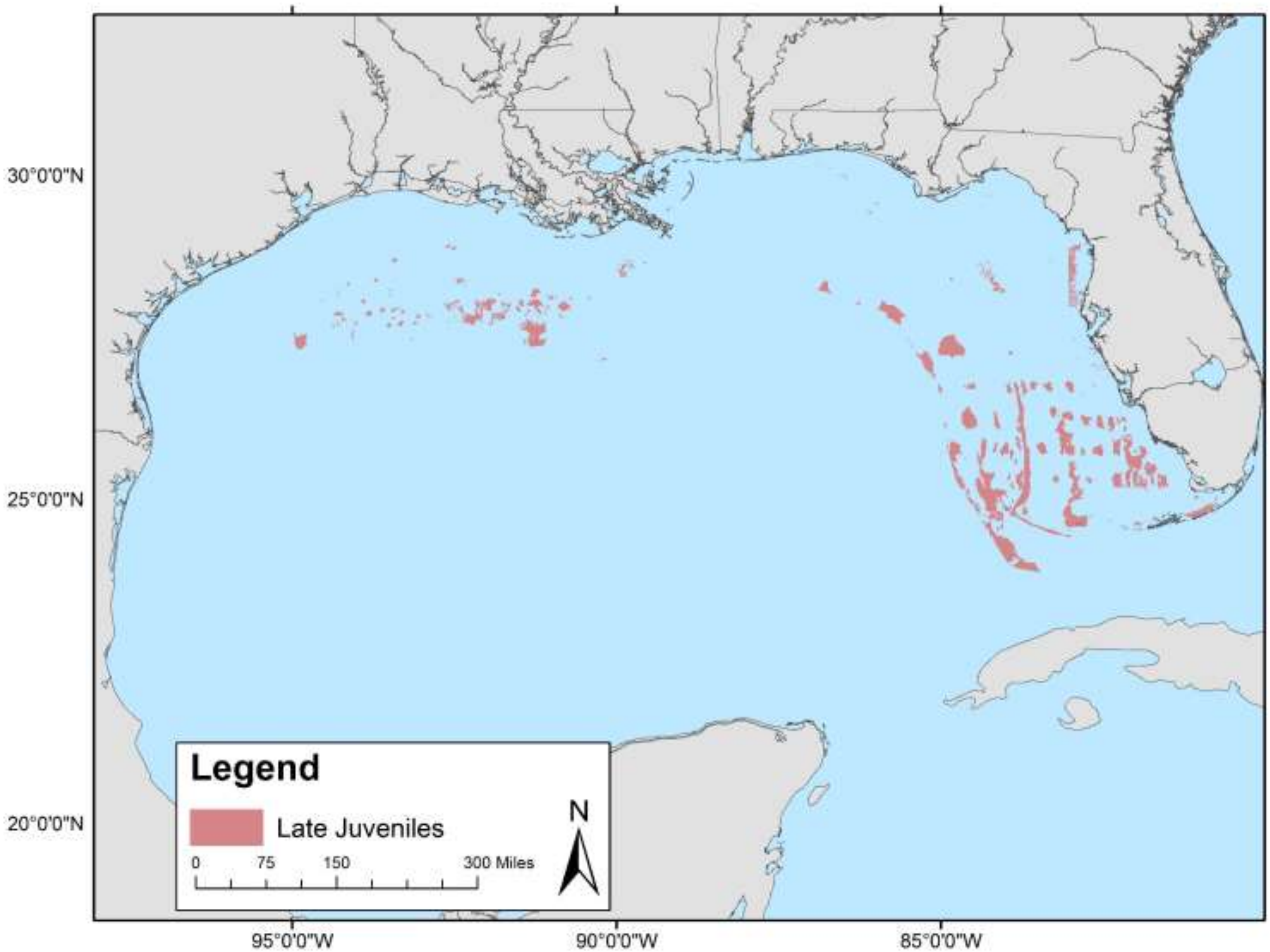

Figure B- 79. Map of benthic habitat use by late juvenile scamp.

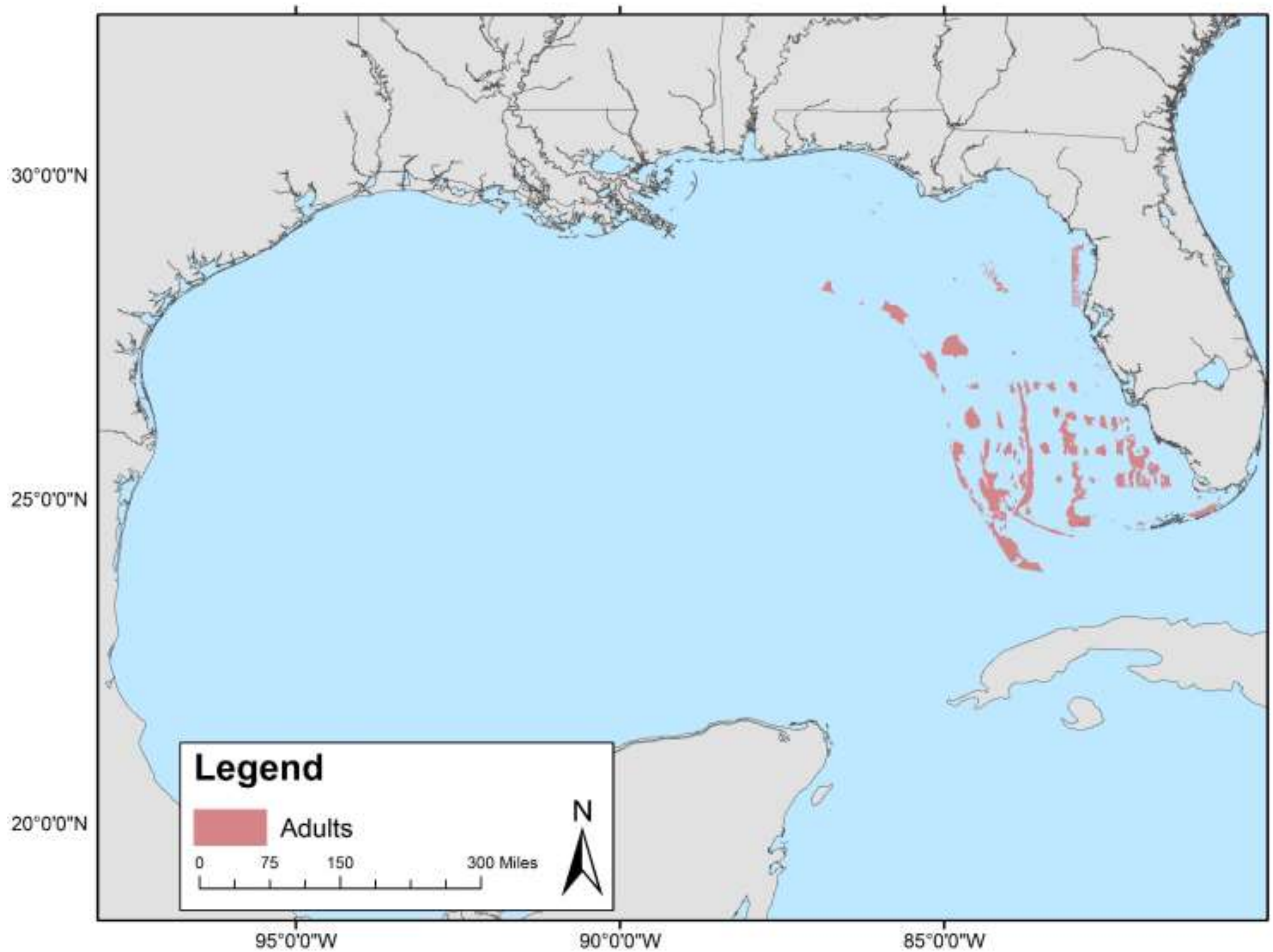

Figure B- 80. Map of benthic habitat use by adult scamp.

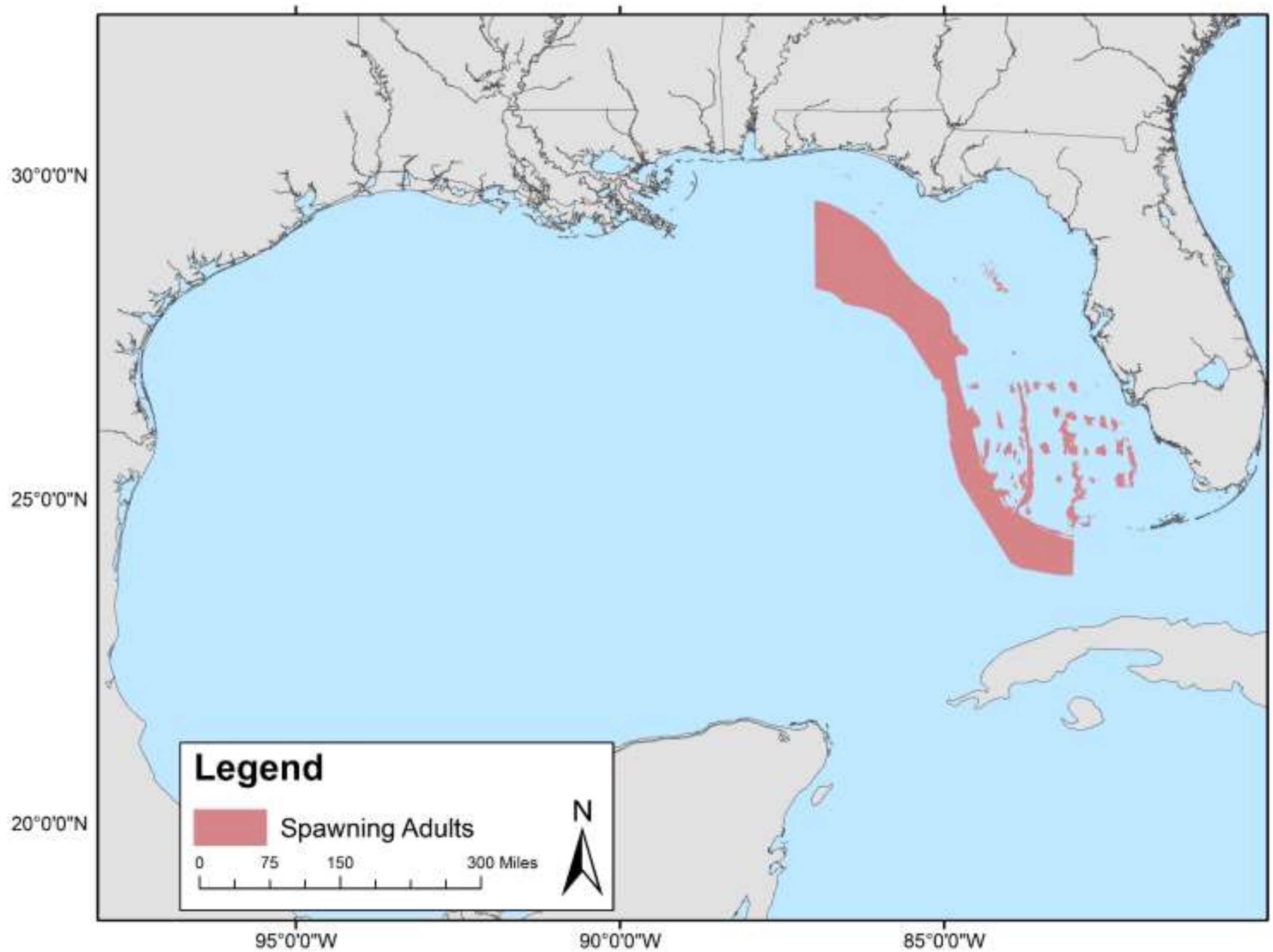

Figure B- 81. Map of benthic habitat use by spawning adult scamp.

Yellowfin Grouper (*Mycteroperca venenosa*) Benthic Habitat Use Maps

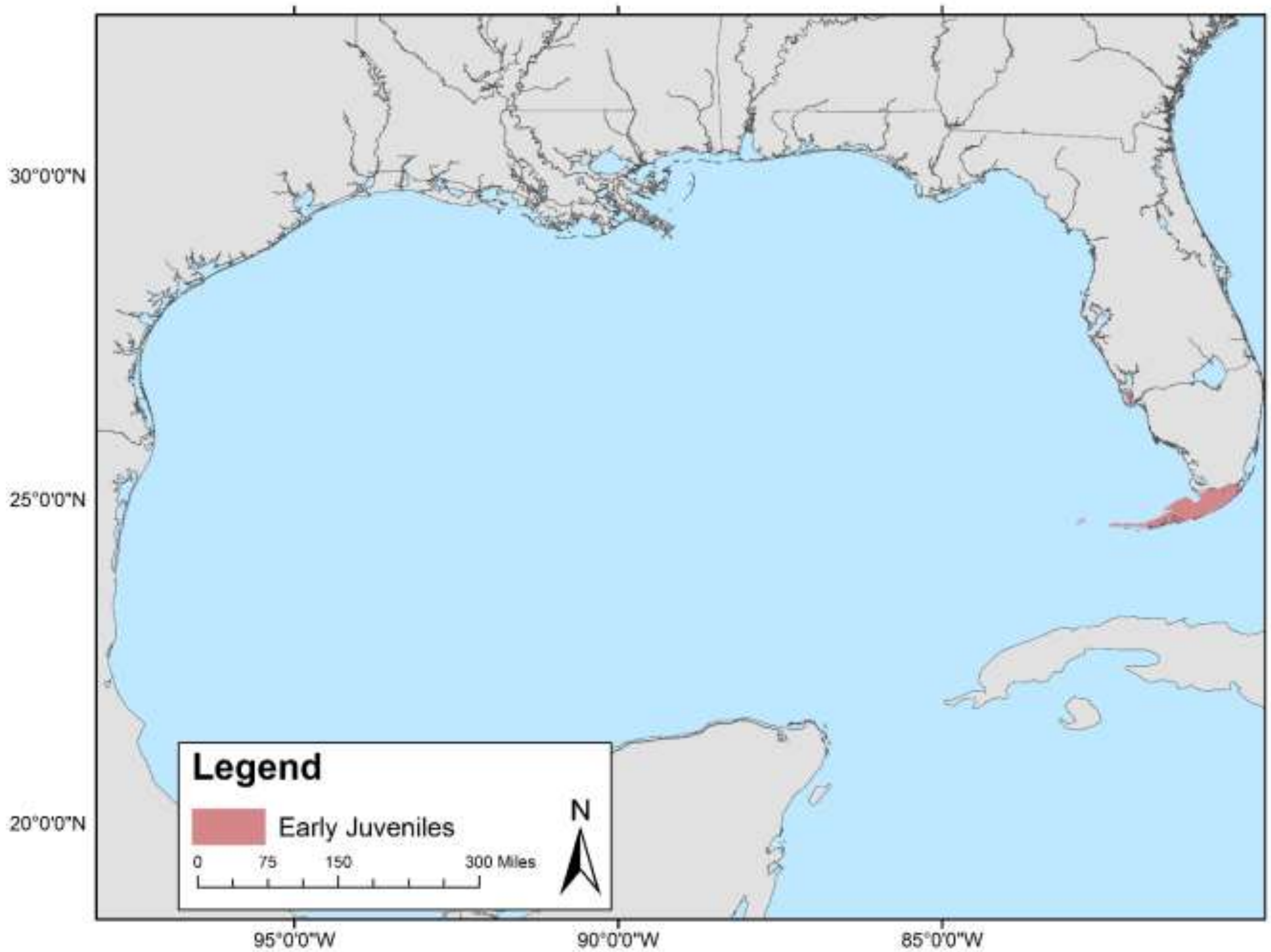

Figure B- 82. Map of benthic habitat use by early juvenile yellowfin grouper.

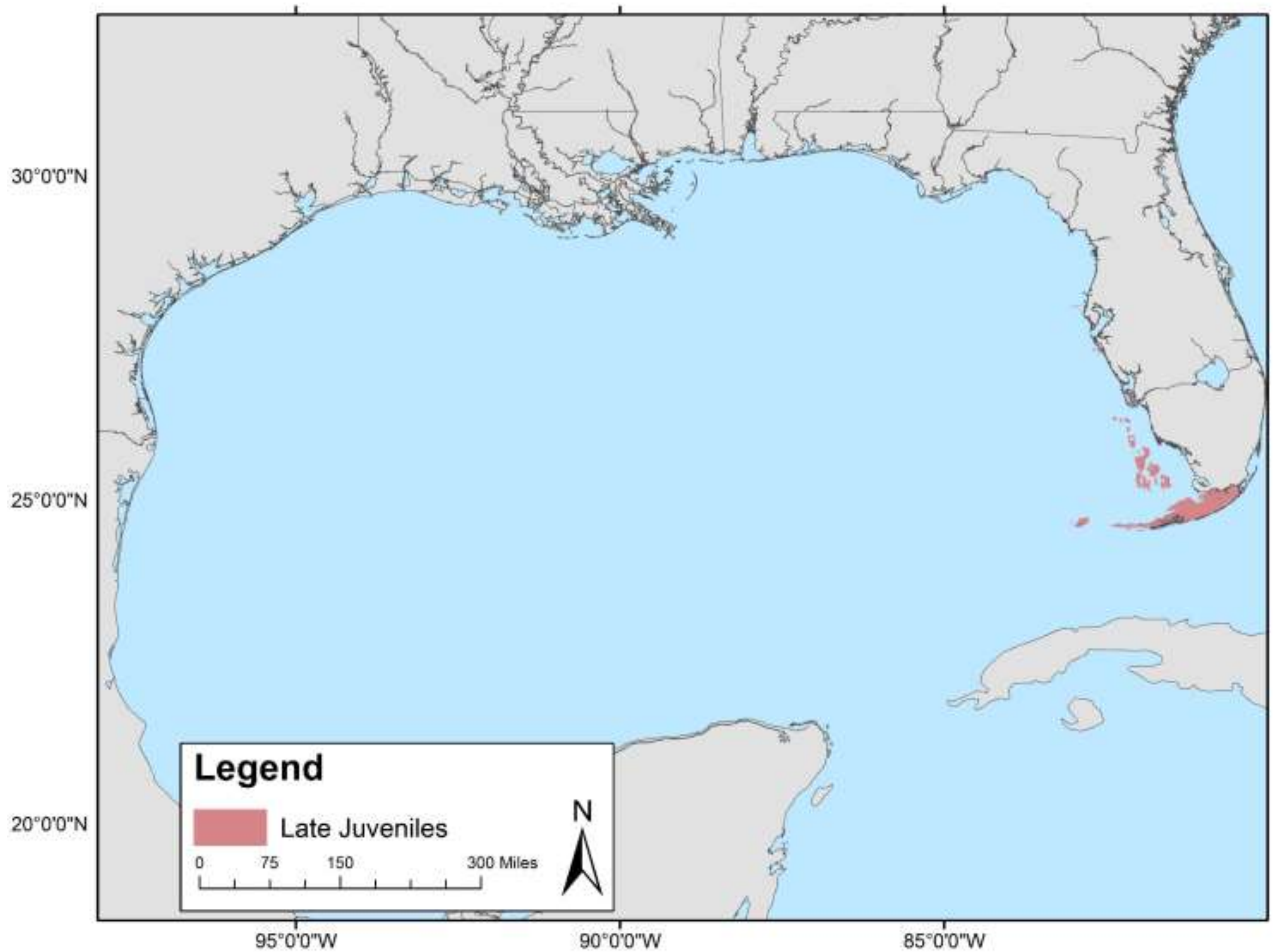

Figure B- 83. Map of benthic habitat use by late juvenile yellowfin grouper.

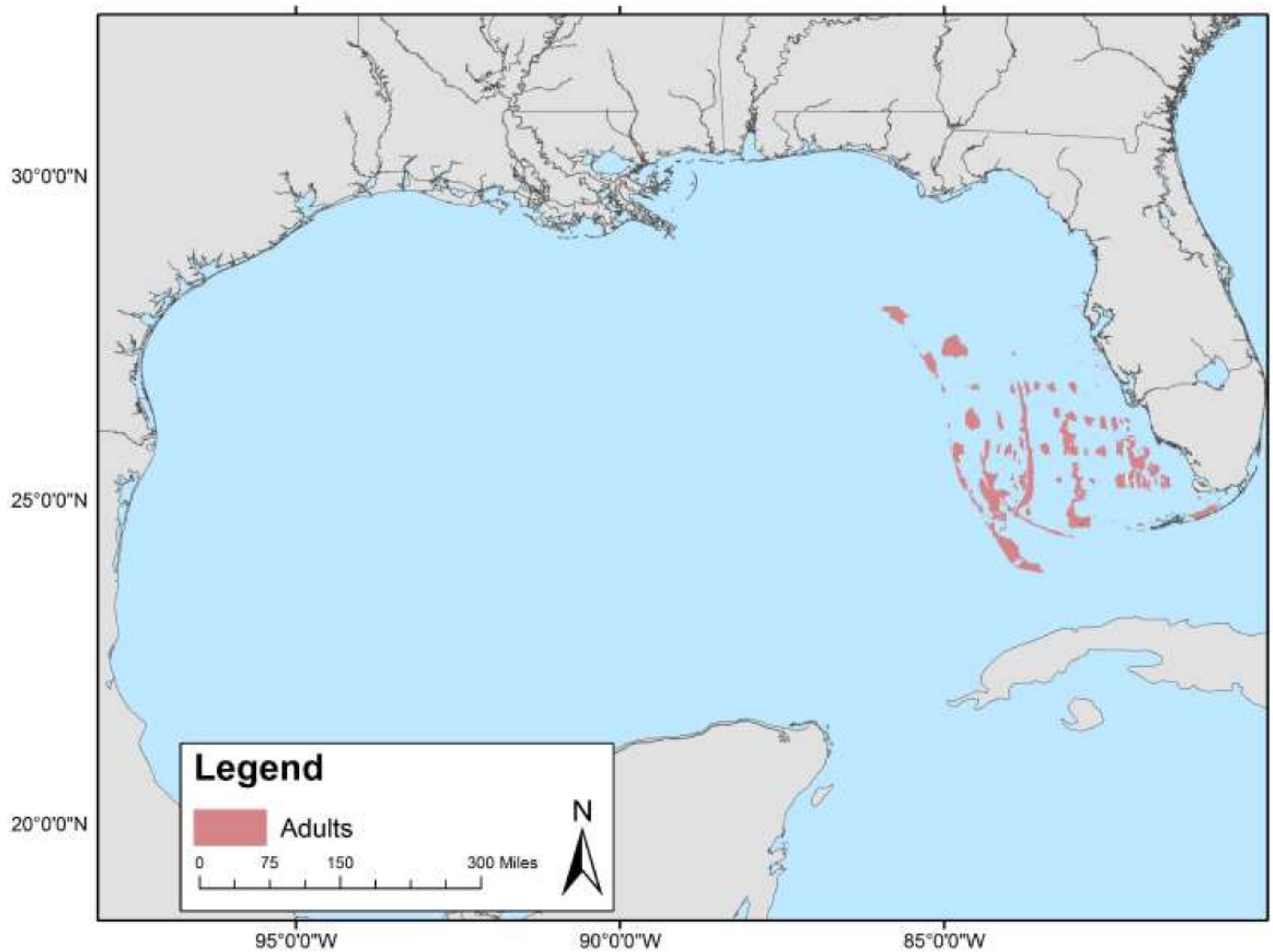

Figure B- 84. Map of benthic habitat use by adult yellowfin grouper.

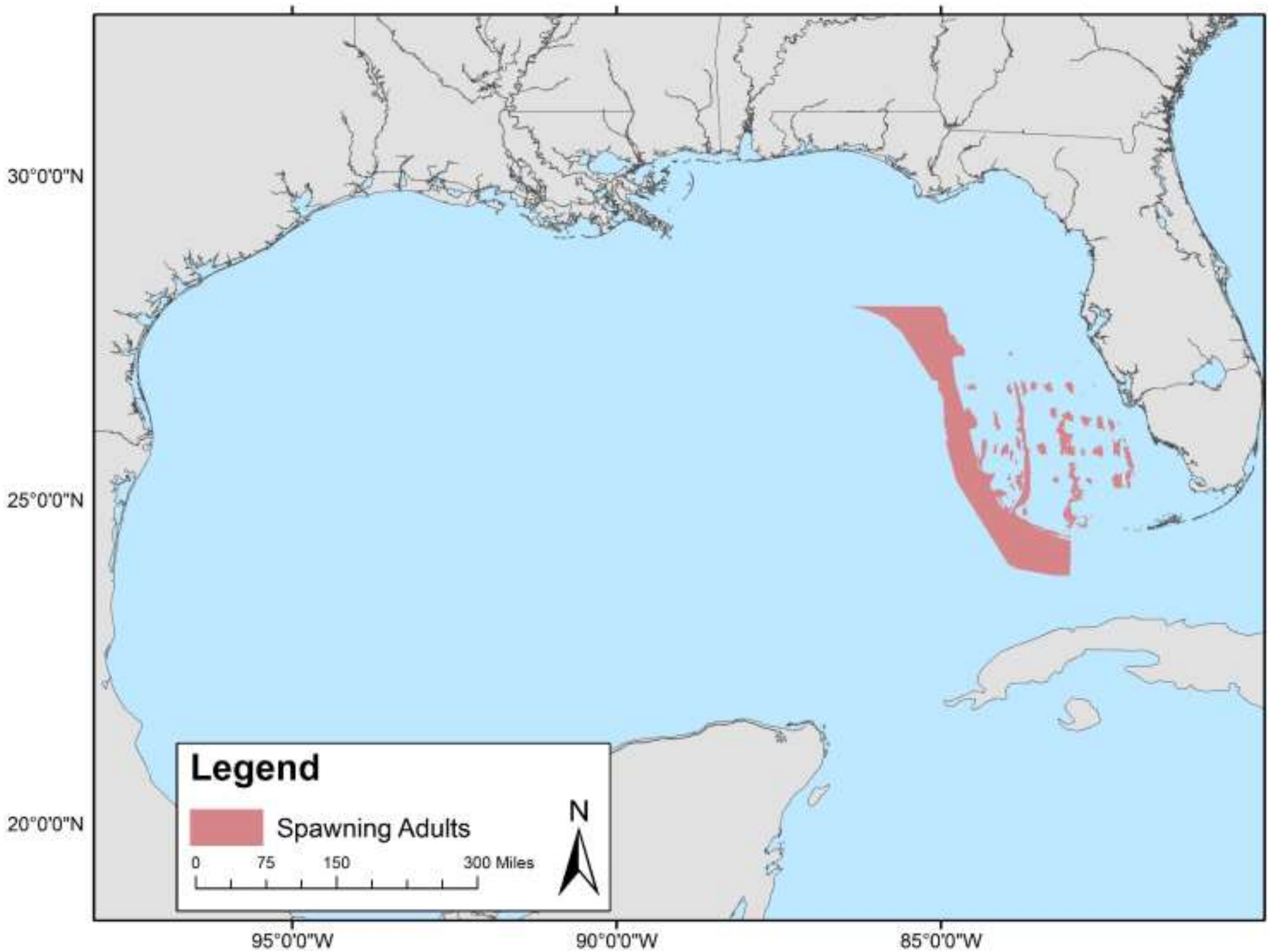

Figure B- 85. Map of benthic habitat use by spawning adult yellowfin grouper.

Goldface Tilefish (*Caulolatilus chrysops*) Benthic Habitat Use Maps

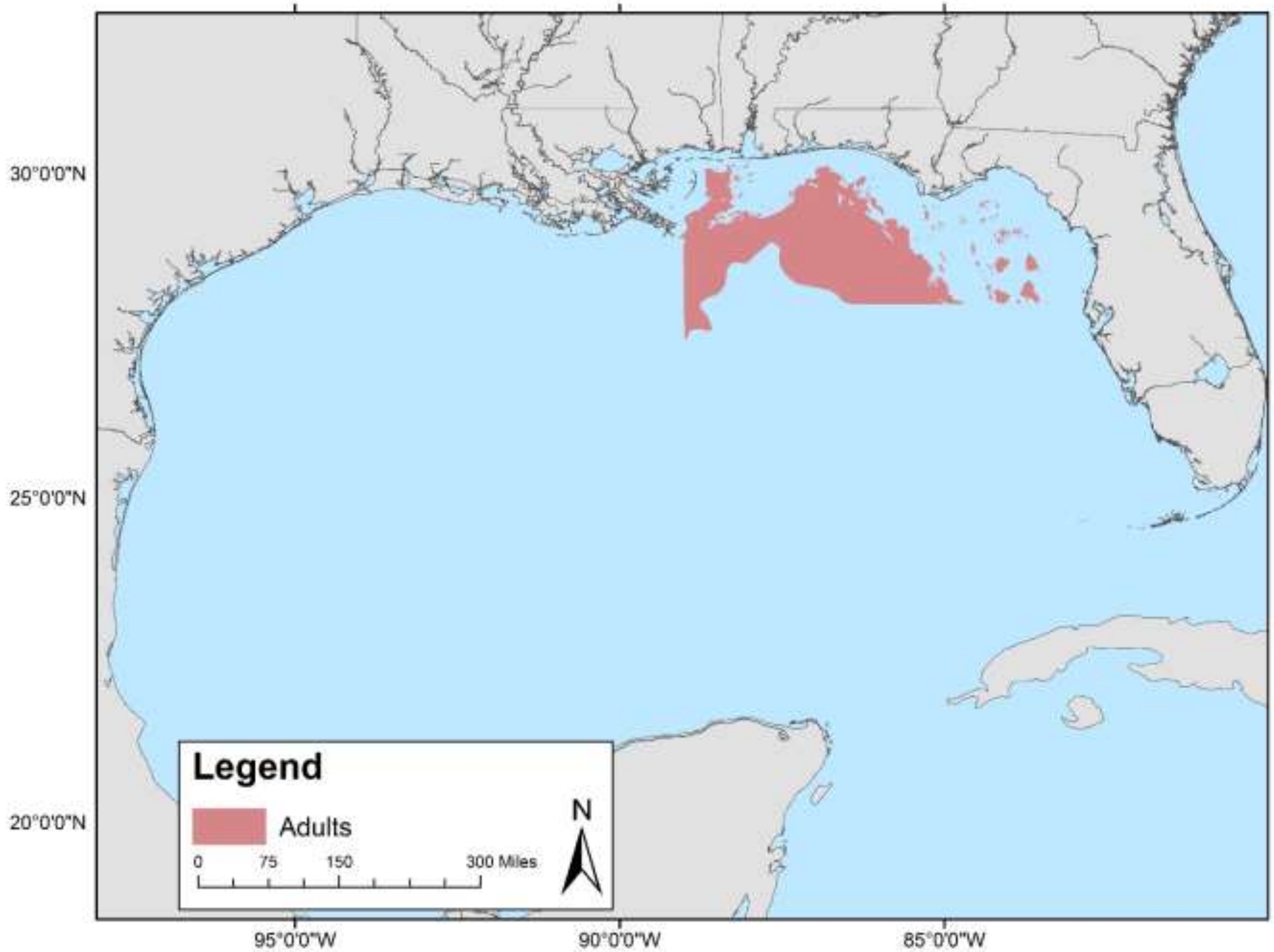

Figure B- 86. Map of benthic habitat use by adult goldface tilefish.

Blueline Tilefish (*Caulolatilus microps*) Benthic Habitat Use Maps

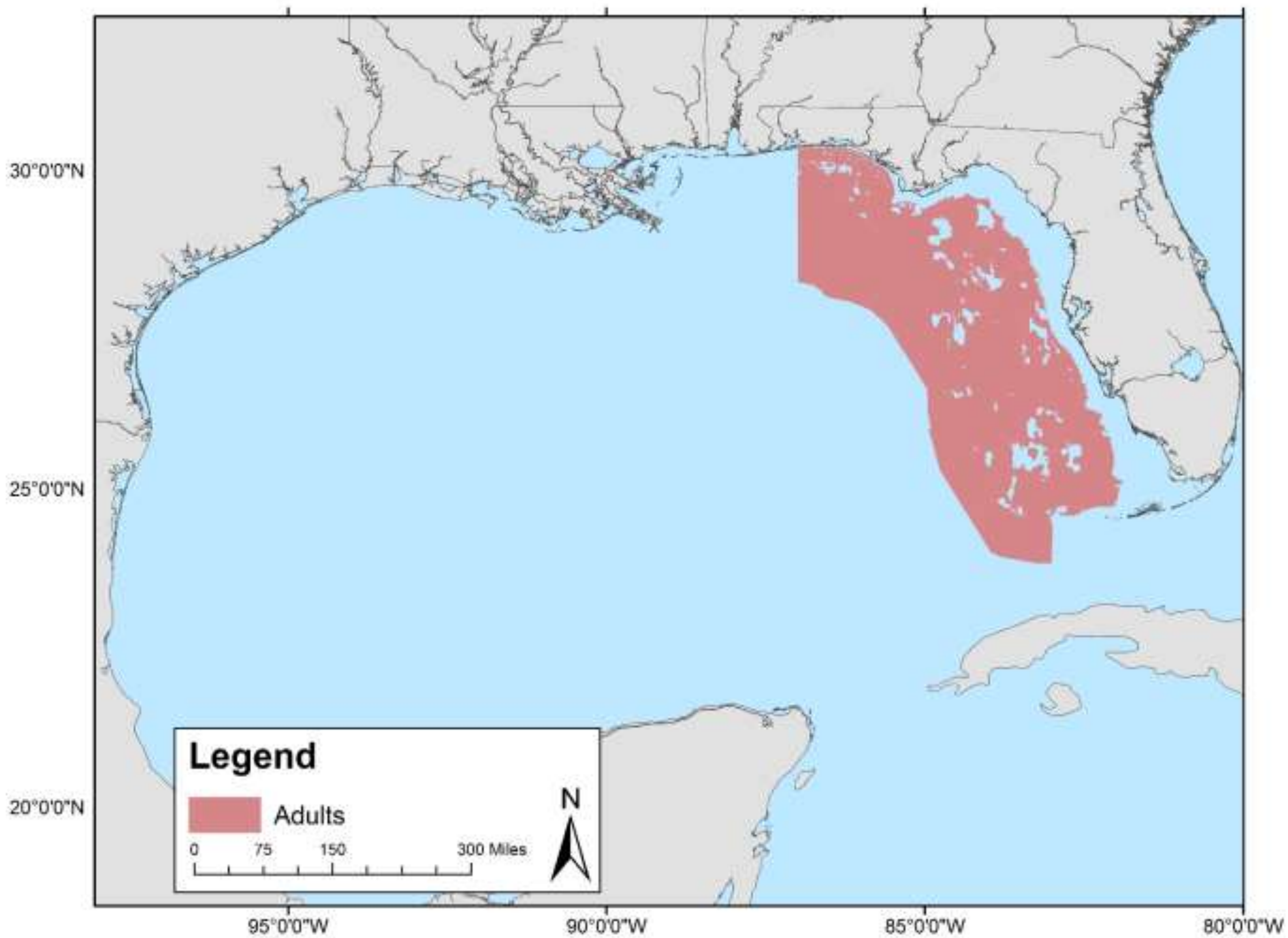

Figure B- 87. Map of benthic habitat use by adult blueline tilefish.

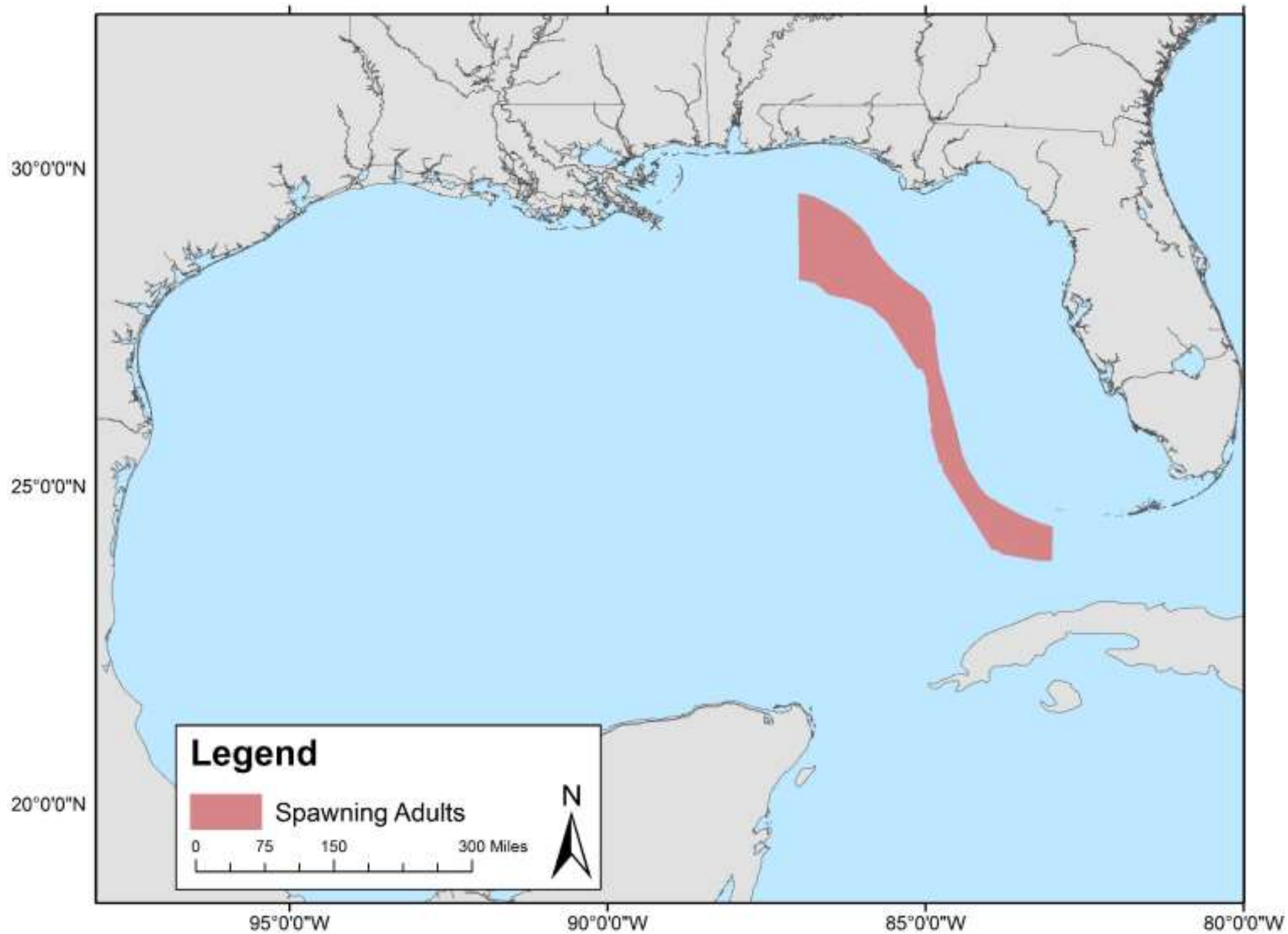

Figure B- 88. Map of benthic habitat use by spawning adult blueline tilefish.

Tilefish (*Lopholatilus chamaeleonticeps*) Benthic Habitat Use Maps

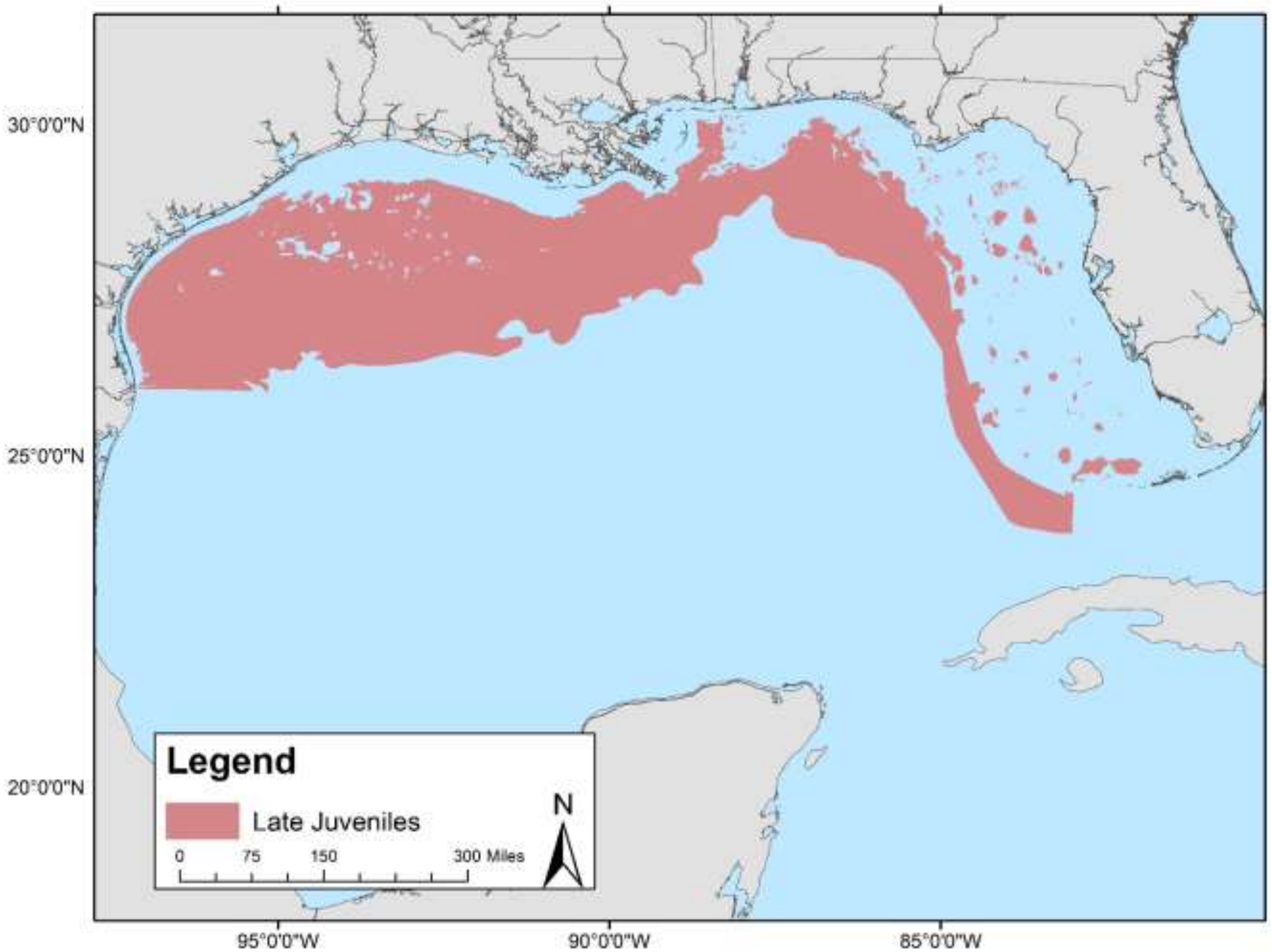

Figure B- 89. Map of benthic habitat use by late juvenile tilefish.

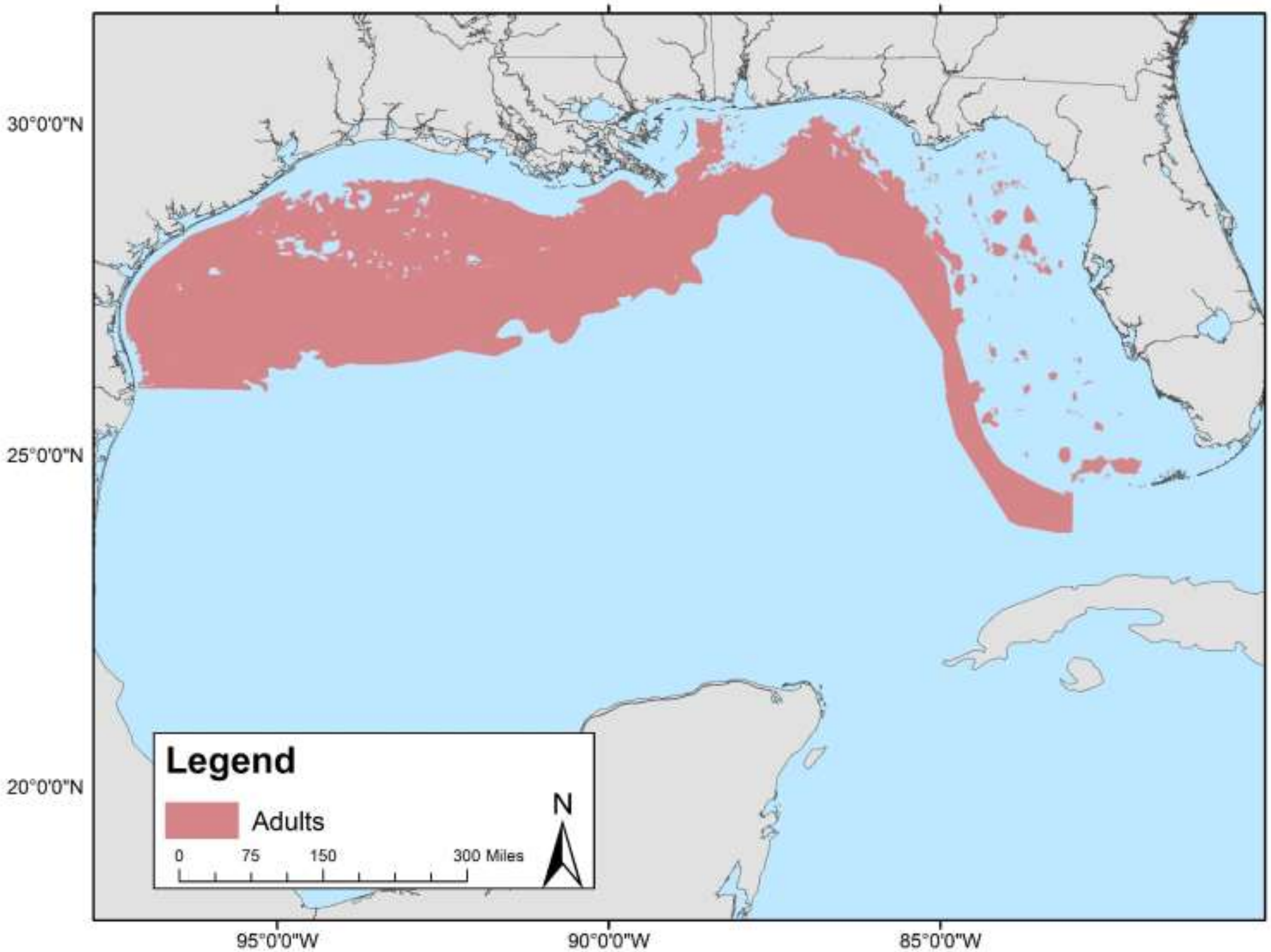

Figure B- 90. Map of benthic habitat use by adult tilefish.

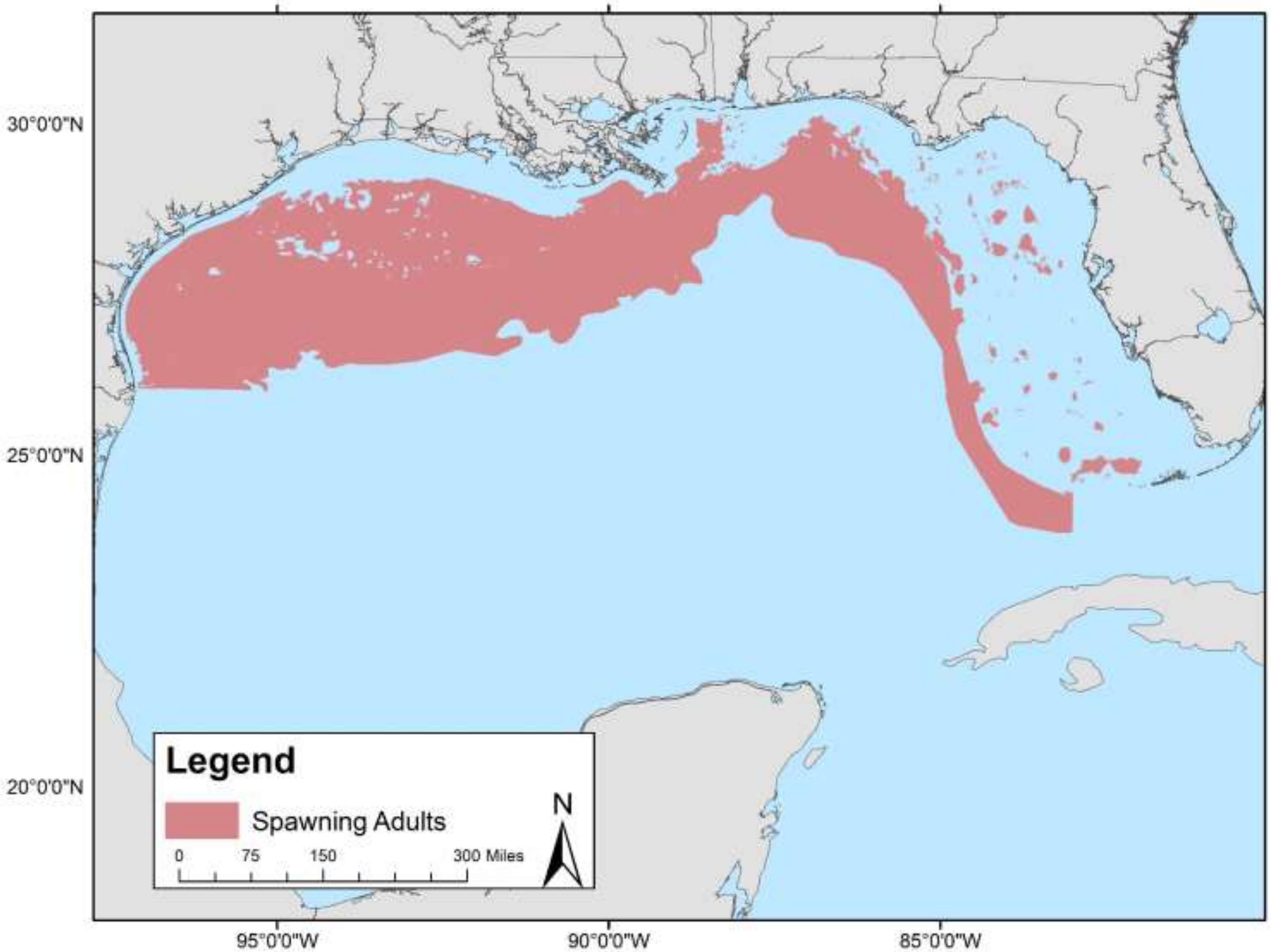

Figure B- 91. Map of benthic habitat use by spawning adult tilefish.

Greater Amberjack (*Seriola dumerili*) Benthic Habitat Use Maps

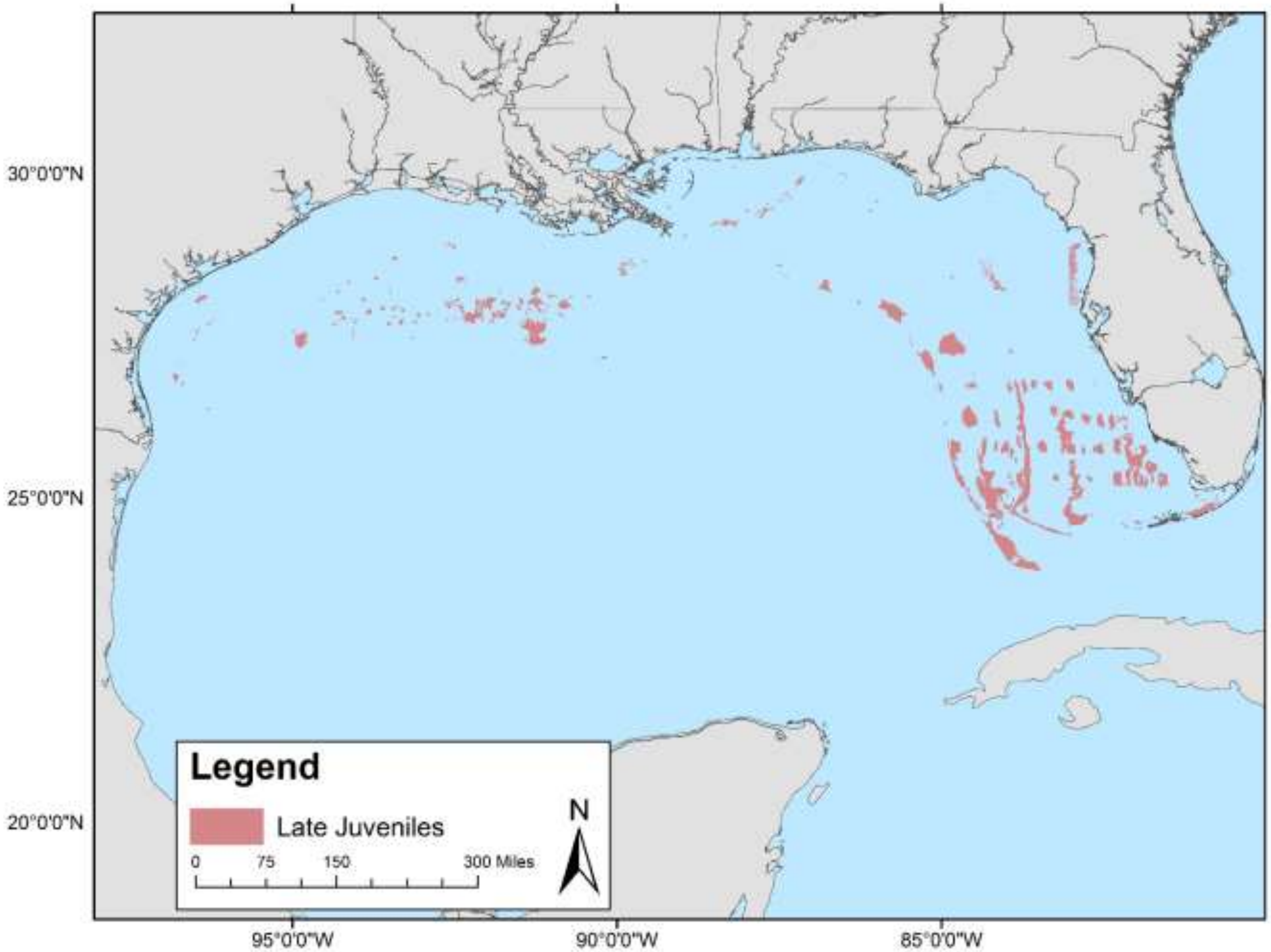

Figure B- 92. Map of benthic habitat use by late juvenile greater amberjack.

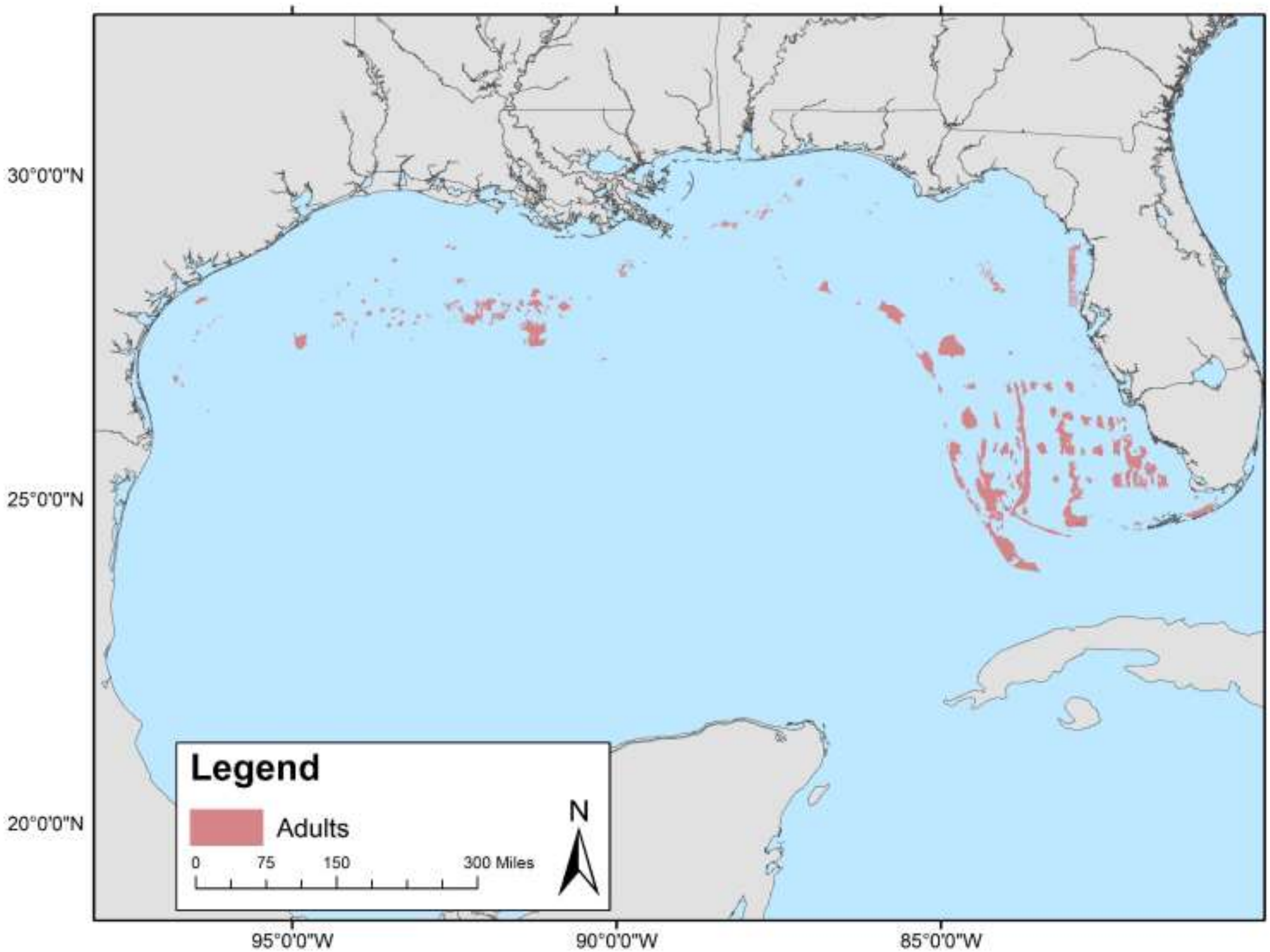

Figure B- 93. Map of benthic habitat use by adult greater amberjack.

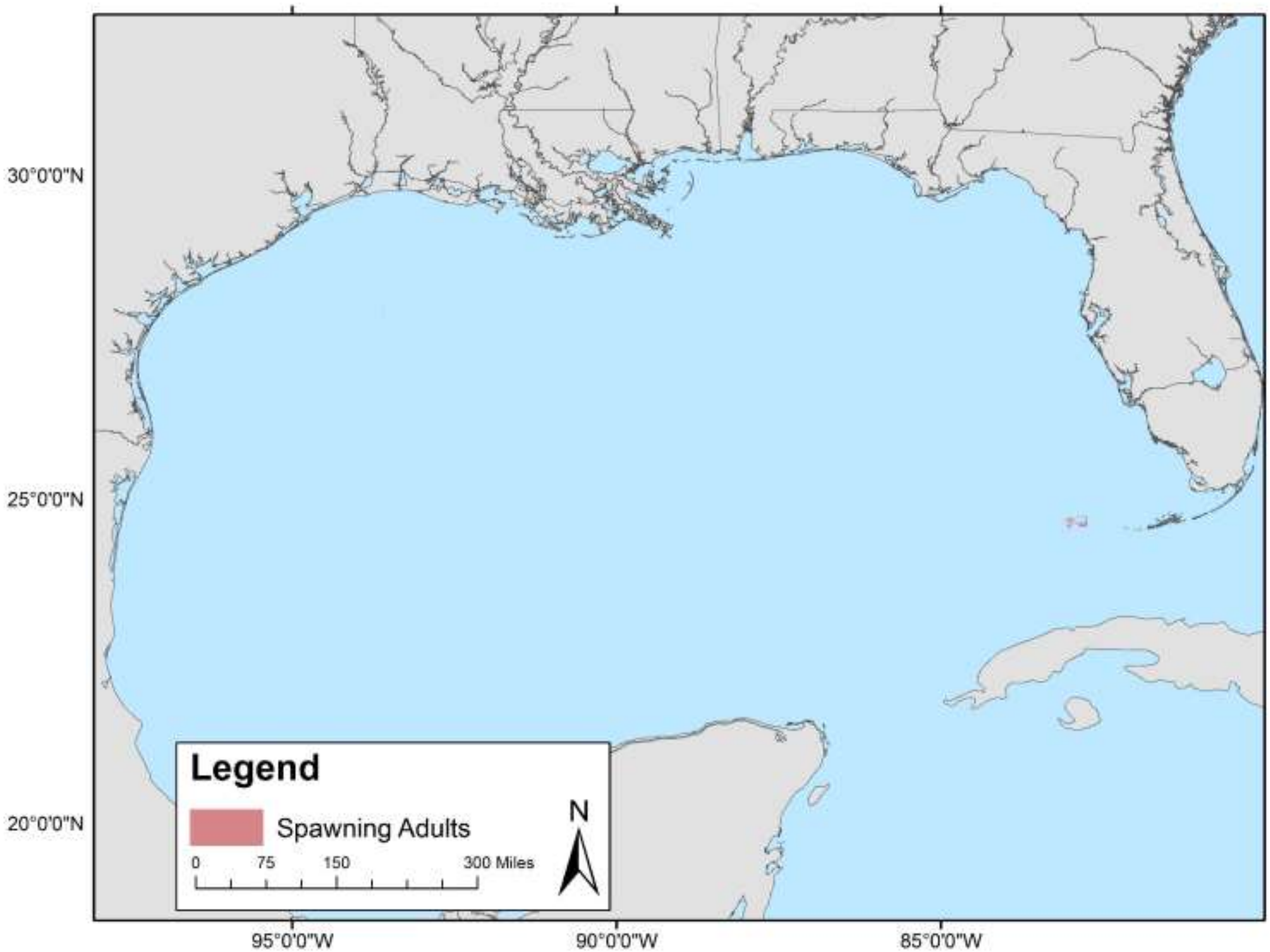

Figure B- 94. Map of benthic habitat use by spawning adult greater amberjack.

Lesser Amberjack (*Seriola fasciata*) Benthic Habitat Use Maps

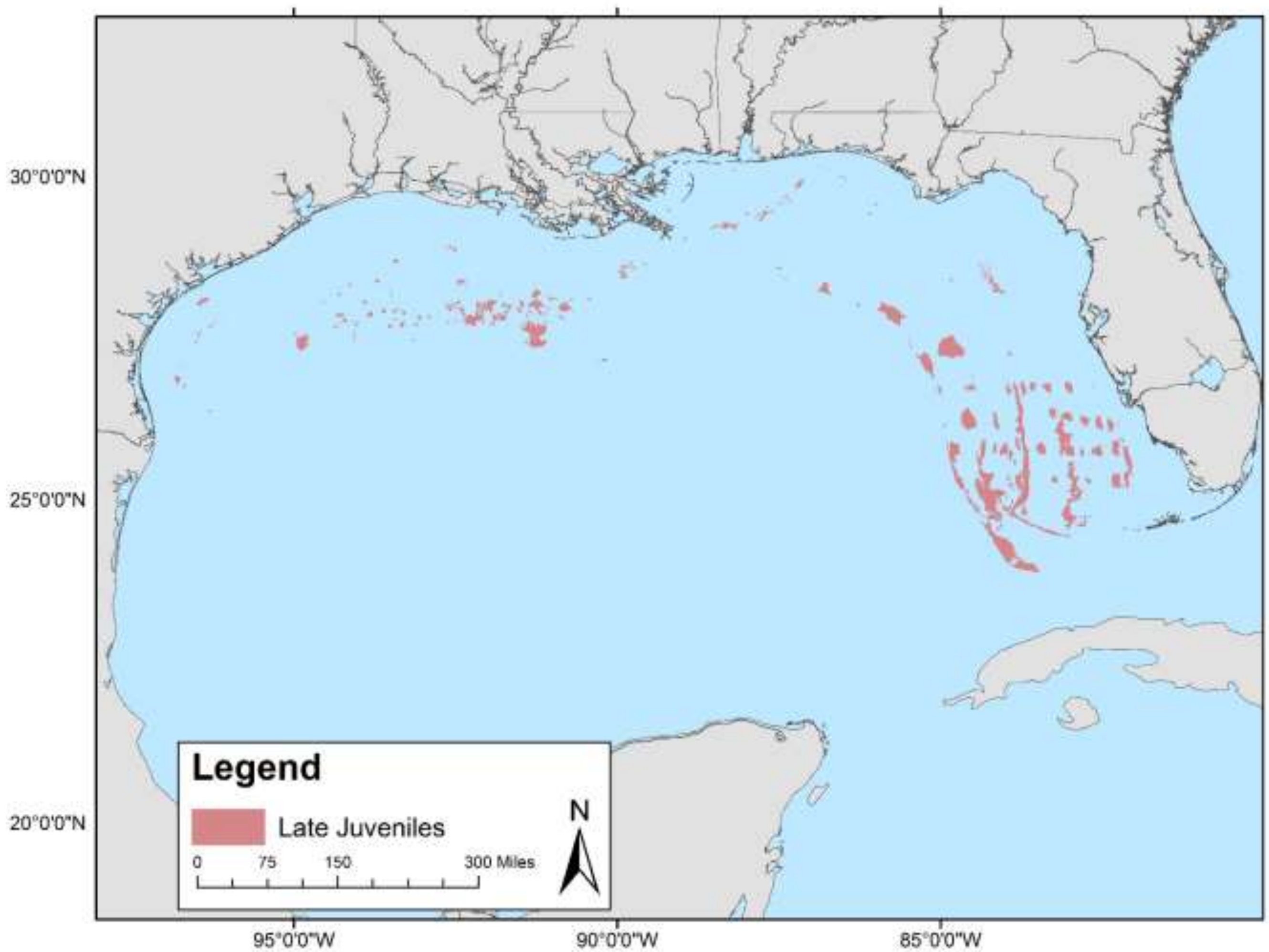

Figure B- 95. Map of benthic habitat use by late juvenile lesser amberjack.

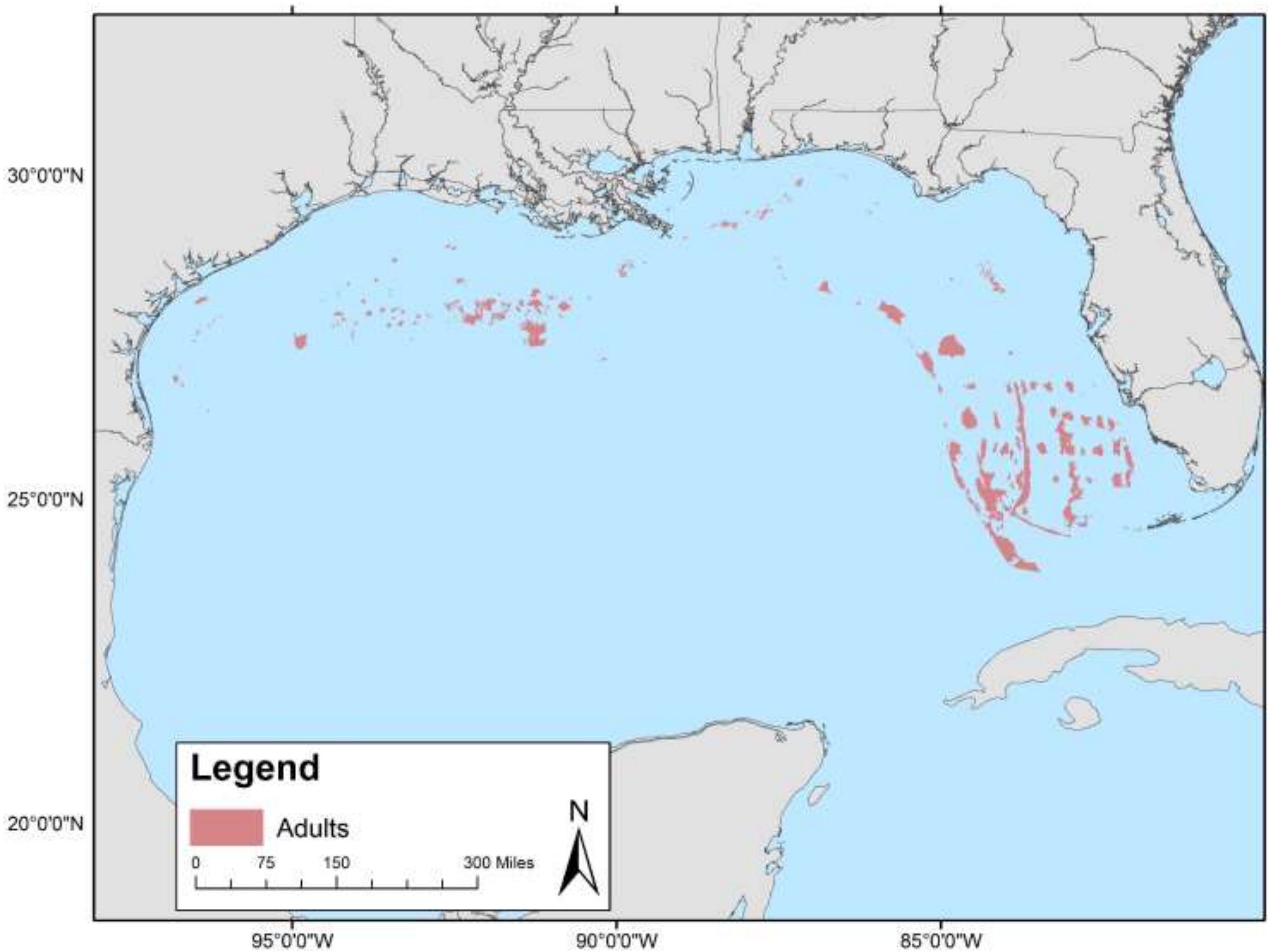

Figure B- 96. Map of benthic habitat use by adult lesser amberjack.

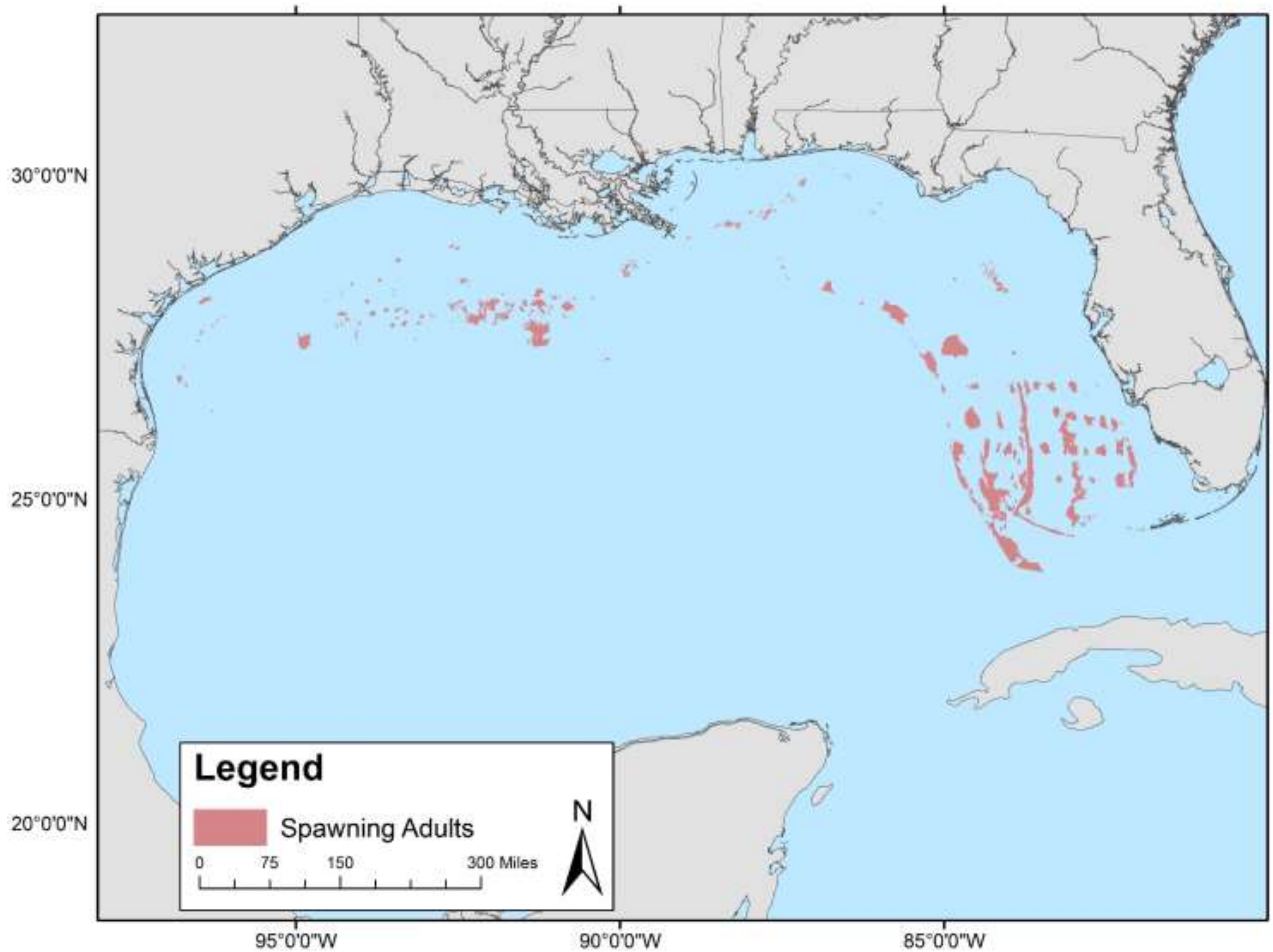

Figure B- 97. Map of benthic habitat use by spawning adult lesser amberjack.

Almaco Jack (*Seriola rivoliana*) Benthic Habitat Use Maps

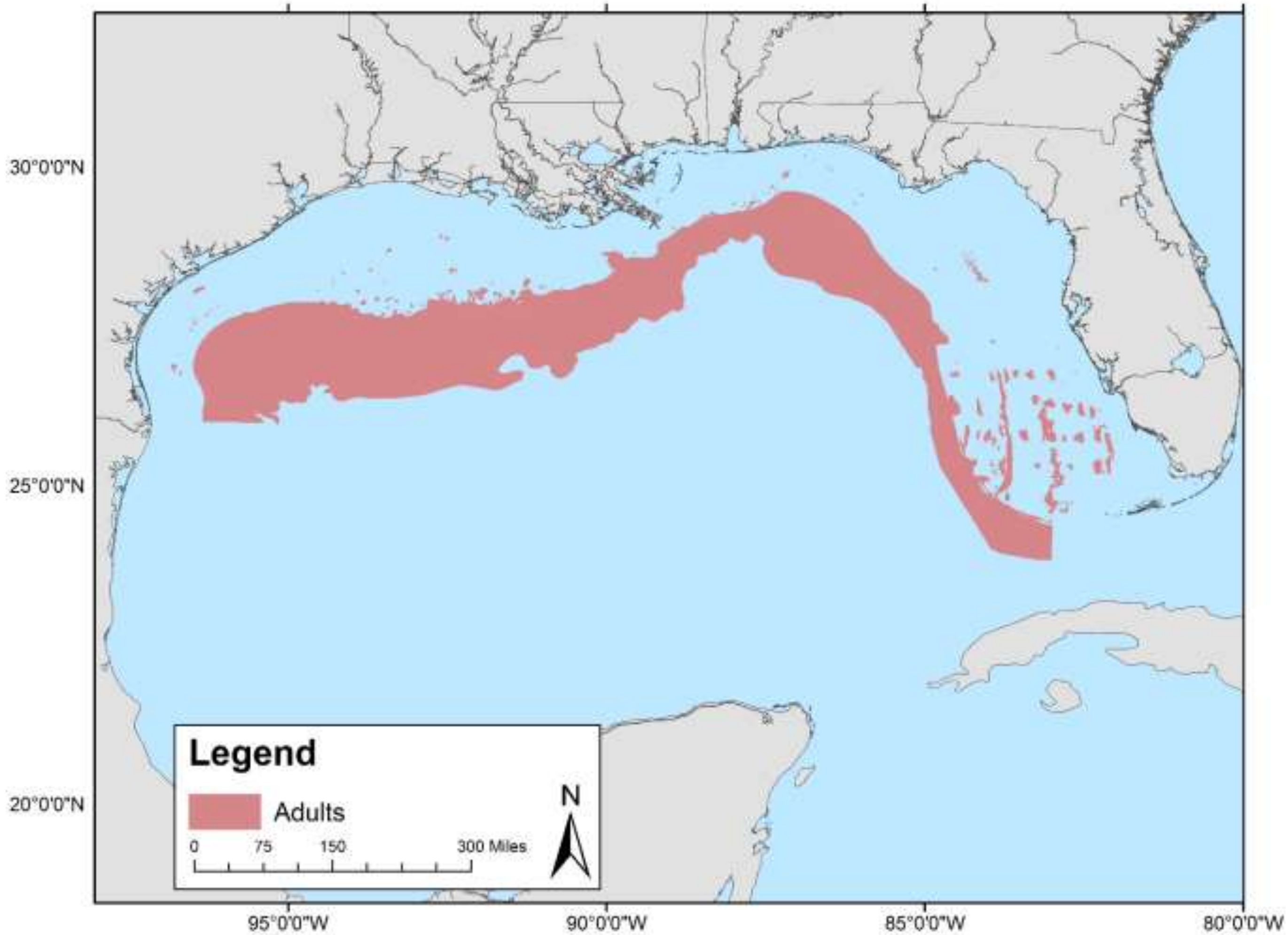

Figure B- 98. Map of benthic habitat use by adult almaco jack.

Gray Triggerfish (*Balistes capriscus*) Benthic Habitat Use Maps

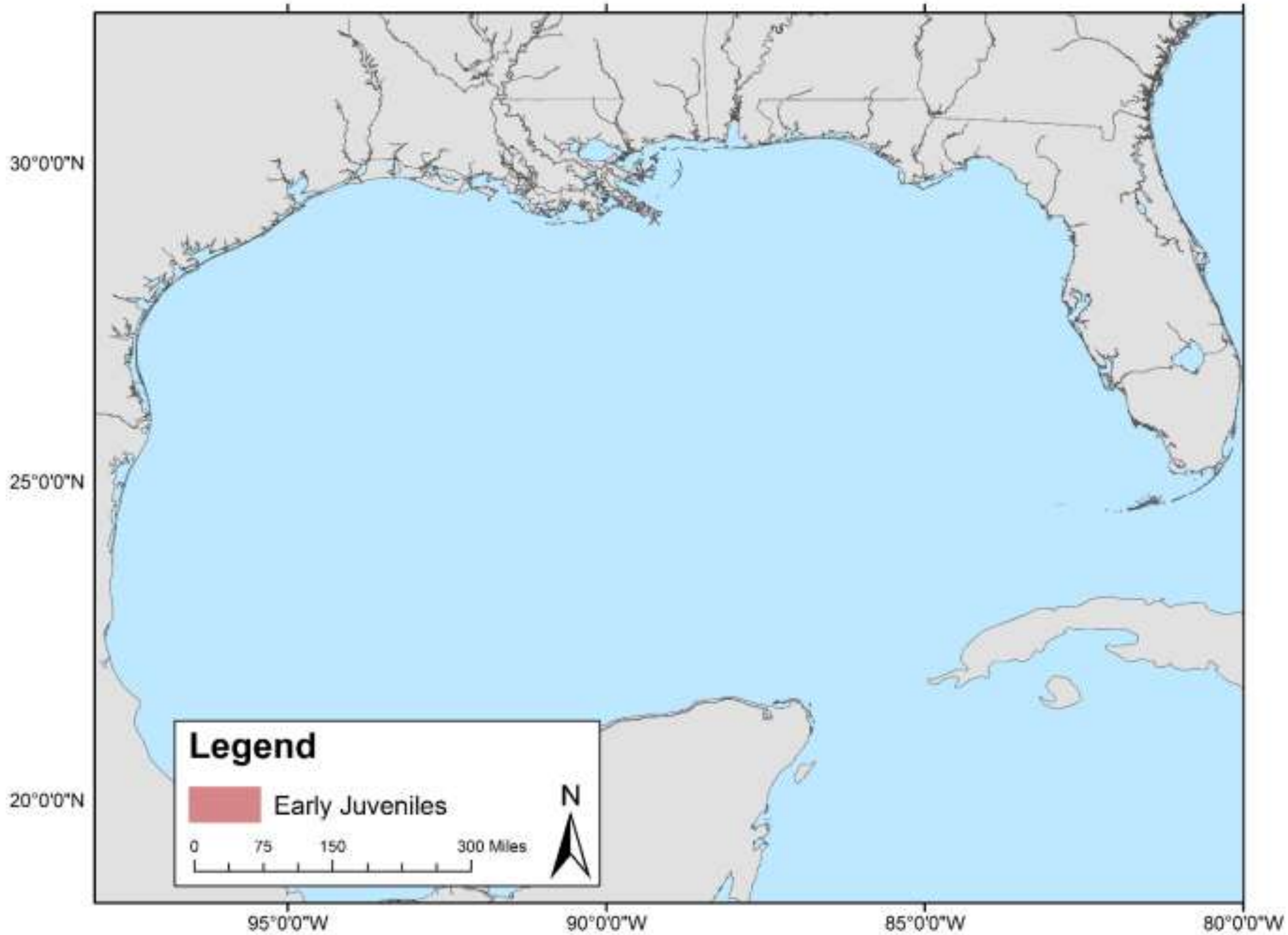

Figure B- 99. Map of benthic habitat use by early juvenile gray triggerfish.

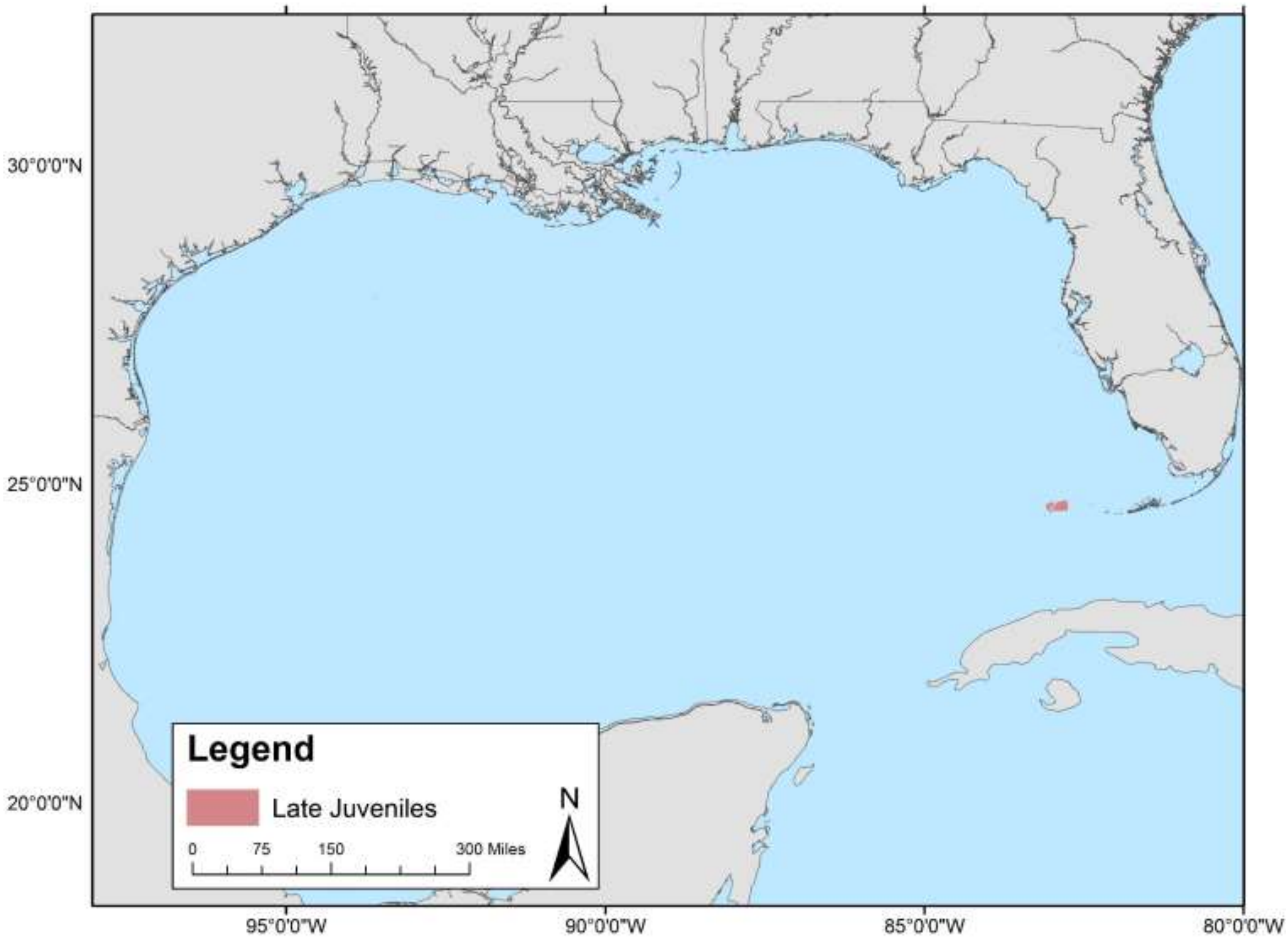

Figure B- 100. Map of benthic habitat use by late juvenile gray triggerfish.

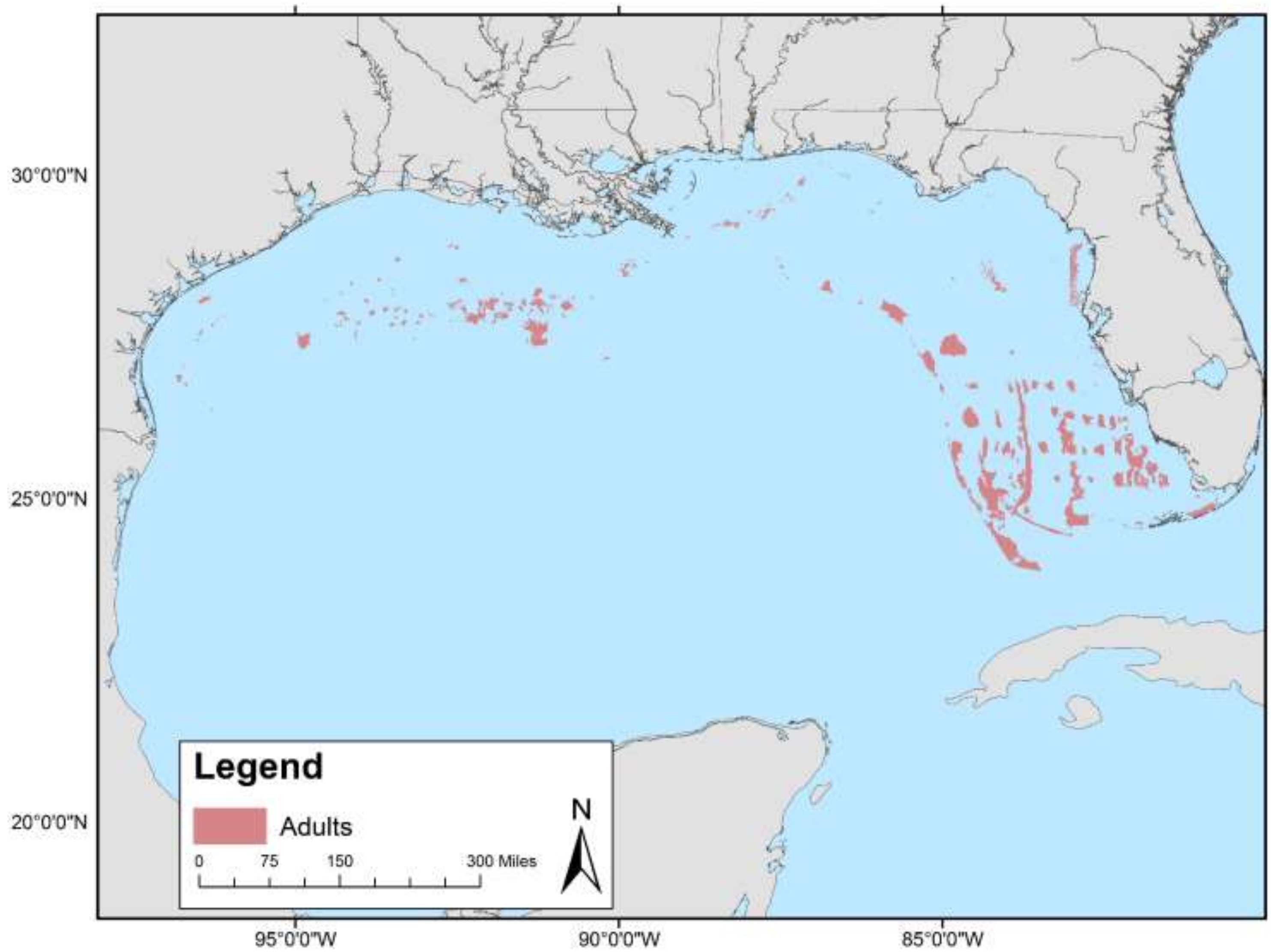

Figure B- 101. Map of benthic habitat use by adult gray triggerfish.

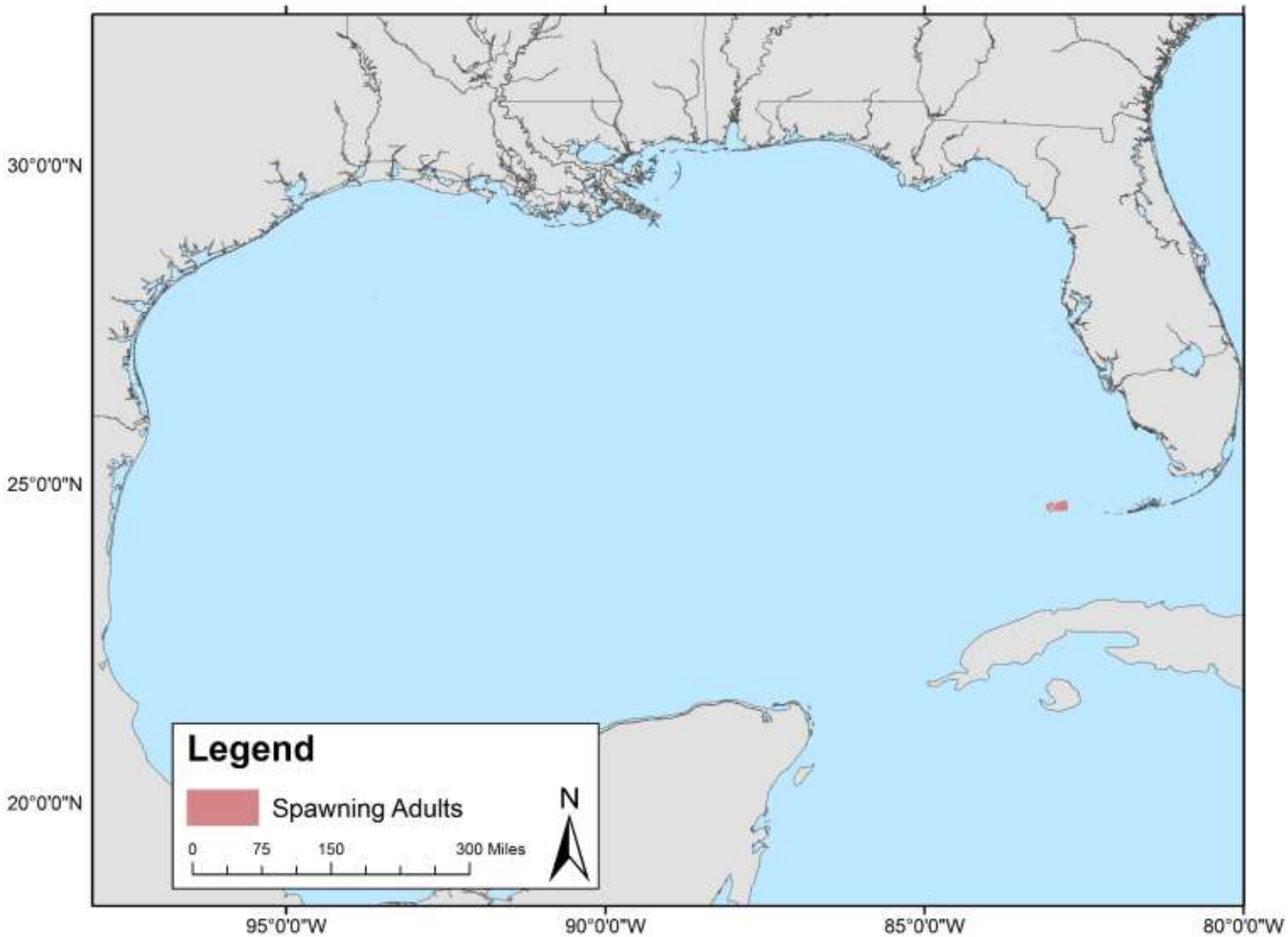

Figure B- 102. Map of benthic habitat use by spawning adult gray triggerfish.

Hogfish (*Lachnolaimus maximus*) Benthic Habitat Use Maps

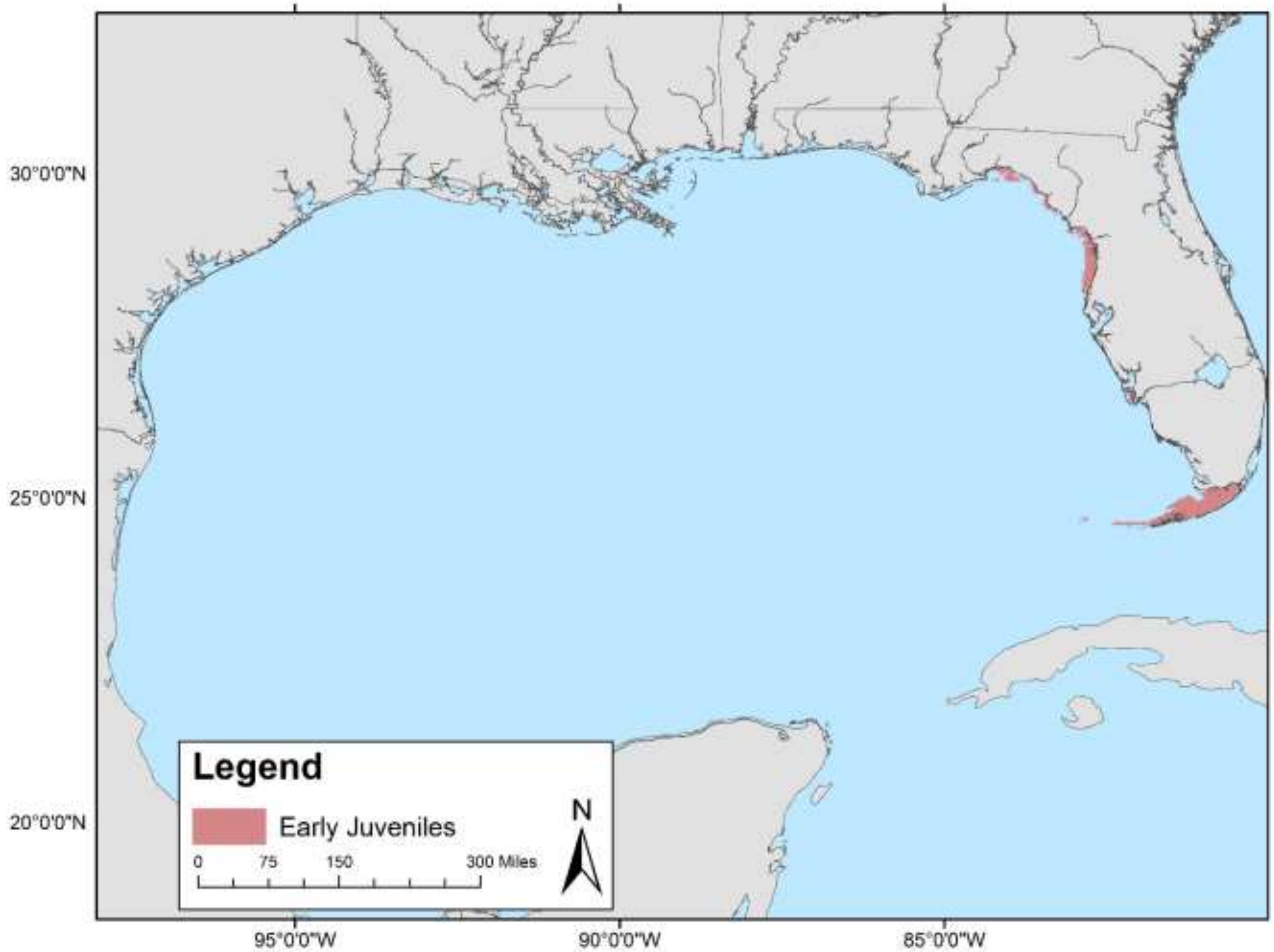

Figure B- 103. Map of benthic habitat use by early juvenile hogfish.

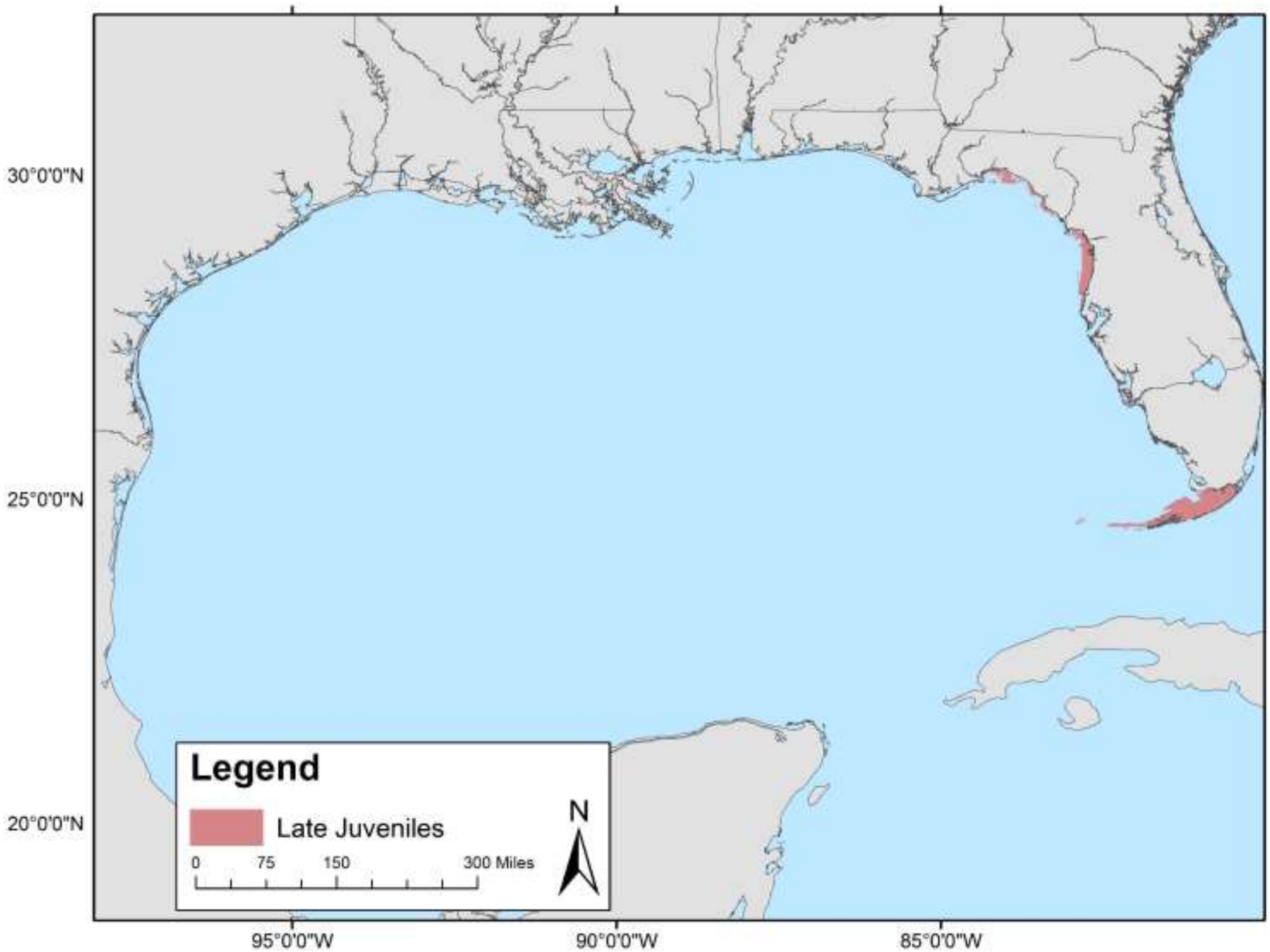

Figure B- 104. Map of benthic habitat use by late juvenile hogfish.

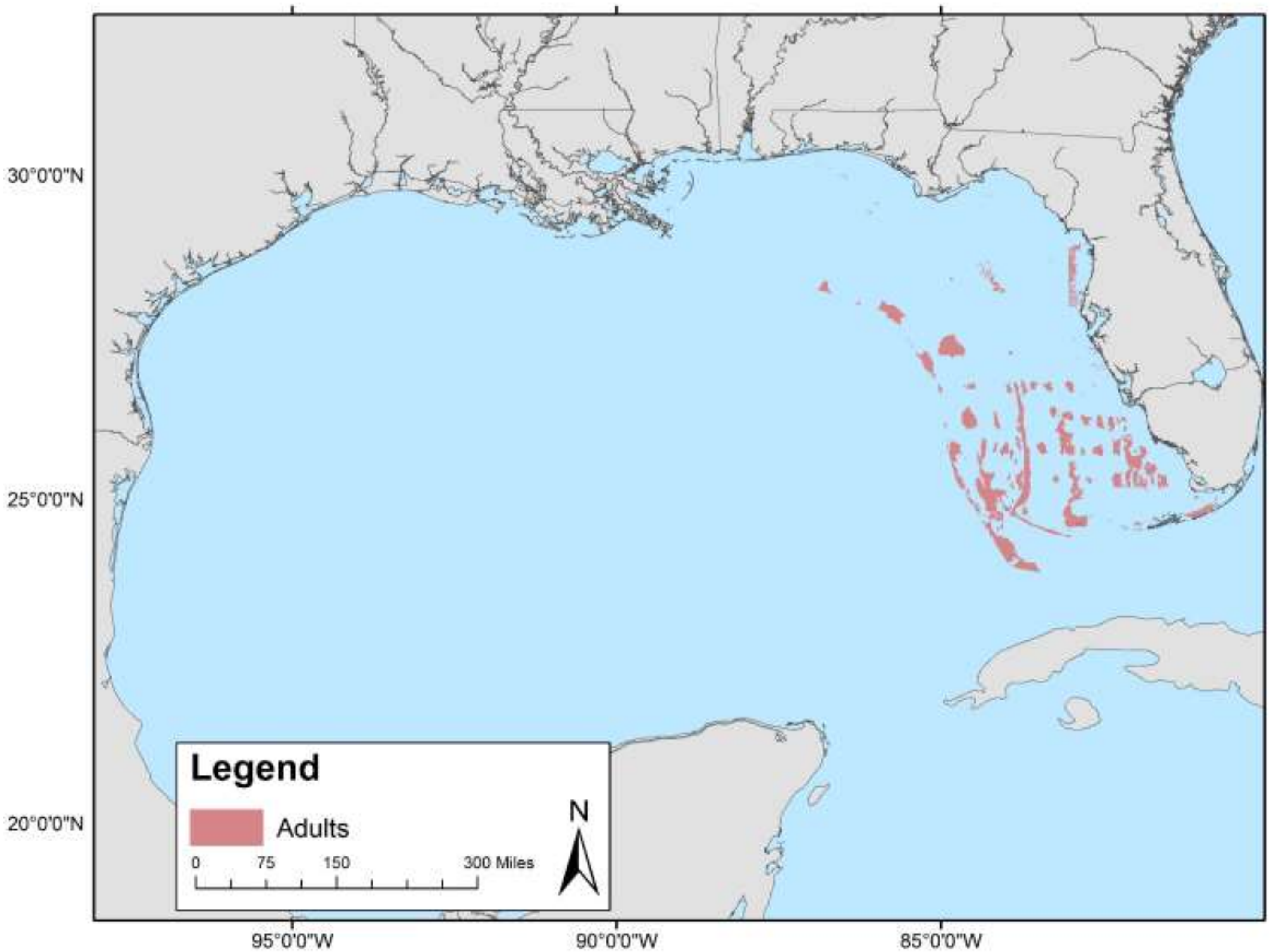

Figure B- 105. Map of benthic habitat use by adult hogfish.

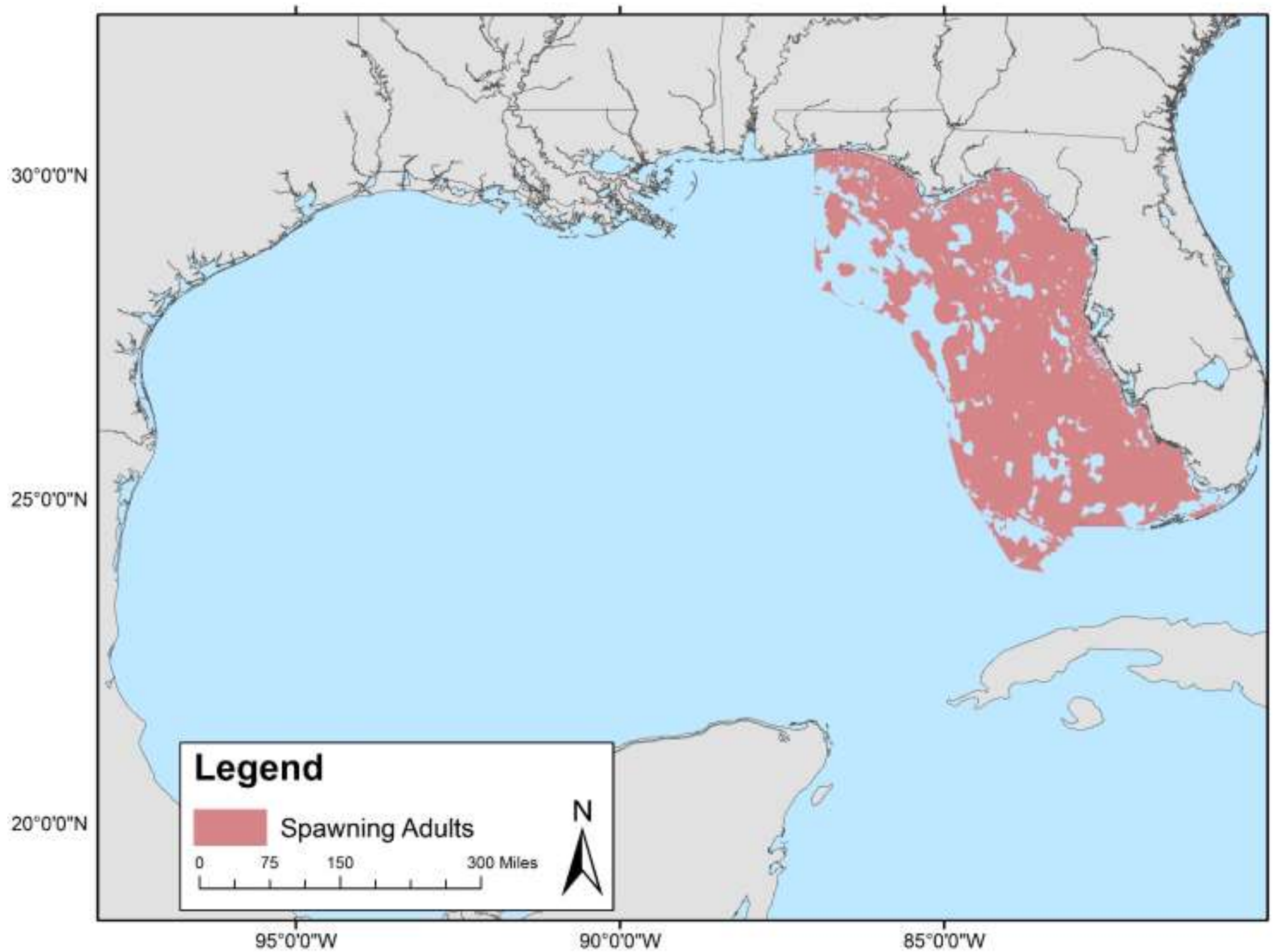

Figure B- 106. Map of benthic habitat use by spawning adult hogfish.

Brown Shrimp (*Penaeus aztecus*) Benthic Habitat Use Maps

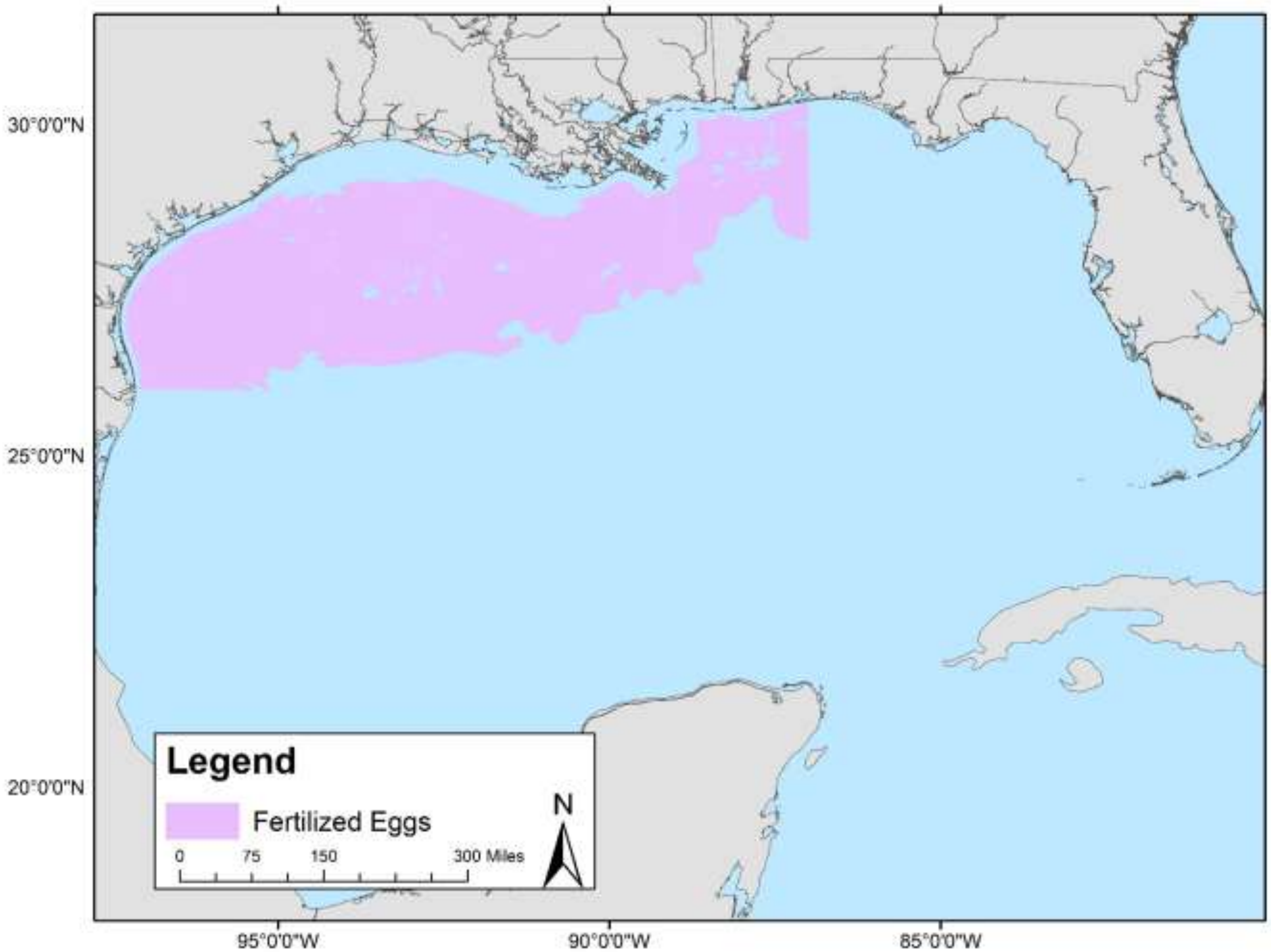

Figure B- 107. Map of benthic habitat use by brown shrimp fertilized eggs.

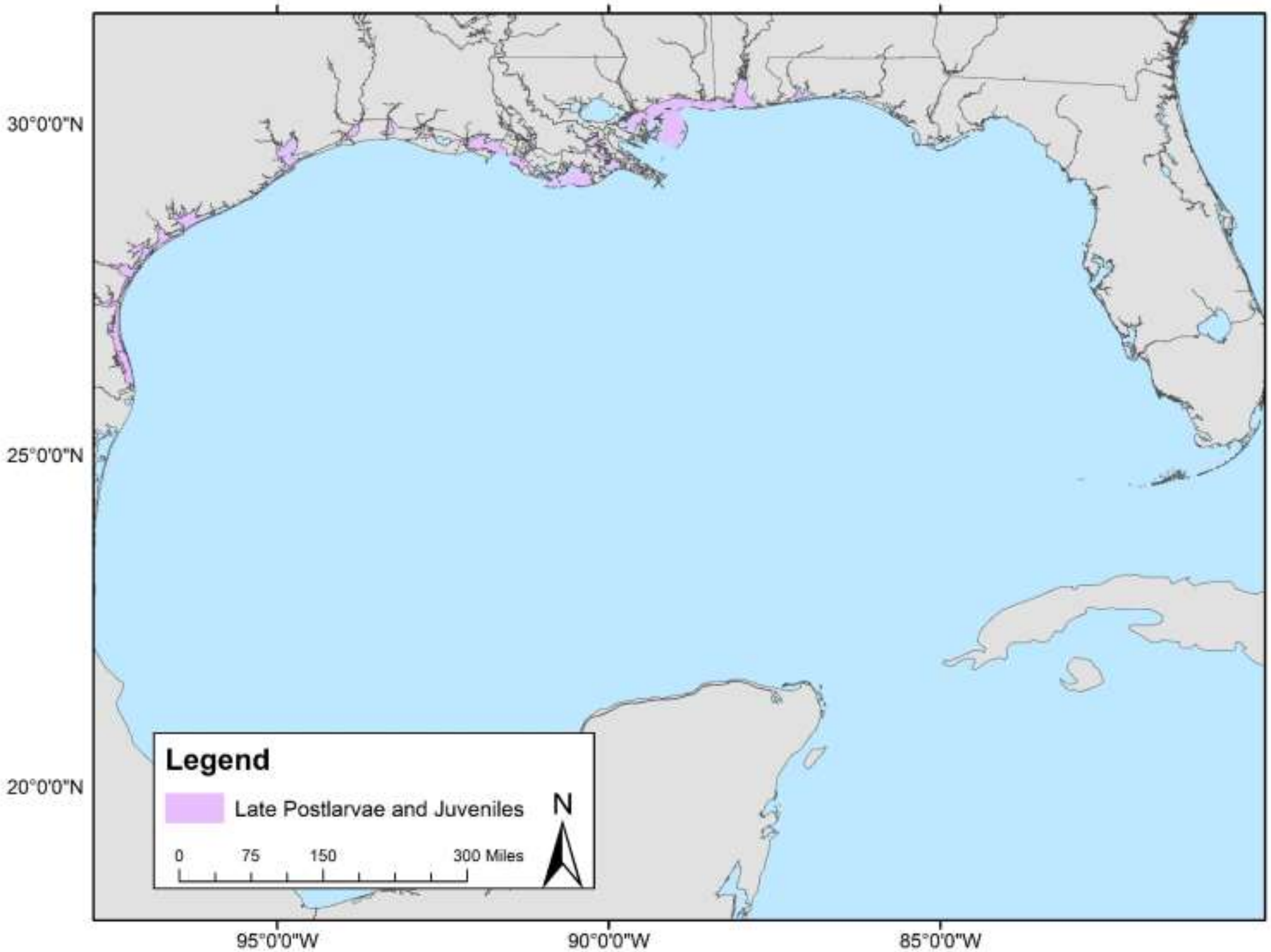

Figure B- 108. Map of benthic habitat use by late postlarval and juvenile brown shrimp.

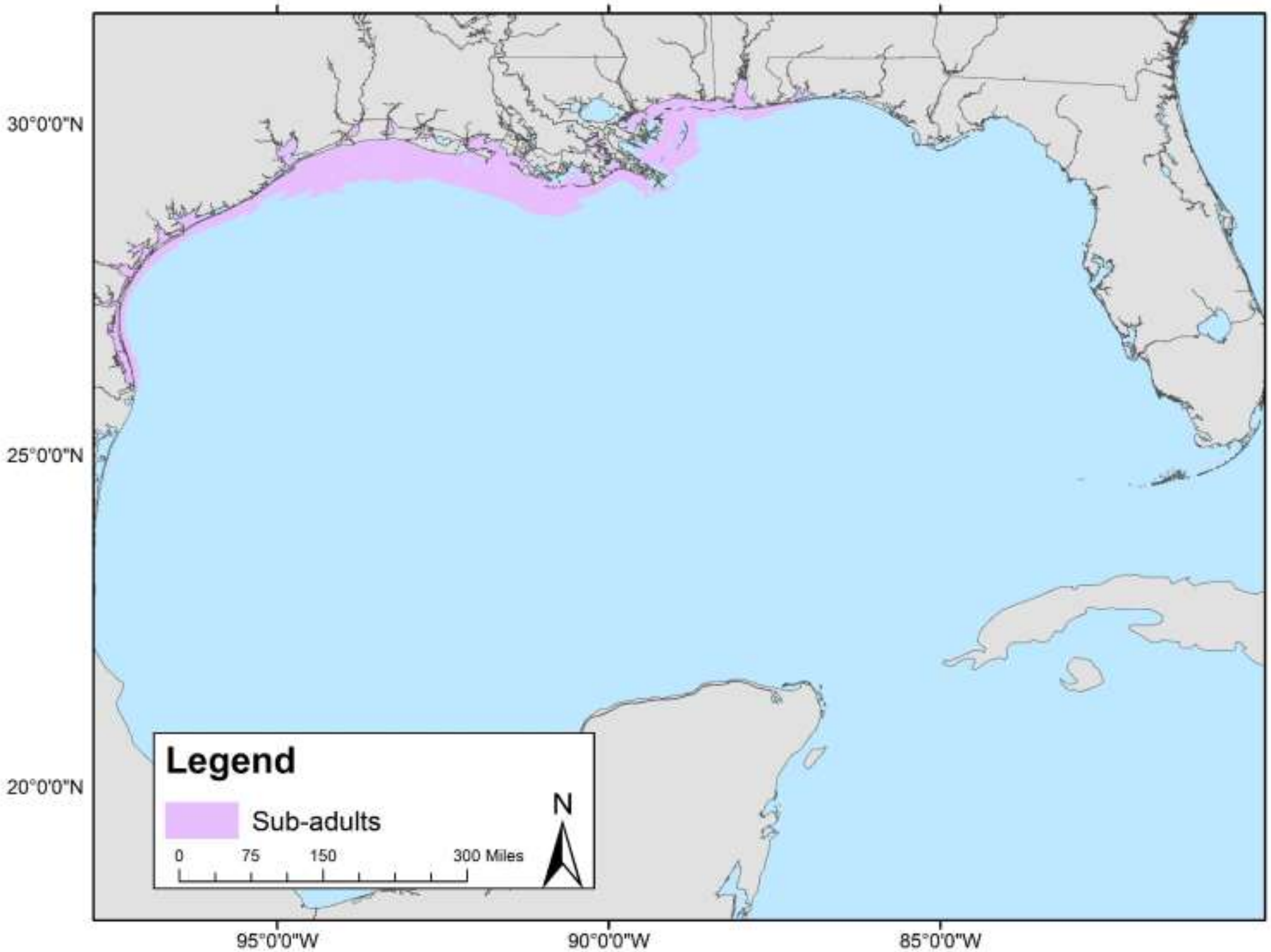

Figure B- 109. Map of benthic habitat use by sub-adult brown shrimp.

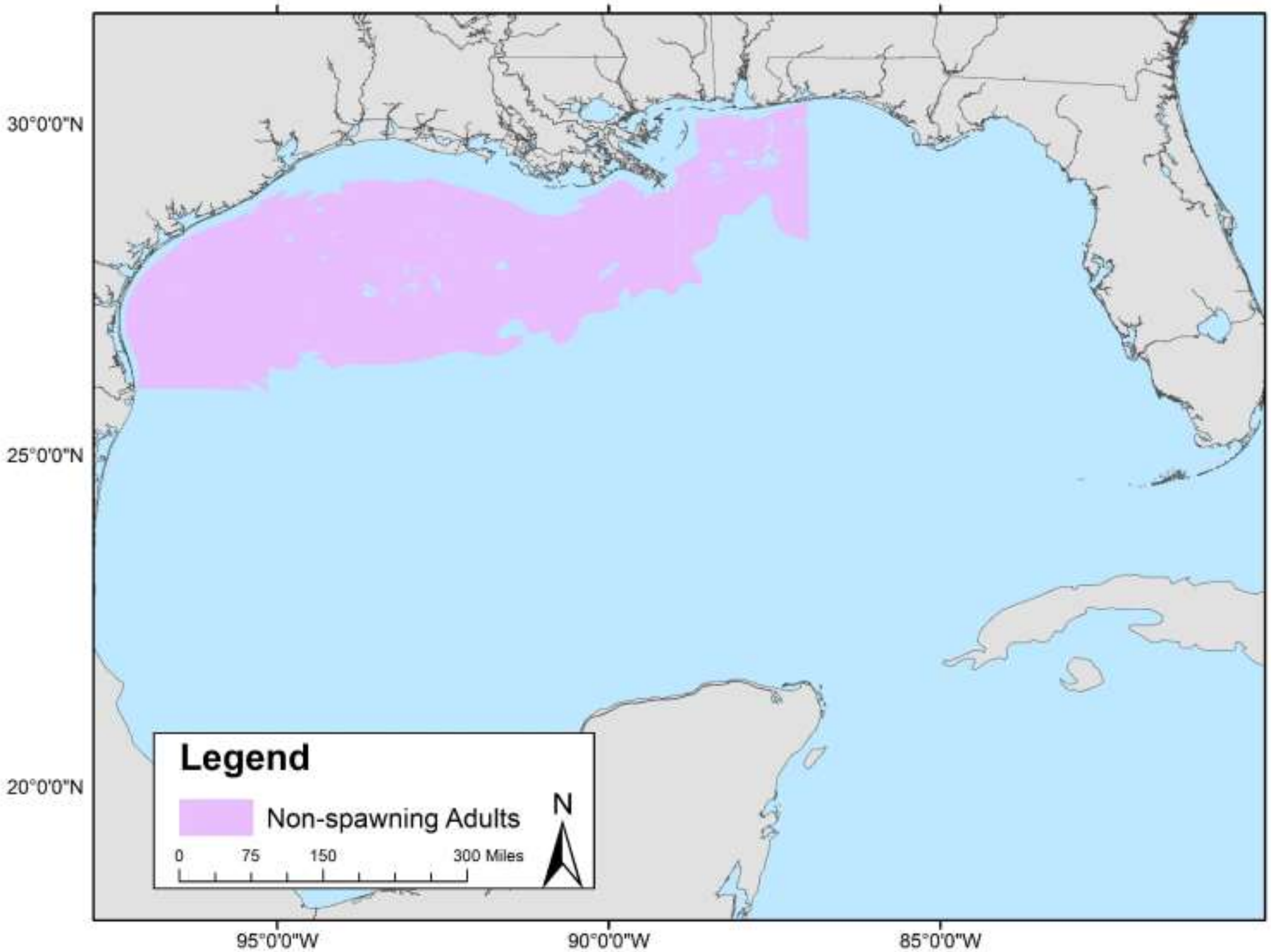

Figure B- 110. Map of benthic habitat use by non-spawning adult brown shrimp.

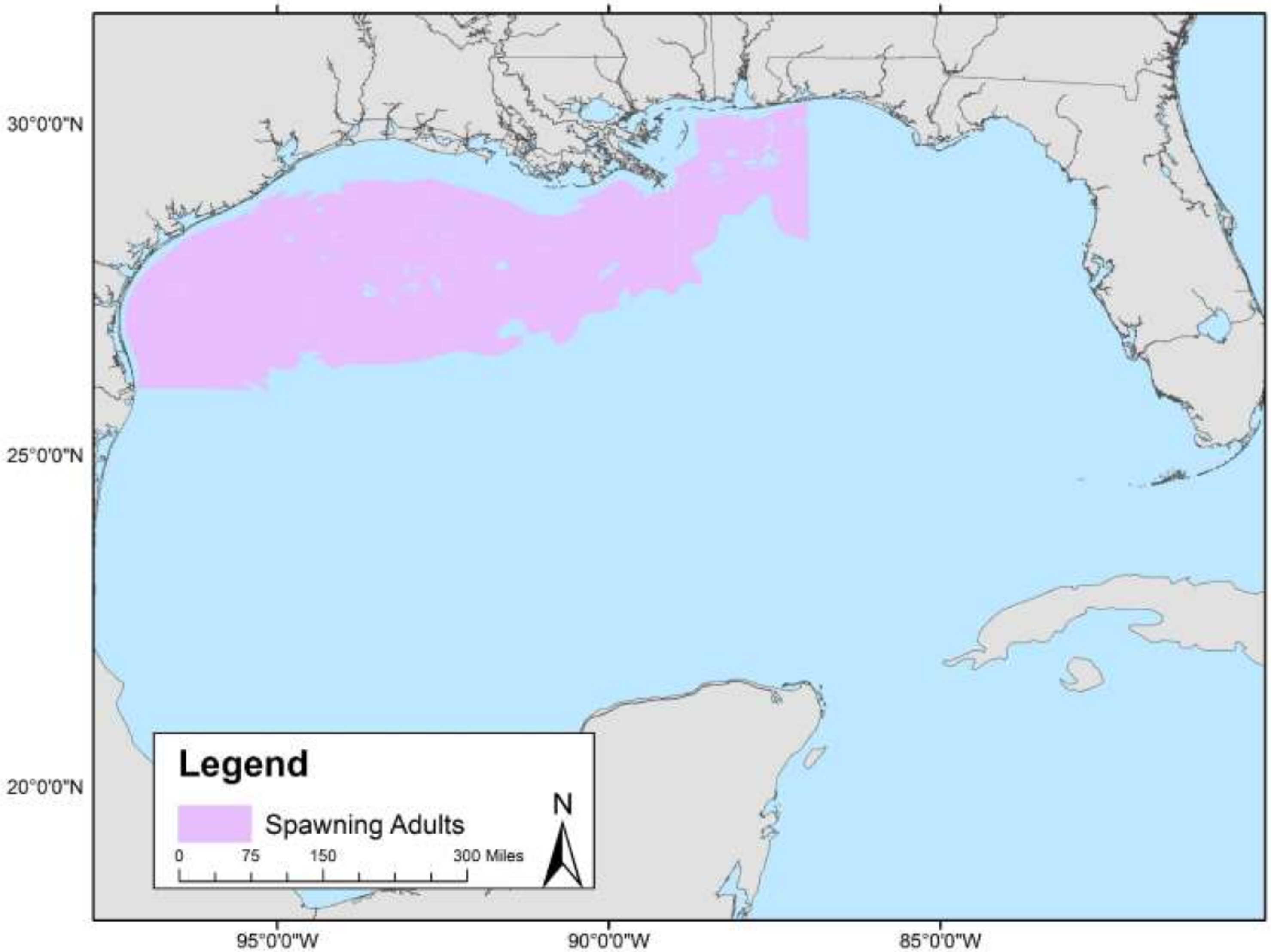

Figure B- 111. Map of benthic habitat use by spawning adult brown shrimp.

White Shrimp (*Penaeus setiferus*) Benthic Habitat Use Maps

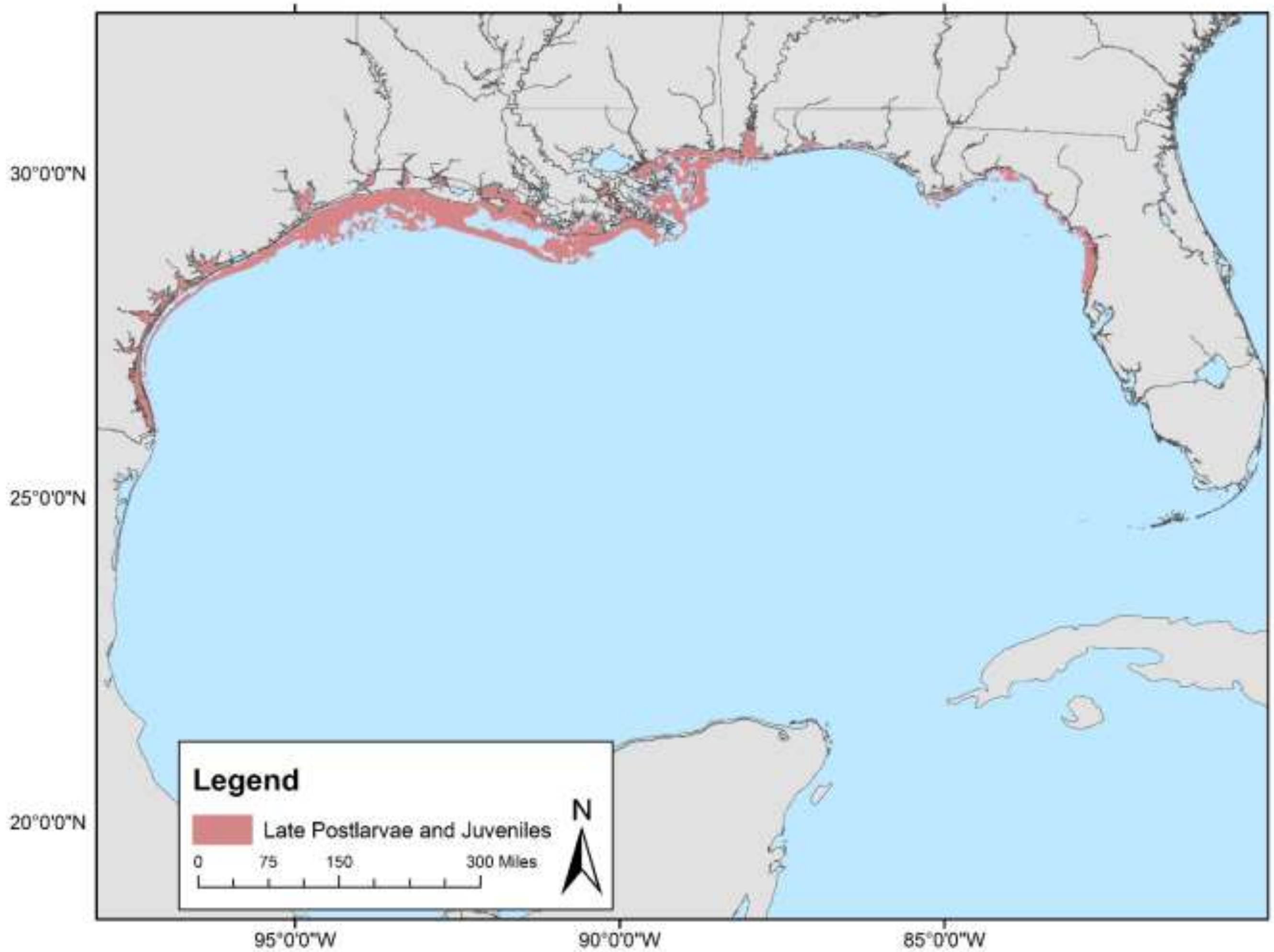

Figure B- 112. Map of benthic habitat use by late postlarvae and juvenile white shrimp.

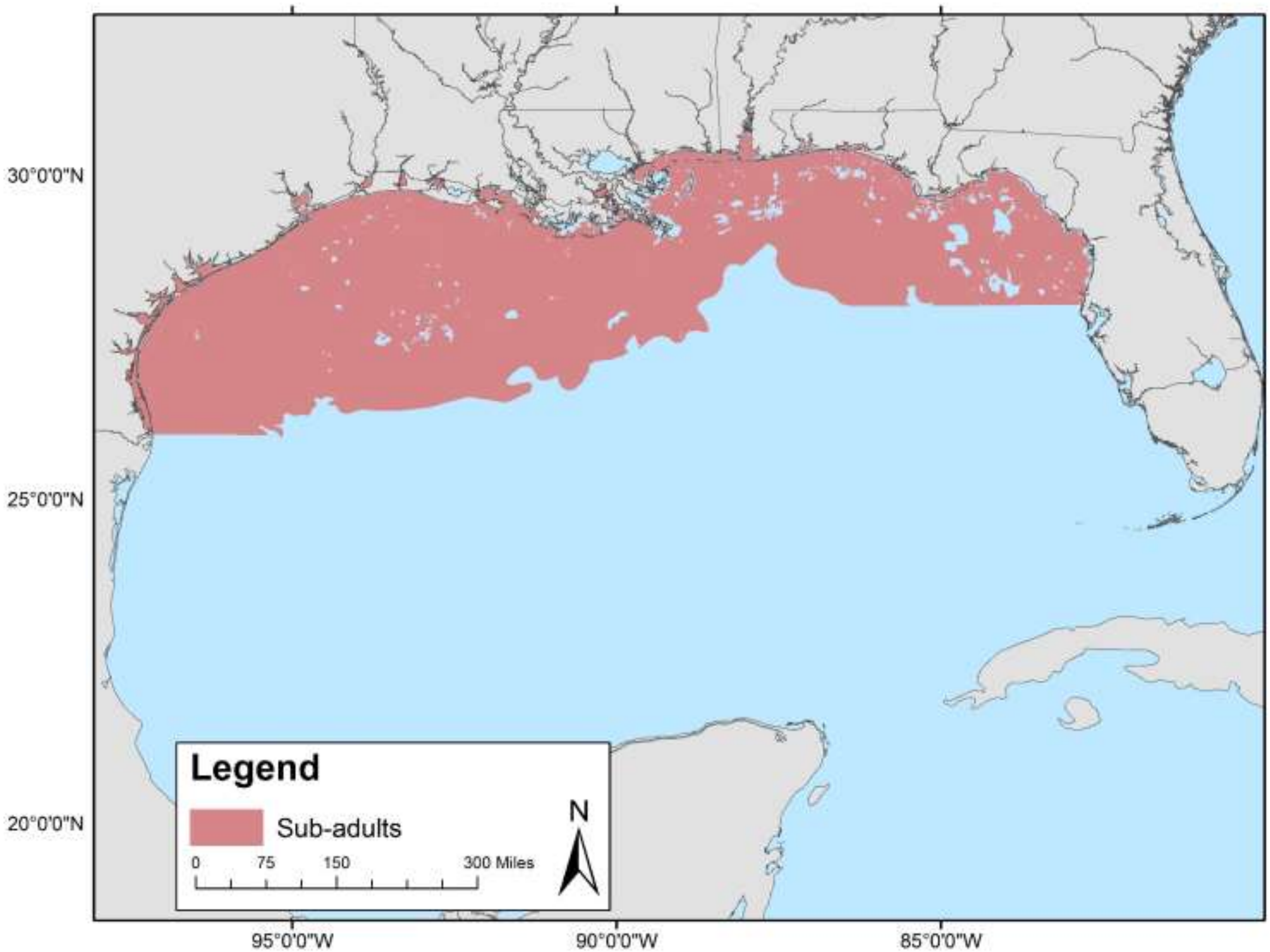

Figure B- 113. Map of benthic habitat use by sub-adult white shrimp.

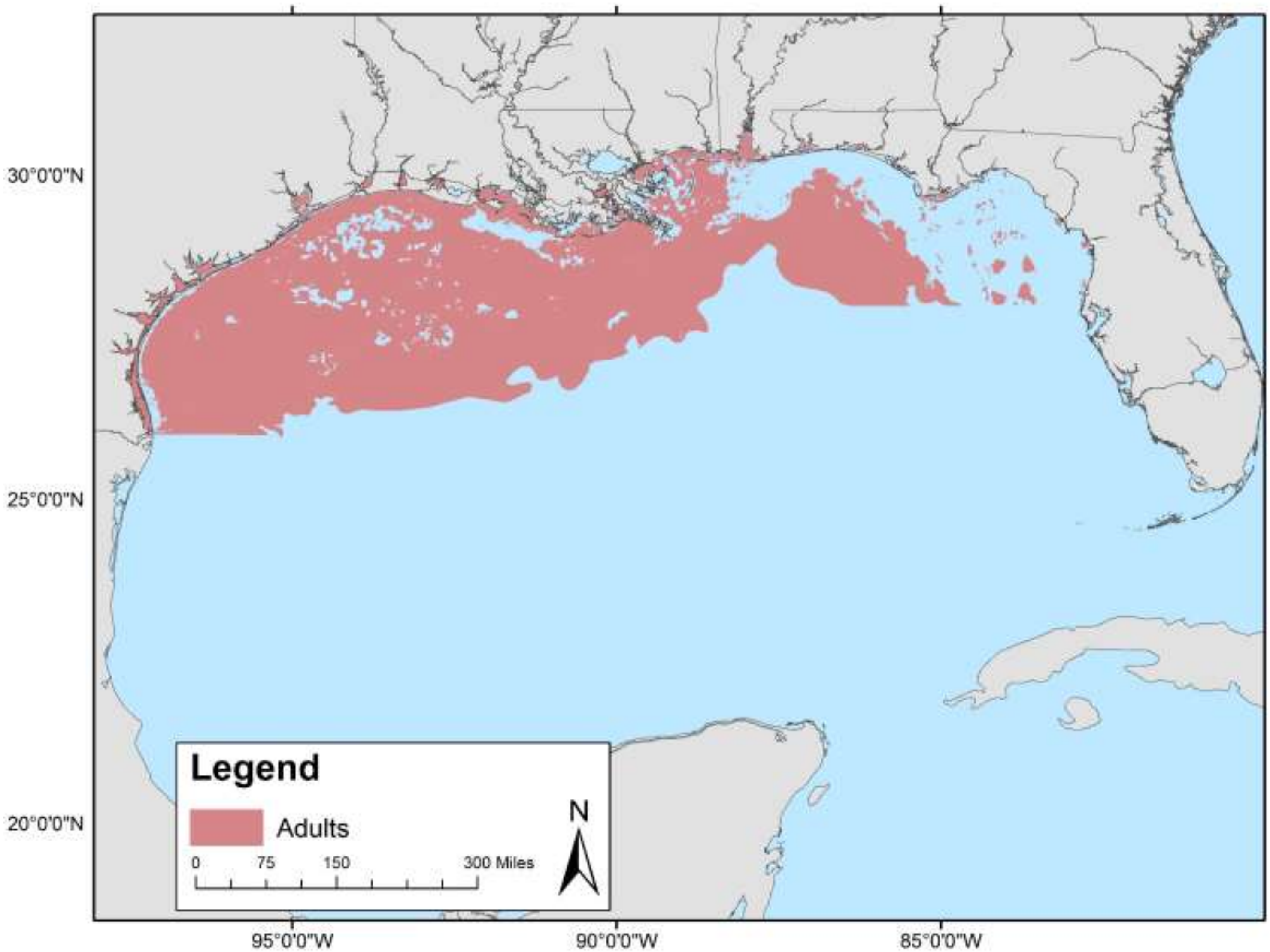

Figure B- 114. Map of benthic habitat use by adult white shrimp.

Pink Shrimp (*Penaeus duorarum*) Benthic Habitat Use Maps

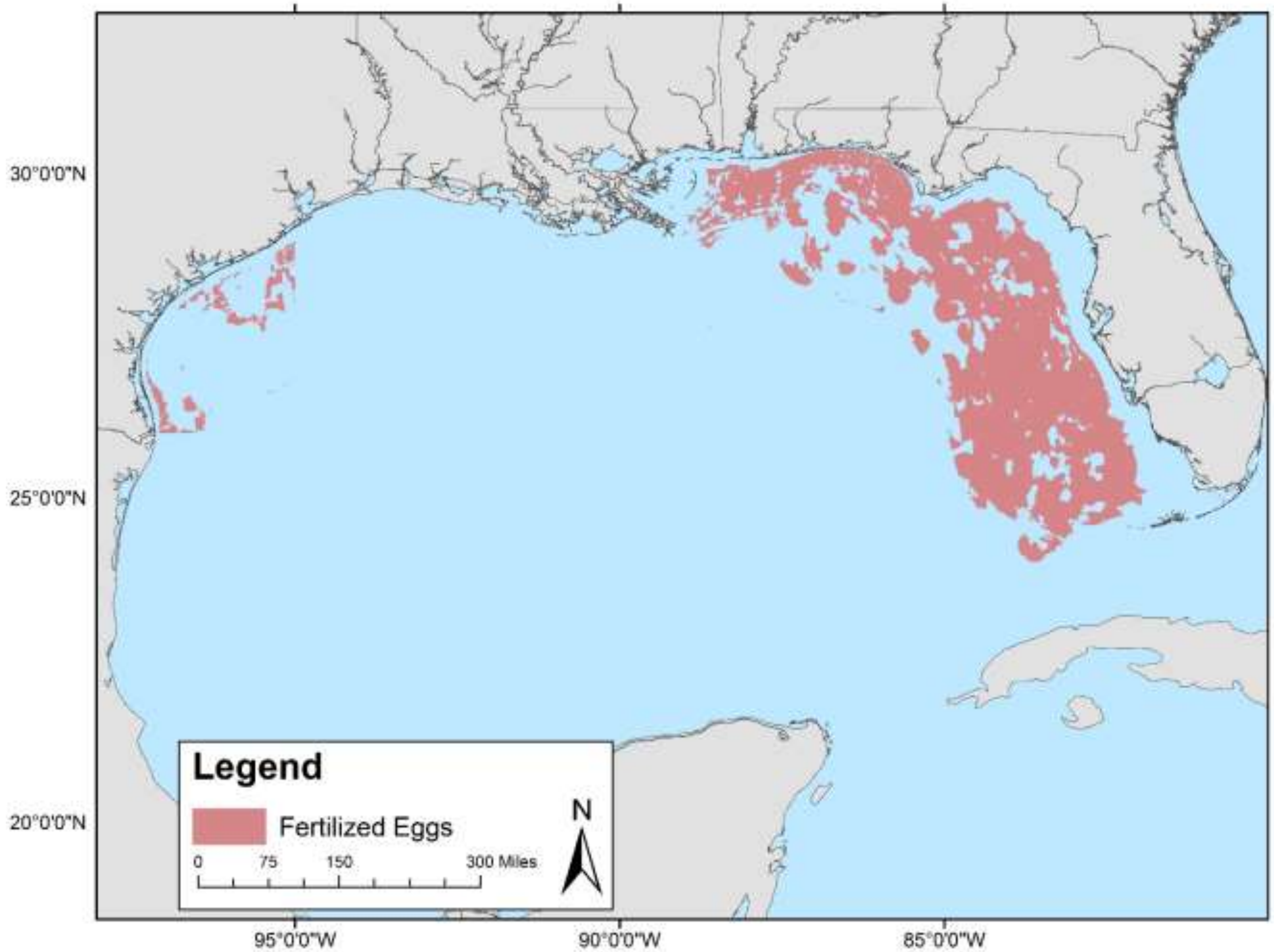

Figure B- 115. Map of benthic habitat use by pink shrimp fertilized eggs.

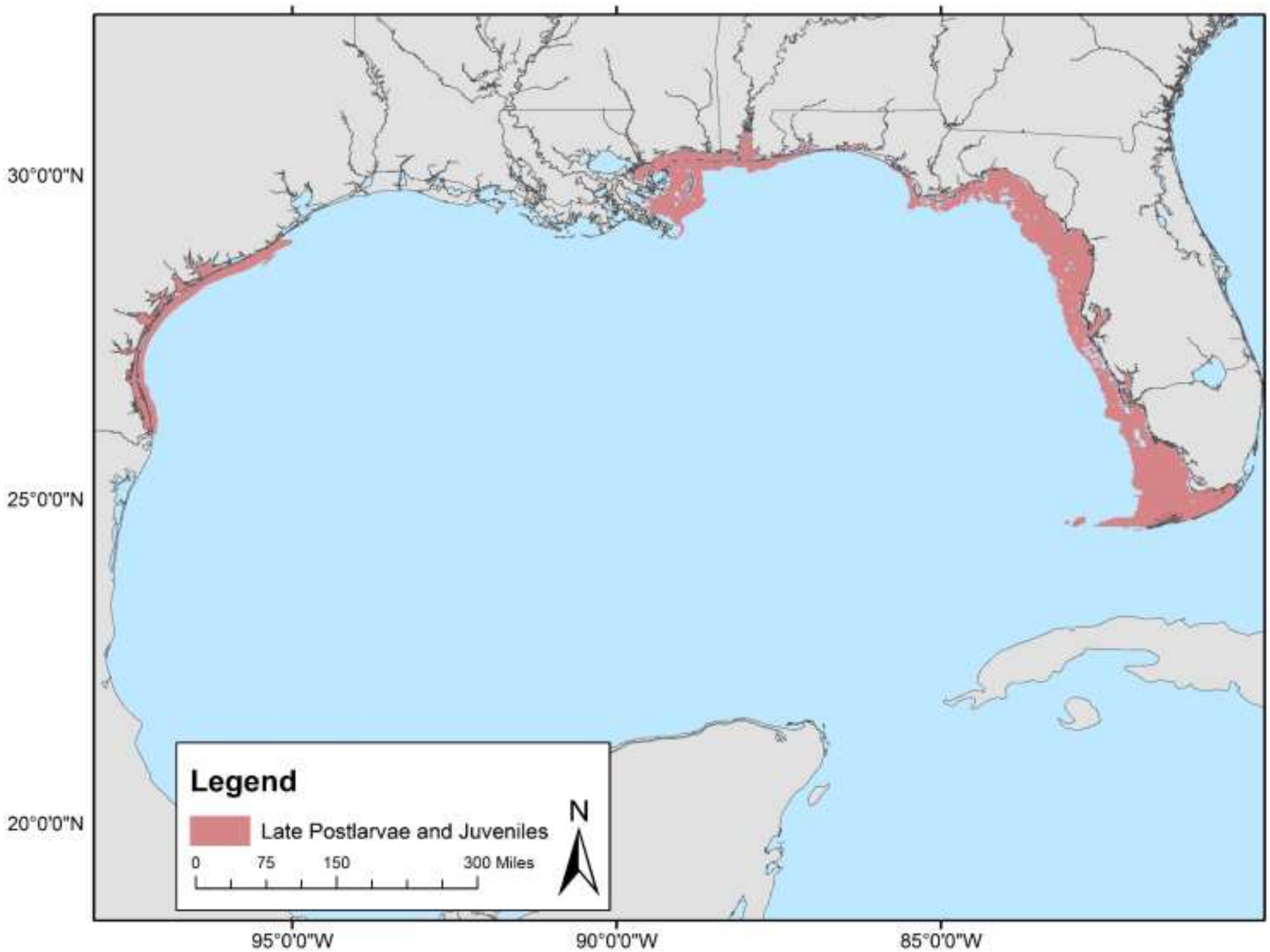

Figure B- 116. Map of benthic habitat use by late postlarval and juvenile pink shrimp.

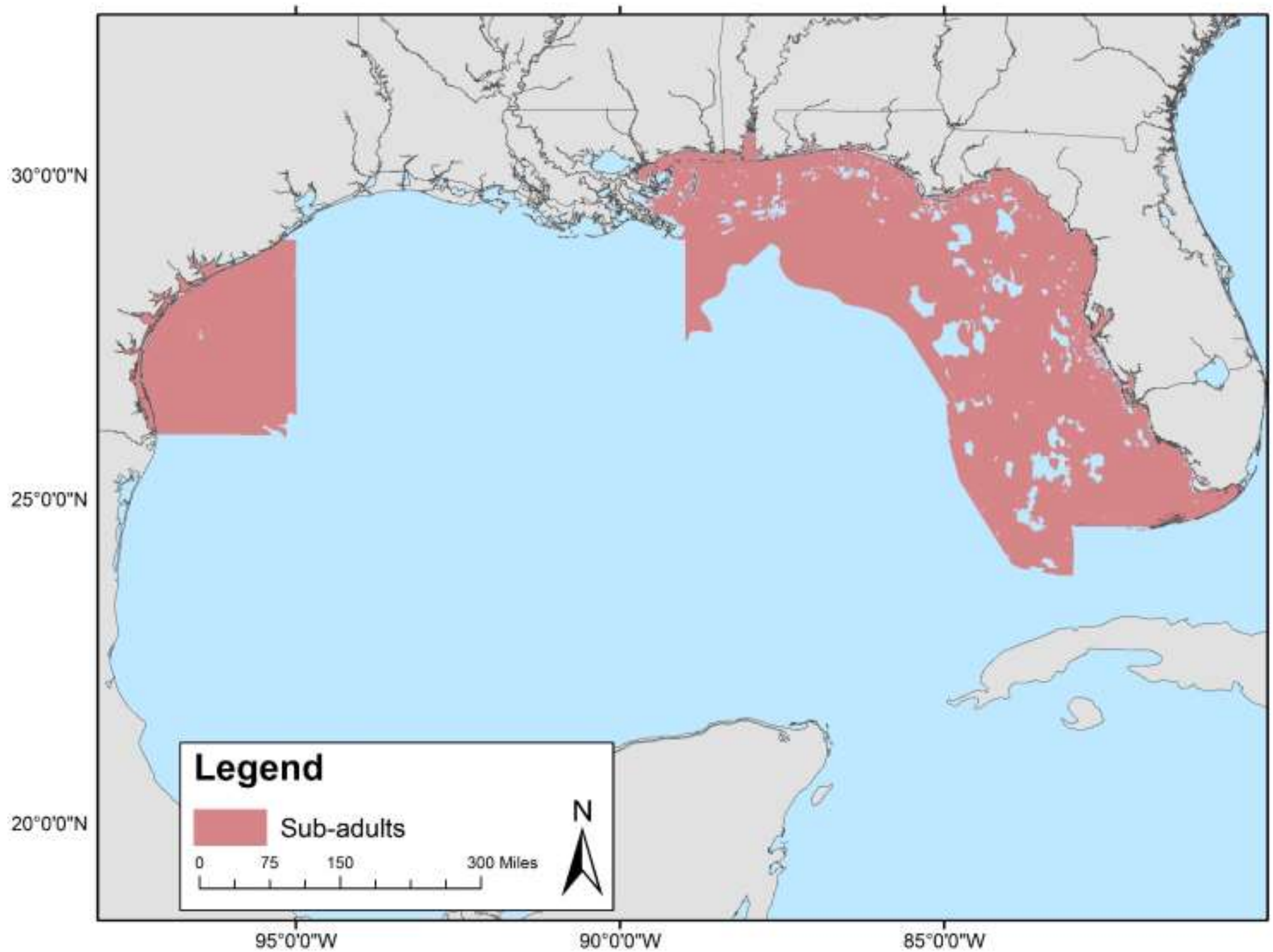

Figure B- 117. Map of benthic habitat use by sub-adult pink shrimp.

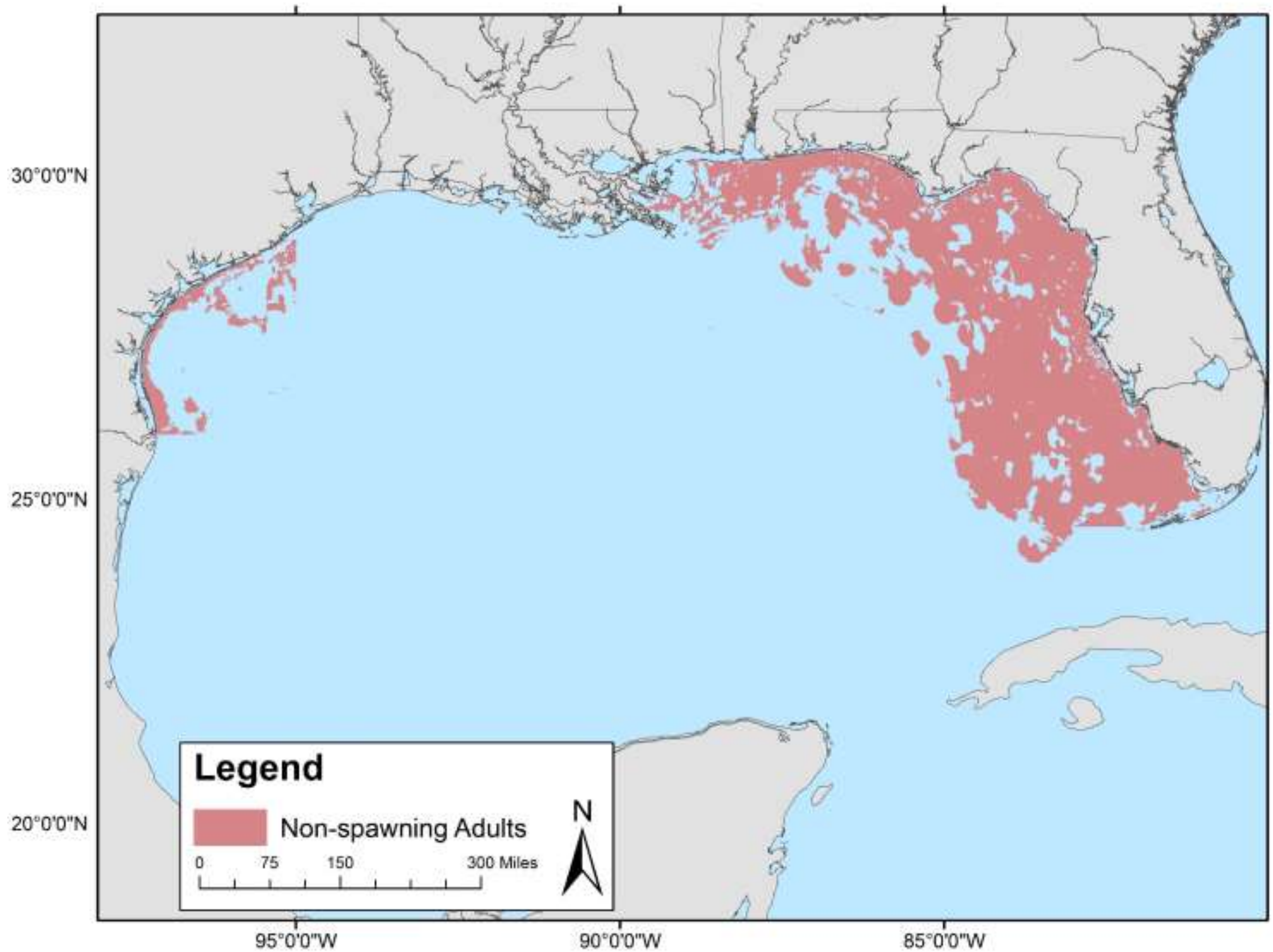

Figure B- 118. Map of benthic habitat use by non-spawning adult pink shrimp.

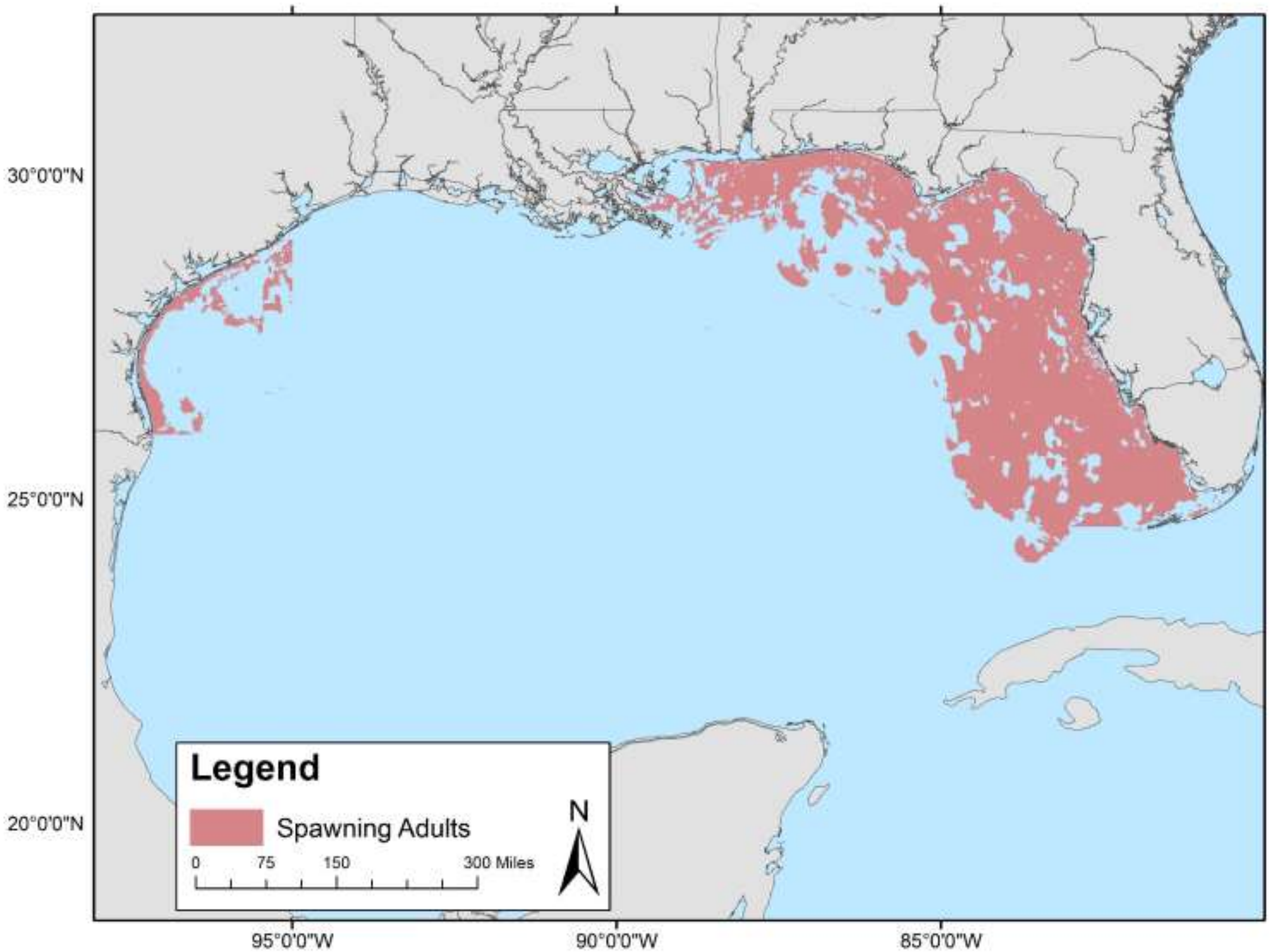

Figure B- 119. Map of benthic habitat use by spawning adult pink shrimp.

Royal Red Shrimp (*Pleoticus robustus*) Benthic Habitat Use Maps

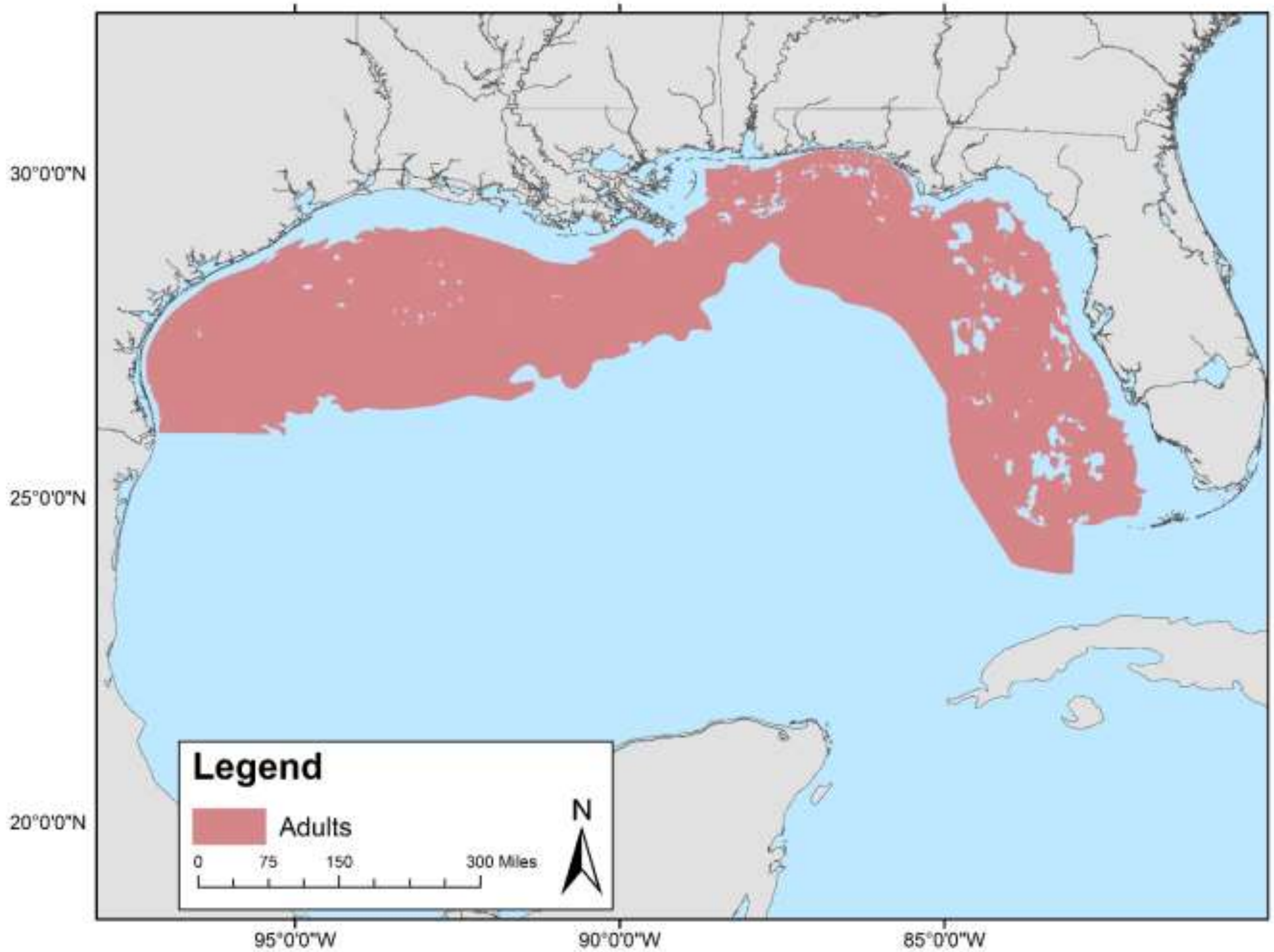

Figure B- 120. Map of benthic habitat use by adult royal red shrimp.

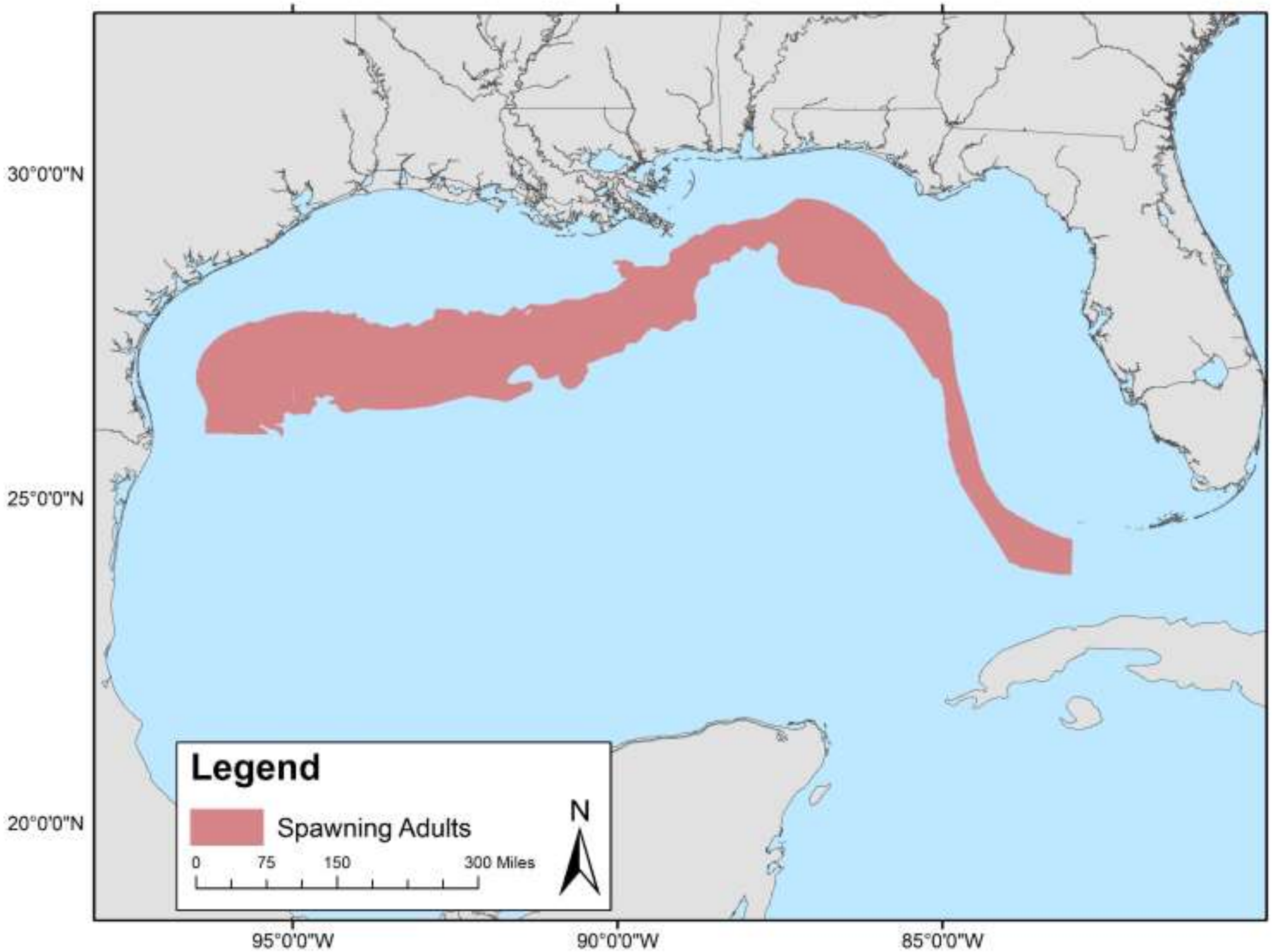

Figure B- 121. Map of benthic habitat use by spawning adult royal red shrimp.

Spiny Lobster (*Panulirus argus*) Benthic Habitat Use Maps

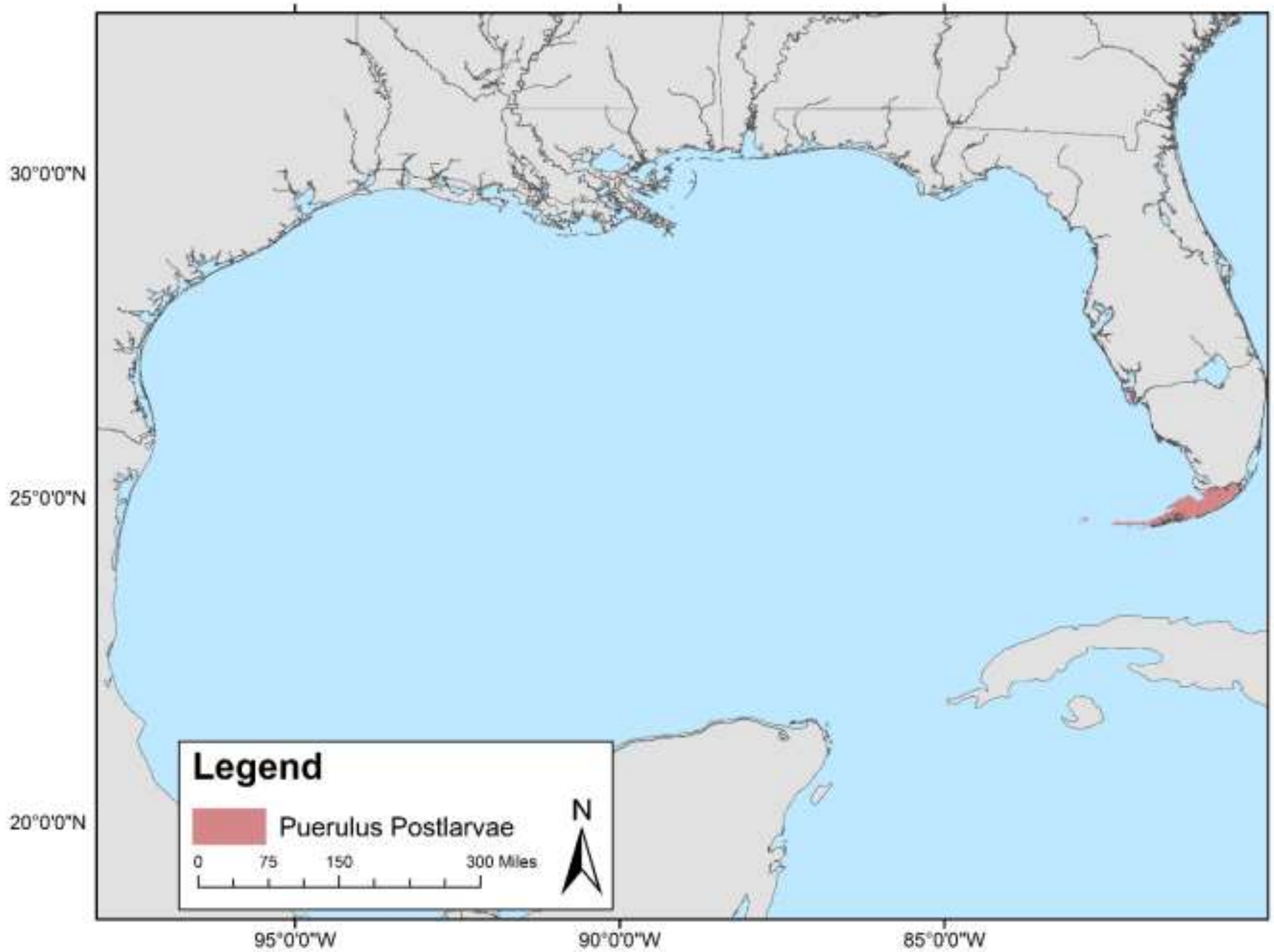

Figure B- 122. Map of benthic habitat use by spiny lobster puerulus postlarvae.

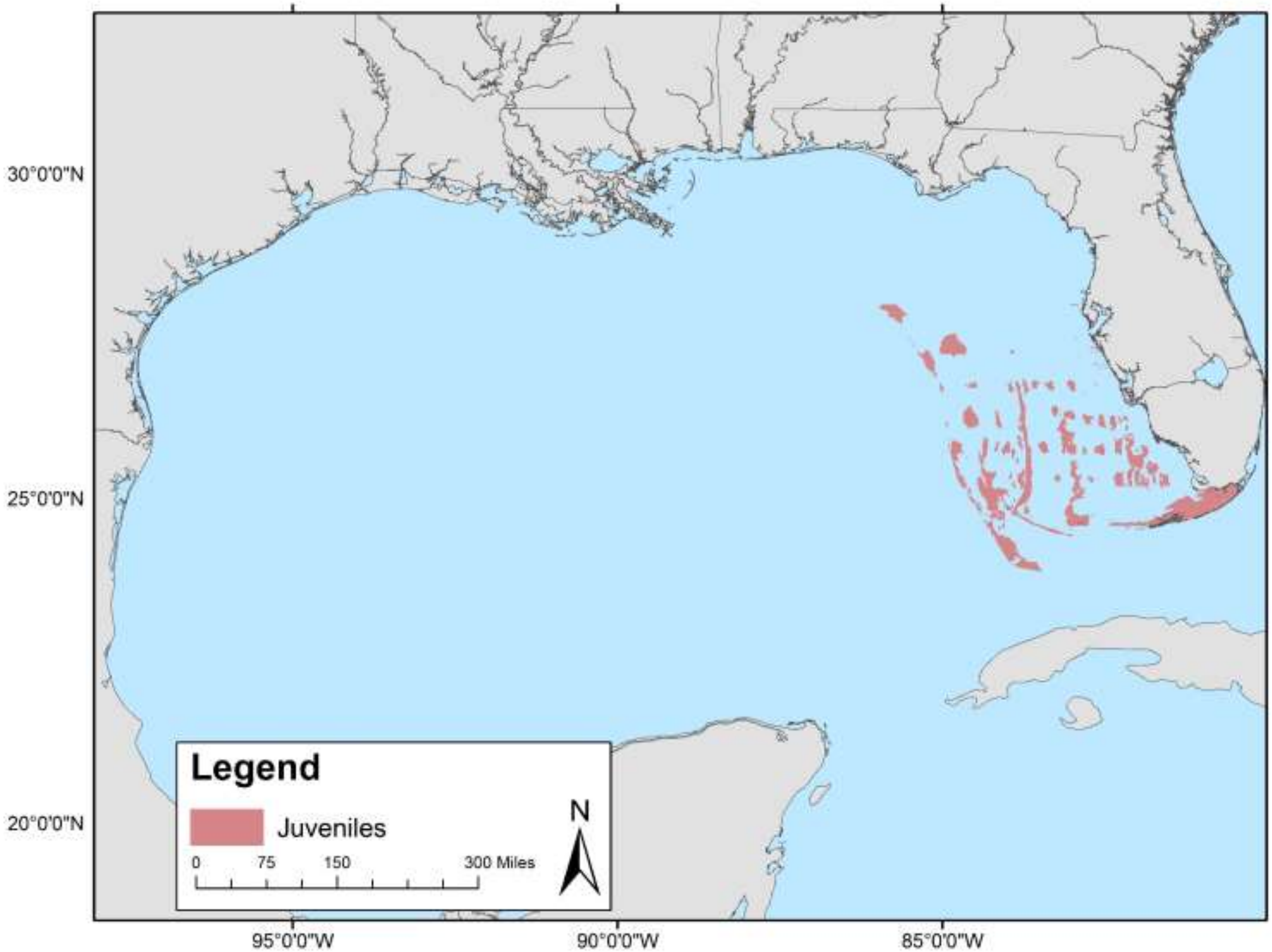

Figure B- 123. Map of benthic habitat use by juvenile spiny lobster.

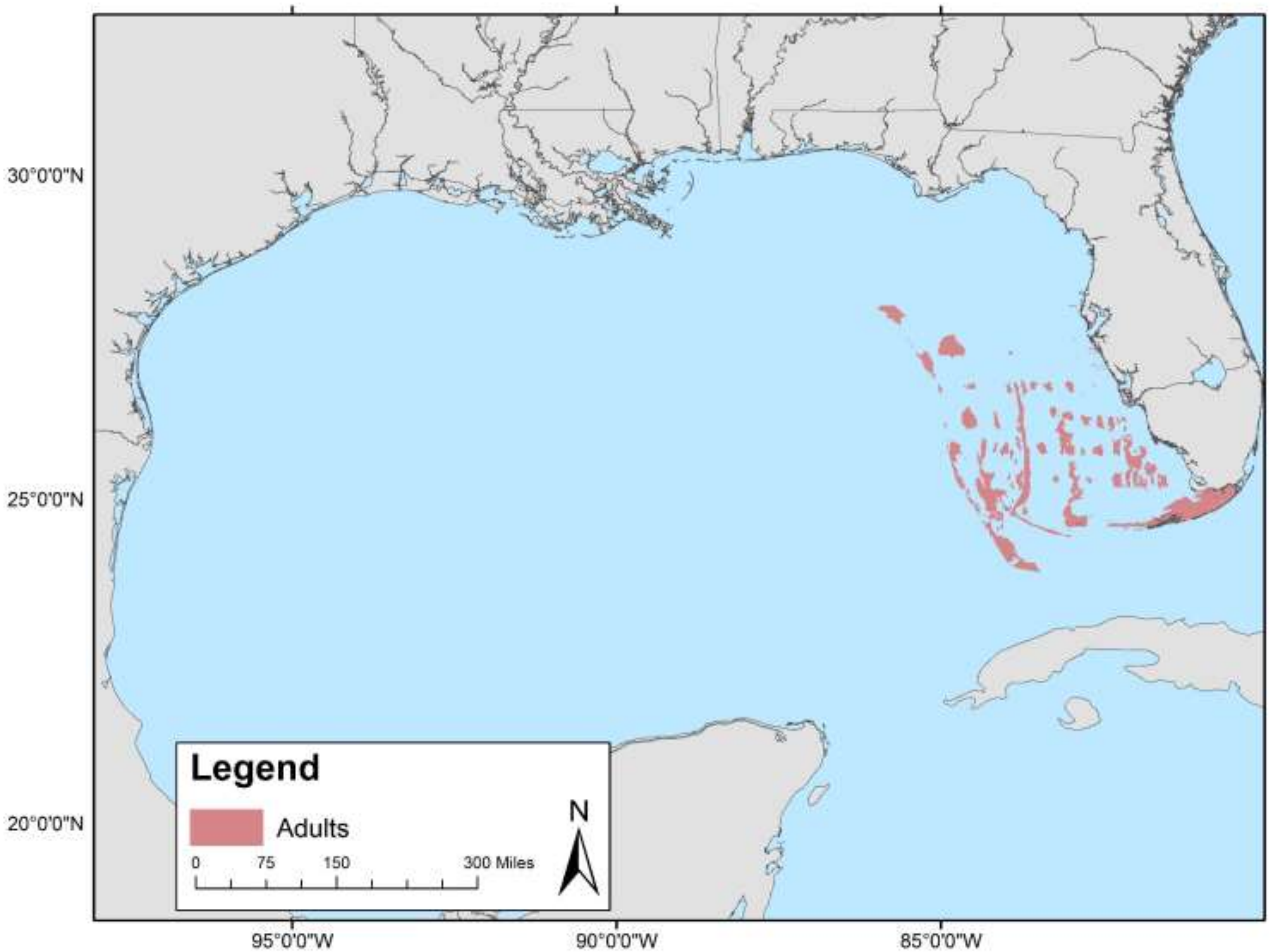

Figure B- 124. Map of benthic habitat use by adult spiny lobster.