Fish fauna of Gray's Reef National Marine Sanctuary and the implications for place-based management.

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Abstract - Marine Protected Areas (MPAs) are becoming an important tool both for single-species and ecosystem-based management, and an important initial step in MPA design is identification of the species that reside in specific areas or that use representative habitats within specific ecosystems. The southeastern U.S. continental shelf ecosystem encompasses a variety of habitats, yet most discussions of MPAs in the region have revolved around the need to protect rocky-reef habitat, which supports important commercial and recreational fisheries. Gray's Reef National Marine Sanctuary could serve a role in a larger network of marine reserves, or could serve as a representative site for documenting the ecology of species associated with inner-shelf rocky reefs; this latter information then could be used in design criteria for selecting other rocky-reef sites to serve as marine reserves. The purpose of this study was to develop a more complete view of the fish species that inhabit Gray's Reef NMS. Data on larval, juvenile, and adult life stages was combined from previous studies to provide as complete a view as possible of the ichthyofauna of Gray's Reef NMS. One-hundred eighty one species of fish were found in the vicinity of the Sanctuary; 27 species were classified as common, and 46 species are currently managed for fishery purposes. Classification of species as either resident or transient revealed that resident species accounted for 37% of the total. The fish species collected in the Sanctuary used a diverse array of habitats over a wide range of bathymetric zones. As adults, fishes were reported from unconsolidated sediments, reefs, submerged vegetation, pelagic, and pelagic vegetation habitats from estuaries to the outer shelf. From the perspective of the ichthyofauna, species that inhabit the Sanctuary use a wide-range of habitats, spread over a large portion of the shelf, and include areas to the north and south of the Sanctuary. Research to quantitatively

understand the inter-dependencies among species and habitats is clearly needed, yet from the qualitative data presented here, Gray’s Reef NMS cannot be managed successfully in isolation, underscoring the broader importance of managing fish and habitat on the southeast U.S. continental shelf using ecosystem-wide approaches to achieve multiple management goals.

Introduction

Marine Protected Areas (MPAs)[1] are becoming an important tool both for single-species and ecosystem-based management (Lubchenco et al., 2003). One subset of MPAs are marine reserves, defined as areas in which some or all of the biological resources are protected from removal or disturbance (NRC, 2001; Lubchenco et al., 2003). Marine reserves are typically implemented to protect or rebuild specific marine resources (e.g., species, representative habitats, representative parts of ecosystems). A number of design criteria have been proposed for marine reserves and other types of MPAs, and an important element of these criteria is knowledge of the distribution, abundance, and dynamics of species within the ecosystem (Hockey and Branch, 1997; Leslie et al., 2003; Roberts et al., 2003a , b). Further, implementation and management of MPAs requires ecological information about constituent species, in particular the dependence of resources within an MPA to outside areas and outside resources, and the movement of resources from inside to outside of the MPA (Polacheck, 1990; NRC, 2001). Thus, an important initial step in MPA and marine reserve design and implementation is identification of the species that reside in specific areas or that use representative habitats within specific ecosystems (see Roberts et al., 2003a, b).

The southeastern U.S. continental shelf ecosystem is comprised of a variety of habitats, yet most discussions of MPAs have revolved around the need to protect rocky-reef habitat, which supports important commercial and recreational fisheries. Rocky reefs are interspersed among unconsolidated sediments along the southeast U.S. continental shelf and upper slope from the east coast of Florida to Cape Hatteras, North Carolina.

[1] Marine Protected Areas are defined as "… any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein". (FR, 2000).

Approximately 30% of the bottom is estimated to be rocky-reef habitat with the remaining bottom covered by unconsolidated sediments (Parker et al., 1983; SEAMAP-SA, 2001). In addition to exposed rock, there are areas where large sessile invertebrates such as sponges and corals attach to the rock, and there are many areas where these sessile invertebrates protrude through a thin veneer of unconsolidated sediment, which covers underlying rock (Wenner et al., 1983). Rocky reefs and sandy areas with associated attached invertebrates will be termed rocky-reef habitat. Rocky-reef habitat supports a distinct assemblage of fishes, which include a number of commercially and recreationally important species (Wenner et al., 1983; Sedberry and Van Dolah, 1984; Parker and Ross, 1986; Parker et al., 1994). For example, many of the 73 species in the South Atlantic Fishery Management Council's (SAFMC) snapper-grouper management unit are associated with rocky-reef habitat (SAFMC, 1998). Some of these fishery species are overfished (17.8%; NMFS, 2003), whereas others are not (13.7%, NMFS, 2003), but the status of the majority of species within the management unit is unknown (68.5%, NMFS, 2003). The SAFMC is considering MPAs, specifically marine reserves that would prohibit bottom fishing, as fisheries management tools to assist in the rebuilding of overfished stocks and to contribute to a strategy of ecosystem management (SAFMC, 1990; 2001).

Along the southeast U.S. coast there are several large coastal MPAs, including National Estuarine Research Reserves and National Marine Sanctuaries (Fig. 1). Gray's Reef National Marine Sanctuary (Gray's Reef NMS) is one of the few MPAs that encompasses continental shelf areas along the southeast coast of the United States. The Sanctuary is 58 km^2 and is located approximately 30 km east of Sapelo Island, Georgia

(Fig. 1). Designated in 1981 (FR, 1981), the Sanctuary is representative of inner-shelf rocky reefs of the southeast U.S. shelf (Sedberry and Van Dolah, 1984; Parker et al., 1994), although it has more vertical relief than most other inshore rocky-reefs (> 1 m, Parker et al., 1994). The objectives of the Sanctuary are to provide protection and comprehensive management for the rocky-reef habitat and associated biological communities (FR, 1981). Gray's Reef NMS was not established as a fisheries management tool (i.e., a marine reserve), and regulations generally conform to fishing restrictions imposed by the SAFMC, which has jurisdiction in federal waters of the region. In addition to following SAFMC regulations, Gray's Reef NMS prohibits wire fish traps, bottom trawling, longlines and spears equipped with explosive projectiles (powerheads). Commercial fishing gear such as vertical hook and line (the dominant gear in the reef fish fishery in the region) is allowed, as is all recreational fishing gear. It is unlikely that Gray's Reef NMS will become a marine reserve (i.e., a no-take zone). However, Gray's Reef NMS could serve a role in a larger network of marine reserves, or could serve as a representative site for documenting the ecology of species associated with inner-shelf rocky reefs. This latter information then could be used in design criteria for selecting other rocky-reef sites on the southeast U.S. shelf to serve as marine reserves.

An important step in understanding the role of Gray's Reef NMS in the larger context of marine reserves on the southeast U.S. shelf is determining the species that occur in the Sanctuary. Adult and large juvenile fishes have been enumerated with trawl collections, trap collections, and diver-conducted video surveys (Sedberry and Van Dolah, 1984; Parker et al., 1994; Sedberry et al., 1998), but these studies emphasized the rocky-reef habitat in the Sanctuary. Although adult fishes have been described in unconsolidated sediments (Parker et al., 1994), there is little information regarding the entire assemblage of species that occur on unconsolidated habitats within the Sanctuary, even though these areas make up approximately 70% of bottom habitat (Matt Kendall, NOAA NOS NCCOS Center for Coastal Monitoring and Assesment, pers. comm.). Further, previous studies have examined adult and large juvenile fishes in the Sanctuary, but there is only limited information regarding the occurrence of larval and juvenile stages.

The purpose of this study was to develop a more complete view of the fish species that inhabit Gray's Reef NMS. We combined additional adult census data with previously published data. We also included larval and juvenile fish data collected around the perimeter of the Sanctuary. The various datasets describe a much more diverse fish fauna, and the view emerges that Gray's Reef NMS is much more than an area protecting rocky-reef habitat and reef fishes. Further, there is evidence for substantial interaction between species that use rocky-reef habitat in the Sanctuary and species that use a number of other habitats in the coastal ocean indicating that management efforts should focus on the entire ecosystem rather than specific habitats.

Materials and methods

Data for fishes in Gray's Reef NMS were derived for three life stages from six sources. Large juvenile/adult data were derived from trawl collections, fish trap collections, diver video transects, and stationary diver point counts. Juvenile data were derived from beam trawl collections. Larval data were derived from ichthyoplankton collections. The specific methods associated with each data source are provided below; the sampling time, effort, and gears used are detailed in Table 1. Only bony fishes (Osteichthyes) will be considered here, because most of the gears reviewed did not collect sharks and rays (Chondrichthyes).

Adult and large juvenile censuses

Bottom Trawls. Trawling was conducted in the area of Gray's Reef NMS before designation as a NMS. Briefly, a 40/54 high rise trawl was used, which is effective in sampling fishes on rough bottom (Sedberry and Van Dolah, 1984). Trawl samples were standardized by towing the net for an approximate distance of 1 km. Adult and large juvenile fish were collected, sorted to species and counted. Data were collected in 1980 and 1981 and stratified by season: winter (January-March, 1980; March 1981), spring (April, 1981), summer (August-September, 1980; July 1981), and fall (October, 1981). Seasonal abundance was calculated as total number of individuals collected in a season divided by number of trawls made in a season (see Sedberry and Van Dolah, 1984).

Traps. Chevron-shaped wire fish traps were baited with cut clupeids and deployed at randomly selected reef stations within Gray's Reef NMS for approximately 90 min. Trap deployments were made during summer (July) from 1993-2002. Upon retrieval of the trap, adult and large juvenile fish were sorted to species and counted. Abundance was calculated as total number of individuals caught divided by the number of trap sets (see Sedberry et al., 1998).

Video Transects. Divers swam 15-min transects at randomly selected sites in five habitats within Gray's Reef NMS. One diver swam with a video camera in a rigid forward position approximately 1 m above the bottom. Transect distance was measured using a towed surface buoy. Videotaped transects were viewed to estimate the abundance of each fish species on a given transect. Video surveys were conducted in the spring (May), summer (August), and fall (November), but data were pooled across season and stratified by habitat. Abundance was calculated as total number of fish counted divided by total transect distance in a given habitat (see Parker et al., 1994).

Point Counts. In 1995, a permanent study site was established on a randomly chosen rocky-reef ledge within the Sanctuary, and 22 stations at this site were randomly selected. At each station, a stainless steel rod (1 cm x 100 cm) was cemented into holes drilled into the reef substrate. Following the random selection of fixed stations, a modified version of the stationary sampling method was used to enumerate fishes (Bohnsack and Bannerot, 1986) with a cylinder width of 4 m radius. Point counts were made over eight years in three seasons: spring (April), summer (June, July, and August), and fall (October and November). Data were stratified by season; abundance was calculated as number of fish counted divided by number of point counts made in a given season.

Juvenile and larval census

Juvenile and larval fish sampling was conducted approximately every other month from April 2000 through February 2002. Ten stations were located approximately 18.5 km apart along a 93-km cross-shelf transect spanning the Georgia shelf. The sampling transect bisected Gray's Reef NMS and four stations were sampled just outside the perimeter of the Sanctuary. All four seasons were sampled: winter (January, February, and March), spring (April and May), summer (June and August), and fall (October). Only the species abundance data by seasons from the stations around Gray's Reef NMS were considered here. The full cross-shelf juvenile fish dataset was analyzed by Walsh et al. (in review) and the full cross-shelf larval fish data set was analyzed by Marancik et al. (2005).

Beam Trawl. At each station, juvenile fish collections were made with a 2-m beam trawl with 6-mm mesh body and a 3-mm mesh tail bag. Three replicate, 5-min tows were made at each station. Juvenile fish abundance was calculated as fish per 5 min tow and the three replicates were averaged to represent abundance at each station. Adults were removed from the analyses of beam trawl collections using the estimated size of first maturity as a minimum size threshold for inclusion in data analysis (see Walsh et al., in review).

Bongo. Larval fish collections were made with a 61-cm paired bongo frame with either 333 or 505 µm mesh nets. The net was fished double obliquely and deployed to within 1 m of the bottom. On one sampling cruise, a 1-m ichthyoplankton sled with 333-µm mesh was used. Larval fish collected with the 1-m sled and 61-cm bongo were similar and data from both gears were used (Marancik, 2003). Larval concentration was calculated as fish 100 m^{-3}.

Data compilation and analysis

Percent abundance was calculated for each taxon from the sum of all abundances-per-unit-effort within a season, or in the case of the video transect data, within a habitat. Species were ranked by relative abundance and cumulative percent abundance was calculated. Common species observed during each census were defined as species making up greater than 5% of the total abundance. Typically, fewer than five species per census and season were classified as common.

Data from the different census techniques were combined to derive an overall species list for Gray's Reef NMS. The species list was then used to derive a list of managed species that occur within the vicinity of the Sanctuary. Data from the larval and juvenile censuses were also used to determine which species are spawning (the occurrence of small larvae) and which species are settling (the occurrence of settlement size juveniles) in the vicinity of the Sanctuary. Sedberry et al. (in press) presented spawning times and locations for a number of fishes on the southeast U.S. shelf based on reproductive data obtained from trawl, trap, and hook-and-lines samples. All records of spawning females within 30 km of Gray's Reef NMS were obtained and used to augment spawning information derived from larval surveys.

Patterns in the seasonal and habitat-specific occurrence of species were then examined qualitatively from comparison of the species number, abundance of fish, and diversity. Species number is simply the number of taxa occurring in a census. Abundance was calculated as the number of fish per unit of sampling (per see above). Species diversity (H') was calculated following Pielou (1969):

$$H' = -\sum_{i=1}^{S} p_i (\log_2 \ p_i)$$

where S is the total number of species and p_i is the proportion of the total sample belonging to species i.

Finally, distribution and habitat information was obtained for each species from the literature. Dominant sources of information included data from studies that were included here (Sedberry and Van Dolah, 1984; Marancik et al., 2005; Walsh et al., in review). However, a number of additional sources were used to compile complete distribution and habitat-specific occurrences of each species (see Appendix 2). Distribution was categorized into six cross-shelf zones: palustrine, estuarine, inner-shelf, mid-shelf, outer-shelf, and upper slope. Six habitat categories were defined: rocky reef, sediment, submerged vegetation, pelagic vegetation, and pelagic. Fish distribution and habitat use was defined for larval, juvenile, and adult life stages. In addition, the mode of spawning was categorized as either pelagic or benthic. Finally, a determination was made whether a species is resident or transient in Gray' Reef NMS. These life history, distribution, and habitat attributes were then summarized to examine general patterns in the ecology of fishes that inhabit Gray's Reef NMS.

Results

Common species

A total of 27 taxa were found to be common (> 5% of total) in one or more fish censuses in the vicinity of Gray's Reef NMS (Table 2). Some of these taxa included multi-species groups (e.g., *Anchoa* spp., *Etropus* spp.), and thus the number of common species in Gray's Reef NMS likely exceeds 30. The adult and large juvenile censuses all provided a similar view of the ichthyofauna of Gray's Reef NMS with common species including

Haemulon aurolineatum, *Stenotomus* spp., *Decapterus macarellus*--*D. punctatus* (the en-dash means that fish were identified as *D. macarellus* or *D. punctatus*), *Halichoeres bivittatus*, *Serranus subligarius*, *Diplodus holbrooki*, and *Centropristis striata*. A different view of common fishes was obtained from juvenile fish collections: *Etropus* spp., *Prionotus* spp., *Ophidion selenops*, *Diplectrum formosum*, *Microgobius carri*, *Stephanolepis hispidus*, *Dactyloscopus moorei*, and *Leiostomus xanthurus*. Larval fish collections provided yet another view of the ichthyofauna of Gray's Reef NMS, with common species including *Caranx* sp.--*Chloroscombrus chysurus*, *Symphurus* spp., *Ophidion marginatum*, *Diplogrammus pauciradiatus*, *Larimus fasciatus*, *Brevoortia tyrannus*, *Micropogonias undulatus*, *Anchoa* spp., *Etropus* spp. *Prionotus* spp., *Microgobius carri* [as included in Gobiidae], *Leiostomus xanthurus*, and *Citharichthys spilopterus*. In addition, sparid larvae were common but could not be identified below family level. Although common species differed between census types, species common in one census were often present in another census in lower numbers and thus, all three approaches (adult, juvenile and larval censuses) provide different, yet complementary views of the ichthyofauna of Gray's Reef NMS.

Managed Species

A total of 46 species managed by various state and federal agencies were found in Gray's Reef NMS (Table 3). Half of these species are part of the SAFMC Snapper-Grouper complex (NMFS, 2003), and a number of managed mackerel and tuna species also occurred in the Sanctuary. Species managed by the Mid-Atlantic Fisheries Management Council (MAFMC), New England Fisheries Management Council (NEFMC) and

Atlantic States Marine Fisheries Commission (ASMFC) were present in Gray's Reef NMS, as well as, a number of species that are regulated by Florida, Georgia, South Carolina, and North Carolina. Managed species that are common (Table 4) include members of the Snapper-Grouper complex managed by the SAFMC and three species managed by the ASMFC (*Micropogonias undulatus*, *Brevoortia tyrannus*, and *Leiostomus xanthurus*), which spawn on the shelf during fall, winter, and spring, and whose juveniles use estuarine habitats.

Spawning

The occurrence of small larvae and spawning females indicated that 53 taxa of fish spawn in the vicinity of Gray's Reef NMS (Table 4). A number of managed species spawn in the vicinity of the Sanctuary, including coastal migratory pelagic species managed by the SAFMC (e.g., *Scomberomorus cavalla* and *S. maculatus*) and species managed by the ASFMC and the southeastern states (e.g., *Brevoortia tyrannus*, *Leiostomus xanthurus*, and *Sciaenops ocellatus*). Although the management focus of Gray's Reef NMS is rocky-reef habitat, the general absence of lutjanid and epinepheline larvae indicates that snapper and grouper are not spawning in the vicinity of Gray's Reef NMS. However, spawning females of *Rhomboplites aurorubens* and *Diplectrum formosum* were collected within 30 km of Gray's Reef NMS (Sedberry et al., in press).

Settlement

Settlement stage juveniles of 20 taxa were found in the vicinity of Gray's Reef NMS (Table 5). In addition, four pelagic species were collected that were undergoing the larval-juvenile transition. A wide range of species were collected that settle to a broad range of habitats. Importantly, very few settlement-stage reef fish were collected, but this likely results from gear biases (i.e., the lack of direct sampling on rocky reefs) rather than the absence of reef fish settlement at Gray's Reef NMS.

Seasonal Patterns in Species Number, Abundance and Diversity

There was a strong seasonal pattern in the number of species collected across gear types (Fig. 2A). Species number was highest during the summer for all collection methods and was second highest in the fall for all censuses except the juvenile census. Winter and spring had a relatively similar number of species with a few more species collected during spring in the adult censuses and more species collected during winter in larval and juvenile censuses. The higher number of species during winter in larval and juvenile fish collections was due in part to the presence of estuarine-dependent species in the vicinity of Gray's Reef NMS during winter (*B. tyrannus, L. xanthurus, M. undulatus*).

Seasonal patterns also were observed in absolute abundance, but were not consistent across censuses (Fig. 2B). Absolute abundance was highest during summer or fall, depending on the census. The high summer and fall abundances in the bottom trawl collections were driven by *Stenotomus* spp. and *Haemulon aurolineatum* in the summer (42.6% and 42.2% of total catch) and *Sardinella aurita* in the fall (43.9% of total catch) (see Table 1). The high summer and fall abundances in adult point counts were driven largely by *Decapterus punctatus--D. macarellus* (77.6% in summer and 54.6% in fall of total catch). Abundances in the juvenile censuses were relatively even over the seasons, but the dominant taxon in the fall was *Prionotus* spp. (52.0% of total catch). Summer abundances of larvae were more even across species with *Anchoa* spp., *Caranx* sp--*Chloroscombrus chrysurus*, *Symphurus* spp., *Diplogrammus pauciradiatus*, and Gobiidae accounting for 80.1% of total abundance.

There was little congruence in the seasonal pattern of species diversity (H') between sampling methods (Fig. 2C), which was expected owing to the patterns observed in the number of species and their numerical abundance. For bottom trawl collections of large juveniles and adults, H' was highest in winter owing to the relatively even distribution of abundance among species. In point counts, H' was highest in spring, again owing to the relatively even distribution of abundance among species. Highest H' in juvenile and larval censuses occurred in the summer and fall respectively because of the high number of species collected. Relatively high H' in winter larval collections was again caused by relatively few species with an even abundance distribution.

Compilation of species and ecological information

A total of 181 species was reported from Gray's Reef NMS from the six censuses combined (Appendix 1). Classification of species as either resident or transient revealed that resident species accounted for 37% of the total (Table 4). A majority of the transient species were likely seasonal migrants (52% of total), and a relatively small number of expatriated species occurred in the Sanctuary (9% of total). Three eel species that move through the Sanctuary during their life cycle also occurred (2% of total; *Anguilla rostrata*, *Conger oceanicus*, and *Myrophus punctatus*). In considering only common species (> 5% of total in any one census method), 49% of common species were resident and 51% were transient, and all the transient species were likely seasonal migrants (Table

6). A higher percentage of managed species were transients (74%) compared to residents (26%), and most of these transients were seasonal migrants with a few expatriates.

Although the management focus of Gray's Reef NMS is rocky-reef habitat and associated biological communities, the fishes collected in the Sanctuary used a diverse array of habitats. As adults, fishes were reported from unconsolidated sediments, reefs, submerged vegetation, pelagic, and pelagic vegetation habitats (in rank order, Fig. 3). Juveniles were reported from a similar array of habitats as adults, but more species occurred in pelagic vegetation as juveniles than as adults. Fewer species were reported from reef habitats as juveniles, but part of this difference resulted from a lack of knowledge of juvenile habitat for many reef fish species. These patterns in habitat use were consistent when considering all species, abundant species, and managed species, with the exception that a greater proportion of managed species were found in reef habitat.

The species that occurred at Gray's Reef NMS were reported to use habitats from the estuary to the slope (Fig. 4). The greatest number of species reportedly use the inner and mid-shelves as adults (~54%). A fewer number of species are reported to use areas inshore of the inner-shelf and offshore of the mid-shelf (23%). A greater percentage of juveniles were found in habitats inshore of the inner-shelf (29%) compared to the inner- and mid-shelves (48%); the percentage of juveniles found in habitats offshore of the mid-shelf was similar to the percentage of adults (23%). A greater percentage of common species were reported from coastal and estuarine areas (27% and 29%) compared to all species combined. The importance of habitats inshore of the inner-shelf was even more evident for the adult and juvenile stages of managed species (30% and 45% of managed species) compared to all species combined.

Discussion

One-hundred eighty one species of fish were found in the vicinity of Gray's Reef NMS. A total of 27 species were common (Table 2), and 46 species are currently managed for fishery purposes (Table 3). A clear pattern in species occurrence from all the censuses was an increase in the number of species in the summer, which has been documented in earlier studies (Sedberry and Van Dolah, 1984; Wenner and Sedberry, 1989; Marancik et al., 2005). Much of the summertime increase in species number was due to the seasonal migration of warmer-water species. There was some additional evidence that species number increases in the summer owing to the settlement from the plankton of warm-water species. In the winter, species diversity (H') was relatively high, because a number of estuarine and pelagic species were abundant again owing to seasonal migrations.

The fraction of marine migratory species using estuaries decreases with latitude (see review by Nordlie 2003). The gradient is illustrated by reviews of fishes in Mid-Atlantic estuaries and Florida Bay. Able and Fahay (1998) determined that in Mid-Atlantic estuaries, 28% of 70 fish species were resident, and 66% were transient. In a similar study of Florida Bay, Powell et al. (in review) reported that 47% of the 60 fish species were resident and 53% were transients. At Gray's Reef NMS, a location in between Mid-Atlantic estuaries and Florida Bay, an intermediate percentage of species were categorized as resident (37%) and transient (63%). These data suggest that the latitudinal trend in marine migratory species in estuarine habitats may extend onto the shelf and future work examining large-scale spatial patterns in the composition of ichtyofauna would contribute to regional management strategies.

Taxonomy remains a limiting factor in the study and management of fishes along the southeast U.S. coast. This study illuminates three general taxonomic issues. First, our ability to identify the early life stages of a number of species is still limited. The larval census (Marancik et al., 2005) identified some common fishes and managed fishes to genus or family only (e.g., *Symphurus* spp., *Urophyscis* spp., Serraninae, *Caranx* sp--*Chloroscombrus chrysurus*). Similarly in the juvenile census, the identification of several abundant species was to genus only (*e.g.*, *Prionotus* spp., *Etropus* spp.). New methods of early life stage identification (e.g., Hare et al., 1998; Sevigny et al., 2000) coupled with traditional techniques (see Fahay, 1984; Richards et al., in press) will improve early life stage taxonomy, but the application of these new techniques is still not widespread. A second taxonomic issue is the identification of species by divers. Without collecting voucher specimens and verifying the identifications of each diver, there may be inconsistencies among divers. An example is the identification of *Decapterus macarellus--D. punctatus*. Divers identified large schools of these fish as either one species or the other. Both species are outwardly similar in appearance (Robins and Ray, 1986) and impossible to identify to species in mixed-species schools. Taxonomic experience of divers can be balanced by sample size if the availability of inexperienced divers leads to greater number of observations (Pattengill-Semmens and Semmens, 1998). Yet, it seems prudent for monitoring programs to determine likely taxonomic problems and either disregard data collected for problematic species or use higher taxonomic groups (as done here). A third issue is outstanding taxonomic uncertainties along the southeast U.S. shelf. For example, *Stenotomus* spp. have been identified as *Stenotomus aculeatus* (Wenner and Sedberry, 1989; Sedberry et al., 1998), but Eschmeyer (2004) considered the taxa as a synonym of *S. chrysops*. Both *S. chrysops* and S. *caprinus* are reported from the area (Carpenter, 2003) and as a result of this taxonomic uncertainity, ecology of *Stenotomus* along the southeast U.S. coast remain unresolved.

In addition to taxonomic limitations, our understanding of Gray's Reef NMS ichthyofauna is limited by several data gaps including: the ecology of juvenile reef fish, understanding of the pelagic fish fauna, trophic linkages between reef and non-reef habitats, and the importance of unconsolidated sediments on the shelf to fish productions. Further, our review considered only bony fishes; information regarding elasmobranches is not included. These data gaps hamper the development of ecosystem approaches to fisheries and place-based management. Very little is known regarding the ecology of juvenile reef fish on rocky reefs along the southeast U.S., yet the ecology of juvenile coral reef fish has been the focus of intense study and has yielded great insights both scientifically and for management (e.g., Lindeman et al., 2000; Levin and Grimes, 2002). Juvenile fish ecology in temperate rocky reefs has also been studied in regions other than the southeast U.S. shelf and again lead to improved management of fisheries and habitat resources (Vigliola et al., 1998; Planes et al, 2000).

Another important data gap includes pelagic fishes. Juvenile and adult pelagic fishes associated with *Sargassum* are relatively well studied (e.g., Dooley, 1978; Coston-Clements et al., 1991; Settle, 1993). Similarly, pelagic fish of commercial importance (e.g., king mackerel, Spanish mackerel) also are well studied (e.g., Collins and Stender, 1987; Collins et al., 1998; Harris and Dean, 1998). In contrast, relatively little is known regarding the juvenile and adult stages of most pelagic fishes. The abundance of these species (e.g., *Decapterus punctatus*, *D. macarellus*, and *Chloroscombrus chrysurus*) suggests an important ecological role in the ecosystem that has yet to be investigated (but see Hales, 1987; McBride et al., 2002).

Concepts of fish habitat utilization are developing on the southeast U.S. shelf (SAFMC, 1998). In a few habitats, particularly submerged vegetation in estuaries, the effect of habitat on vital rates has been examined (Hoss and Thayer, 1993; Irlandi and Crawford, 1997; Taylor and Miller, 2001; Levin and Hay, 2003). However, such detailed information on the interaction between habitat and fish population vital rates has not been conducted for the majority of habitats in the southeast U.S. ecosystem.

The focus of Gray's Reef NMS is protection of rocky-reef habitat. Additionally, the Sanctuary is mandated to provide protection and comprehensive management for biological communities associated with rocky-reef habitat. From the perspective of the ichthyofauna, associated biological communities include a wide-range of habitats, spread over a large portion of the shelf, and include areas to the north and south of the Sanctuary. Most species reported from the Sanctuary have pelagic larvae (Appendix 1) and thus, the ichthyofauna is connected to other areas through pelagic larval transport (sensu Roberts et al., 1997; Cowen, 2002); the areal extent of these connections has not yet been quantified. Additionally, a number of the adult stages, which inhabit rocky reefs in the Sanctuary, use other habitats as both juveniles and adults. *Mycteroperca microlepis* and *Centropristis striata* use habitats within estuaries as juveniles (Able et al., 1995; Ross and Moser, 1995); *M. microlepis* spawns on the edge of the continental shelf, and *C. striata* spawns across the shelf (Sedberry et al., in press). Several species of *Caranx* use pelagic sargassum as juvenile habitat (Coston-Clements et al., 1991; Settle, 1993). *Centropristis ocyurus* and *Stenotomus* sp. use unconsolidated sediments during both juvenile and adult stages (Wenner et al., 1983; Sedberry and Van Dolah, 1984; Walsh et al., in review).

In addition to using multiple habitats, there are a large number of transient species that spend a portion of their life cycle in Gray's Reef NMS. The seasonal pattern in species number in part reflects the increase in transient species using the system in the summer. However, a number of transient species also use the Sanctuary in the fall and winter. The abundance of these transient species is affected in part by ecological processes and human actions outside of the Sanctuary's boundaries.

Many resident species are distributed over a wide cross-shelf region, yet the movement of individuals has only been examined for a few of the 67 resident species. Tagging indicated that approximately 6% of *C. striata* in Gray's Reef NMS move out of the Sanctuary within one month (Sedberry et al., 1998). Seasonal data is documented for other species, but more shorter-time scale information on movement is not available for the remaining 66 species resident in Gray's Reef NMS.

Diet studies and stable isotope analyses indicate trophic links between pelagic, unconsolidated sediments, and rocky-reef habitats (e.g., Sedberry 1989; Thomas and Cahoon, 1993). Although these links have been identified, they have yet to be combined into a trophic model of the ecosystem (e.g., Polovina, 1984).

From the perspective of the ichthyofauna, the connections among life history stages, habitats, and different portions of the shelf (both along and across), indicate that associated biological communities include much of the southeast U.S. ecosystem. Thus, it is not possible for Gray’s Reef NMS to protect and provide comprehensive management for the ichthyofauna associated with ‘live-bottom’ and rocky-reef habitats, since authority does not extend to the biological boundaries of the ichthyofauna. In addition, the Sancturay imposes few restrictions on harvest beyond those employed by the regional fisheries management council (SAFMC). In fact, Gray’s Reef NMS is an area of intense recreational fishing and fishing mortality there may exceed other areas of the shelf. Management objectives need to be achieved by working with other management groups that have authority in the areas outside the Sanctuary boundaries (e.g., SAFMC, State of Georgia), and by extending the Sanctuary boundaries to encompass a greater range of the southeast U.S. continental shelf ecosystem. Such large sanctuaries do exist in the Florida Keys and along the west coast of the United States.

From the perspective of MPAs and marine reserves on the southeast U.S. shelf, the present study indicates that separating individual components of the ecosystem for protection will be difficult. For example, many of the species that use rocky-reef habitat also use a range of other habitats; protecting only rocky-reef habitat will provide only partial protection for these species. Similar difficulty was encountered identifying Essential Fish Habitat (EFH) for the 72 species of the snapper-grouper management unit; almost every structural habitat type was identified as EFH (SAFMC, 1998; Lindeman et al., 2000). If management goals include the protection of one to several species, specific habitats and cross-shelf regions could be defined, but as the number of species expands and protection goals move from species to habitats, the scale required for protection quickly becomes most, if not all of the elements of the southeast U.S. shelf ecosystem. In 1990, cross-shelf MPA corridors were discussed (SAFMC, 1990), but then were dropped from consideration. Modeling studies with sessile invertebrates indicate that to protect biodiversity, the scale of MPAs needs to be approximately equal to the scale of larval dispersal (Botsford et al., 2003; Shanks et al., 2003). In the case of marine fishes, the protection of biodiversity becomes much more complicated with ontogenetic movements and seasonal migrations. The fishes of Gray's Reef NMS depend on a broad array of habitats and areas throughout much of the southeast U.S. continental shelf ecosystem. Research to quantitatively understand these inter-dependencies is needed. Yet, from the qualitative data presented here, Gray's Reef NMS cannot be managed successfully in isolation, underscoring the broader importance of managing the southeast U.S. continental shelf ecosystem to achieve multiple management goals (NMFS, 1999).

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Table 1. Sampling details for various fish censuses of Gray's Reef National Marine Sanctuary considered in this study stratified by season. Habitats sampled are abbreviated as: reef (R), live-bottom (LB), unconsolidated sediments (US), and pelagic (P)

Census Type	Sampling method	Effort	Habitat	Season and Year	Reference
Adult trawl census	40/54 high rise trawl	12 tows	R, LB, US	Winter, 1980 & 1981	1980 data – Sedberry and Van Dolah (1984) 1981 data - previously unpublished
		11 tows	R, LB, US	Summer, 1980, 1981	1980 data – Sedberry and Van Dolah (1984) 1981 data - previously unpublished
		6 tows	R, LB, US	Spring, 1981	previously unpublished
		6 tows	R, LB, US	Fall, 1981	previously unpublished
Adult trap census	Chevron traps	412 counts	R, LB	Summer, 1993-2002	Sedberry et al. (1998) 1993-1995 Previously unpublished, 1996-2002
Adult video census	Diver-conducted video transects	22 transects	R		Parker et al. (1994)
		22 transects	Dense LB		Parker et al. (1994)
		22 transects	Moderate LB		Parker et al. (1994)
		23 transects	Sparse LB		Parker et al. (1994)
		21 transects	US		Parker et al. (1994)
Adult point counts	Diver-conducted stationary 4 m^2 cylinder point counts	83 counts	R	Fall, 1995-2002	previously unpublished
		105 counts	R	Spring, 1995-2002	previously unpublished
		124 counts	R	Summer, 1995-2002	previously unpublished
Juvenile trawl census	2-m Beam Trawl	36 tows	US	Winter 2000-2002	Walsh et al. (in review)
		23 tows	US	Spring 2000-2002	Walsh et al. (in review)
		46 tows	US	Summer 2000-2002	Walsh et al. (in review)
		24 tows	US	Fall 2000-2002	Walsh et al. (in review)
Larval census	60 cm bongo with 505 um mesh	26 tows	P	Winter 2000-2002	Marancik et al. (2005)
		11 tows	P	Spring 2000-2002	Marancik et al. (2005)
		25 tows	P	Summer 2000-2002	Marancik et al. (2005)
		15 tows	P	Fall 2000-2002	Marancik et al. (2005)

Table 2. Common fish species occurring in the vicinity of Gray's Reef National Marine Sanctuary. Percent total abundance calculated as abundance of taxa divided by sum abundance of all taxa. Only those species that comprised >5% of total abundance in at least one census were considered common. Bold numbers indicate abundance >5%. No entry indicates that taxa was not collected in that particular season or gear. The stratification of collection data is described in the Methods and the following abbreviations are used: Sp – spring, Su – summer, F – fall, W – winter, L – ledge, DLB – dense live-bottom, MLB – moderate live-bottom, SLB – sparse live-bottom, and S - sand. Parker et al. (1996) provides more detail regarding the habitat definitions.

	Adult and Large Juvenile													Juvenile and Small Adult				Larvae				
	Bottom Trawl				Traps	Video Transect					Point Count			Beam Trawl				Bongo				
Taxa	Sp	Su	F	W	Su	L	DLB	MLB	SLB	US	Sp	Su	F	Sp	Su	F	W	Sp	Su	F	W	Notes
Stenotomus sp.	**93.4**	**42.6**	**10.2**	**33.9**	**34.8**	1.0	**8.2**	**15.1**	**38.9**	**53.8**	0.3	1.2	0.5	1.7	3.5	0.4	0.2					
Haemulon aurolineatum		**42.2**	**20.4**		**7.4**	**44.8**	**15.0**	**7.4**	0.4		**23.7**	**9.8**	**29.7**		1.2							
Urophycis regia	0.7			**20.8**										1.7			2.4				1.6	1
Centropristis striata	1.6	3.1	0.7	**6.7**	**50.5**	3.9	4.8	2.1	0.9	1.4	1.9	0.6	0.5	0.1	0.9							
Lagodon rhomboides	0.0	0.2	0.3	**14.8**	4.1								0.0								3.9	
Sparidae																		0.7	1.1		**7.6**	
Decapterus macarellus--D. punctatus	0.3	1.8	1.3			**25.7**	**44.6**	**59.4**	**41.7**	**32.3**		**77.6**	**54.6**		4.1				0.5	0.3		
Halichoeres bivittatus	0.3	0.1	0.0		0.0	**13.0**	**20.1**	**10.1**	**9.1**	1.4	**26.0**	2.5	4.8		0.3				0.6			
Diplodus holbrooki	0.1	0.0		0.6	1.7	1.3	0.3	0.5			**22.4**	3.4	3.7									
Serranus subligarius		0.0				1.7	2.2	0.8	0.4		**14.0**	1.0	1.4						0.8			
Sardinella aurita	0.0	0.3	**43.9**												0.2							
Anchoa spp.			**20.9**												1.7	**6.6**		**24.2**	**35.7**	**5.2**		
Etropus spp.														**44.2**	**11.2**	4.9	**62.8**	4.3	0.4	0.8	**7.7**	
Prionotus spp	0.7	2.5	0.1	0.4										**18.9**	3.2	**53.4**	**8.8**	**40.3**	1.2	**17.3**	1.6	2
Ophidion selenops		0.0												**12.6**	3.4	**12.8**	4.7		0.3	0.5		
Diplectrum formosum	0.1	0.5	0.4		0.1	0.0	0.2	0.3	0.9	1.8	0.0	0.0	0.1	1.1	**30.0**	1.5	0.1		0.9	1.2		
Microgobius carri-- Gobiidae						0.0	0.1	0.1	0.4	1.4				0.3	**13.0**	2.4		**19.5**	4.9	**5.8**	1.6	3
Stephanolepis hispidus		0.8	0.5	0.2	0.1	0.1	0.1	0.1	0.4		0.0	0.0		0.7	**5.1**	1.6	0.1					
Dactyloscopus moorei				0.4										3.9	2.5	**7.2**	5.0		1.1	1.7		
Leiostomus xanthurus																	**9.5**			1.8	**12.7**	
Caranx sp.--*Chloroscombrus chysurus*		0.0	0.0		0.1	0.5	0.1	0.2	0.4			1.1	0.5			0.2			**21.1**	0.5		4
Symphurus spp.														2.1	3.6	2.6	1.1		**11.7**	3.5	1.7	5
Ophidion marginatum															0.6	0.1	0.1		0.1	**24.4**		
Diplogrammus pauciradiatus															0.4				**7.4**	**7.7**	1.7	
Larimus fasciatus		0.0																	0.1	**6.3**		
Brevoortia tyrannus																	0.4				**32.0**	
Micropogonias undulatus																			0.1	2.1	**12.2**	
Citharichthys spilopterus																					**6.7**	

Notes

1 - Larvae identified as *Urophycis* spp. (the most-defined taxonomic level for this genus in larval identifications) were included here.

2 - Adults and juveniles identified as *Prionotus* spp., *Prionotus carolinus*, *Prionotus ophryas*, and *Prionotus scitula* were grouped and considered as *Prionotus* spp. owing to inability to identify larvae, some juveniles and some adults to species.

3 - Larvae identified as Gobiidae (the most-defined taxonomic level for this family in larval identifications) were included here.

4 - Adults and juveniles identified as *Chloroscombrus chrysurus*, *Caranx bartholomaei*, *Caranx crysos*, *Caranx ruber*, and *Caranx dentex* were grouped and considered as Caranx spp.--*Chloroscombrus chrysurus* owing to inability to identify larvae to species.

5 - Juveniles identified as *Symphurus urospilus*, *Symphurus minor*, *Symphurus diomedianus*, and *Symphurus plagiusa* were grouped and considered here as *Symphurus* spp. owing to the inability to identify larvae to species.

Table 3. List of managed fish species reported from the vicinity of Gray's Reef National Marine Sanctuary. Common species (Table 2) are indicated by a C. Management authorities included are Atlantic States Fisheries Management Commission (ASFMC), Northeast Fisheries Management Council (NEFMC), Mid-Atlantic Fisheries Management Council (MAFMC), South Atlantic Fisheries Management Council (SAFMC), National Marine Fisheries Service (NMFS), State of Florida (FL), State of Georgia (GA), State of South Carolina (SC), and State of North Carolina (NC).

Scientific Name	Common Name		Management Authority
Anguilla rostrata	American eel		ASFMC, NC
Brevoortia tyrannus	Atlantic menhaden	C	ASFMC
Centropristis ocyurus	bank sea bass		SAFMC, SC
Centropristis striata	black sea bass	C	MAFMC, SAFMC, ASFMC, FL, GA, SC, NC
Centropristis philadelphica	rock sea bass		SAFMC, SC
Mycteroperca microlepis	gag		SAFMC, FL, GA, SC, NC
Mycteroperca phenax	scamp		SAFMC, FL, SC, NC
Pomatomus saltatrix	bluefish		MAFMC, ASFMC, FL, GA, SC, NC
Rachycentron canadum	cobia		SAFMC, FL, GA, SC, NC
Caranx bartholomaei	yellow jack	C	SAFMC, SC, NC
Caranx crysos	blue runner	C	SAFMC
Caranx rubber	bar jack	C	SAFMC, SC, NC
Seriola dumerili	greater amberjack		SAFMC, FL, GA, SC, NC
Seriola rivoliana	almaco jack		SAFMC, SC, NC
Coryphaena hippurus	dolphin		SAFMC, FL, GA, SC, NC
Lutjanus campechanus	red snapper		SAFMC, FL, SC, NC
Lutjanus griseus	gray snapper		SAFMC, FL, SC, NC
Lutjanus analis	mutton snapper		SAFMC, FL, SC, NC
Ocyurus crysurus	yellowtail snapper		SAFMC, FL, SC, NC
Rhomboplites aurorubens	vermilion snapper		SAFMC, FL, SC, NC
Haemulon aurolineatum	tomtate	C	SAFMC
Haemulon plumieri	white grunt		SAFMC, SC, NC
Archosargus probatocephalus	sheepshead		SAFMC, FL, GA, SC, NC
Calamus bajonado	jolthead porgy		SAFMC, SC, NC
Calamus leucosteus	whitebone porgy		SAFMC, SC, NC
Pagrus pagrus	red porgy		SAFMC, FL, GA, SC, NC
Stenotomus sp.	scup	C	SAFMC, ASFMC, SC, NC
Pogonias cromis	black drum		FL, GA
Cynoscion regalis	weakfish		ASFMC, FL, GA, SC, NC
Menticirrhus americanus	southern kingfish		GA
Menticirrhus littoralis	gulf kingfish		GA

Micropogonias undulatus	Atlantic croaker	C	ASFMC, GA
Sciaenops ocellatus	red drum		NMFS, ASFMC, FL, GA, SC, NC
Leiostomus xanthurus	spot	C	ASFMC, GA
Chaetodipterus faber	Atlantic spadefish		SAFMC, SC, NC
Mugil curema	white mullet		FL
Mugil cephalus	striped mullet		FL
Tautoga onitis	tautog		ASFMC
Scomberomorus cavalla	king mackerel		SAFMC, FL, GA, SC, NC
Scomberomorus maculates	Spanish mackerel		SAFMC, ASFMC, FL, GA, SC, NC
Euthynnus alletteratus	little tunny		SAFMC
Peprilus triacanthus	butterfish		MAFMC
Paralichthys lethostigma	southern flounder		FL, GA, SC, NC
Paralichthys albigutta	gulf flounder		FL, GA, NC
Scophthalmus aquosus	windowpane		NEFMC
Balistes capriscus	gray triggerfish		SAFMC, FL, SC, NC

Table 4. List of species that likely spawn in the vicinity of Gray's Reef National Marine Sanctuary. Determination of spawning was made from the occurrence of small larvae in ichthyoplankton collections made in the vicinity of the Sanctuary (source = Larvae) and the occurrence of spawning females within 30 km of the Sanctuary (source = Adults). Common species are indicated by a C (see Table 2).

Scientific Name	Common Name	Source	
Anchoa spp.	anchovies	Larvae	C
Beloniform	flying fishes	Larvae	
Blenniidae	blennies	Larvae	
Brevoortia tyrannus	Atlantic menhaden	Larvae	C
Caranx sp.--*Chloroscombrus chysurus*	jacks	Larvae	C
Citharichthys spilopterus	bay whiff	Larvae	C
Coryphaena hippurus	dolphin	Larvae	
Cynoscion nothus	silver seatrout	Larvae	
Cynoscion regalis	weakfish	Larvae	
Dactyloscopus moorei	sand stargazer	Larvae	C
Decapterus macarellus—D. punctatus	mackerel / round scad	Larvae	C
Diplectrum formosum	Sand perch	Adult	C
Diplogrammus pauciradiatus	spotted dragonet	Larvae	C
Etropus crossotus	fringed flounder	Larvae	
Etropus spp.	smallmouthed flounders	Larvae	C
Euthynnus alletteratus	little tunny	Larvae	
Gobiidae	gobies	Larvae	C
Halichoeres bivittatus	slippery dick	Larvae	C
Hippoglossina oblonga	four spot flounder	Larvae	
Lactophrys quadricornis	scrawled cowfish	Larvae	
Lagodon rhomboides	pinfish	Larvae	
Larimus fasciatus	banded drum	Larvae	C
Lutjanus spp.--Ophisthognathidae	snapper/jawfish	Larvae	
Menticirrhus americanus	southern kingfish	Larvae	
Menticirrhus littoralis	gulf kingfish	Larvae	
Micropogonias undulatus	Atlantic croaker	Larvae	C
Myrophus punctatus	speckeled worm eel	Larvae	
Ophichthus cruentifer	margined snake eel	Larvae	
Ophidion holbrooki—O. antipholis	cusk eel	Larvae	
Ophidion marginatum	striped cusk eel	Larvae	C
Ophidion selenops	moon eyed cusk eel	Larvae	C

Opisthonema oglinum	Atlantic thread herring	Larvae	
Peprilus burti	gulf butterfish	Larvae	
Peprilus paru	butterfish	Larvae	
Peprilus triacanthus	butterfish	Larvae	
Pogonias cromis	black drum	Larvae	
Prionotus spp.	searobins	Larvae	C
Rhomboplites aurorubens	Vermillon snapper	Adult	
Sciaenidae	drums	Larvae	
Sciaenops ocellatus	red drum	Larvae	
Scomberomorus cavalla	king mackerel	Larvae	
Scomberomorus maculatus	Spanish mackerel	Larvae	
Scorpaenidae	scorpionfish	Larvae	
Serraniculus pumilio	pygmy seabass	Larvae	
Serranus subligarius	belted sandfish	Larvae	C
Sparidae	porgies	Larvae	C
Sphoeroides spp.	pufferfishes	Larvae	
Syacium papillosum	gulf stream flouder	Larvae	
Synodontidae	lizardfishes	Larvae	
Trinectes maculates	hogchocker	Larvae	
Uranoscopidae	stargazers	Larvae	
Urophycis spp.	hakes	Larvae	
Xyrichthys novacula	pearly razorfish	Larvae	

Table 5. List of species that undergo the larval/juvenile transition in the vicinity of Gray's Reef National Marine Sanctuary. Determination of 'settlement-stage' was made based on fish size and comparison of size-at-settlement data in the literature (see Walsh et al., in review). Common species are indicated by a C (see Table 2).

Species Name	Common name	
Anchoa spp.	anchovies	C
Ancylopsetta quadrocellata	Ocellated flounder	
Ariosoma balearicum	bandtooth conger	
Bothus ocellatus—B. robinsi	eyed/spottail flounder	
Brevoortia tyrannus	Atlantic menhaden	C
Citharichthys spp.	Whiffs	C
Cynoscion nothus	silver seatrout	
Cynoscion regalis	weakfish	
Dactyloscopus moorei	sand stargazer	C
Decapterus macarellus—D. punctatus	mackerel / round scad	C
Diplectrum formosum	sand perch	C
Etropus spp.	smallmouthed flounders	C
Leiostomus xanthurus	spot	C
Microgobius carri	seminole goby	C
Stephanolepis hispidus	planeheaded filefish	C
Ophidion selenops	moon-eye cusk eel	C
Peprilus triacanthus	butterfish	
Prionotus spp.	searobins	C
Scophthalmus aquosus	windowpane flounder	
Serraniculus pumilio	pygmy sea bass	
Stenotomus sp.	scup	C
Syacium papillosum	gulf stream flounder	
Synodus foetens	inshore lizardfish	
Urophycis regia	spotted hake	C

Table 6. Designation of fishes from Gray's Reef National Marine Sanctuary as resident or transient, and further designation of transient species as seasonal migrants, expatriates, and other. Other includes three eel species that move through the Sanctuary during their life cycle.

	Resident	Transient	Seasonal Migrants	Expatriates	Other
All Species	67	114	94	17	3
Abundant Species	17	18	18	0	0
Managed Species	12	34	29	4	1

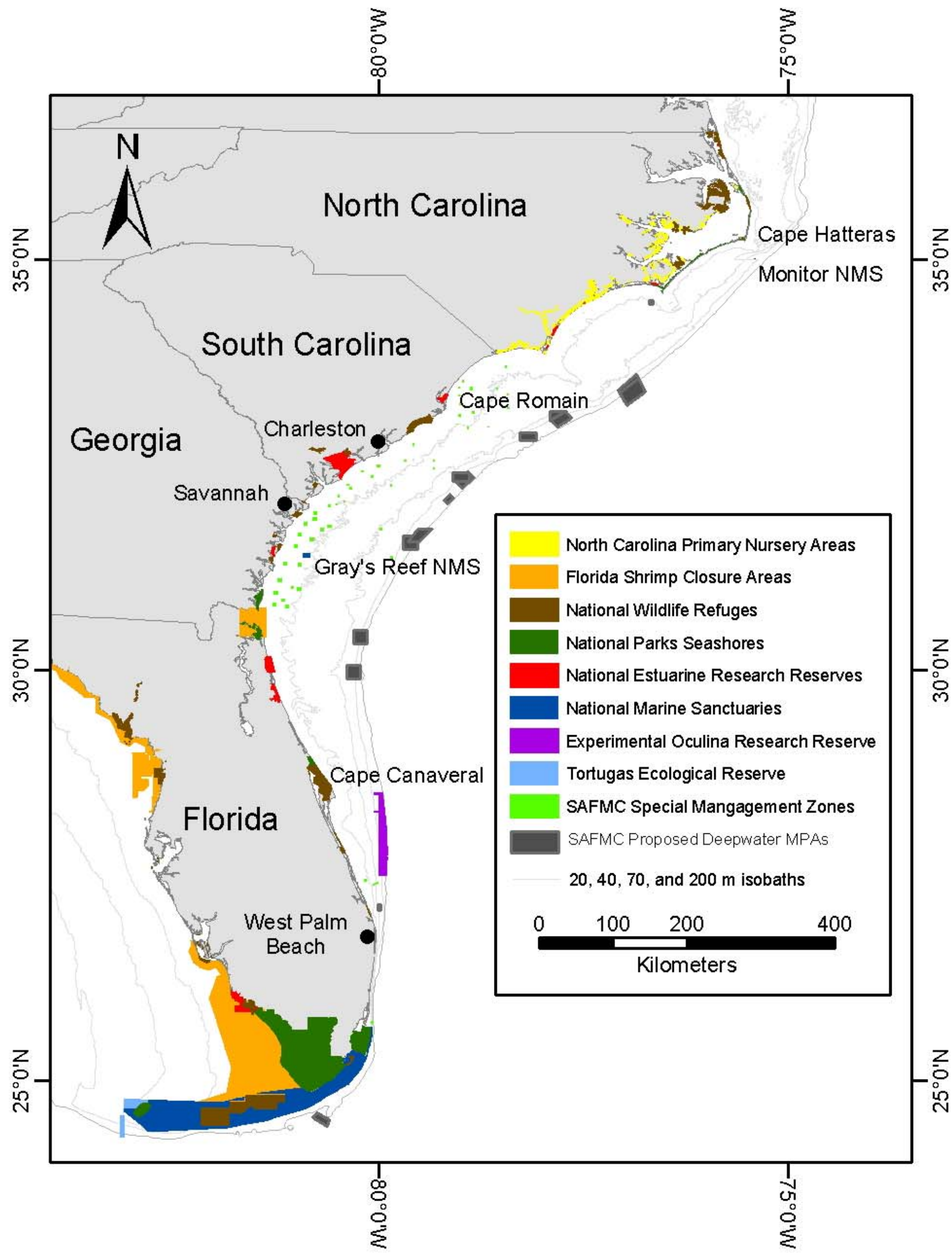
Figure 1. Map of the southeast U.S. continental shelf showing the location of Gray’s Reef National Marine Sanctuary.

Figure 2. The number of fish species, abundance, and species diversity for each of four seasons from four fish censuses conducted at Gray’s Reef National Marine Sanctuary.

Figure 3. The percentage of species reported from Gray’s Reef National Marine Sanctuary that occur in different habitats of the southeast U.S. continental shelf ecosystem. Data are presented for both adult and juvenile life stages. Data are provided in Appendix 1, and sources are provided in Appendix 2.

Figure 4. The percentage of species reported from Gray’s Reef National Marine Sanctuary that occur in different cross-shelf zones of the southeast U.S. continental shelf ecosystem. Data are presented for both adult and juvenile life stages. Data are provided in Appendix 1, and sources are provided in Appendix 2.

Figure 1



80°0'W
75°0'W
35°0'N
30°0'N
25°0'N
N
North Carolina
South Carolina
Georgia
Florida
Cape Hatteras
Monitor NMS
Cape Romain
Charleston
Savannah
Gray's Reef NMS
Cape Canaveral
West Palm Beach
North Carolina Primary Nursery Areas
Florida Shrimp Closure Areas
National Wildlife Refuges
National Parks Seashores
National Estuarine Research Reserves
National Marine Sanctuaries
Experimental Oculina Research Reserve
Tortugas Ecological Reserve
SAFMC Special Mangagement Zones
SAFMC Proposed Deepwater MPAs
20, 40, 70, and 200 m isobaths
0 100 200 400
Kilometers

Figure 2

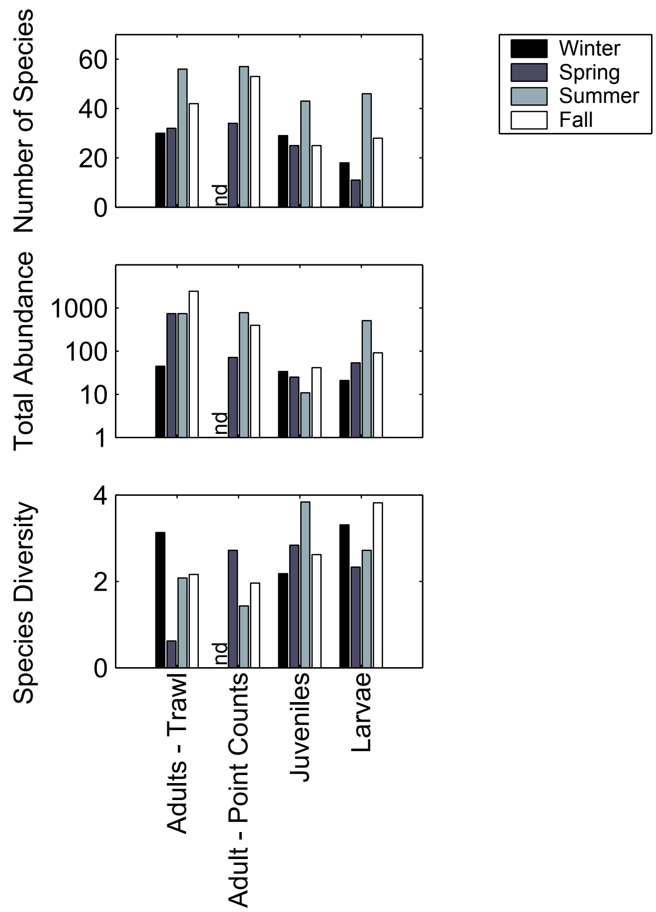

Number of Species
Total Abundance
Species Diversity
Winter
Spring
Summer
Fall
nd
Adults - Trawl
Adult - Point Counts
Juveniles
Larvae

Figure 3

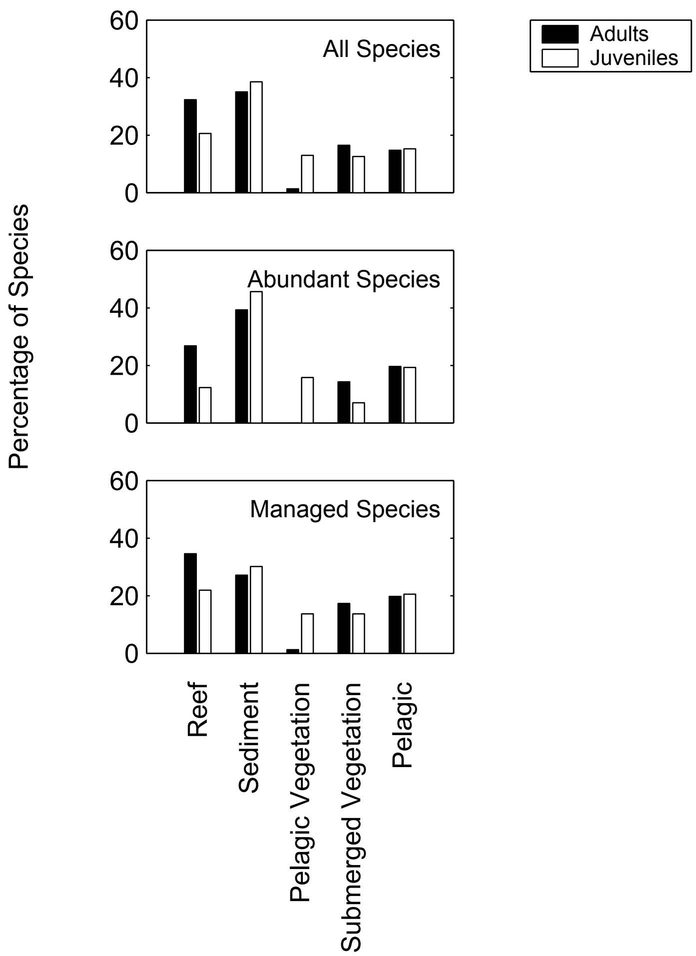
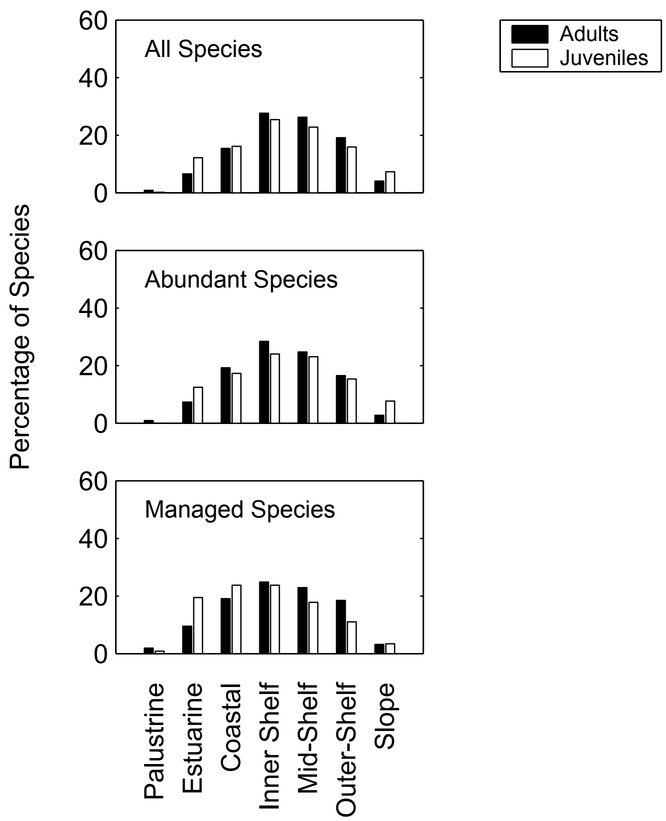

Percentage of Species
All Species
Abundant Species
Managed Species
60
40
20
0
Adults
Juveniles
Reef
Sediment
Pelagic Vegetation
Submerged Vegetation
Pelagic

Figure 4



Adults
Juveniles
All Species
Abundant Species
Managed Species
Percentage of Species
60
40
20
0
Palustrine
Estuarine
Coastal
Inner Shelf
Mid-Shelf
Outer-Shelf
Slope

Appendix 1. Compilation of life history information for fishes reported from Gray's Reef National Marine Sanctuary.

Species	Common name	Abundance	Spawning	Resident / Transient	Expatriates / Life History	Egg: Pelagic \ Non-pelagic	Larvae: Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Emergent Vegetation	Submerged Vegetation	Emergent Sediment	Submerged Sediment	Pelagic	Reef
Angullia rostrata	American eel			T	L	P						OS	SI	Ab					P	
Myrophus punctatus	speckled worm eel			T	L	P				IS	MS								P	
Letharchus velifer	sailfin eel			R		P				IS	MS	OS							P	
Ophichthus cruentifer	margined snake eel			R		P				IS	MS	OS							P	
Ophichthus puncticeps	palespotted snake eel			R		P				IS	MS	OS							P	
Ariosoma balearicum	bandtooth conger			R		P				IS	MS	OS							P	
Gymnothorax moringa	spotted moray			R		P					MS	OS							P	
Conger oceanicus	conger eel			T	L	P				IS	MS	OS	SI	Ab					P	
Opisthonema oglinum	Atlantic thread herring			T	S	P			C	IS	MS	OS							P	
Brevoortia tyrannus	Atlantic menhaden	a		T	S	P				IS	MS	OS							P	
Sardinella aurita	Spanish sardine	a		T	S	P	NO DATA ----------------------------------												P	
Anchoa hepsetus	striped anchovy	a		T	S	P			C	IS	MS	OS							P	
Anchoa lamprotenae	bigeye anchovy			T	S	P	NO DATA ----------------------------------												P	
Anchoa lyolepis	dusky anchovy			T	S	P	NO DATA ----------------------------------												P	
Anchoa mitchilli	bay anchovy	a		T	S	P		E	C	IS									P	
Engraulis eurystole	silver anchovy			T	S	P					MS	OS							P	
Etrumeus teres	round herring			T	S	P					MS	OS							P	
Synodus foetens	inshore lizardfish			R		P				IS	MS	OS							P	
Synodus intermedius	sand diver			R		P				IS	MS	OS							P	
Trachinocephalus myops	snakefish			R		P				IS	MS	OS							P	
Urophycis earlli	Carolina hake			R		P				IS	MS	OS							P	
Urophycis floridana	southern hake			T	S	P				IS	MS	OS							P	
Urophycis regia	spotted hake	a		T	S	P				IS	MS	OS							P	
Ophidion holbrooki	bank cusk-eel			R		P				IS	MS	OS							P	
Ophidion holbrooki--O. antipholis				R		P				IS	MS	OS							P	
Ophidion josephi				R		P				IS	MS	OS							P	
Ophidion marginatum	striped cusk-eel	a		R		P				IS	MS								P	
Ophidion selenops	mooneye cusk-eel	a		R		P				IS	MS	OS							P	
Otophidium omostigmum	polka-dot cusk-eel			T	S	P				IS	MS	OS							P	
Opsanus pardus--O. tau	leopard/oyster toadfish			R		N	NO DATA ----------------------------------											S		R
Porichthys plectrodon	Atlantic midshipman			T	S	N	NO DATA ----------------------------------											S		R
Ogcocephalus nasutus	shortnose batfish			R		P					MS								P	
Ogcocephalus parvus	roughback batfish			R		P					MS								P	
Gobiesox strumosus	skilletfish			R		?	NO DATA ----------------------------------											S		R
Hirundichthys affinis	fourwing flyingfish			T	S	N				IS	MS	OS							P	
Hemiramphus brasiliensis	ballyhoo			T	S	N	NO DATA ----------------------------------												P	
Syngnathus louisianae	chain pipefish			T	S	N			C	IS									P	
Syngnathus springeri	bull pipefish			T	S	N					MS	OS							P	
Hippocampus erectus	lined seahorse			R		N			C	IS									P	
Scorpaena brasiliensis	barbfish			R		?				IS	MS	OS							P	
Scorpaena calcarata	smoothhead scorpionfish			T	S	?				IS	MS	OS							P	
Scorpaena dispar	hunchback scorpionfish			T	S	?				IS	MS	OS							P	
Scorpaena plumieri	spotted scorpionfish			R		?				IS	MS	OS							P	
Prionotus carolinus	northern searobin	a		R		P				IS	MS	OS							P	
Prionotus ophryas	bandtail searobin			T	S	P				IS	MS	OS							P	
Prionotus scitulus	leopard searobin			R		P				IS	MS	OS							P	
Datylopterus volitans	flying gurnard			T	S	N						OS							P	
Centropristis ocyurus	bank sea bass			R		P				IS	MS	OS							P	
Centropristis philadelphica	rock sea bass			R		P	NO DATA ----------------------------------												P	
Centropristis striata	black sea bass	a		R		P				IS	MS	OS							P	
Diplectrum formosum	sand perch	a		R		P				IS	MS	OS							P	
Serranus subligarius	belted sandfish	a		R		P					MS	OS							P	
Serraniculus pumilio	pygmy sea bass			R		P					MS								P	
Mycteroperca microlepis	gag			T	S	P					MS	OS							P	
Mycteroperca phenax	scamp			T	S	P					MS	OS							P	
Rypticus saponaceus	greater soapfish			T	S	P				IS	MS	OS							P	
Rypticus maculatus	whitespotted soapfish			R		P				IS	MS	OS							P	
Priacanthus arenatus	bigeye			T	S	P					MS	OS							P	
Pristigenys alta	short bigeye			T	S	P					MS	OS							P	

Species	Juveniles: Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Bethic Vegetation	Submerged Sediment	Pelagic Vegetation	Reef	Pelagic
Angullia rostrata	P	E	C	IS	MS				BV	S			
Myrophus punctatus		E	C							S			
Letharchus velifer				IS	MS	OS				S			
Ophichthus cruentifer					MS	OS	SI			S			
Ophichthus puncticeps				IS	MS					S			
Ariosoma balearicum				IS	MS	OS				S			
Gymnothorax moringa			C	IS	MS	OS			BV			R	
Conger oceanicus		E	C	IS	MS	OS				S		R	
Opisthonema oglinum	NO DATA ----------------------------------												P
Brevoortia tyrannus		E	C	IS									P
Sardinella aurita			C	IS	MS	OS					PV		P
Anchoa hepsetus			C	IS	MS								P
Anchoa lamprotenae				IS									P
Anchoa lyolepis	NO DATA ----------------------------------												P
Anchoa mitchilli		E	C										P
Engraulis eurystole	NO DATA ----------------------------------												P
Etrumeus teres					MS								P
Synodus foetens		E	C	IS	MS	OS				S			
Synodus intermedius	NO DATA ----------------------------------												
Trachinocephalus myops				IS	MS	OS				S			
Urophycis earlli	NO DATA ----------------------------------												
Urophycis floridana	NO DATA ----------------------------------												
Urophycis regia		E	C	IS	MS	OS				S			
Ophidion holbrooki				IS						S			
Ophidion holbrooki--O. antipholis				IS						S			
Ophidion josephi				IS	MS					S			
Ophidion marginatum				IS	MS					S			
Ophidion selenops				IS	MS	OS				S			
Otophidium omostigmum					MS	OS				S			
Opsanus pardus--O. tau		E	C	IS	MS	OS			BV			R	
Porichthys plectrodon					MS	OS				S			
Ogcocephalus nasutus				IS	MS					S			
Ogcocephalus parvus				IS						S			
Gobiesox strumosus	NO DATA ----------------------------------												
Hirundichthys affinis				IS	MS	OS	SI				PV		P
Hemiramphus brasiliensis			C	IS	MS						PV		P
Syngnathus louisianae		E	C	IS	MS	OS	SI		SV		PV		
Syngnathus springeri				IS	MS	OS	SI		SV	S	PV		
Hippocampus erectus				IS	MS	OS	SI		SV	S	PV		
Scorpaena brasiliensis	NO DATA ----------------------------------												
Scorpaena calcarata	NO DATA ----------------------------------												
Scorpaena dispar				IS	MS	OS				S		R	
Scorpaena plumieri				IS	MS	OS				S		R	
Prionotus carolinus		E	C	IS	MS	OS				S			
Prionotus ophryas					MS					S			
Prionotus scitulus					MS					S			
Datylopterus volitans	NO DATA ----------------------------------									S		R	
Centropristis ocyurus					MS	OS				S		R	
Centropristis philadelphica	NO DATA ----------------------------------												
Centropristis striata		E	C	IS						S		R	
Diplectrum formosum					MS	OS	SI		SV	S		R	
Serranus subligarius			C	IS					SV			R	
Serraniculus pumilio				IS	MS	OS				S		R	
Mycteroperca microlepis		E	C						SV			R	
Mycteroperca phenax			C	IS	MS				SV			R	
Rypticus saponaceus						OS				S		R	
Rypticus maculatus						OS				S		R	
Priacanthus arenatus					MS	OS	SI			S	PV	R	
Pristigenys alta					MS	OS	SI			S	PV	R	

Species	Adults: Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Pelagic Vegetation	Submerged Vegetation	Submerged Sediment	Pelagic	Coral, Rocky, Oyster Reef	References (see Appendix 2)							
Angullia rostrata	P	E	C							SV	S			45	1						
Myrophus punctatus		E	C	IS							S			25	30	53					
Letharchus velifer				IS	MS	OS					S			25	30						
Ophichthus cruentifer					MS	OS	SI				S			25	30	3					
Ophichthus puncticeps				IS	MS	OS					S			25	30						
Ariosoma balearicum				IS	MS	OS					S			46	47						
Gymnothorax moringa			C	IS	MS	OS				SV			R	5	48						
Conger oceanicus			C	IS	MS	OS	SI				S		R	1	46	47					
Opisthonema oglinum			C	IS								P		31	28	21					
Brevoortia tyrannus			C	IS	MS	OS						P		1	53	33	3	28	54	21	
Sardinella aurita			C	IS	MS	OS	SI					P		31	54	21					
Anchoa hepsetus		E	C	IS								P		21	28	54					
Anchoa lamprotenae			C	IS								P		54	21						
Anchoa lyolepis			C	IS	MS							P		21							
Anchoa mitchilli		E	C									P		21							
Engraulis eurystole			C	IS	MS	OS						P		31	28	54	21				
Etrumeus teres				IS	MS	OS	SI					P		31	28	54	21				
Synodus foetens		E	C	IS	MS	OS					S			1	28	54	2	56			
Synodus intermedius			C	IS	MS	OS	SI				S			28	2	56					
Trachinocephalus myops			C	IS	MS	OS	SI			SV	S		R	28	54	2	56				
Urophycis earlli				IS	MS	OS					S		R	31	28						
Urophycis floridana				IS	MS	OS	SI				S			31	28						
Urophycis regia				IS	MS	OS	SI				S			1	33	31	28	54			
Ophidion holbrooki			C	IS	MS	OS					S			28	34	56					
Ophidion holbrooki--O. antipholis						OS					S			28	56	24					
Ophidion josephi			C	IS	MS						S			31	28						
Ophidion marginatum			C	IS	MS						S			1	28						
Ophidion selenops				IS	MS	OS					S			28	54						
Otophidium omostigmum											S			31	28	54					
Opsanus pardus--O. tau		E	C	IS	MS	OS				SV	S		R	31							
Porichthys plectrodon				IS	MS	OS					S			31	54						
Ogcocephalus nasutus				IS	MS	OS					S			28	54	7					
Ogcocephalus parvus					MS	OS					S			31	28	56	7				
Gobiesox strumosus										SV			R	33							
Hirundichthys affinis				IS	MS	OS						P		54	31						
Hemiramphus brasiliensis		E	C	IS						SV		P		54	31						
Syngnathus louisianae		E	C	IS	MS	OS	SI		PV	SV				28	13						
Syngnathus springeri					MS	OS	SI		PV	SV	S			28	54	13					
Hippocampus erectus		E	C	IS	MS	OS			PV	SV			R	1	28	54	13				
Scorpaena brasiliensis			C	IS	MS	OS					S		R	54	14	56					
Scorpaena calcarata				IS	MS	OS					S			28	14						
Scorpaena dispar					MS	OS							R	28	54	14					
Scorpaena plumieri				IS	MS	OS							R	28	54	14					
Prionotus carolinus		E	C	IS	MS	OS					S			1	28	54	42				
Prionotus ophryas				IS	MS	OS					S			41	28	42					
Prionotus scitulus		E	C	IS							S			41	28	54	42				
Datylopterus volitans				IS	MS	OS					S		R	33	3	28	56				
Centropristis ocyurus				IS	MS	OS					S		R	41	54	8	56				
Centropristis philadelphica				IS	MS						S		R	41	18						
Centropristis striata				IS	MS	OS							R	1	3	54	8				
Diplectrum formosum				IS	MS	OS				SV	S		R	38	6	28	54	8	56		
Serranus subligarius				IS									R	41	28	8					
Serraniculus pumilio				IS	MS	OS				SV	S		R	41	28	54	8				
Mycteroperca microlepis				IS	MS	OS				SV			R	28	8	19					
Mycteroperca phenax					MS	OS							R	28	8						
Rypticus saponaceus				IS	MS								R	6	41	22					
Rypticus maculatus				IS	MS	OS							R	8							
Priacanthus arenatus					MS	OS	SI				S		R	28	54	50					
Pristigenys alta				IS	MS	OS					S		R	28	54	50	56				

						Egg	Larvae														Juveniles													Adults													
		Abundance	Spawning	Resident / Transient	Expatriates / Life History	Pelagic \ Non-pelagic	Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Emergent Vegetation	Submerged Vegetation	Emergent Sediment	Submerged Sediment	Pelagic	Reef	Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Bethic Vegetation	Submerged Sediment	Pelagic Vegetation	Reef	Pelagic	Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Pelagic Vegetation	Submerged Vegetation	Submerged Sediment	Pelagic	Coral, Rocky, Oyster Reef	References (see Appendix 2)
Apogon pseudomaculatus	twospot cardinalfish			R		N					MS	OS							P					IS	MS					S		R					IS	MS	OS	SI						R	6 28 54
Pomatomus saltatrix	bluefish			T	S	P					MS	OS							P			E	C										P			C	IS	MS	OS						P		1 3 28
Rachycentron canadum	cobia			T	S	P					MS	OS							P			E	C										P			C	IS	MS	OS	SI					P	R	43
Echeneis naucrates	sharksucker			T	S		NO DATA ----------------------------------												P		NO DATA ----------------------------------												P				IS	MS	OS						P		33 22
Remora remora	remora			T	S		NO DATA ----------------------------------												P		NO DATA ----------------------------------												P				IS	MS	OS						P		41
Caranx bartholomaei	yellow jack	a		T	S	P			C	IS	MS	OS							P						MS	OS	SI			S	PV		P					MS	OS						P	R	28 54 23
Caranx crysos	blue runner	a		T	S	P			C	IS	MS	OS							P						MS	OS	SI			S	PV		P			C	IS	MS	OS						P	R	28 23
Caranx dentex	white trevally	a		T	S	P			C	IS	MS	OS							P			E	C	IS	MS	OS	SI				PV		P		E	C	IS								P	R	28
Caranx ruber	bar jack	a		T	S	P			C	IS	MS	OS							P						MS	OS	SI				PV		P			C	IS								P	R	28 22
Chloroscombrus chrysurus	Atlantic bumper	a		T	S	P			C	IS	MS	OS							P					IS	MS					S	PV		P			C	IS								P		28 54 23
Decapterus macarellus	mackerel scad	a		T	S	P				IS	MS	OS							P						MS	OS	SI			S	PV		P					MS	OS	SI					P	R	6 28 54 23
Decapterus punctatus	round scad	a		T	S	P				IS	MS	OS							P					IS	MS	OS	SI			S	PV		P				IS	MS	OS						P	R	6 28 54 23
Selene spp.	lookdown / moonfish			T	S	P						OS							P		NO DATA ----------------------------------												P		E	C	IS								P	R	33 28 23
Seriola dumerili	greater amberjack			T	S	P						OS							P					IS	MS	OS	SI				PV		P				IS	MS	OS	SI					P	R	28 23
Seriola rivoliana	almaco jack			T	S	P						OS							P					IS	MS	OS	SI				PV		P					MS	OS	SI					P	R	28 23
Trachurus lathami	rough scad			T	S	P						OS							P		NO DATA ----------------------------------												P					MS	OS						P	R	28 23
Coryphaena hippurus	dolphin			T	S	P				IS	MS	OS							P					IS	MS	OS	SI				PV		P				IS	MS	OS	SI		PV			P		28 23
Lutjanus analis	mutton snapper			T	E	P						OS							P			E	C	IS					SV			R				C	IS	MS	OS				SV			R	28 54 9
Lutjanus campechanus	red snapper			T	S	P						OS							P				C	IS	MS					S		R					IS	MS	OS							R	28 9
Lutjanus griseus	gray snapper			T	E	P						OS							P			E	C						SV			R				C	IS	MS	OS				SV			R	1 28 9
Ocyurus chrysurus	yellowtail snapper			T	E	P						OS							P			E	C	IS					SV			R				C	IS	MS	OS				SV	S		R	9
Rhomboplites aurorubens	vermilion snapper			T	S	P						OS							P						MS	OS	SI				PV	R						MS	OS					S		R	28 9 56
Gerreidae	mojarras			T	S	P				IS	MS	OS							P		NO DATA ----------------------------------								SV	S					E	C	IS	MS					SV	S			33 28 23
Haemulon aurolineatum	tomtate	a		R		P					MS	OS							P				C	IS	MS	OS			SV	S		R				C	IS	MS	OS				SV	S		R	41 28 54 56 23
Haemulon plumieri	white grunt			T	S	P					MS	OS							P					IS	MS	OS				S		R				C	IS	MS						S		R	41 28 23
Orthopristis chysoptera	pigfish			R		P					MS	OS							P			E	C	IS					SV	S					E	C	IS	MS					SV	S			23
Archosargus probatocephalus	sheepshead			R		P				IS	MS	OS							P			E	C	IS					SV			R			E	C	IS						SV	S		R	41 23
Calamus bajonado	jolthead porgy			R		P				IS	MS	OS							P		NO DATA ----------------------------------																IS	MS	OS				SV			R	41 40
Calamus leucosteus	whitebone porgy			R		P				IS	MS	OS							P		NO DATA ----------------------------------																IS	MS	OS				SV			R	41 40
Diplodus holbrooki	spotfin pinfish	a		R		P				IS	MS	OS							P		NO DATA ----------------------------------														E	C	IS	MS					SV	S		R	41 23
Lagodon rhomboides	pinfish	a		T	S	P			C	IS	MS								P			E	C	IS	MS				SV	S		R		P	E	C	IS	MS	OS				SV	S		R	28 54 23
Pagrus pagrus	red porgy			R		P					MS	OS							P					IS	MS	OS	SI				PV	R						MS	OS	SI				S		R	28 27
Stenotomus sp	scup	a		R		P				IS	MS	OS							P					IS	MS					S		R				C	IS	MS	OS					S		R	54 23
Cynoscion nothus	silver seatrout			T	S	P			C	IS	MS								P			E	C	IS						S						C	IS							S			33 41 28 54
Cynoscion regalis	weakfish			T	S	P			C	IS									P			E	C	IS					SV	S					E	C	IS						SV	S			1 33 3 28 54
Equetus acuminatus	high-hat			T	E	P	NO DATA ----------------------------------												P		NO DATA ----------------------------------																IS						SV	S		R	6
Equetus lanceolatus	jackknife-fish			T	E	P	NO DATA ----------------------------------												P		NO DATA ----------------------------------																IS	MS	OS					S		R	6 56
Equetus umbrosus	cubbyu			R		P	NO DATA ----------------------------------												P		NO DATA ----------------------------------																IS	MS	OS					S		R	41
Pogonias cromis	black drum			T	S	P		E	C	IS									P			E	C	IS					SV	S					E	C	IS							S		R	1 33 28
Larimus fasciatus	banded drum	a		T	S	P			C	IS	MS								P				C	IS						S						C	IS	MS						S			33 28 54
Leiostomus xanthurus	spot	a		T	S	P				IS	MS								P			E	C	IS						S					E	C	IS	MS	OS				SV	S			1 33 28 54
Menticirrhus americanus	southern kingfish			T	S	P			C	IS									P				C	IS						S					E	C	IS							S			33 28 54
Menticirrhus littoralis	gulf kingfish			T	S	P			C	IS									P				C							S					E	C	IS							S			33
Micropogonias undulatus	Atlantic croaker	a		T	S	P			C	IS	MS								P			E	C							S					E	C	IS	MS	OS				SV	S			1 33 3 28
Sciaenops ocellatus	red drum			T	S	P			C	IS									P			E	C						SV	S		R			E	C	IS						SV	S		R	33 41 28
Mulloidichthys martinicus	yellow goatfish			T	S	P						OS							P				C	IS	MS	OS	SI			S	PV	R					IS	MS	OS					S		R	41 28 22
Mullus auratus	red goatfish			T	S	P						OS							P		NO DATA ----------------------------------																IS	MS	OS					S			41 28 56
Pseudopeneus maculatus	spotted goatfish			T	S	P						OS							P				C	IS	MS	OS	SI			S	PV	R					IS	MS						S		R	28 22
Upeneus parvus	dwarf goatfish			T	S	P						OS							P		NO DATA ----------------------------------																	MS	OS				SV	S		R	41 28 22
Chaetodipterus faber	Atlantic spadefish			R		P	NO DATA ----------------------------------												P		NO DATA ----------------------------------													P	E	C							SV		P	R	23
Chaetodon ocellatus	spotfin butterflyfish			R		P						OS							P			E	C	IS	MS							R				C	IS	MS								R	1 28 22
Chaetodon sedentarius	reef butterflyfish			T	E	P						OS							P					IS	MS	OS						R					IS	MS	OS							R	28 22
Holocanthus bermudensis	blue angelfish			R		P	NO DATA ----------------------------------												P					IS	MS	OS						R					IS	MS	OS							R	
Holocentrus ascencionis	squirrelfish			T	E	P						OS							P					IS	MS							R					IS	MS								R	41 28 22
Abudefduf saxatilis	sargeant major			T	E	N						OS							P				C	IS	MS	OS	SI				PV	R					IS								P	R	28 22
Pomacentrus partitus	bicolor damselfish			T	E	N						OS							P					IS	MS							R					IS	MS								R	28 22
Pomacentrus variabilis	cocoa damselfish			T	E	N						OS							P					IS	MS							R					IS	MS								R	28 22
Mugil cephalus	striped mullet			T	S	P				IS	MS								P			E	C	IS	MS					S			P	P	E	C	IS								P		1 33 28 54 23
Mugil curema	white mullet			T	S	P					MS	OS							P			E	C	IS						S			P		E	C	IS	MS							P		1 33 28 54 23
Sphyraena barracuda	great barracuda			T	S	P						OS							P			E	C	IS					SV	S			P			C	IS	MS	OS				SV		P	R	41 28 29
Sphyraena borealis	northern sennet			T	S	P						OS							P			E	C	IS					SV	S			P			C	IS						SV		P	R	33 28 29

						Egg	Larvae															Juveniles														Adults													
		Abundance	Spawning	Resident / Transient	Expatriates / Life History	Pelagic \ Non-pelagic	Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Emergent Vegetation	Submerged Vegetation	Emergent Sediment	Submerged Sediment	Pelagic	Reef		Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Bethic Vegetation	Submerged Sediment	Pelagic Vegetation	Reef	Pelagic		Palustrine	Estuarine	Coastal	Inner-shelf	Mid-shelf	Outer-shelf	Slope	Abysall	Pelagic Vegetation	Submerged Vegetation	Submerged Sediment	Pelagic	Coral, Rocky, Oyster Reef	References (see Appendix 2)
Halichoeres bivittatus	slippery dick	a		R		P					MS								P						IS	MS							R						IS	MS					SV	S		R	41 28 54 39
Halichoeres caudalis	painted wrasse			R		P					MS								P							MS	OS						R							MS	OS							R	41 39
Tautoga onitis	tautog			T	E	P	NO DATA ----------------------------------												P				E	C	IS								R					C	IS	MS								R	41 15
Xyrichthys novacula	pearly razorfish			R		P					MS	OS							P						IS	MS	OS				S								IS	MS	OS					S			1 3 28 54 56 37
Cryptotomus roseus	bluelip parrotfish			T	E	P					MS	OS							P			NO DATA ----------------------------------								SV			R					C	IS	MS	OS				SV			R	28 22
Nicholsina usta	emerald parrotfish			T	E	P					MS	OS							P			NO DATA ----------------------------------								SV	S		R					C	IS	MS	OS				SV	S		R	41 28
Scarus taeniopterus	princess parrotfish			T	E	P					MS	OS							P					C	IS								R						IS	MS								R	28 22
Sparisoma aurofrenatum--S. radians	redband / bucktooth parrotfish			T	E	P					MS	OS							P					C	IS					SV			R					C	IS	MS					SV			R	41 28 22
Uranoscopidae	stargazers			T	S	P				IS	MS	OS							P					C	IS	MS	OS	SI			S							C	IS	MS	OS	SI				S			41 28
Dactyloscopus moorei	sand stargazer	a		R		P				IS	MS	OS							P						IS	MS					S								IS	MS						S			28 54 12
Hypleurochilus geminatus	crested blenny			R		P				IS	MS	OS							P			NO DATA ----------------------------------								SV	S		R					C	IS	MS					SV			R	41 54
Ophioblennius atlanticus	redlip blenny			R		P				IS	MS	OS							P			NO DATA ----------------------------------											R					C	IS									R	15
Parablennius marmoreous	seaweed blenny			R		P				IS	MS	OS							P				E	C	IS	MS	OS	SI		SV	S	PV	R						IS	MS					SV			R	54 15
Starksia ocellata	checkered blenny			R		P				IS	MS	OS							P			NO DATA ----------------------------------																	IS	MS								R	6 41
Diplogrammus pauciradiatus	spotted dragonet	a		R		P				IS	MS	OS							P						IS	MS	OS				S							C	IS						SV	S			28 54 11
Coryphopterus glaucofraenum	bridled goby			R		P				IS	MS	OS							P						IS	MS					S		R						IS	MS					SV	S		R	6 41 28
Gobiosoma ginsburgi	seaboard goby			T	S	P		E	C	IS	MS	OS							P				E	C	IS						S		R				E	C	IS	MS						S		R	1 33
Ioglossus calliurus	blue goby			R		P				IS	MS	OS							P							MS					S								IS	MS	OS					S			41 28 54
Microgobius carri	Seminole goby	a		R		P				IS	MS	OS							P						IS	MS	OS				S								IS							S			41 28 4
Acanthurus bahianus	ocean surgeon			T	E	P					MS								P						IS	MS							R						IS	MS								R	41 28 22
Acanthurus chirugus	doctorfish			T	E	P					MS								P						IS	MS							R						IS	MS								R	41 28 22
Auxis rochei--A. thazard	bullet / frigate mackerel			T	S	P				IS	MS	OS							P						IS	MS	OS	SI						P					IS	MS	OS	SI					P		3 28 10
Scomberomorus cavalla	king mackerel			T	S	P						OS							P						IS	MS	OS							P				C	IS	MS	OS						P		33 28
Scomberomorus maculatus	Spanish mackerel			T	S	P				IS									P						IS	MS								P				C	IS	MS							P		33 28
Euthynnus alletteratus	little tunny			T	S	P				IS	MS	OS							P						IS	MS								P					IS	MS	OS						P		28 10
Psenes maculatus	silver driftfish			T	S	P				IS									P						IS	MS	OS	SI				PV		P							OS	SI					P		17
Peprilus burti	gulf butterfish			T	S	P				IS	MS	OS							P				E	C	IS	MS								P				C	IS	MS	OS	SI				S	P		28 35
Peprilus paru	butterfish			T	S	P				IS	MS	OS							P				E	C	IS							PV		P					IS	MS	OS					S	P		33 28 29
Peprilus triacanthus	butterfish			R		P		E	C	IS	MS	OS							P				E	C	IS	MS					S	PV		P				C	IS	MS	OS					S	P		1 3 28 54 29
Bothus ocellatus--B. robinsi	eyed/spottail flounder			R		P					MS	OS							P						IS	MS	OS				S								IS	MS	OS					S			28 54 51 56
Etropus cyclosquamus		a		R		P				IS	MS	OS							P						IS	MS					S								IS	MS						S			28 51 16 26
Etropus crossotus	fringed flounder	a		T	S	P				IS	MS	OS							P				E	C							S							C	IS	MS						S			28 51 16 52 55
Cyclopsetta fimbriata	spotfin flounder			T	S	P					MS	OS							P						IS	MS	OS				S									MS	OS					S			28 54 51 56
Citharichthys macrops	spotted whiff			R		P				IS	MS	OS							P				E	C	IS	MS	OS				S								IS	MS	OS					S			54 51 52 55
Etropus microstomus	smallmouth flounder	a		R		P			C	IS	MS	OS							P				E	C	IS						S							C	IS	MS						S			1 3 28 51 16 52 26
Syacium papillosum	dusky flounder			T	S	P					MS	OS							P						IS	MS	OS				S								IS	MS	OS					S			41 28 54 51 56
Citharichthys spilopterus	bay whiff	a		T	S	P				IS	MS	OS							P				E	C							S							C	IS	MS						S			28 52 55
Etropus rimosus	gray flounder	a		R		P				IS	MS	OS							P						IS	MS	OS				S									MS	OS					S			28 51 16 52 26
Ancylopsetta quadrocellata	ocellated flounder			T	S	P	NO DATA ----------------------------------												P				E	C	IS	MS	OS				S							C	IS	MS	OS					S			54 51 55
Scophthalmus aquosus	windowpane			T	S	P		E	C	IS	MS								P				E	C	IS						S						E	C	IS	MS						S			1 55
Hippoglossina oblonga	american fourspot flounder			T	S	P					MS								P			NO DATA ----------------------------------									S								IS	MS	OS	SI				S			28 16 29
Paralichthys albigutta	gulf flounder			T	S	P					MS	OS							P				E	C							S						E	C	IS	MS	OS					S			28 16 36 55
Paralichthys lethostigma	southern flounder			T	S	P					MS	OS							P				E	C							S						E	C	IS	MS						S			33 28 16 36 55
Symphurus diomedianus	spottedfin tonguefish			T	S	P				IS	MS	OS							P						IS	MS					S									MS	OS					S			28 54 32
Symphurus minor	largescale tonguefish			R		P				IS	MS	OS							P						IS	MS	OS				S								IS	MS	OS					S			28 54 32
Symphurus plagiusa	blackcheek tonguefish			T	S	P				IS	MS	OS							P				E	C	IS						S						E	C	IS	MS						S			28 54 55 32
Symphurus urospilus	spottail tonguefish			R		P				IS	MS	OS							P						IS	MS	OS				S								IS	MS	OS					S		R	28 54 32
Trinectes maculatus	hogchoker			T	S	P			C	IS									P				E	C							S					P	E	C	IS	MS						S			1 28 51 55
Gymnachirus melas	naked sole			T	S	P					MS	OS							P						IS	MS	OS				S								IS	MS	OS					S			41 28 51
Aluterus heudeloti	dotterel filefish			T	S					IS	MS	OS							P				E	C	IS	MS	OS	SI		SV	S	PV						C	IS	MS	OS				SV	S		R	6 56
Aluterus schoepfi	orange filefish			T	S					IS	MS	OS							P				E	C	IS	MS	OS	SI		SV	S	PV					E	C	IS	MS	OS				SV	S		R	54 29
Aluterus scriptus	scrawled filefish			T	S					IS	MS	OS							P				E	C	IS	MS	OS	SI		SV		PV							IS	MS					SV		P	R	6
Balistes capriscus	gray triggerfish			R								OS							P				E	C	IS	MS	OS	SI				PV							IS	MS	OS					S		R	28 29
Cantherhines pullus	orangespotted filefish			T	S							OS							P				E	C	IS	MS	OS	SI				PV						C	IS	MS								R	6 28
Stephanolepis hispidus	planehead filefish	a		R								OS							P				E	C	IS	MS	OS	SI			S	PV							IS	MS	OS					S		R	28 54 56 29
Lactophrys quadricornis	scrawled cowfish			R						IS	MS	OS							P						IS	MS	OS			SV	S							C	IS	MS	OS				SV	S		R	38 6 28 54
Lactophrys trigonus	smooth trunkfish			T	S					IS	MS	OS							P			NO DATA ----------------------------------								SV								C	IS	MS					SV			R	38 6
Sphoeroides dorsalis	marbled puffer			T	S					IS	MS	OS							P					C	IS	MS	OS				S									MS	OS					S	P		56 44
Sphoeroides maculatus	northern puffer			T	S					IS	MS	OS							P						IS					SV	S			P			E	C	IS	MS					SV			R	1 44
Sphoeroides spengleri	bandtail puffer			T	S					IS	MS	OS							P				E	C	IS	MS	OS	SI		SV		PV							IS	MS					SV			R	44
Chilomycterus schoepfi	stripped burrfish			R			NO DATA ----------------------------------												P			NO DATA ----------------------------------								SV			R				E	C	IS						SV			R	33 41

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