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Project Title: *NOAA CRCG 2002 Habitat Characterization of Pulley Ridge and the Florida Middle Grounds*

Part I: *Status and Trends in Habitat Characterization of The Florida Middle Grounds*

by

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Dedication

To Dr. Thomas S. Hopkins, University of Alabama, we extend our collective gratitude and admiration, for allowing us to benefit from his tremendous historical insights, his enthusiasm for participating in the work, and unwavering dedication to the pursuit of knowledge about the west Florida shelf. It was indeed an honor.

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Part I

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Abstract

The intent of this study was to assess the current status of the biotic communities of the Florida Middle Grounds, an area off the West Florida Shelf in the northeastern Gulf of Mexico. We compared our data with that of other similar studies done 25 to 30 years ago in the 1970s to determine whether the area has experienced significant change in benthic cover and associated fish fauna. The Middle Grounds is unique because it represents the northernmost extent of mid-shelf octocoral communities in North America. and is the confluence of at least two faunal components, Caribbean and Carolinian. This study was not intended as a description of community dynamics, but only as a ‘snapshot’ of present conditions. We found no indications of coral die-off nor of other deseases in the benthic community, but there was an obvious paucity of economically important fish species which we attribute to fishing. The Florida Middle Grounds should be monitored at least decadally to assess the potential impacts of global warming, coastal development, offshore oil and gas exploration, and ocean dumping--all of which can have profound influences even in remote areas and affect the quality of the associated communities.

Introduction

In addition to managing fish stocks, the Gulf of Mexico Fishery Management Council is responsible for protecting essential fish habitat and for managing the coral and coral reef resources of the region. It does this primarily by designating areas as Habitat Areas of Particular Concern (HAPC) or as marine reserves. Those areas designated as HAPCs[1] in the early 1980s (1982) all contain significant coral communities (Figure 1). HAPC designation at that time afforded these areas protection from coral harvest and the use of fishing gear that could damage coral communities, including bottom longlines, traps, pots, bottom trawls, dredges, and toxic chemicals. While four other sites were designated as HAPCs in the Gulf of Mexico Essential Fish Habitat Amendment (GMFMC 1998), none of these was provided with similar protection.

Fundamental to the study and management of natural resources in Habitat Areas of Particular Concern is the development of objective, systematic, and intuitively understandable maps. General geomorphologic and habitat maps already exist for some parts of the Flower Gardens, the Oculina Banks (Scanlon *et al.* 1999, Koenig *et al.* 2000, Koenig *et al.* In press), and the Florida Middle Grounds (BLM 1981, Hopkins et al. 1977, Mallinson 2000). Most other areas in the Gulf of Mexico have neither the habitat maps nor adequate descriptions of the benthic geomorphology, the basis for developing habitat maps.

From 1978 to 1980, the Mineral Management Service sponsored seven cruises to the area designed in part to integrate geophysical mapping with biological and chemical sampling. The primary biological objectives were to determine whether the Florida Middle Ground should be designated as a HAPC, and to devise cost effective monitoring approaches that could moderate decision making relative to oil and gas exploration (BLM 1981). The study included, among other things, descriptions of the benthic cover (Grimm and Hopkins 1977, BLM 1981) and the associated fish fauna (Clarke 1986).

Using the BLM (1981) study as a guide, our intent was to establish a status and trends benthic habitat and fish fauna monitoring program for the Florida Middle Grounds using ROV-video transects and wet-diving sampling. We also evaluated a number of other sites that included other types of habitat, including important commercial (hook and line) fishing sites. While this study is not nearly so intensive or comprehensive as the BLM study, we have supplied a survey of the basic habitat features and primary ichthyofauna that allows us to make a realistic comparison. Assessing habitat change is critical in an environment already experiencing heavy fishing pressure and likely to experience increased oil and gas exploration and other types of human-induced impacts, including ocean dumping (e.g., the Environmental Protection Agency recently approved permits to dump 500,000 gallons of phosphate waste across the west Florida shelf).

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[1] Areas identified as HAPCs in the 1970s include the Flower Garden Banks in the western Gulf of Mexico (now the Flower Gardens National Marine Sanctuary), the Oculina Banks off the east coast of Florida (now expanded to 300 NM^2 and containing a 92 NM^2 experimental marine reserve), and The Florida Middle Grounds in the northeastern Gulf of Mexico.

Study Site

The northeastern Gulf of Mexico has the most extensive hardbottom habitat of the entire United States Atlantic coast (Parker Jr. et al. 1983), although most of the relief is less than one meter (m) in height. The highest and most estensive relief (> 2m) in less than 60 m water depths occurs within the Florida Middle Grounds (FMG), an area on the West Florida Shelf some 137 km off Florida's coast (Figure 2). The FMG is unique in this part of the Gulf in having carbonate bank ledges rising as much as 15 m off the bottom, cresting at ~25 to 30 m below sea level (Figure 3). The ledges form a broad carbonate platform simlar to Campeche Bank (Hine and Mullins 1983), developed from karst topography on the usually flat muddy and sandy bottom of the region (Brooks 1973, Pyle et al. 1974). The occurrence of this reef complex indicates paleoceanographic conditions in the eastern Gulf of Mexico that were significantly different from those that exist today. Rock outcrops like those that exist in the FMG typically form from undercut ledges representing previous sea-level stands. Brooks (1962) attributes the FMG relief to underlying Pleistocene reef structure, based on seismic data. More recent work by Mallinson (2000) suggests that the FMG is a relict (dead) coral-reef complex that has morphological similarities to modern patch-reef complexes over basement rock of Miocene age karst relief.

The FMG reefs trend north-northwest parallel to the platform margin with at least five separate ridges separated by troughs or channels at shelf depths. Two ridges appear in the northern and central regions; a third ridge appears between these two ridges in the southern range, thereby narrowing the troughs between ridges. The third and fourth lower-relief ridges occur on the western margin of the area. The ridges consist of steep-sided flat-topped banks and numerous pinnacles with rock rubble and sediments collected at the bases. Sediments (carbonate, molluscan, and barnacle-derived sand) form sand waves in a pattern that suggests east and west tending currents. Further, the bank slopes are highly bioeroded and undercut, producing significant structural complexity. High local relief supports active reef growth, while the broad flat-topped banks are likely older, relict coral-reef/patch-reef complexes that have eroded to produce carbonate sands. It appears that organism abundance and diversity in the FMG are significantly influenced by the slope margins. From previous submersible work, we observed the water currents flow up and over the reef structures, often times creating strong currents that bring nutrients and plankton from deeper water, up the slope, and on to the horizontal platform.

The physical conditions of the FMG provide opportunities for a unique community to exist in the region. The bank and pinnacle tops are covered with patchily-distributed relatively high relief communities of stony corals and octocorals (Hopkins *et al.* 1977, 1979, 1981a, Hopkins 1981c, b, Gittings *et al.* 1992) typical of deep Caribbean reefs, with associated invertebrate and fish assemblages indicative of an impoverished coral reef fauna (Grimm and Hopkins 1977, Rezak *et al.* 1985). The region represents the northernmost extent of coral communities in the United States. Historically, *Millepora alcicornis* (branching fire coral) dominated the biotically-derived benthic cover and relief, with a dense zooxanthelate gorgonian assemblage that was absent elsewhere in the northern Gulf of Mexico (Rezak *et al.* 1985), including the Flower Garden Banks in the northwestern Gulf (Hopkins 1981c), and an extraordinarily diverse sponge fauna (Austin and Jones 1974). Despite the diversity, Hopkins suggests that the region is under stress, based on coral growth that is upward rather than lateral, indicative of a system that is not flourishing.

The set of circumstances allowing such a unique and diverse biota to exist in the FMG depends in large part on the physical features of the region. The FMG occurs on the mid-shelf, whereas most hardbottom areas occur at greater depths, associated with the shelf edge (Rezak et al. 1985, Phillips et al. 1990). It occurs in a temperate region where minimum winter seawater temperatures (16° C) are marginal for many tropical marine organisms, and where hurricanes and tropical storms occur with some frequency, exposing organisms to significant storm surge (Austin and Jones 1974, Sturges and Blaha 1976). However, its position on the mid-shelf provides an interesting juxtaposition between converging water masses: a lower salinity turbid coastal water mass and the intermittent outer shelf high salinity stable tropical water mass of the Loop Current. (The Loop Current has a northward intrusion along the West Florida Shelf in the spring and summer, although there is not a clear seasonality to it.) The convergence results in high water column productivity in the FMG (Bullock and Smith 1979). The presence of the Loop Current also provides a mechanism for the transport of more tropical species to the region. The biotic communities of the Florida Middle Grounds also may well depend on the Loop Current to transport larvae from the tropics for recolonization (Collins 1885, Moe 1963).

The unique features of the Florida Middle Grounds have not gone unnoticed. Roughly 348 NM^2 of area between 28° 10' and 28° 45' N and 084°00' and 084°25' W is considered a habitat area of particular concern. This area is roughly 150 km south of the north Florida coast, and 160 km northwest of Tampa Bay (Figure 2). The boundaries of the HAPC capture the primary high-relief and live bottom features of the area.

As with many unique marine habitats, fishers were the first to discover the FMG area because it was once an important red snapper (*Lutjanus campechanus*) fishing ground from as early as the 1880s (1976). It is still important today, but for other species. The fish assemblages are diverse. Smith (Clarke 1986) summarized and compared reef fishes throughout the northeastern Gulf of Mexico and found the FMG had two to three times the number of reef fish taxa as were observed at other hard bottoms areas. In 1978-1979, a quantitative survey of reef fishes was undertaken via SCUBA (Shipp *et al.* 1986), followed by a characterization of the fish assemblage conducted by submersible (1983). Economically important fish were studied at the FMG via standard fishing techniques, such as bottom longlines, handlines, and traps, by Tyler (1979) and the unique assemblages of sponge-dwelling fishes described by Livingston (Mumby and Harborne 1999).

Materials and Methods

We used a systematic scheme of habitat classification (1977), but modified for our purposes. Our scheme relies on a geomorphologic framework for the evaluation of habitat function and allows spatial and temporal expansion of these studies throughout the rest of the Florida Middle Grounds. It also provides a basis for the scientific investigation of habitat function on national and international scales. To wit, we supplied this same protocol to the National Geographic's Sustainable Seas Expedition in 2001 so that archived video records from these geo-referenced data throughout the Gulf of Mexico would be comparable.

We used a combination of maps to form a base map for our studies, including:

(1) historical study-site maps from Grimm and Hopkins (NGDC 2003);
(2) three second gridded bathymetry data for the entire HAPC from National Oceanic and Atmospheric Administration's (NOAA) National Geophysical Data Center (NGDC) hydrographic sounding database (Krebs 1999);
(3) high-resolution multibeam bathymetric surveys of 42 NM^2 (129 $km^{2,}$ roughly between latitudes 28° 32' N and 28° 37' N) (Mallinson 2000).

We used these data to estimate the proportion of bottom area by depth range (Table 1, Figure 3).

We evaluated 12 sites, including 6 sites previously visited by Hopkins et al in the 1970s[2] and several additional sites chosen specifically for this study. The science team consisted of ten scientific divers, an ROV operator, and two data managers. We evaluated all sites for physical and biological habitat features using digital video and still underwater images taken by remotely operating vehicle (ROV) (Table 2) and SCUBA (Nitrox) divers (Table 3) onboard a chartered vessel (20 m) (Figure 4).

The biological communities of algae, sessile invertebrates, and fishes were characterized and classified using a systematic hierarchical clustering technique (Aronson *et al.* 1994). It includes percent cover (Jaap and McField 2001, Jaap *et al.* 2003), density of dominant sessile species, taxonomic composition to the lowest determinable taxon, taxonomic richness, other taxonomic diversity measures to the lowest determinable taxon, and spatial pattern of dominant species (i.e., random, regular, or clumped).

Our approach here was threefold: first, to conduct studies for direct comparison by duplicating the methods used by Hopkins et al. to the extent practicable; second, to conduct ROV transects to characterize greater portions of the historical sites; and three, to investigate as many additional sites as practicable during our time at sea. In all instances, we used strip (belt) transects. Strip transects (essentially long, thin quadrats), unlike square or round quadrats, cut across many variations or patches (habitat heterogeneity) in the habitat and thus increase precision. Multiple random transects were useful for density (number per unit area) determination and many other community measures.

ROV component:

The National Undersea Research Center (University of North Carolina, Wilmington) supplied the ROV (Phantom S2 mini-ROV) and ROV-operator for this cruise through a rapid-response funding proposal submitted by one of us (Dennis, USFW). Two cameras mounted on the ROV allowed us to obtain both videographic (Sony color CCD video camera with 460+ lines of resolution, auto iris, 12:1 zoom, and auto/manual focus) and still images (Insite-Tritech Scorpio digital still camera, TTL strobe, PC control, 3.34 megapixel CCD, 4X zoom). Both cameras had parallel-beam lasers set 10 cm apart to provide scale and to measure organisms. Both cameras

[2] Environmental impact studies for petroleum exploration and development in the 1970s documented 103 species of algae, 40 sponges 75 mollusks, 56 decapod crustaceans, 41 polycheates, 23 echinoderms, and 170 species of fish (Hopkins et. al., 1977, Smith et al, 1975). *Millepora alcicornis*, *Madracis decactis*, and *Dichocoenia stokesii* were the most abundant stony coral species. The major Caribbean reef-building Scleractinia genera: *Acropora, Montastraea*, *Diploria*, and *Colpophyllia* do not occur at the FMG and massive coral buttresses are not found.

could be rotated from forward-looking to downward-looking positions. The forward-looking videos and still photos provided images for identifying species, relief, and zonation, and the down-looking images for determining percent cover by the various community components.

ROV surveys consisted of quantitative strip (belt) transects within defined geomorphologic features, covering a greater area and more extensive relief than the SCUBA surveys do. The ROV maintained a near-bottom elevation of approximately 0.5 to 1.0 meter, moving at a speed of 0.5 m/s or less to ensure clear images (a shutter speed of 1/125 was found to stop blur caused by the ROV movement). Transect duration of two minutes provided transect lengths of at least 25 m and facilitated keeping a single transect within similar habitat. Five two-minute video transects were taken at each site. The video camera view setting on wide angle allowed coverage of about 1 m on either side of the ROV. A TRACKPOINT ultra-short baseline system provided accurate positioning (+/- 5 m) of the ROV. The ship position was determined with differential GPS. The ship and the ROV position were logged each second throughout the dive with HYPACK software. Though most dives occurred during the day when ambient light and visibility (> 10 m) were good, the use of lights ensured the capture of correct colors that are crucial for accurate identification of many taxa.

Four downward-looking digital still images taken before and after each transect helped characterize the benthic habitat. During each dive, discrete haphazard digital still photographs taken at the same viewing angle as the video camera provided higher resolution images for taxonomic identification and characterization of the epibiota. The sampling was not strictly random because of the discrete sampling of unusual taxa and economically important species. Videos taken of each dive in mini-DV format were analyzed in the laboratory. All data were duplicated, archived, and entered into a Geographical Information System (GIS) database. A viewer analyzed each tape in the laboratory, identifying all fish to the lowest taxon, enumerating the abundance of each species, and noting the location on the tape by time. Processing of the navigation data after each dive provided the distance traveled along the bottom, based on hand-recorded start and stop locations for each transect. A software glitch on one dive did not allow position logging. Once obviously spurious readings were removed from the navigation data, a revised time and location dataset was established. This allows the position of every observation from video and still cameras to be determined from the time.

SCUBA component

SCUBA divers conducted detailed surveys on the reef top and reef slope, leaving broad surveys to the ROV. Two different SCUBA dive teams surveyed the sites. One team concentrated on benthic structure (geological and biogenic), while the other conducted surveys of the ichthyofauna.

Both SCUBA teams assessed seven locations at depths ranging from 29 to 35 m, including five historical sites (FMG147, FMG247, FMG251, FMG151, FMG491), and two new sites ("Goliath Grouper Rock", and "Fisherman's Ledge") (Figure 4). Bottom time was limited to about 30 minutes per dive because of depth and gas supply, especially on FMG 491, where less sampling was possible.

The dive team assessing habitat conducted both strip transect sampling to determine benthic percent cover and quadrat sampling to determine densities of organisms within four major taxonomic groups (i.e., algae, sponges, scleractinian corals, octocorals), collecting voucher specimens as needed. At some sites, divers focused on broad scale surveys rather than quantitative survey to get a better understanding of the range of benthic communities.

A single 50 m long reference transect line was set at each site within defined geomorphologic features running generally from the reef break back across the reef flats. Divers made multiple video transects along this line, covering an area roughly 25 m x 0.4 m, (≈10 m^2 per transect, planar area). The camera used was a Sony TVR 900 three chip digital camera in a modified Amphibico Dive Buddy 2 housing (2004) with laser lights to keep the camera lens 40 cm from the reef surface. Individual specimens were photographed with a Nikon Coolpix camera in an underwater housing with an Ikelite 200 underwater strobe. The base transect was marked at 2 m intervals (3 m for sponges) to identify locations for quadrat surveys. Quadrat placement sites along the base transect line were randomly determined, but each quadrat was placed perpendicular to the baseline. Divers then counted the number of each type of organism within each quadrat, collecting voucher specimens as needed for identification, and sediment samples to determine benthic foraminiferan species. Algal specimens were preserved in 4% formalin in seawater, small specimens in 20 ml scintillation vials and large specimens in zip-loc bags. A list of selected specimens deposited in the National Museum of Natural History Herbarium collection appears in the appendix (Appendix A).

Divers conducting fish surveys videographed four or five random strip transects along the reef flat and down the reef face, taking from 12 to 29 minutes of Hi-8 video (SONY Video Camera) footage at each site (Table 3). Video analysis occurred in the laboratory. The first occurrence of each species was recorded by tape time, as were any unusual or unique fish observations. Discrete digital images of reef fishes were also obtained from the epifaunal dive team. We follow Eschmeyer et al. (Nelson *et al.* 2004) for taxonomic names and Nelson et al. (Boesch 1977) for common names of fishes.

All videos were used to develop a general descriptive summary of the habitat.

Statistical analyses

Analysis of community characteristics from epifaunal diver surveys includes determinations of percent cover, density of dominant sessile species, species composition, species richness and other species diversity measures, spatial pattern of dominant species (i.e., random, regular, or clumped). Habitat-structuring organisms classified as major taxa (e.g., gorgonian, sponge, algae)--or at finer taxonomic and morphological scales when possible--provided a means of characterizing and classifying habitat.

We used Sorensen's similarity index to compare species composition of historical and recent samples from major taxa (algae, octocorals, stony corals, and fishes) except sponges. The taxonomy of the historical sponge samples was not clear enough to make meaningful comparisons. Sorensen's similarity index is a binary method that compares presence-absense data and treats all species equally. It was necessary to use a binary method because the historical data for the most part were not quantitative.

Video images were frame grabbed using Ravenview ™ software programmed to select a series of images with approximately 5 percent overlap, and saved as JPG files (N = 143 to 219 images per site). Each image was analyzed using point count (ten randomly distributed points per image) analysis to estimate the percent cover of the principal benthic groups: algae, sponges, octocorals, scleractinian corals, *Millepora* (fire corals), anemones, and substrate (rock and sediments). Point count for coral reefs is a public domain program that superimposes random points on each image. Point count data are saved as a spreadsheet for statistical analyses.

Each ROV and fish video transect consists of a strip transect 2-m wide and the distance covered in length. Because of the narrow transect width, minimal viewer error occurred, allowing a total census of the area. All data in these analyses are expressed as number of individuals per 100 m. Each transect was assigned to one of eight habitat categories (Table 4), based on five pre-determined equally-spaced time interval observations of habitat type along the transect. At the end of each interval, the video was stopped to evaluate the benthic habitat type. Erratic logging by the ROV on Dive no. 12 resulted in not conducting transects.

We summarized fish taxa by site and habitat and explored the relationship between habitat and site using cluster analysis. These data were subjected to agglomerative hierarchical clustering using the Sorenson similarity measure and flexible sorting linkage method to construct clusters (Dufrene and Legendre 1997). Rare tax that occurred at less than 10% of the site-habitat units were removed from the dataset to reduce potential bias from chance occurrences and poor sampling. Species indicator analysis determined the appropriate level and identity of taxa that characterized each cluster group (indicator species being the most characteristic taxa for a group) (McCune and Mefford 1999). Starting at the two-cluster level, each level was compared using the sum of the indicator values. The maximum sum of indicator values provided a measure of the appropriate clustering level for interpreting the data. Clusters below this level do not provide further substantive information on the relationship among groups. The taxon-specific indicator value was evaluated for statistical significance using the Monte Carlo test. Only those taxa with a probability level greater than 0.05 were considered significant indicators of a group. We used the PC-ORD program for these analyses (Krebs 1999).

Among habitat differences were determined for four community parameters:

- total number of taxa
- total number of individuals
- diversity
- evenness
- abundance of the top five taxa.

The Shannon-Weiner (H') provides an estimate of cumulative diversity,

$$H' = \sum_{i=1}^{s} (p_i)(\log_e p_i)$$

where H' = index of species diversity
s = number of species
p_i = proportion of total sample belonging to the *i*th species.
The larger the value of H', the greater the uncertainty. A community with only one species in it has no uncertainty and H' = 0. H' typically increases with the number of species in the community, but typically does not exceed 5.0 (Pielou 1977).

Evenness estimates follow from this equation:

$$J'n = \frac{H'}{\log_e s}$$

where J' = the evenness of the community (Day and Quinn 1989). Abundance values were log transformed and habitat compared in a one-way ANOVA. Ryan's Q test was used as a post-hoc test for differences among habitat when the overall ANOVA was significant (Peres-Neto 1999), where

$$CV = \frac{Q_{(p,df)} SE_c}{\sqrt{2}}$$

where p = the number of means in the group to be tested, b = adjusted significance level for a test of the equality of *p* means. $b = a - (1-a)^{p/m}$; because $p \le m$, $ap/m \le 1-(1-a)^{p/m}$, so that the test using $1\text{-}(1\text{-}a)^{p/m}$ is more powerful. The ANOVA *p* values were adjusted for multiple tests using the Bonferroni procedure (Krebs 1999), When heterogeneity of variance was high, a non-parametric equivalent, Kruskal-Wallis test, was used in conjunction with Dunn;s multiple comparison test.

The Bray Curtis Measure evaluates the level of similarity among sites,

$$B = \frac{\sum \left| X_{ij} - X_{ik} \right|}{\sum \left(X_{ij} + X_{ik} \right)}$$

where B = Bray-Curtis measure of dissimilarity
X_{ij}, X_{ik} = Number of individuals in species I in each sample
N = Number of species in samples
The measure of similarity is the complement (1.0 - B).

Understanding that the historical sampling was longer term and more intensive than that conducted in our study, and that the historical samples were primarily taken during the summer while ours were taken in late spring, we evaluated sample similarity using the Coefiicient of Sorensen. This is a binary coefficient that weights matches in species composition between two samples more heavily than mismatches (1981c). The coefficient is as follows:

$$S_s = \frac{2a}{2a + b + c}$$

where S_s = Sorensens's similarity coefficient,
a = number of species present in sample A and B conjoined,
b = number of species in sample B but not in sample A, and
c = number of species in sample A but not in sample B.

Results

The data we collected in May 2003 represent a reasonable assessment of the FMG sites sampled in the mid-1970s (27-28 years ago). We benefited tremendously by having two of the original researchers onboard with us, including then Chief Scientist Thomas Hopkins (University of Alabama) and Michael Dardeu (Dauphin Island Research Laboratory). These two scientists provided visual confirmation of the bottom based on ROV video to help us select the dive sites. The sites did not appear to have original markers. Thus, although we were in the general area, we cannot verify we were sampling the same place that Hopkins et al. (1977) sampled.

Changes in navigation and positioning technologies of the last few decades made exact location of study sites difficult. The BLM (1981) sites studied in the 1970s were located using LORAN C, Decca Hi Fix technology, and a Raytheon DE 719B echosounder. Although it is possible to convert these coordinates to latitude – longitude coordinates, they are not geo-referenced as are the satellite-based GPS coordinates. Sites visited in this study relied solely on Global Positioning System because the vessel chartered had a malfunctioning fathometer, making it difficult to locate ledges. Using the ROV in essence as a fathometer was problematic.

Data obtained include the following:

1. from ROV transects,
    - 13 hours of ROV video covering an area of 16,582 m^2
    - 1517 obligue digital still images;
2. from SCUBA transects at 7 locations:
    - bottom-looking video to characterize benthic habitat and associated benthic organisms
    - 133 minutes of forward-looking video (Table 3) to characterize habitat and fish species,
    - 137 still images of corals and sponges

Habitat characterization

Video and still images provided data for habitat characterizations. The ROV transects provided classifications by dominant habitat type (modified from Grimm and Hopkins (1977) and Clarke (1986) (Table 4), and supplemented the epifaunal data analyses.

Sediment Samples

Sediment samples collected from the Florida Middle Grounds are being included in a larger study conducted by Camille Daniels and Pamela Hallock, College of Marine Science, University of South Florida. The intent of the larger study is to develop a method for using sediment constituents as indicators of reef condition. The Middle Grounds samples provide an outlier group in the analysis.

Grain-size analysis followed standard procedures. Sediments from the 0.5 - < 1 mm and 1 - 2 mm size classes were well mixed to create a subsample, which was sprinkled into a gridded tray and evaluated using a stereomicroscope. The first 300 calcareous grains encountered were identified into functional groups (Table 5) and counted. Proportions of skeletal fragments of zooxanthellate organisms (stony corals and larger foraminifers), autotrophic carbonate producers (coralline and calcareous algae), and heterotrophic carbonate producers (molluscs, echinoids, worm tubes, smaller forams, etc.), as well as unidentifiable carbonate grains, were weighted and summed to yield a single-metric value, called the SEDCON Index, for each sediment sample (Table 5).

Foraminifers in the 0.5 to 2 mm size fractions were noted. *Amphistegina gibbosa* was prevalent at all six sites. Other genera observed include *Planorbulina, Trioculina, Laevipeneroplis bradyi, L. proteus, Textularia, Quinqueloculina, Archaias,* and *Asterigerina*.

Algae

Twenty eight species of algae were identified in this study. Red algae proved the most diverse and abundant algal phylum, comprising 62% of the species present, followed by Chlorophyta (20%), and Phaeophyta (17%). The greatest species diversity (N = 11) occurred at FMG 247. The lowest diversity (N = 2) occurred at the Goliath Grouper Rock (GGR). *Champia salicornides* and *Dictota menstrualis* were the most commonly collected species, occurring at four of the stations; 20 of the algae (genera/species) only occurred at one station (Table 6). The majority of the species were rare, thus there is not a high degree of similarity among the sites (Table 14).

Sponges

Many of the sponges occurring in the FMG are large, erect barrel and vase forms that add significantly to the biotic relief of the habitat. Forty-one species of sponges observed in this study (Table 7) include 34 positively identified species and 7 unidentified species collected for taxonomic evaluation. Quantitative assessment of sponges occurred at three sites (FMG247, FMG251, and FMG151) in which every individual colony was identified and counted. Hopkins et al. (2002) did not develop a complete species list of sponges because of the poorly developed state of sponge taxonomy at the time. The taxonomy still appears to be in some disarray. Our search on the web revealed at least two different systematic arrangements: The International Taxonomic Information System (ITIS: http://www.it is.usda.gov) and the classification of The Zoological Museum of Amsterdam at the University of Amsterdam (http://www.science.uva.nl/ZMA/Invertebrates.htm). Until we can obtain a correct classification of sponges, which appears in Hooper and Van Soest (1974), we include the historical list only as an appendix (Appendix B). The most abundant species historically were

Thirty-three of the species identified in this study occurred within the sampled quadrats, which represented 16 m^2 (planar area) of reef surface. The average number of colonies per square meter for the three survey sites ranged from 9 to 12.2, with a combined average of 10.6 colonies/m^2. The most common species encountered were *Pseudoceratina crassa*, *Niphates erecta*, *Amphimedon compressa*, *Cribrochalina vasculum*, an unidentified hard orange sponge, *Cinachyra alloclada*, and *Scopalina reutzleri*. The abundance of these common sponge species ranged from 1.4 to 0.6 colonies/m^2.

Octocorals

We did not have an octocoral taxonomist available for this study so the identifications are not comparable in detail to those conducted by Grimm and Hopkins (1977). We identified ten octocoral species at the sampling sites (Table 8), compared to 13 species identified in the 1970s. Perhaps because of this, the similarity of the earlier studies with this one are not particularly high (Table 14). *Muricea spp.* (Sea fans) were the most abundant species found at five sampling sites, with 161 colonies at FMG 151 (N = 9 quadrats), 27 at FMG 247 (N = 10), and 88 colonies at FMG 251 (N = 5). This species was very abundant at all sites sampled in the 1970s. The octocorals in the Florida Middle Grounds, though relatively limited when compared to those of Caribbean reefs, are more diverse than other areas of the Gulf. Bright and Pequegnat (Jeffrey *et al.* 2001), for instance, found no octocorals in the West Flower Garden Banks.

Hydrocorals (Milliporina) and Stony Corals (Scleractinians)

We found 1 hydrocoral (*Millepora alcicornis*) and 16 species of stony corals at the Florida Middle Grounds (Table 9), compared to the single hydrocoral and 18 species of stony coral observed by Hopkins *et al*. (1977). The two species present in historical samples that we did not observe were both cup corals, *Phyllangia americana* (The Hidden Cup Coral) and *Astrangia poculata*. Both these species were rare in historical studies so their absence in our quadrats is not surprising. Four species we observed but did not quanitify because they appeared outside of quadrats, including *Agaricia fragilis* (Fragile saucer coral), *Siderastrea siderea* (Massive starlet coral), *Manicina areolata* (Rose coral), and *Cladocora arbuscula* (Tube coral). We also observed one coral that did not appear in historical samples: *Oculina robusta.* Of greater interest is the absence of certain species at sites where they had been abundant in the 1970s. These include *Madracis decactis* (Ten-ray star coral) at FMG 247, and *Porites porites divaricata* (Thin finger coral) at FMG 147, 247, and 251. The latter species was generally in low abundance at all sites sampled in this study. Despite these differences, the species compositions were relatively similar (S = 0.690; Table 14).

Fire coral formed massive colonies in the FMG during the 1970s, clearly contributing most to the frame building of the coral cover especially at 30-31 m.

Benthic cover

Biogenic cover was greatest at FMG 251 (Figure 7), where it was nearly 60%. Octocorals dominated at this site, followed by sponges and algae. Sites with >30% cover included FMG 151 and FMG 47. Sites with cover around 20%, included GGR, FMG 491 and FMG 247. The least amount of cover occurred at FH.

The functional groups that provided the most biotic cover were different at each of the sites. Sponges dominated Fisherman's Hole, and provided at least 20% of the cover at FMG 491, FMG 247, FMG 251, and Goliath Grouper Rock (Figure 8). Octocorals dominated most of the sites sampled (i.e., FMG 047, FMG151, FMG251, FMG 491, and Goliath Grouper Rock), whereas benthic algae dominated FMG 247. Fire coral (*Millepora*) was most abundant at FMG 491, where it provided nearly 32% of the benthic cover. It was least abundant (<10%) at FMG 247, FMG 251, and at the Fisherman's Hole. Stony corals (scleractinia) were most abundant at FMG 151, where they provided nearly 13 % of the cover.

Given the benthic cover and classification, it appears that FMG 047 and FMG 151 are very similar, as are Fisherman's Hole and Goliath Grouper Rock (Figure 9). FMG 251 had little in common with the other sampling sites, which is likely do the preponderance of octocorals at this site.

Fishes

All fish species identified appear in Table 10. Seventy-four species were identified from the ROV video (Appendix C, species list by ROV sampling site), with an additional 16 species added from the ROV still images (Appendix D, species list by ROV sampling site), two species from the SCUBA fish transect videos, and three species from the SCUBA still images (Appendix E contains species by SCUBA sampling site).

We ranked these species based on the method of data collection (appendices B-D, Table 10). The main difference in rank order of taxa determined from ROV video and from still images is the difficulty of identifying cryptic species with the lower resolution video camera. This is particularly evident in the *Coryphopterus* species of goby and seaweed blenny *Parablennius marmoreus,* common components of the ichthyofauna that only appeared in still images. The top five most abundant species include two planktivores (purple reeffish, *Chromis scotti*); yellowtail reeffish, *Chromis enchrysura*), one benthic carnivore (slippery dick, *Halichoeres* cf. *bivittatus*), and two herbivores (striped parrotfish *Scarus* cf *iserti;* cocoa damselfish *Stegastes variabilis*). The purple damselfish was overwhelmingly the most abundant species. This assemblage is similar to the reef fish assemblage in the Florida Keys, but differs in some important aspects. None of the top six species at the Dry Tortugas is common at the Florida Middle Grounds (Rocha 2003).

Economically Important species

Three economically important species ranked among the top 20 species: grey snapper *Lutjanus griseus*, scamp *Mycteroperca phenax*, and red grouper *Epinephelus morio*. Grey snapper was represented by an adult population that occurred primarily along the shallow reef flat, especially abundant at FMG 147 and FMG 247. Only subadult scamp and red grouper were seen. Red snapper *Lutjanus campechanus* and gag *Mycteroperca microlepis* rarely appeared in our surveys, although they are among the most economically important species in the northeastern Gulf of Mexico.

New species and unusual fish

This study adds thirteen newly recorded species to the existing list for the FMG (Appendix F, marked with asterices). A summary of their position in the regional ichthyofauna along with the discussion of some additional records from museum collections and historical still images will be published in the future.

Two species occur as unusual forms in the FMG. One of these is a new form of slippery dick *Halichoeres cf. bivittatus*, part of a subtropical group with individuals ranging from North Carolina through Florida and Bermuda (Humann and DeLoach 2002). The FMG form differs from the Caribbean form in its initial coloration phase by being more orange and more frequently having an enlarged mid-dorsal fin spot. The Caribbean form is typically tan or greenish and lacks the mid-dorsal fin spot (see pictorial glossary for fish). The FMG terminal phase has black and white bars on the caudal fin that are lacking in the Caribbean form

The other species of interest is a form of striped parrotfish *Scarus* cf. *iserti.* The FMG *Scarus* form is most closely related to *S. iserti,* but differs in coloration from the Caribbean form. The FMG initial phase has dusky stripes with a yellowish caudal peduncle and caudal. The FMG terminal phase is smaller than the Caribbean form and has a more prominent yellow mid-body bar. This form awaits genetic analysis to determine if it is a separate species because the specimens we obtained were lost in a power failure during the hurricanes of 2004. This form is also found at the Dry Tortugas (Bohnsack *et al.* 1987).

Fish by habitat type.--A comparison of fish abundance (number per 100 m^2) for the top five taxa and community parameters among habitat types using ANOVA indicated that the major differences occurred between sand and all other habitats (Table 11). The low relief sand habitat had few taxa, low abundance, and little reef fish diversity. The reef flat had surprisingly few taxa and low abundance, that may relate to its low rugosity and relief.

Purple reef fish were most abundant on the reef crest and reef slope, and present in all other habitats with the exception of sand. Slippery dick abundance also differed among habitats, being most abundant over rubble and sand (Table 11), a habitat important to its congener in the keys (Austin 1971). Yellowtail reeffish was patchily distributed. Heterogeneity in variance was high, although a Kruskal-Wallis test still indicated differences among habitats. This species had substantially greater abundance on the reef base, particularly at the Sink Hole. The striped parrotfish and cocoa damselfish demonstrated no significant habitat-related differences in abundance (Table 11).

Among-site comparisons were made using a habitat-by-site summary of reef fish abundance to account for variance in both factors. Cluster analysis applied to 34 widely-distributed taxa—those found in at least 10% of the habitat-site combinations—provided relevant information on relationships (Figure 9). We compared cluster levels with the species indicator value (IV). The sum of IVs was greatest at the four-cluster level, indicating that this level had maximum information on differentiating groups. Based on the cluster analysis, Group 1 included habitats in deeper water at Deep South and Midway (Figure 9). The gobiids, the yellowhead jawfish *Opistognathus aurifrons*, tattler *Serranus phoebe,* sand diver *Synodus intermedius* had significantly higher IVs for this group (Table 12). Group 2 included sand habitat and the reef base at FMG 251, where few fish occurred. Only one species had a significant IV in this group, the hovering burrow-dwelling blue dartfish *Ptereleotris calliura,* which occurs in sand patches among reefs and on sandy bottom. Group 3 included the main set of reef habitats that is unique to and characteristic of the FMG. Purple reeffish, scamp *Mycteroperca phenax*, and cocoa damselfish are indicators of this group (Table 12). Group 4 is a poorly resolved set of shallow reef flat and reef crest transects at sites FMG 147 and FMG 047. No taxa had significant IV in this group, although greenblotch parrotfish *Sparisoma atomarium* has a maximum IV here. This group indicates that there are differences in habitat among sites. These two sites are characterized by low abundance of common taxa, such as purple reeffish and cocoa damselfish.

There is little difference in dominant species observed when compared to surveys by Clarke (1986), though rank order did differ (Table 13). It appears that yellowtail reeffish, grey snapper, and barred hamlet were more abundant in the recent survey, while neon gobies, greater amberjack, and red porgy were more common in the historical surveys. Based on the Sorensen coefficient of similarity, the fish fauna from historical studies were remarkably similar for the top twenty species evaluated (S = 0.941). The similarity was considerably lower when comparing our study to all historical studies (S = 0.550). Ours were most similar to Smith et al (1975) (S = 0.567) and least similar to Hopkins (1981) (S = 0.517) (Table 14). The differences over all occur when the rarer species are included. Thus, these differences may be more a function of sampling intensity than any real differences in faunal composition.

Discussion

It has been nearly 25 years since last survey of The Florida Middle Grounds. Previous studies were conducted in the 1970s by Austin (1974), Smith and Ogren (1979), Livingston (Grimm and Hopkins 1977, Grimm 1978), Grimm (Hopkins 1974, Hopkins *et al.* 1977, Hopkins 1981a, Hopkins 1981c, b), and Hopkins (1977), among others.

The historical algal diversity was far greater (N = 74-79 species) than the diversity we encountered (N = 28). This likely results from the seasonality of algal species. Diversity is far greater in the summer and early fall than at other times of year. Indeed, Hopkins et al. (1977) found winter diversity to be about a third of that occurring in the warm season, which is consistent with our mid-spring finding. In addition, the algae cover percentages we describe are remarkably similar to those reported in Hopkins et al. (Grimm and Hopkins 1977). Hopkins reported 61% of the species present were Rhodophyta, 28 % Chlorophyta, and 11% Phaeophyta. He also reported that Chlorophyta often dominated in terms of biomass. Gelatinous red algae seemed to be the most conspicuous and abundant in late May.

The sponges formed a conspicuous and important component of the benthic community in the Florida Middle Grounds, making a major contribution to the total percentage of living cover of the reef at all sites sampled.

The Florida Middle Ground stony corals are considered impoverished compared to the corals of Caribbean reefs (1981c). Nonetheless, the FMG is unique for the northeastern Gulf of Mexico by having any corals at all. .

Hopkins (Bullock and Smith 1979) suggests that the hard and soft corals of the Florida Middle Grounds experienced a major environmentally-induced trauma between the summers of 1976 and 1978, a period between two of his intensive sampling operations. Soft corals declined in number and many appeared emaciated when present. *Millepora alcicornis,* formerly abundant on the reef, declined dramatically, and, along with *Dichocoenia, Oculina,* and *Porites* colonies, were dead. The suspected culprits include exceptionally cold winters bringing 12-13°C water in shallow waters of that section of the Gulf of Mexico, and extreme storm surge (Doyle and Sparks 1980). Hopkins suggests that this combination of events could result in the following impacts on coral:

- Partial burial of low-aspect species (e.g., *Scolymia*, *Manicina, Meandrina*)
- Uprooting and breakage of delicate corals (e.g., *Agaricia, Millepora*) and many gorgonians
- Zooxanthellae expulsion and tissue necrosis in all soft and stony coral species.

Using the National Oceanic and Atmospheric Administration's World Ocean Database (http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html), we found that from 1975 through 2001, the fall bottom temperatures (October – December) reported from scientifici cruises in or near the FMG ranged from 19.3° to 29.6° C, while winter temperatures (January – March) ranged from 14.1° to 23.4°C. The only reference to temperatures at the FMG dropping to 11°C occurred on 2 September 1990, so we suspect this may actually represent a thermometer malfunction. It is not clear in the Bullock and Smith paper whether the cold temperatures experienced inshore in the 1970s extended as far offshore as the FMG. However, correlative evidence of cold stress is found in their report of die-offs of tropical reef fishes (e.g., butterfly fishes, angelfishes), and poor body condition of temperate reef species (e.g., gray snapper and hogfish). They did not report on the condition of the corals, except inshore as it related to localized storm surge.

Sediment movement during the severe weather conditions of hurricanes and tropical storms certainly occurs, as evidenced by the large fields of both small and large sand waves apparent along this part of the shelf (1966). We observed small sand waves throughout the low relief sandy areas of the Florida Middle Grounds at about 37 meters depth (Figure 12). We evaluated the major storms (tropical storms, no-name storms, and hurricanes) (Figure 13) occurring over or near the Florida Middle Grounds for wind speed and wave height, based on information from the following sources:

(1) *in situ* NOAA data buoys
    - 42003 (located at 26.01 N 85.91 W)
    - 42036 (located at 28.51 N 84.51 W)
(2) Unisys Hurricane database (http://weather.unisys.com/hurricane/atlantic/)
(3) NOAA hurricane archives (http://www.nhc.noaa.gov/pastall.shtml).

We included only those storms that created waves at least 4 m high near the FMG. These waves (which fall somewhere in between deep water gravity waves and shallow water gravity waves) can cause significant horizontal velocities near the bottom at 20 to 40 m depths. Plots of these relationships (Figures 14 and 15), following Phillips (Moe 1963, Smith 1976) show maximum horizontal velocities during the overhead passage of a surface gravity wave. The speeds are those that would occur 2 m above the bottom. Keep in mind that a particle traces the path of an ellipse in the vertical each time a wave passes overhead. These ellipses flatten out toward the bottom so that motion is nearly back and forth. The plots here give only the maximum speeds during one of these cycles. The first plot shows maximum particle speeds for different wavelengths (from 10 to 100 m) for 20 m, 30 m, and 40 m total water depth. The second plot is for 30 m water depth (about that found in much of the coral-covered area of the FMG) and shows how the maximum velocity near the bottom varies with wavelength. For reasonable values, these fall between about 0.5 to 2.0 m/s, which is sufficient to stir up the sediment and perhaps break delicate corals. The speed is a function of wave period, wave height, wavelength, ocean depth, and height above the bottom. For either very shallow water or very deep water, we can simplify this further, but for this region, it's difficult to say whether the deep or shallow water limit applies so it remains a bit complicated.

Fish populations in the Florida Middle Grounds have long experienced intensive fishing effort from both commercial and recreational fishers (1977). Indeed, populations experience intense, but largely unquantified fishing pressure. The most sought after species historically were red grouper, black grouper, red snapper, and scamp, with most of the activity occurring in the summer (Moe 1963). While the area is protected from coral harvest and certain types of bottom gear (i.e., traps, trawls, and longlines), no other fishing restrictions occur. Yet no studies have evaluated the impact of this intensive activity on reef fish populations and only one study (Mallinson 2000) has evaluated the effect on habitat.

Most of these were largely descriptive in nature. Clarke's (1986) study, however, provided the first real census of fish populations and demonstration of species habitat relationships.

Recommendations

The Florida Middle Ground is clearly a unique area. The only other coral habitat in the northern Gulf of Mexico occurs in the western Gulf, particularly in the Flower Gardens National Marine Sanctuary. The faunal make-up of these two areas are distinct, however, and should be treated as such. The Flower Gardens received significantly more attention following its designation as a National Marine Sanctuary. While we are not necessarily recommending the same treatment for the Florida Middle Grounds, we do think that more study in the Florida Middle Grounds is warranted. Both areas are protected from coral harvest and the use of bottom-associated fishing gear. However, fishing activity by hook and line remains intense and largely unquantified, both by commercial and recreational fishers. There is some concern that anchor use in the FMG could prove detrimental to the unique and delicate coral and sponge communities of the region. We make the following simple recommendations for the Florida Middle Grounds:

- Establishment of permanent station markers at the sites evaluated in this study;
- Periodic (ten-year) monitoring of the health of benthic communities
- In-depth assessment of commercial and recreational fishing activity
- In-depth assessment of the importance of the FMG as source habitat for ecologically and economically important species
- Permanent closure to all extractive and destructive uses of the high-relief reef habitat (northern half of the FMG; Figure 3) because of its unique habitat and diverse species composition.

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Table 1. Bottom area by depth strata for the Florida Middle Ground HAPC based on bathymetry data from the NOAA NGDC Coastal Relief Model.

Depth Range (m)	% Area	km^2
< 25	0.002	0.03
25-29.9	2.6	39.9
30-34.9	15.5	233.1
35-39.9	48.8	735.6
40-44.9	21.0	316.2
>45	11.8	177.9
TOTAL HAPC (km^2)		1506.9

Table 2a. Florida Middle Ground remotely operating vehicle (ROV) sampling sites, May 2003. Sites with the prefix "Hopkins" were previously sampled in the 1970s by Hopkins et al. (1981). Summary of information on ROV dives by location including date, start and end location, survey time, and survey area.

Dive No.	Sampling Site	Date	Start Time (EDT)	Start Latitude (N)	Start Longitude (W)	End Time (EDT)	End Latitude (N)	End Longitude (W)	Survey Time (min)	Survey Area (m^2)
1	Hopkins 147	5/20/2003	18:20	28.61412	-84.33662	19:15	28.61365	-84.34106	55.0	1244
2	Hopkins 047	5/21/2003	18:54	28.56498	-84.33586	19:53	28.56346	-84.33691	58.9	1238
3	Hopkins 151	5/22/2003	08:31	28.52359	-84.31457	09:54	28.52449	-84.31200	77.9	1482
4	Hopkins 251a	5/22/2003	13:45	28.54209	-84.26920	14:00	28.54164	-84.26893	16.5	372
5	Hopkins 247	5/25/2003	07:39	28.59988	-84.26345	08:36	28.60390	-84.26286	55.8	1062
6	Sink Hole (= SH)	5/25/2003	11:37	28.56179	-84.26334	12:38	28.56393	-84.26363	61.1	2376
7	Hopkins 251b	5/25/2003	13:45	28.54117	-84.27017	15:01	28.54023	-84.27616	76.4	1296
8	Midway 151-251	5/25/2003	17:36	28.52085	-84.28877	18:51	28.52015	-84.29057	75.0	1822
9	Hopkins 151	5/26/2003	08:40	28.53106	-84.31221	09:41	28.53495	-84.30927	61.0	1336
10	Hopkins 491	5/26/2003	13:51	28.45659	-84.28729	15:44	28.45935	-84.28774	113.2	3152
11	Deep South (= DS)	5/26/2003	18:53	28.41897	-84.35329	19:52	28.41780	-84.34811	58.9	1202
12	Goliath Grouper Rock (= GGR)	5/27/2003	07:37	28.53621	-84.25785	08:42	28.53590	-84.25215	65.1	-

Table 2b. Depths and distance covered by ROV transects conducted in The Florida Middle Ground Habitat Area of Particular Concern. Locations include Hopkins historical sites (numbers), SH – Sink Hole, MW – Midway, DS – Deep South, and GGR – Goliath Grouper Rock. At the Sink Hole site, data are separated into reef (r) and sand (s) transects. Distance was estimated for dive no. 3 and no distance is available for dive no. 12.

		Sampling Sites												
		147	**047**	**151**	**251a**	**247**	**SH**	**SH**	**251b**	**MW**	**151**	**491/492**	**DS**	**GGR**
Depth (m)	Mean	30	30	28	28	26	28	30	25	35	26	29	46	29
	Minimum	26	27	26	27	23	26	30	23	33	23	28	45	27
	Maximum	34	32	37	29	33	30	30	27	38	38	33	48	34
Distance (m)		622	619	741	186	531	722	466	648	911	668	1576	601	---

Table 3. Florida Middle Ground SCUBA sampling sites, May 2003. Sites with the prefix 'Hopkins' were sampled in the 1970s by Hopkins et al. (1981). .Summary of information on SCUBA dives by location including date, location, and survey time.

Dive No.	Location	Date	Time (EDT)	Latitude (N)	Longitude (W)	Video Time (min)
1	Hopkins 147	5/21/2003		28.61293	-84.33972	25.8
2	Hopkins 247	5/25/2003		28.60113	-84.26570	13.8
3	Hopkins 251	5/25/2003		28.54047	-84.27473	13.8
4	Hopkins 151	5/26/2003	10:42	28.53460	-84.30868	25.3
5	Hopkins 491	5/26/2003		28.45772	-84.28653	12.0
6	Goliath Grouper Rock (= GGR)	5/27/2003		28.53572	-84.25195	13.6
7	Fish Rock (=FR)	5/27/2003		28.63960	-84.27593	28.7

Table 4. Habitat types of the West Florida Shelf in The Florida Middle Grounds HAPC, modified from Grimm and Hopkins (1977) and Clarke (1986). *categories added in this study.

Type	Depth (m)	Description	Relief (m)
Shallow Reef Flat	25-30	Gentle slope w/ scattered sand patches. Dominated by sponges, gorgonians *Murecia* spp., and scleractinians *Dichocoenia* and *Porites.* At 28-30 m, gorgonians replaced by *Dichocoenia* and *Madracis.*	
Reef Crest	26-34	Transition between reef flat and slope. Sharply defined break along upper reef face with near vertical escarpment of exposed rubble (e.g., FMG 247). Hard corals (*Millepora alcicornis* and *Madracis decactis*).dominate. Rough habitat incised by numerous valleys resembles spur and groove of shallow reefs (Shinn 1963). Poorly developed at FMG 491, FMG 492 (Clarke 1986)	1-6
Reef Slope	29-38	Steeply inclined (~ 45-75°) with numerous erosional sand-filled spillways traversing down reef face interspersed with rubble outcrops. Occasionally interrupted by narrow horizontal terraces. Hard and soft corals and sponges patchily distributed, with *Millepora* and *Madracis* dominating (Clarke 1986).	
Reef base	37-40	Transition zone between reef slope and surrounding sand bottom, composed of small rock outcrops interspersed with clumps of exposed rubble and coarse sand.	>1
Patch Reef	25-50	Low to moderate slope with large rubble outcrops and coral formations separated by sand (e.g., FMG 491, but absent from FMG 151, FMG 247, FMG 481). In deep water on the seaward side, the bottom slopes gently to the shelf edge. This area consists of low relief hardbottom exposed through coarse sand and rubble. Habitat resembles that of the reef flat, but the epibiota dominated by coralline algae, encrusting sponges and azooxanthellate gorgonians. Coral formations	0.5
Rubble		Derived from reef, occurring at reef base with coarse sand. Large rubble areas in deep water provide a unique biotope for fishes (Dennis and Bright 1988, Dennis and Weaver 2004). Corals and sponges attached to rubble	
Sand bottom		Away from the reefs, the bottom consists of carbonate sands. Primary structure is rubble and sand waves.	<0.3

Table 5. Preliminary classification of sediment samples collected in the Florida Middle Ground Habitat Area of Particular Concern, May 2003. Analysis is being conducted by Camille Daniels and Pamela Hallock, College of Marine Science, University of South Florida. Descriptions of sampling sites appear in Tables 2 and 3. FR = fish rock. GGR = goliath grouper rock.

	Sampling Sites					
	151	247	251	491	FR	GGR
Larger Forams	8	8	8	2	4	4
Stony Coral	14	5	5	27	3	7
Coralline Algae	22	8	8	4	2	4
Gastropods	63	95	82	74	86	77
Calcar Algae	8	3	3	4	1	2
Echinoid Spines	3	6	6	2	2	7
Worm Tubes	13	12	11	16	48	16
Other	12	13	7	4	14	32
Unidentifiable	157	150	170	167	140	151
Total counted	300	300	300	300	300	300
SEDCON Index	1.189	0.94	0.88	1.369	0.79	0.877

Table 6. Algae species composition by site. Numbers = sites. X = presence.

	Sampling Sites														
	1976			1979					This Study						
	047	151	247	047	151	247	481	491	047	247	151	251	GGR	FR	Freq
Chlorophyta															
Anadyomene stellata	X	X		X	X	X									
Avrainvillea levis	X	X	X		X	X									
Avrainvillea sp		X	X		X	X									
Bryopsis pennata								X							
Caulerpa microphysa		X	X		X										
Caulerpa peltata						X		X							
Caulerpa prolifera								X							
Caulerpa racemosa		X	X												
Cladophora sp					X										
Codium carolineanum		X	X		X	X				X					.17
Codium intertextum	X	X	X		X	X		X		X					.17
Codium isthmocladium	X	X	X	X	X	X	X	X		X					.17
Codium n. sp. A				X	X	X	X	X							
Codium n. sp. B	X	X	X		X										
Derbesia vaucheriaeformis								X							
Enteromorpha sp.	X														
Ernodesmus verticellata	X	X	X		X										
Halimeda discoidea	X	X	X	X	X	X	X	X		X					.17
Halimeda opunta					X	X									
Halimeda dixonii												X			.17
Halimeda tuna					X	X	X	X							
Halimeda sp.					X			X							
Pseudocodium floridanum					X	X									
Pseudocodium sp.	X	X	X												
Rhiplia sp.											X				.17
Struvea elegans		X			X										
Struvea pulcherruma			X												
Udotea flabellum	X	X	X		X	X									
Udotea dixonii										X		X	X	X	.67

Table 6, continued

	Sampling Sites														
	1976			1979					This Study						
	047	151	247	047	151	247	481	491	047	247	151	251	GGR	FR	Freq
Udotea verticulosa											X				.17
Valonia macrophysa	X	X	X		X	X	X	X							
Phaeophyta															
Ascocylus orbicularis					X										
Cladosyphon occidentalis						X									
Colopermenia sinuosa		X	X	X	X	X	X	X			X		X		.33
Dictyota bartayresii	X	X						X							
Dictyota ciliolata			X												
Dictyota dichotoma		X	X	X	X	X		X							
Dictyota divaricata		X	X		X										
Dictota menstrualis									X	X		X		X	.67
Dictyota pulchella											X				.17
Lobophora variegate		X													
Nemacystus howei						X		X							
Padina gymnospora								X							
Padina profunda					X										
Padina sp		X													
Rosenvingea intricate	X		X		X	X	X	X							
Sargassum filipendula			X			X									
Sargassum fluitans	X		X					X							
Sargassum sp					X	X		X							
Spatoglossum schroederi			X												
Sporochnus bolleanus	X		X	X	X	X		X							
Sporolithon episporum									X						.17
Rhodophyta															
Agardhiella tenera					X	X	X	X							
Agardhinula browneae			X												
Amphiroa fragilissima								X							

Table 6, continued

	Sampling Sites														
	1976			1979					This Study						
	047	151	247	047	151	247	481	491	047	247	151	251	GGR	FR	Freq
Amphiroa sp			X												
Botryocladia occidentalis	X	X	X	X	X	X		X			X	X			.33
Centroceras clavulatum					X										
Ceramium sp			X												
Ceramium Codii								X							
Champia parvula	X	X	X	X	X	X	X	X				X			.17
Champia salicornioides			X						X	X	X	X			.67
Chrysmenia enteromorpha			X	X	X	X	X	X			X	X		X	.50
Chrysmenia halymenioides	X		X	X											
Chrysmeania sp		X												X	.17
Coelarthrium albertisii		X	X	X	X	X	X	X							
Dasya sp		X	X			X									
Digenia simplex								X							
Dudresnaya crassa			X												
Erythrocladia sp					X										
Erythrocladia subintegra					X										
Eucheuma isforma		X	X		X	X									
Fauchea sp			X												
Fosliella sp					X										
Galaxauna obtusata		X	X	X											
Gelidium sp									X						.17
Gonolithium sp		X	X												
Gracillaria blodgettii			X		X										
Gracilaria cylindrical			X	X	X										
Gracillaria mamillaris			X	X											
Gracillaria sp								X							
Halmenia floridana									X		X	X			.50
Halymena sp		X	X		X	X	X	X							
Jania adhaerens									X		X	X			.50

Table 6, continued

	Sampling Sites													
	1976			1979					This Study					
	047	151	247	047	151	247	481	491	047	247	151	251	GGR	FR	Freq
Kallymenia perforate	X		X	X	X	X									
Kallymenia westii									X		X				.33
Kallymenia sp.												X			.17
Laurencia intricata	X	X	X	X	X	X	X	X							
Laurencia sp.						X									
Liagora Ceranoides	X	X	X		X										
Lithothamnion mesomorphum	X	X	X												
Lithoththamnion ruptile												X			.17
Lithothamnion sp.	X	X							X						.17
Lithophyllum congestum										X					.17
Lomentari sp.			X												
Mesohyllum mesomorphum										X					.17
Nemastoma gelatmosum		X	X												
Peyssoniella sp. A			X												
Peyssoniella sp. B	X	X													
Peyssoniella sp. C					X	X	X								
Peyssoniella rubra			X												
Polysiphonia binneyi			X	X	X	X									
Polysiphonia sphaerocarpa						X									
Porolithon pachydermum									X						.17
Rhodophyllis gracilarioides				X		X		X							
Rhodymenia occidentalis			X	X	X	X									
Sciania complanata	X				X	X									
Solieria ramossissuma			X												
Solieria tenera	X		X												
Spermothamnion sp.		X			X										
Trichogloea sp.					X	X		X	X	X					.33
Number of species	26	37	54	20	49	40	14	33	10	10	10	11	2	4	

Table 7. Quantitative information on sponges identified off the West Florida Shelf in The Florida Middle Grounds Habitat Area of Particular Concern, May 2003.*Observed in the study area, but not in the quadrat examined.

Species		This Study Sampling Sites			Total	Frequency
		251	247	151		
CLASS DEMOSPONGIAE						
Subclass Homoscleromorpha						
Family Plakinidae						
*Plakortis angulospiculatus**						
Subclass Tetractinomorpha						
Family Tetillidae						
Cinachyra alloclata		1	3	7	11	1
Family Geodiidae						
Erylus formosus		0	1	2	3	.67
Geodia neptuni		2	3	0	5	.67
Family Clionaidae						
*Cliona delitrix**						
Anthosigmilla varians		3	1	0	4	.67
Family Placospongiidae						
Placospongia melobesioides		2	0	2	4	.67
Family Spirastrellidae						
Spirastrella coccinea		0	0	1	1	.33
Subclass Ceractinomorpha						
Family Agelasidae						
Ageles clathrodes		0	2	2	4	.67
Agelas dispar	*x*					
Suborder Microcionina						
Family Microcionidae		0	0	1	1	.33
Clathria (Thalysias) juniperina						
Suborder Myxillina						
Family Crambeidae						
Monanchora unguiferus		0	4	2	6	.67
Monanchora barbadensis		2	0	0	2	.33

Species	Sampling Sites 121	247	151	Total	Frequency
Suborder Mycalina					
Family Mycalidae					
Mycale laxissima	0	0	2	2	.33
Suborder Mycalina					
Family Mycalidae					
Family Axinellidae					
Axinella corrugata	0	0	2	2	.33
Dragmacidon lunaecharta	1	1	0	2	.67
Family Dictyonellidae					
Scopalina reutzleri	*5*	*3*	*2*	*10*	*1*
Family Callyspongiidae					
Callyspongia vaginalis	*4*	*1*	*4*	*9*	*1*
Callyspongia armigera	0	1	0	1	.33
Callyspongia fallax1					
Niphates erecta	*4*	*10*	*3*	*17*	*1*
Amphimedon compressa	8	1	3	12	1
Cribochalina vasculum	6	1	5	12	1
Family Ircinidae					
Ircinia fasciculata					
Ircina felix	*2*	*4*	*0*	*6*	*.67*
Ircina campana	1	0	3	4	.67
Ircina strobilina	2	0	1	3	.67
Family Darwinellidae					
Aplysilla sulfurea	*1*	*1*	*0*	*2*	*.67*
Family Halisarcidae					
Halisarca sp.	0	1	0	1	.33
Family Aplysinidae					
Aplysina laculosa	*1*	*0*	*0*	*1*	*.33*
Aplysina cauliformis[4]					
Family Pseudoceratinidae					
Pseudoceratina crassa	5	10	7	22	1

1 Observed in this study but not in the quadrat

Species		121	247	151	Total	Frequency
		Sampling Sites				
UNIDENTIFIED SPECIES						
Gray, encrusting on Geodia						
Black ball						
Hard, orange						
Orange, ball						
Brown, encrusting						
Orange, Tethya						
Geodia gibberosa (?)	*x*					
TOTALS						
Number of species:		22	20	21	33	
Number of colonies:		55	54	61	170	
Diversity, H'n, $\log_e$		2.83	2.62	2.85	3.09	2.83
Eveness, J'n		0.94	0.92	0.95	0.88	0.94
No. of 1 m^2 quadrats		5	6	5	16	
Density, colonies/m^2		11	9	12.2	10.63	

Table 8. Octocoral taxonomic distribution among sites off the West Florida Shelf from The Florida Middle Grounds Habitat Area of Particular Concern. Descriptions of sampling sites are given in Tables 2 and 3. H = historical sample reproduced from Grimm and Hopkins (1981b) TS = sample from this study, obtained in May 2003. A = Abundant (20 to 50% of colonies), C = Common (10 to 20%), R = Rare (1 to 5%). X = present. FR= Fish Rock. GGR = goliath grouper rock.

	Sampling sites										
Scientific name	047	146	147	151		247		251		FR	GGR
	H	*H*	*H*	*H*	*TS*	*H*	*TS*	*H*	*TS*	*TS*	*TS*
Order Alcyonacea —Soft Corals											
Suborder Scleraxonia											
Family Anthothelidae											
Diodiogorgia nodulifera	*R*	*R*	*R*	*R*		*R*		*R*		*X*	
Suborder Holaxonia											
Family Gorgonidae											
Pseudoptogorgia acerosa	*R*	*R*	*R*	*R*		*R*		*R*			
Pseudopterogorgia rigida				*R*					*X*		*X*
Pseudopterogorgia sp											
Lophogorgia cardinalis	*C*	*R*	*R*	*R*		*C*		*R*		*X*	*X*
Lophogorgia hebes						*R*					
Pterogorgia guadalupensis						*R*					
Family Plexauridae											
Eunicea calyculata	*A*	*A*	*A*	*A*	*X*	*A*	*X*	*A*	*X*	*X*	
Eunicea knightii	*R*	*R*	*R*	*R*				*x*		*x*	*x*
Muricea elongata	*A*	*A*	*A*	*A*		*A*		*A*			
Muricea laxa	*A*	*A*	*A*	*A*		*A*		*A*			
Muricea sp					*X*		*X*		*X*	*X*	*X*
Plexaurella fusifera	*C*	*R*	*R*	*C*		*R*		*R*			
Plexaurella flexuosa	*C*	*A*	*A*	*A*		*C*		*C*			
Plexaurella sp.							*x*		*x*		
Pseudoplexaura wagenarri	*R*					*R*				*x*	
Pseudoplexaura sp.									*x*		
Mean no. individuals/m2	17	5	9	12		5		8			
Number of species	10	10	11	9	2	11	3	8	5	6	4
H'	1.52	1.51	1.34	1.42		1.54		1.16			
J'	*0.69*	*0.69*	*0.61*	*0.65*		*0.79*		*0.72*			

Table 9. Stony Corals (Milleporina and Scleractinia) identified from The Florida Middle Grounds Habitat Area of Particular Concern. Desciptions of sampling sites appear in Tables 2 and 3. Historical entries are taken from Grimm and Hopkins (1977). Data for this study were collected in May 2003 and include the total number of individuals counteand the frequency. For historical samples, A = Abundant, C = Common, R = Rare. For this study, numbers indicate the total number of observations of a particular species within all quadrats examined. Ttl = total number of individuals of each species seen across all sampling sites. Freq = frequency of occurrence within quadrats sampled.

	Sampling Sites												
	Historical (1975-1976)						This Study						
	146	147	047	151	251	247	*147*	*247*	*151*	*251*	*GGR*	Ttl	Freq
Order MILLEPORINA													
Family Milleporidae													
Millepora alcicornis							15	9	13	5	1	43	1
Order SCLERACTINIA													
Family Astrocoeniidae													
Stephanocenia michelinii	R	R	R	R	R	R	---	---	---	---	1	1	.20
Family Pocilloporidae													
Madracis decactis	A	A	A	A	A	A	9	---	15	14	25	63	.80
Madracis pharensis	---	---	---	---	---	---	---	---	---	1	---	1	.20
Family Agariciidae Gray													
Agaricia fragilis[a]	C	R	R	R	R	R							a
Family Siderastreidae													
Siderastrea radians	---	R	---	---	R	R	---	---	---	2	---	2	.20
Siderastrea sidereaa	---	---	---	---	---	---	---	---	---	---	---		a
Family Poritidae													
Porites branneri	R	R	R	R	R	---	---	---	1	1	---	2	.40
Porites porites divaricata	A	A	A	A	A	A	---	---	3	---	---	3	.20
Family Faviidae													
Manicina areolataa	R	R	R	---	R	R						a	a
Cladocora arbusculaa	---	R	---	---	R	R						a	a
Phyllangia americana	---	---	---	---	---	R	---	---	---	---	---	0	0

Table 9, *continued*

	Sampling Sites												
	Historical (1975-1976)						*This Study*						
	146	*147*	*047*	*151*	*251*	*247*	*147*	*247*	*151*	*251*	*GGR*	*Ttl*	*Freq*
FAMILY RHIZANGIDAE													
Astrangia poculata	---	---	---	---	---	*R*[3]	---	---	---	---	---	*0*	*0*
FAMILY OCULINIDAE													
Oculina diffusa	*R*	*C*	*R*	*R*	*R*	*R*	---	*1*	*1*	---	---	*2*	*.40*
Oculina robusta	---	---	---	---	---	---	---	---	---	---	*1*	*1*	*.20*
FAMILY MEANDRINIDAE GRAY, 1847													
Meandrina meandrites	R	R	---	R	---	---							
Dichocoenia stokesii	C	R	R	C	R	R	2	1	14	3	---	20	.80
Dichocoenia stellaris	R	C	A	A	C	C	---	---	---	---	---	0	0
FAMILY MUSSIDAE ORTMAN, 1890													
Scolymia lacera	R	R	C	C	R	R	---	---	1	---	---	1	.20
Scolymia cubensis	R	R	R	R	R	R	---	---	1	6	---	7	.40
Number of species	11	13	10	10	12	13	3	3	8	6	4	12	
Number of colonies							26	11	49	32	28	146	
Diversity H'n, $\log_e$	1.74	1.88	1.85	1.90	1.53	1.57	0.9	0.6	1.6	1.5	0.4	1.5	
Eveness, J'n	0.73	0.73	0.77	0.77	0.62	0.63	0.8	0.6	0.8	0.8	0.6	0.6	
No. of quadrats (5 m^2 in 1970s, 1 m^2 in this study)	10	10	5	10	10	10	9	5	6	8	5	33	
Density, colonies (m^2)							2.9	2.2	8.2	4.0	5.6	4.4	

[3] Reported in Hopkins

Table 10. List of icthyofauna in alphabetical order by family observed by gear type. The number of individuals and the top 20 rank abundance are listed for ROV transect data. Frequency of occurrence by site for the ROV video data includes observations outside of transects (P). Only presence data presented for SCUBA data.

Scientific Name	Common Name	ROV Video			ROV STill			SCUBA	
		No.	Rank	Freq.	No.	Rank	Freq.	Video	Still
Acanthuridae									
Acanthurus bahianus	ocean surgeonfish	3		2	1		1	P	
Acanthurus chirurgus	doctorfish	8		5	6		4	P	P
Acanthurus spp.								P	
Apogonidae									
Apogon maculatus	flamefish				1		1		
Apogon pseudomaculatus	twospot cardinalfish				5		2		P
Apogon spp.	cardinalfishes	1		1	1		1		
Balistidae									
Balistes capriscus	gray triggerfish	P		4	1		1	P	P
Blenniidae									
Parablennius marmoreus	seaweed blenny	2		1	114	**7**	10		P
Carangidae									
Seriola dumerili	greater amberjack	13		2	4		1	P	P
Seriola rivoliana	almaco jack	49	**10**	2	32	**13**	1	P	P
Carcharhinidae	requiem shark	1		1					
Chaetodontidae									
Chaetodon ocellatus	spotfin butterflyfish	12		10	18	**18**	6	P	
Chaetodon sedentarius	reef butterflyfish	10		9	4		3	P	P
Dactyloscopidae	sand stargazer				1		1		
Diodontidae									
Diodon holocanthus	ballonfish				1		1		P

***Table 10**, continued*

Taxon	Common Name	ROV Video No.	ROV Video Rank	ROV Video Freq.	ROV Still No.	ROV Still Rank	ROV Still Freq.	SCUBA Video	SCUBA Still
Ephippidae									
Chaetodipterus faber	spadefish							P	
Gobiidae									
Coryphopterus glaucofraenum	bridled goby				47	11	11		P
Coryphopterus punctipectophorus	spotted goby				83	8	9		P
Coryphopterus spp.	gobies	6		2					
Elacatinus oceanops	neon goby	1		1	16	20	6	P	P
Elacatinus xanthiprora	yellowprow goby	1		1	4		2		P
Gobiidae 1	goby	33	12	6	9		4		P
Gobiidae 2	goby	19	18	2					
Haemulidae									
Haemulon aurolineatum	tomtate	7		1					
Haemulon plumierii	white grunt	1		2	1		1	P	
Holocentridae									
Holocentrus adscensionis	squirrelfish	22	16	11	11		4	P	P
Holocentrus rufus	longspine squirrelfish				1		1		
Holocentrus spp.	squirrelfish							P	
Myripristis jacobus	blackbar solidierfish	1		1					
Sargocentron bullisi	deepwater squirrelfish	2		1	7		2		P
Labridae		65	6	4	1		1		
Bodianus rufus	Spanish hogfish								P
Halichoeres bathyphilus	greenband wrasse	9		1	14		2		
Halichoeres caudalis	painted wrasse	32	14	5	7		3		
Halichoeres cf. *bivittatus*	slippery dick	504	2	12	259	3	12	P	P

Table 10, *continued*

Taxon	Common Name	ROV Video No.	ROV Video Rank	ROV Video Freq.	ROV Still No.	ROV Still Rank	ROV Still Freq.	SCUBA Video	SCUBA Still
Labridae (continued)									
Halichoeres garnoti	yellowhead wrasse	P		1				P	
Lachnolaimus maximus	hogfish	2		4	6		2	P	P
Thalassoma bifasciatum	bluehead	14		5	14		6	P	P
Xyrichtys novacula	pearly razorfish	3		1	2		1		
Labrisomidae									
Labrisomus sp.?	scaled blenny				1		1		
Malacoctenus triangulatus	saddled blenny				1		1		
Lutjanidae									
Lutjanus campechanus	red snapper	1		2	2		1		
Lutjanus griseus	gray snapper	57	8	8	76	9	6	P	P
Microdesmidae									
Ptereleotris calliura	blue dartfish	47	11	8	135	6	8	P	P
Monacanthidae									
Cantherhines macrocerus	whitespotted filefish	P		1	2		1		
Cantherhines pullus	orangespotted filefish				2		1		
Mullidae									
Pseudupeneus maculatus	spotted goatfish							P	
Muraenidae									
Gymnothorax moringa	spotted moray	P		1				P	
Opistognathidae									
Opistognathus aurifrons	yellowhead jawfish	17	20	2	44	12	8		
Opistognathus lonchurus	moustache jawfish				1		1		

Table 10, continued

Taxon	Common Name	ROV Video No.	ROV Video Rank	ROV Video Freq.	ROV Still No.	ROV Still Rank	ROV Still Freq.	SCUBA Video	SCUBA Still
Ostraciidae									
Acanthostracion polygonius	honeycomb cowfish				1		1		
Acanthostracion quadricornis	scrawled cowfish	1		2	1		1		
Acanthostracion spp.	cowfish	3		4	2		1		
Pomacanthidae									
Holacanthus bermudensis	blue angelfish	58	7	11	52	10	9	P	P
Holacanthus tricolor	rock beauty	14		2	1		1		
Pomacentridae									
Chromis enchrysura	yellowtail reeffish	357	3	5	176	4	9		P
Chromis scotti	purple reeffish	3802	1	12	1492	1	12	P	P
Stegastes partitus	bicolor damselfish	22	16	10	11		3	P	P
Stegastes variabilis	cocoa damselfish	150	4	11	156	5	10	P	P
Priacanthidae									
Priacanthus arenatus	bigeye				1		1		
Pristigenys alta	short bigeye	2		7	12		3		
Scaridae		7		2	1		1		
Cryptotomus roseus	bluelip parrotfish	8		6	21	16	8		
Nicholsina usta	emerald parrotfish	3		1	1		1		
Scarus cf. *iserti*	striped parrotfish	82	5	8	262	2	9	P	P
Sparisoma atomarium	greenblotch parrotfish	14		8	20	17	8		P
Sparisoma aurofrenatum	redband parrotfish	7		7	11		6	P	
Sciaenidae									
Equetus lanceolatus	jackknife-fish	P		1	6		2		
Pareques umbrosus	cubbyu	6		1	12		3	P	P

Table 10, continued

Taxon	Common Name	ROV Video No.	ROV Video Rank	ROV Video Freq.	ROV Still No.	ROV Still Rank	ROV Still Freq.	SCUBA Video	SCUBA Still
Scorpaenidae									
Scorpaena plumieri	spotted scorpionfish								P
Serranidae		1		1					
Centropristis ocyurus	bank sea bass	18	19	7	7		4		
Cephalopholis cruentata	graysby	32	14	9	17	19	6	P	P
Diplectrum sp.	sand perch	P		2	4		2		
Epinephelus adscensionis	rock hind	P		1	1		1	P	
Epinephelus drummondhayi	speckled hind	P		1					
Epinephelus morio	red grouper	15		11	23	14	9	P	P
Hypoplectrus puella	barred hamlet	55	9	12	22	15	8	P	P
Mycteroperca microlepis	gag							P	
Mycteroperca phenax	scamp	33	12	10	10		4	P	P
Mycteroperca spp.	grouper							P	
Rypticus maculatus	whitespotted soapfish				3		2		
Serranus annularis	orangeback bass	P		1	10		4		
Serranus notospilus	saddle bass	1		1					
Serranus phoebe	tattler	11		2	15		3		
Serranus subligarius	belted sandfish				1		1		P
Serranus tigrinus	harlequin bass	1		1					
Sparidae									
Calamus nodosus	knobbed porgy	7		10	13		6	P	P
Calamus spp.	porgy	P		1	2		2		
Pagrus pagrus	red porgy	P		1	3		1		

***Table 10**, continued*

Taxon	Common Name	ROV Video No.	ROV Video Rank	ROV Video Freq.	ROV Still No.	ROV Still Rank	ROV Still Freq.	SCUBA Video	SCUBA Still
Sphyraenidae									
Sphyraena barracuda	great barracuda	1		1					
Syngnathidae	pipefish				1		1		
Synodontidae									
Synodus intermedius	sand diver	16		9	15		7		P
Synodus spp.	lizardfish	6		3	1		1	P	
Synodus synodus	red lizardfish								P
Tetraodontidae									
Canthigaster jamestyleri	goldface sharpnose puffer	1		1					
Canthigaster rostrata	Atlantic sharpnose puffer	2		2	6		3		P
Osteichthyes	unidentified fish	9		1					
	No. Stations			13			12		
	Number of species	74			4			1	3

Table 11. Among habitat comparisons of community parameters and top five taxa based on analysis of variance. Levels among habitats were compared with Ryan's Q-test when the overall test had a significant Bonferroni adjusted P value. Habitat types: Low Rugosity includes SA = sand (N = 5), SR = Sand/rubble (N = 9), RU = rubble (N = 12), LB = live bottom (N = 18), SRF = shallow reef flat (N = 56), RB = reef base (N = 10), and RF = reef face (N = 5). High rugosity includes only RE = reef crest (N = 6). KW = Kruskal-Wallis Test.

							Ryan's Q-test				
Factor	F	df		P	High			Mean Value			Low
No. Taxa	9.24	7	117	>0.001	RF	SR	RU	SRF	RE	RB	LB	SA
No. Individuals	13.27	7	117	>0.001	SR	RE	RF	RU	SRF	RB	LB	SA
S-W Diversity	6.66	7	117	>0.001	SR	RB	RF	RU	LB	SRF	RE	SA
Evenness	2.98	7	117	0.006	SA	LB	RB	SR	RU	SRF	RF	RE
Most abundant species												
• Purple reeffish	5.72	7	117	>0.001	RE	RF	SR	RU	SRF	RB	LB	SA
• Slippery Dick	3.71	7	117	0.001	SR	RU	RE	RF	SRF	LB	RB	SA
• Yellowtail reeffish	KW			>0.001	RB	RU	SR	SRF	RE	RF	LB	SA
• Cocoa damselfish	1.65	7	117	0.129								
• Striped parrotfish	1.90	7	117	0.076								

Table 12. Species Indicator Analysis for cluster groups 1-4 identified using Sorenson similarity measure and flexible sorting linkage method (see Figure 9). Maximum group, observed indicator value, randomized mean and standard deviation, and probability. *P values < 0.05 indicate significant indicator species (in bold). IV = indicator value.

Taxon	Common Name	Cluster	Observed	Randomized Groups		
		Group	IV	Mean	SD	P
Acanthurus bahianus	Ocean surgeonfish	3	20.0	19.10	10.99	0.462
Acanthurus spp.		2	26.9	18.80	10.07	0.179
Calamus nodosus	Knobbed porgy	1	12.4	21.20	11.61	0.832
Centropristis ocyurus	Bank seabass	1	47.2	25.40	13.06	0.073
Cephalopholis cruentata	Graysby	3	32.1	26.60	12.80	0.258
Chaetodon ocellatus	Spotfin butterflyfish	3	11.4	23.60	11.85	0.894
Chaetodon sedentarius	Reef butterflyfish	3	16.8	21.50	11.76	0.608
Chromis enchrysura	Yellowtail reeffish	1	40.4	30.10	14.61	0.204
Chromis scotti	**Purple reeffish***	**3**	**82.6**	**35.20**	**7.56**	**0.001**
Coryphopterus spp.	Goby sp	1	42.3	20.40	11.29	0.060
Cryptotomus roseus	Bluelip parrotfish	3	13.1	21.70	11.95	0.760
Epinephelus morio	Red grouper	3	22.0	24.80	11.27	0.532
Gobiidae	**Gob.***	**1**	**53.0**	**27.60**	**11.64**	**0.047**
Halichoeres cf. *bivittatus*	Slippery dick	3	32.1	37.40	10.42	0.638
Halichoeres caudalis	Painted wrasse	3	38.7	28.10	12.78	0.176
Holocentrus adscensionis	Squirrelfish	3	18.0	25.90	12.64	0.684
Holacanthus bermudensis	Blue angelfish	3	53.0	35.00	11.54	0.095
Hypoplectrus puella	Barred hamlet	3	38.0	33.00	8.16	0.257
Labridae	Wrasse	3	25.7	28.90	13.56	0.484
Lachnolaimus maximus	Hogfish	3	11.5	19.40	11.76	0.739
Lutjanus griseus	Grey snapper	3	27.8	25.30	12.00	0.332
Mycteroperca phenax	**Scamp***	**3**	**52.7**	**25.80**	**10.67**	**0.027**
Opistognathus aurifrons	**Yellowhead jawfish***	**1**	**47.1**	**20.50**	**11.23**	**0.034**
Ptereleotris calliurus	**Blue dartfish***	**2**	**58.8**	**30.50**	**13.08**	**0.034**
Scarus* cf. *iserti	**Striped parrotfish***	**3**	**61.7**	**34.10**	**14.06**	**0.038**
Scaridae	Parrotfish	2	29.1	19.50	11.09	0.185
Serranus phoebe	**Tattler***	**1**	**67.2**	**21.80**	**11.44**	**0.005**
Sparisoma atomarium	Greenblotch parrotfish*	4	21.0	25.60	12.23	0.540
Sparisoma aurofrenatum	Redband parrotfish	3	33.3	22.90	12.68	0.187
Stegastes partitus	Bicolor damselfish	3	21.5	25.30	11.94	0.536
Stegastes variabilis	**Cocoa damselfish***	**3**	**62.0**	**31.20**	**7.79**	**0.001**
Synodus intermedius	**Sand diver***	**1**	**55.1**	**26.50**	**11.77**	**0.023**
Synodus spp.	Lizardfish	1	32.9	22.10	11.96	0.172
Thalassoma bifasciatum	Bluehead wrasse	3	36.4	28.10	13.42	0.214

Table 13. Ichthyofauna from The Florida Middle Grounds: comparison of ranks of the 20 most abundant species from historical surveys (1978-1979 by Clarke, 1986) and the 20 most abundant species in this study (May 2003).

Scientific Name	Common name	Historical	Current	Comments
Chromis scotti	Purple reeffish	1	1	
Halichoeres cf. *bivittatus*	Slippery dick	2	2	
Chromis enchrysura	Yellowtail reeffish	11	3	
Stegastes variabilis	Cocoa damselfish	7	4	
Scarus cf. *iserti*	Striped parrotfish	9	5	
Holacanthus bermudensis	Blue angelfish	8	7	
Lutjanus griseus	Grey snapper	18	8	
Hypoplectrus puella	Barred hamlet	16	9	
Seriola rivoliana	Almaco jack	--	10	not in Clarke (1986)
Ptereleotris calliura	Blue dartfish	12	11	
Coryphopterus spp.[1]	Goby sp.	6	12	8th & 11th, ROV still images
Mycteroperca phenax	Scamp	15	13	
Cephalopholis cruentata	Graysby	32	14	
Halichoeres caudalis	Painted wrasse	27	15	
Holocentrus adscensionis	Squirrelfish	26	16	
Stegastes partitus	Bicolor damselfish	43	17	
Centropristis ocyurus	Bank seabass	20	19	
Opistognathus aurifrons	Yellowhead jawfish	41	20	
Elacatinus oceanops	Neon goby	3	54	20th - ROV still images
Parablennius marmoreus	Seaweed blenny	4	47	7th - ROV still images
Seriola dumerili	Greater amberjack	5	26	
Pagrus pagrus	Red porgy	10	-	only in ROV still images
Elacatinus xanthiprora	Yellowprow goby	13	55	rare in ROV still images
Balistes capriscus	Gray triggerfish	14	P	
Pareques umbrosus	Cubbyu	17	39	
Calamus nodosus	Knobbed porgy	19	34	
Mycteroperca microlepis	Gag	23	-	absent from ROV survey

[1]includes *glaucofraenum* and *punctipectophorus*

Table 14. Measure of similarity between historical collections and current species assemblages in the Florida Middle Ground reef habitat. Similarity (Sorensen binary) values range from 0 (no similarity) to 1 (identical).

Taxonomic Group	**Sorensen Coefficient**
Algae	0.185
Sponges	---------*
Octocorals	0.545
Stony Corals	0.690
Fish (top 20)	0.941
Fish (all)	0.550
Fish (Smith et al. 1975)	0.567
Fish (Hopkins 1981)	0.517

*historical samples and taxonomy too poor for comparison

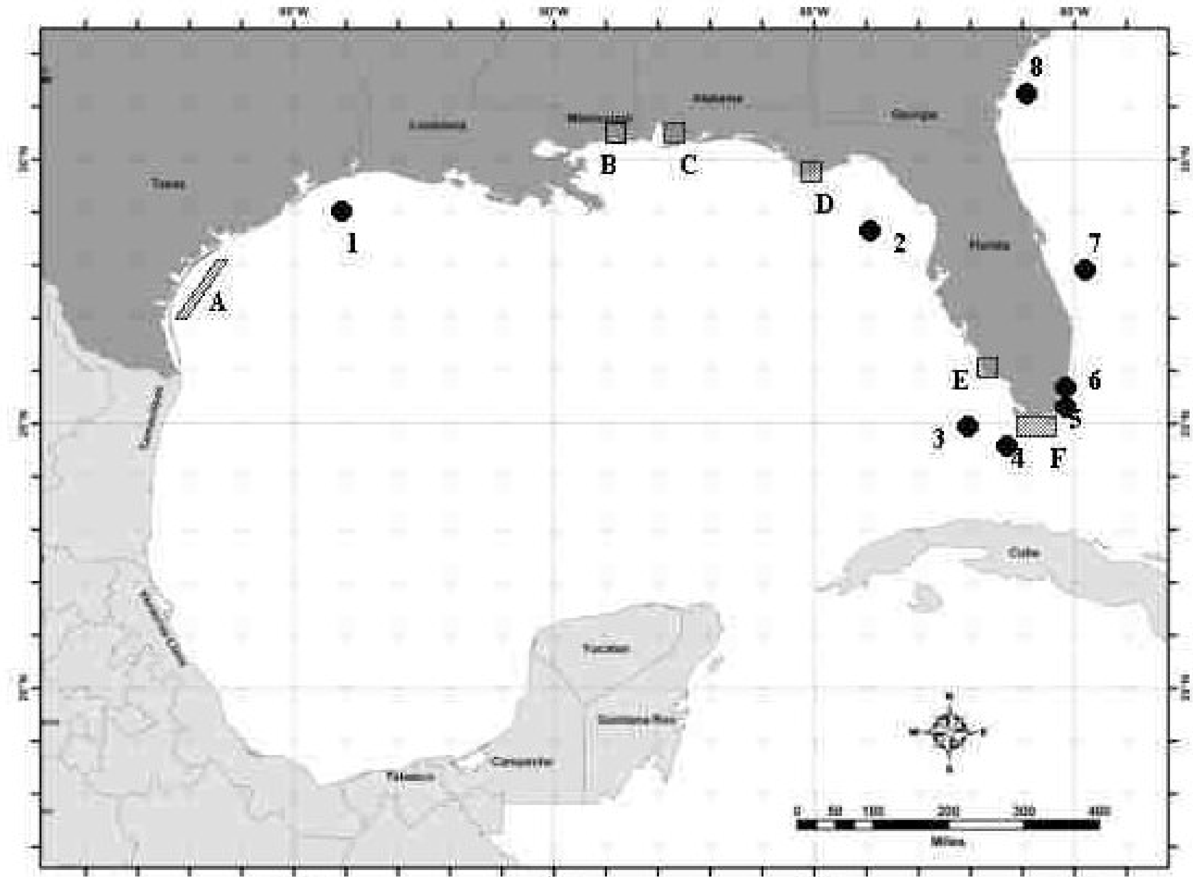
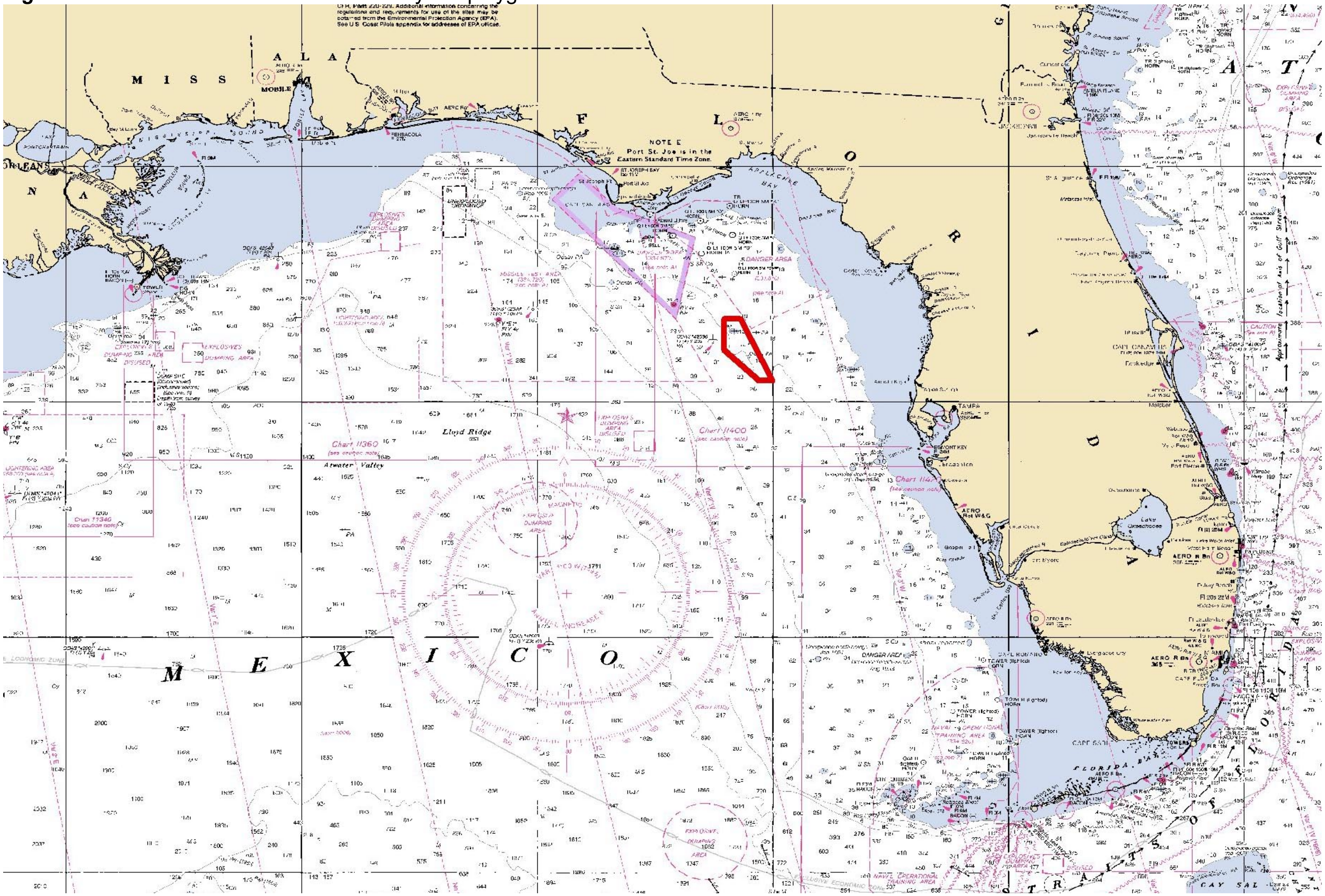


Figure 1. Habitat Areas of Particular Concern designated in GMFMC and SAFMC original coral fishery management plans (numbers) and in the GMFMC EFH Amendment (grey blocks, unless otherwise noted). Black dots have some form of protection. Grey areas have no protection.

1. East and West Flower Garden Banks
2. Florida Middle Grounds
3. Dry Tortugas
4. Looe Key
5. Key Largo Coral Reef
6. Biscayne National Park
7. Oculina Bank
8. Gray's Reef

A. Topographical Highs (identified in the original coral FMP)
B. Grand Bay, Mississippi
C. Weeks Bay National Estuarine Research Reserve
D. Apalachicola National Estuarine Research Reserve
E. Rookery Bay National Estuarine Research Reserve
F. Florida Bay

Figute 2. Florida Middle Grounds marked by red polygon.



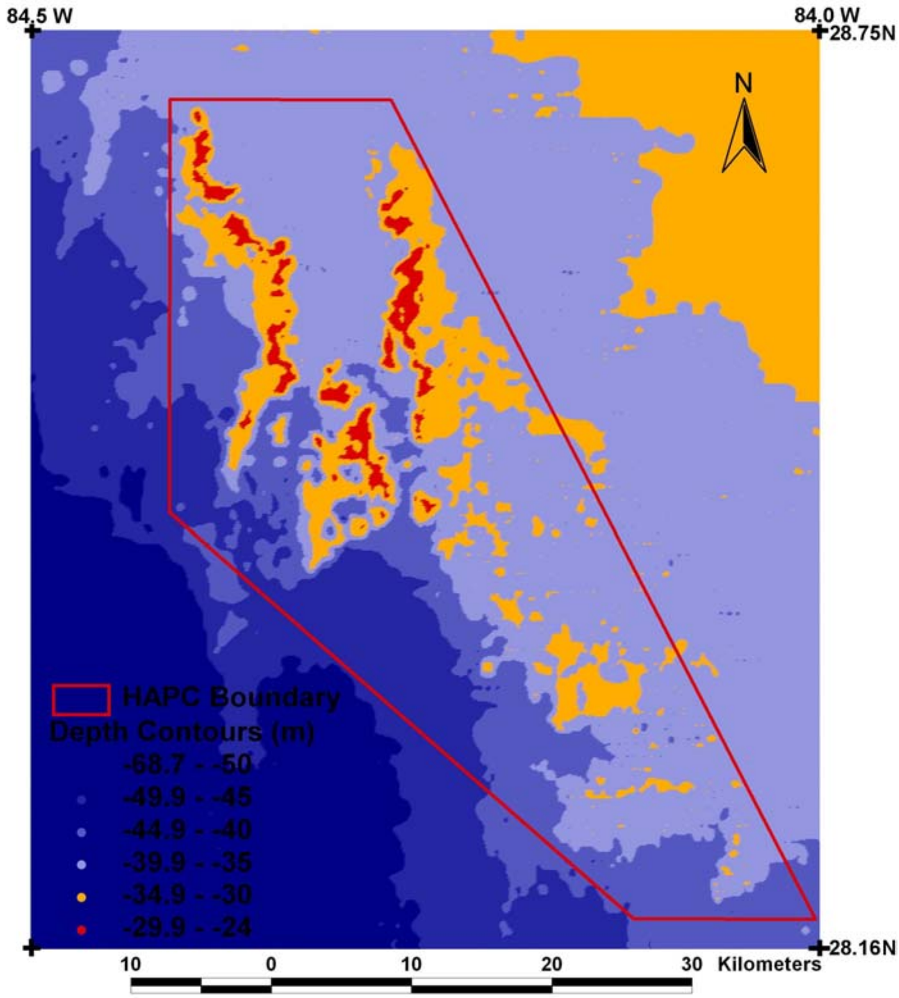


Figure 3. Florida Middle Grounds topography with Habitat Area of Particular Concern (HAPC) boundary marked in red.

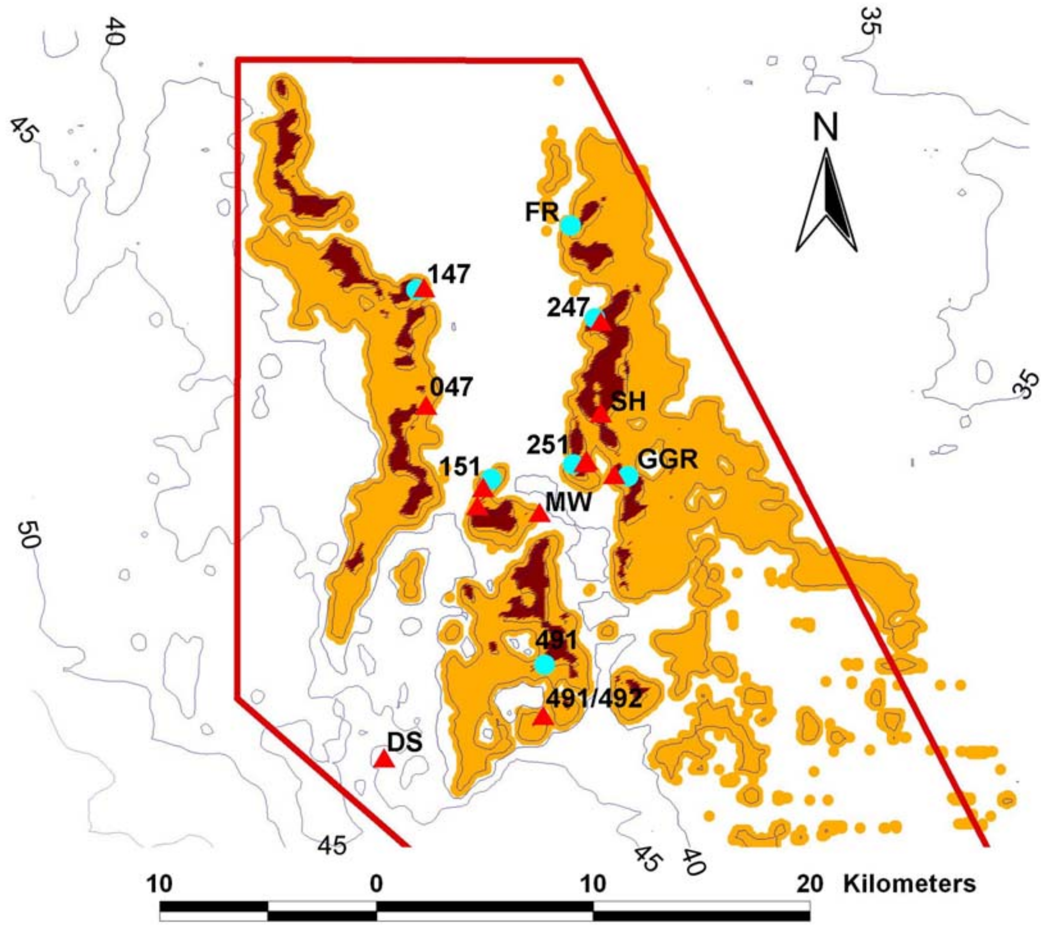


Figure 4. Sampling locations at the Florida Middle Grounds during the 2003 cruise. Red triangles indicate ROV sites and light blue circles SCUBA sites.

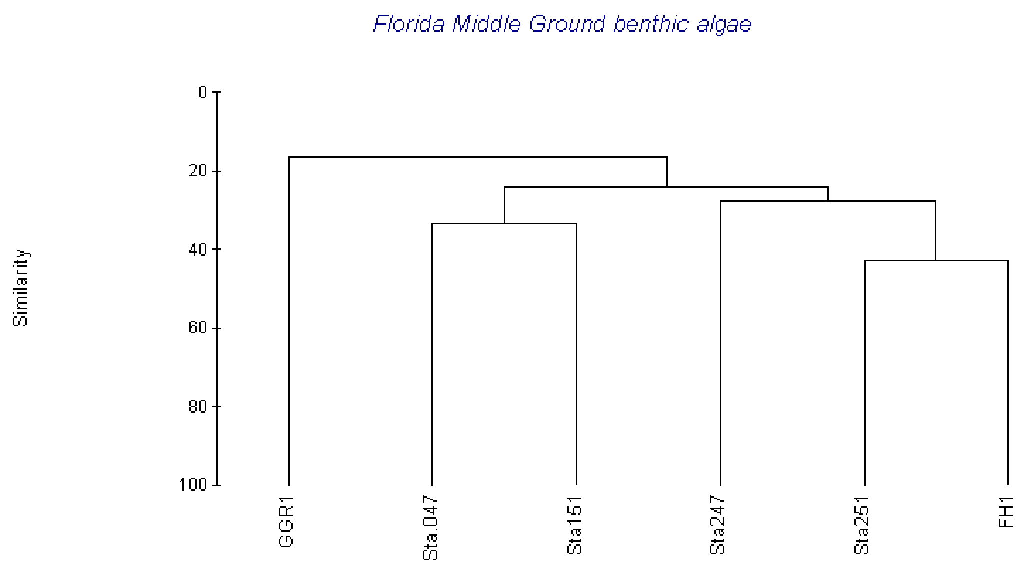


Figure 5. Similarity of benthic algae communities at six stations in The Florida Middle Grounds using group average sorting from Bray Curtis similarities using the presence or absence of algae taxa as the initial data input.

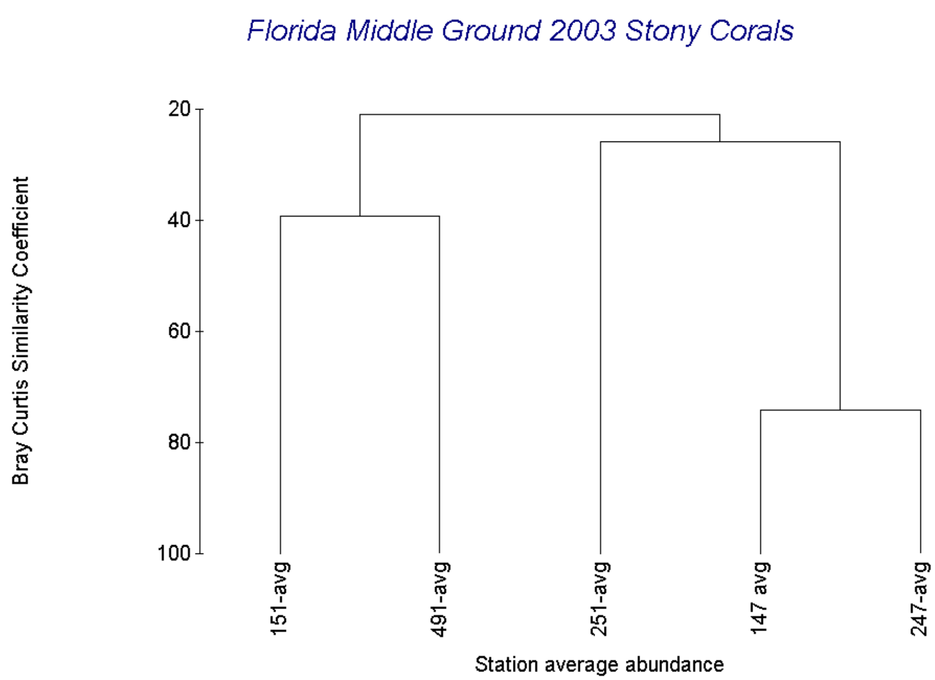


Figure 6. Similarity of coral communities at five stations in The Florida Middle Grounds using group average sorting from Bray Curtis similarities using the presence or absence of coral taxa as the initial data input.

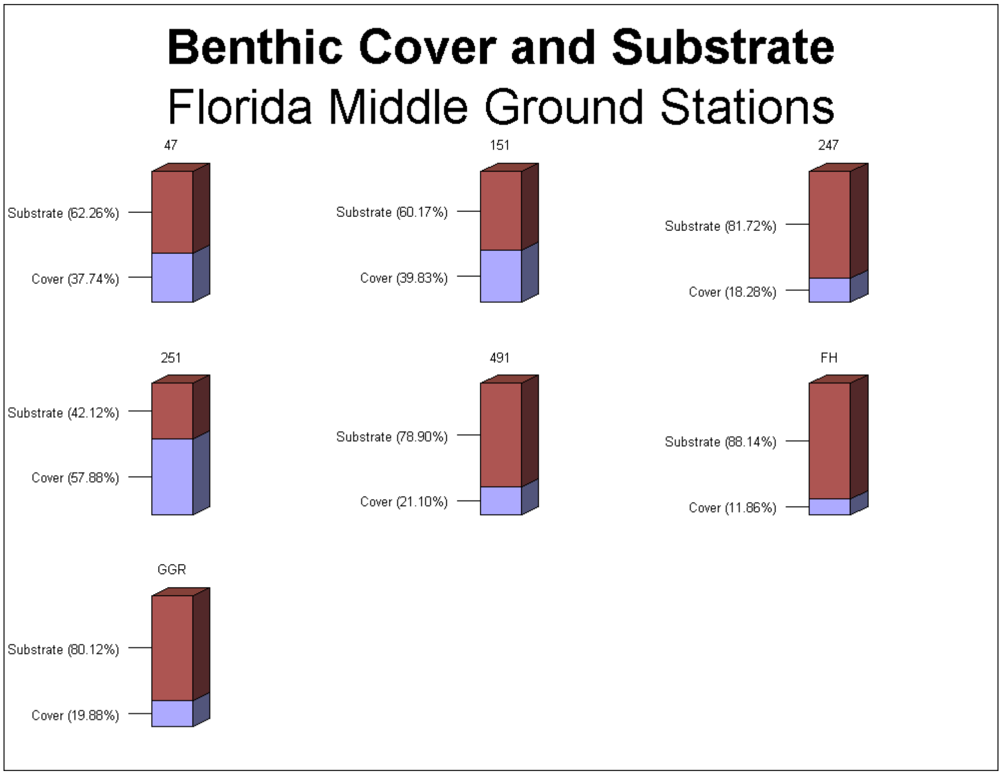


Figure 7. *Benthic cover and substrate from point count analysis, video imagery. Substrate = rock, rubble, or sediment devoid of living cover. Cover = biogenic cover.*

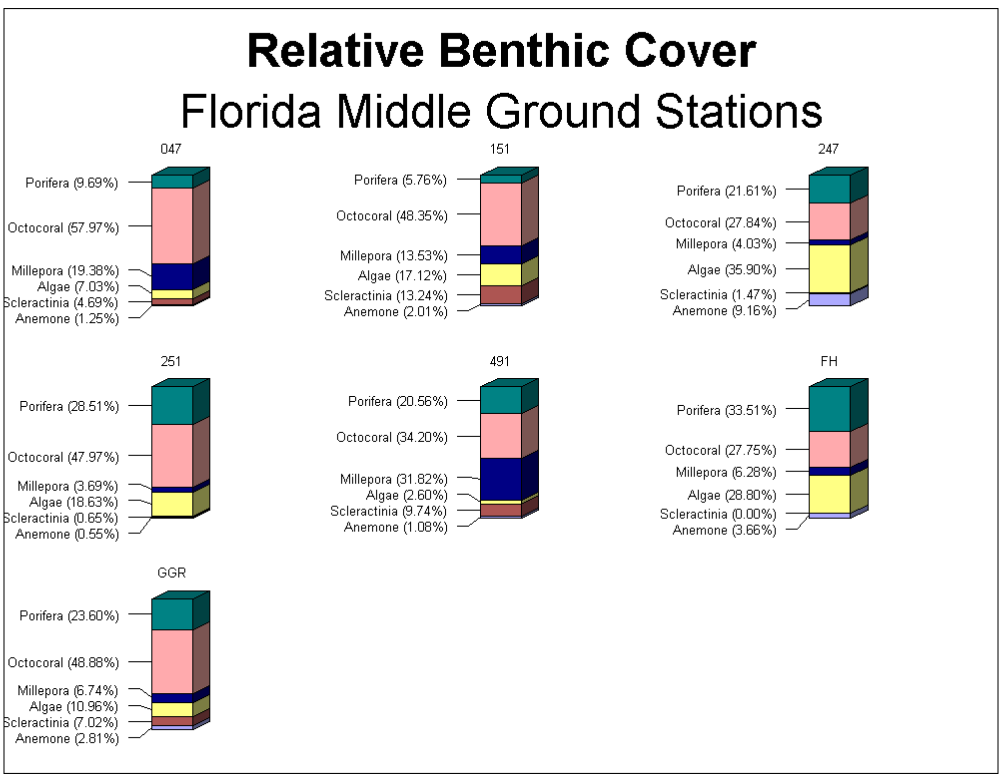


Figure 8. *Relative benthic cover, FMG sites, May 2003.*

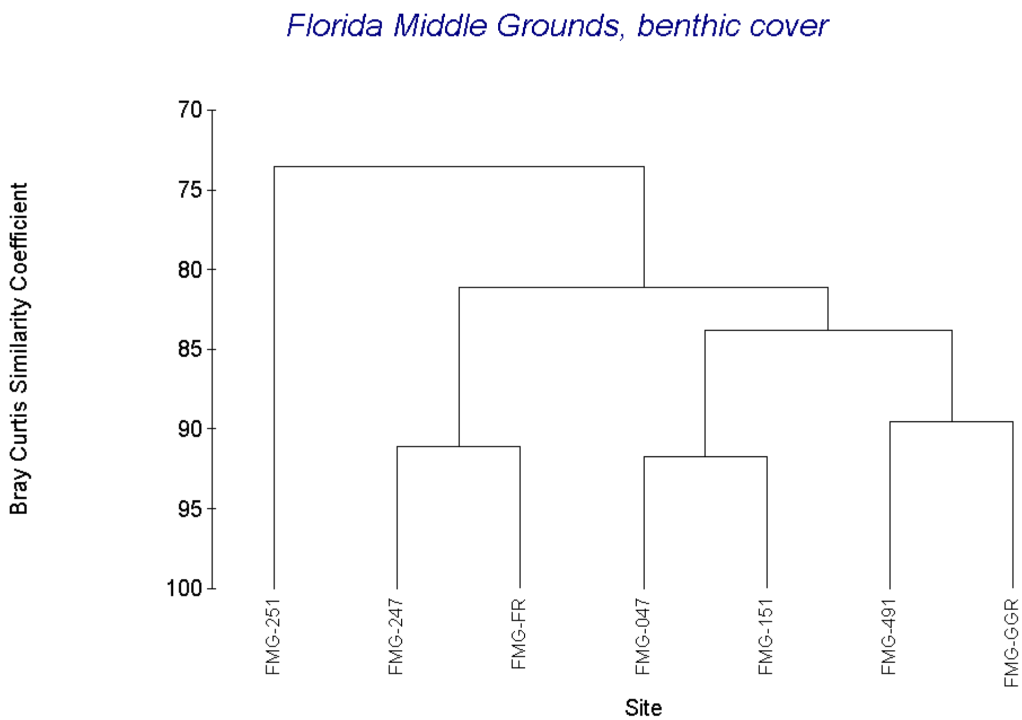


Figure 9. *Dendrogram of the Florida Middle Grounds benthic cover using group average clustering from Bray Curtis similarities, square root transformed cover data. Sampling sites are listed in Table 3. FR = Fisherman's Rock. GGR = goliath grouper rock.*

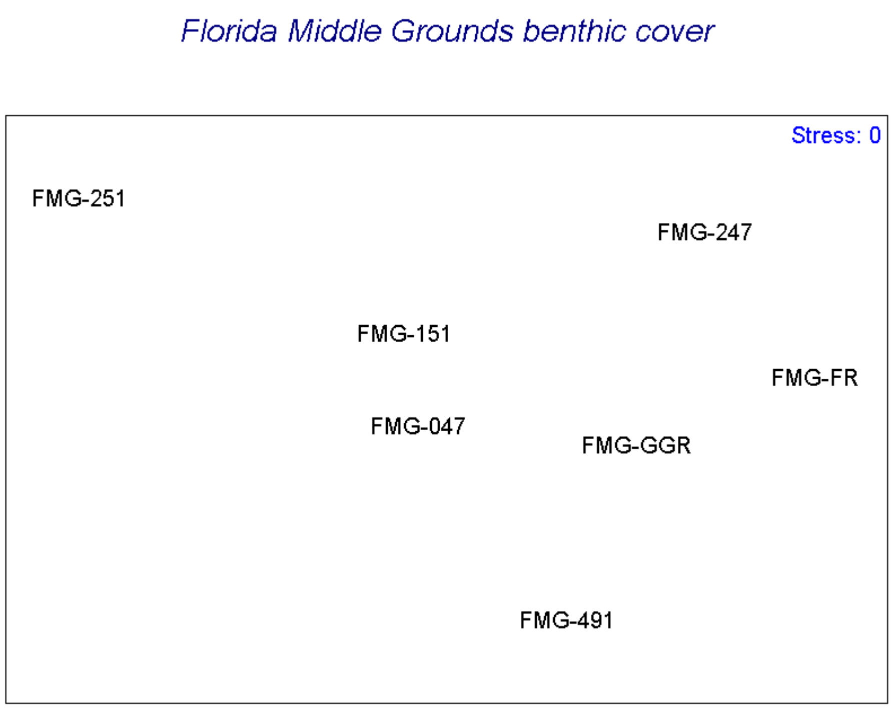


Figure 10. Two-dimensional MDS configuration of benthic cover Bray Curtis Similarity, Florida Middle Grounds.

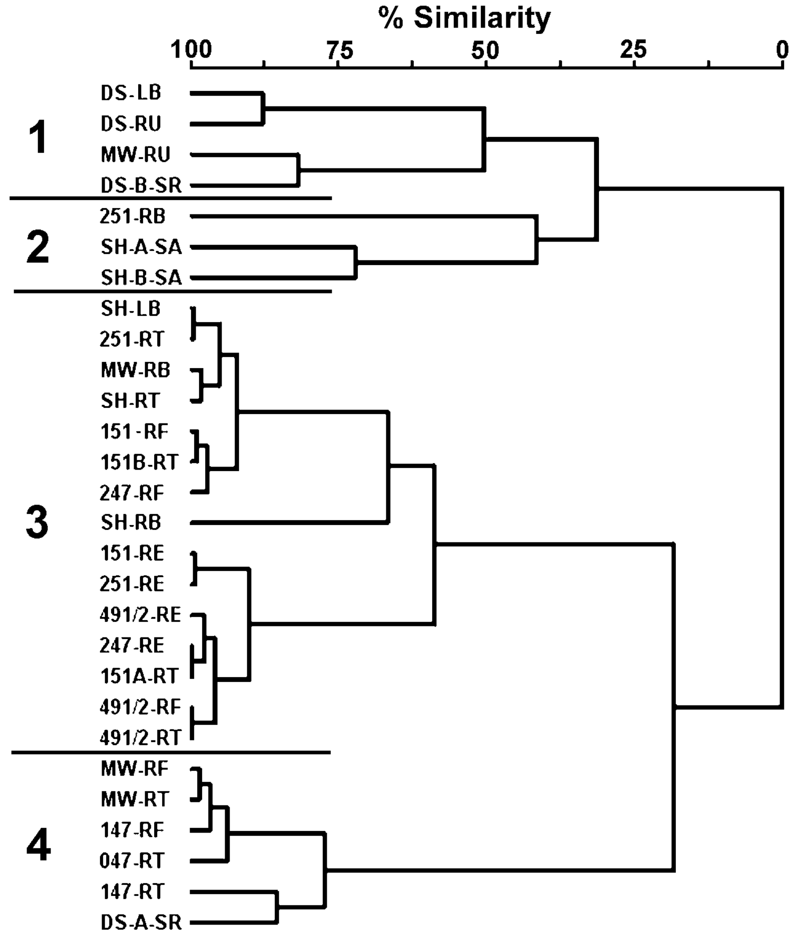


Figure 11. Cluster analysis of reef fish abundance by sampling site (prefix) and habitat type (suffix) using Sorenson similarity measure and flexible sorting linkage method. Habitats sampled included shallow reef flat (RT), reef crest (RE), reef face (RF), reef base (RB), live bottom (LB), rubble (RU), sand/rubble (SR), and sand (SA). Sampling sites and abbreviations are listed in Table 3.

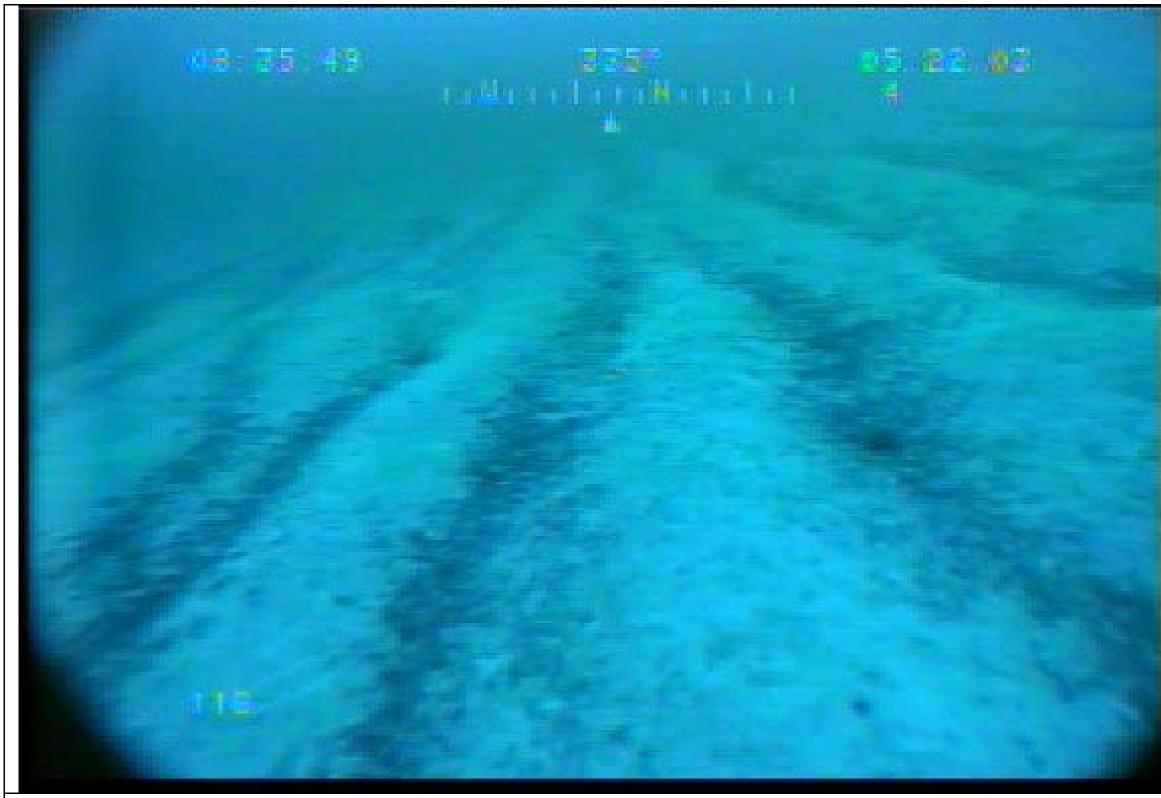
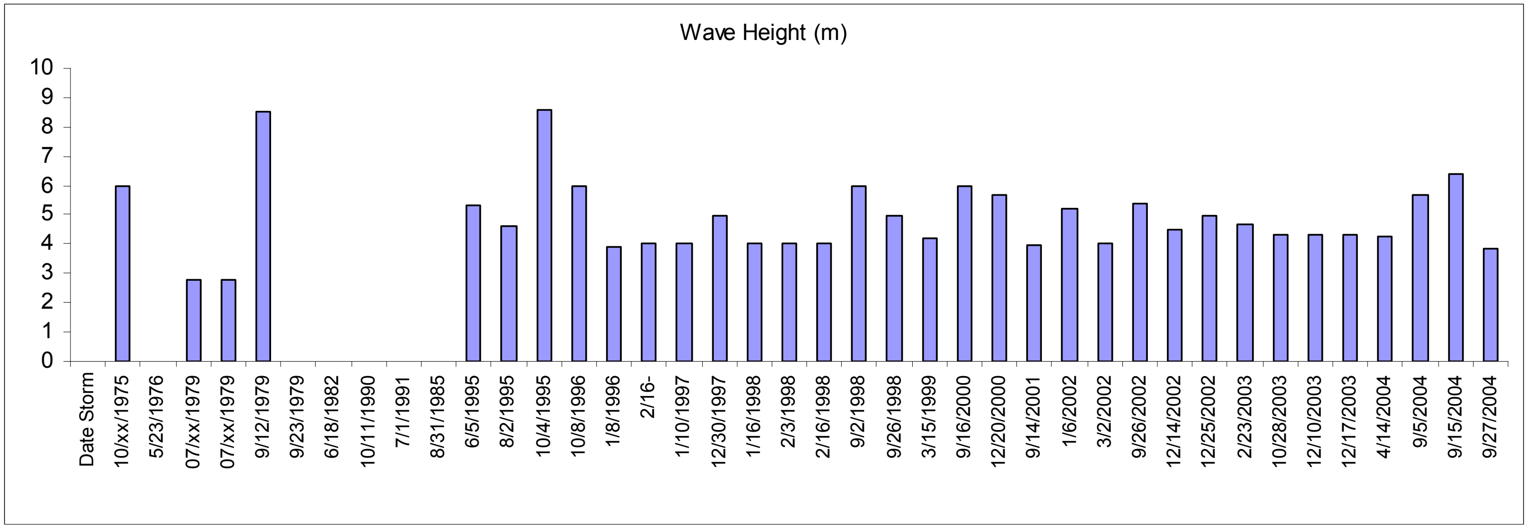
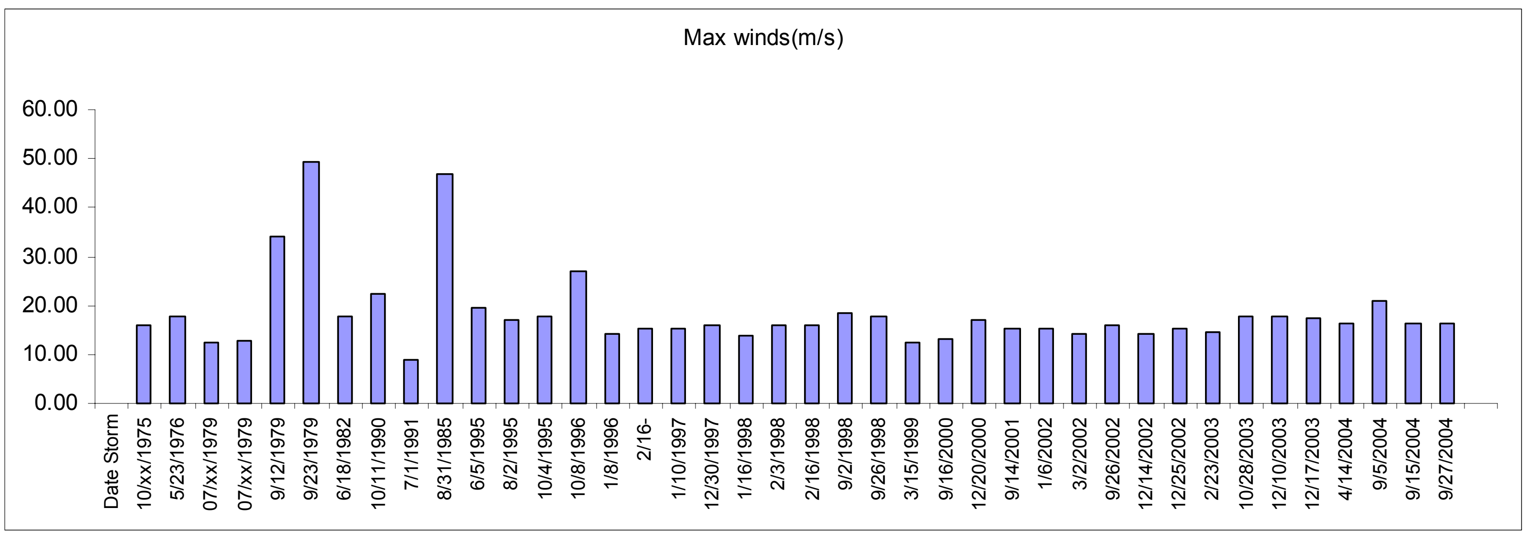


Figure 12 . *Sand waves in the Florida Middle Grounds at about 37 m, May 2003*

Figure 13. Wave height and maximum wind speed for all tropical storms and hurricanes influencing wave height in the area of the Florida Middle Grounds between 84 and 85 degrees west longtitude and 28 and 29 north latitude.





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Out[32]= a Cosh• •••••Csch• •••
         ─────────────────────────
                   T

In[45]:= Plot• •u•10, 4, l, •38, 40•; u•10, 4, l, •28, 30•; u•10, 4, l, •18, 20••;•
          •l, 10, 100•; AxesLabel• ••wavelength •m••, " "•;
          PlotStyle• •Thickness•.001•; Thickness•.005•; Thickness•.01••;•
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             bottom •depth 20m•thick, 30m, 40m•thin••••4m wave height"••
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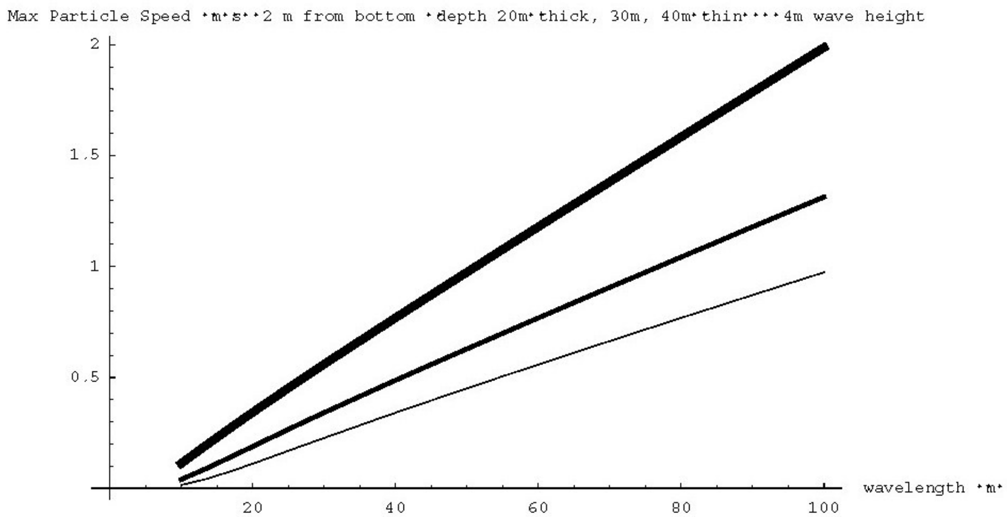


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Figure 14. Maximum particle speeds for different wavelengths (from 10 to 100 m) for 20m, 30m, and 40m total water depth.

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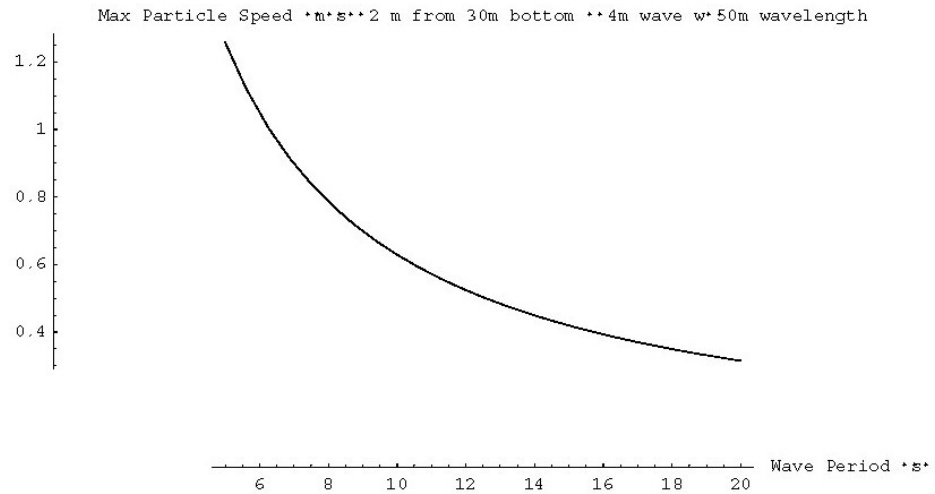


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Figure 15. Variance in the maximum particle speed near the bottom with wavelength at 30 m water depth.

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PICTORIAL ATLAS

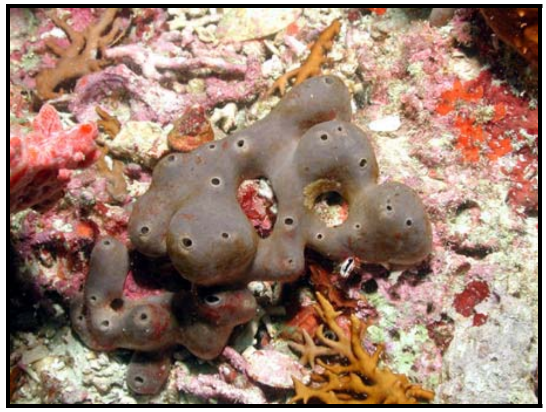
Organisms Identified in The Florida Middle Grounds[1] Habitat Area of Particular Concern

May 2003

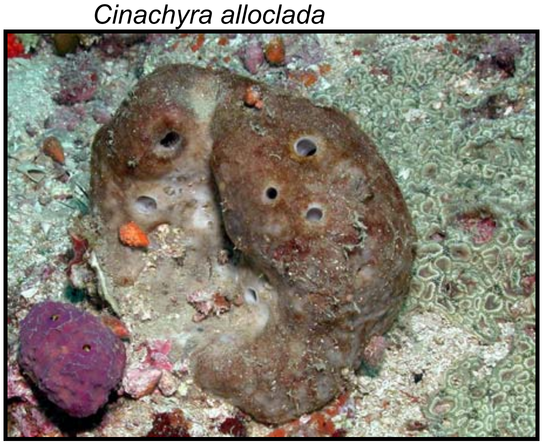
[1] Unless otherwise indicated, all photographs were taken in the Florida Middle Grounds

The Florida Middle Grounds Sponges

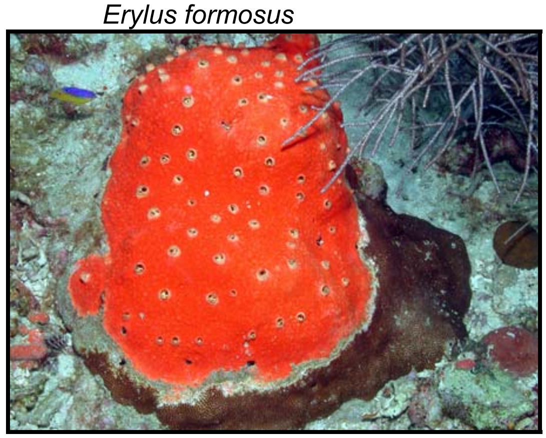
Subclass Tetractinomorpha
Order Spirophorida
Family Tetillidae
Cinachyra alloclada



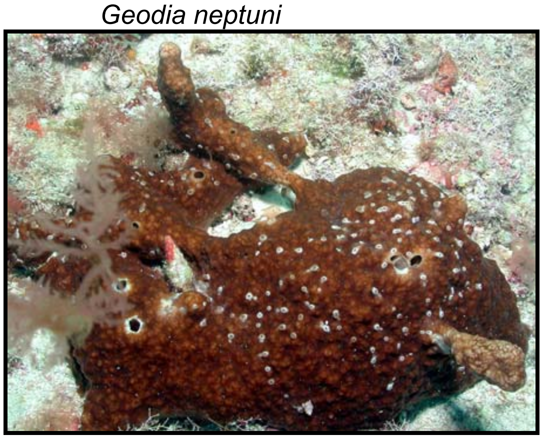
Order Astrophorida
Family Geodiidae
Erylus formosus



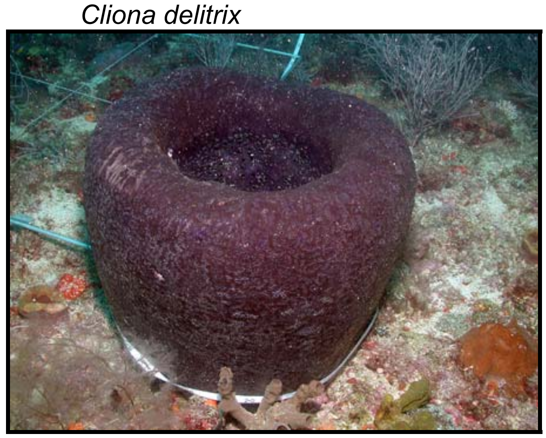
Order Astrophorida
Family Geodiidae
Geodia neptuni



Order Hadromerida
Family Clionaidae
Cliona delitrix

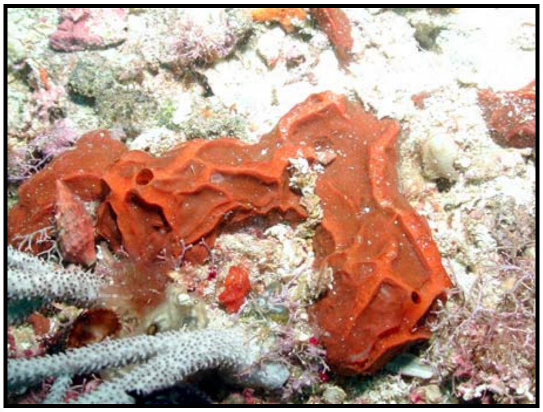


Order Hadromerida
Family Clionaidae
Anthosigmella varians



Order Hadromerida
Family Clionaidae
Spheciospongia vesparium

The Florida Middle Grounds Sponges

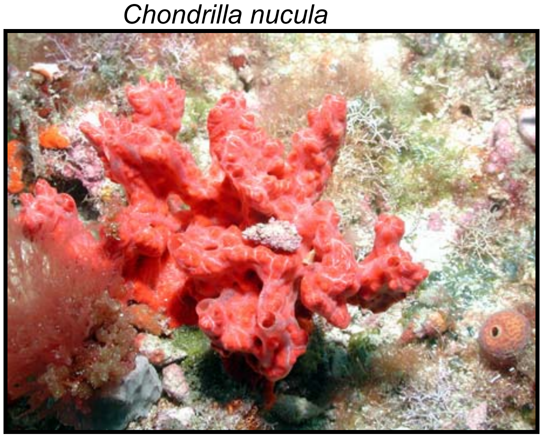


Order Hadromerida
Family Placospongiidae
Placospongia melobesioides

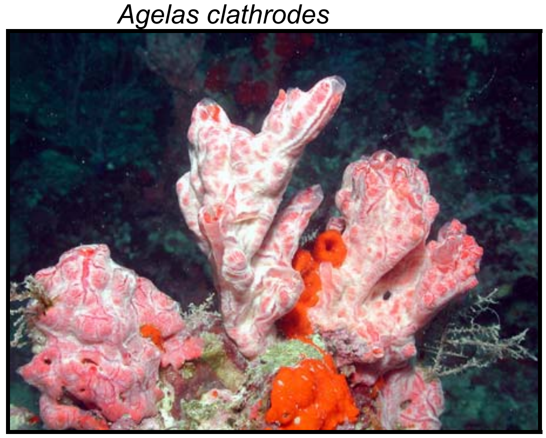
Order Hadromerida
Family Spirastrellidae
Spirastrella coccinea

Order Chondrosida
Family Chondrillidae
Chondrilla nucula

Subclass Ceractinomorpha
Order Agelasida
Family Agelasidae
Agelas clathrodes



Order Poecilosclerida
Suborder Microcionina
Family Microcionidae
Clathria (Thalysias) juniperina

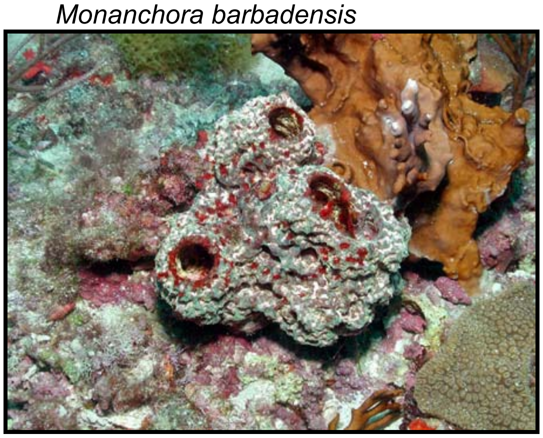


Order Poecilosclerida
Suborder Myxillina
Family Crambeidae
Monanchora unguiferus

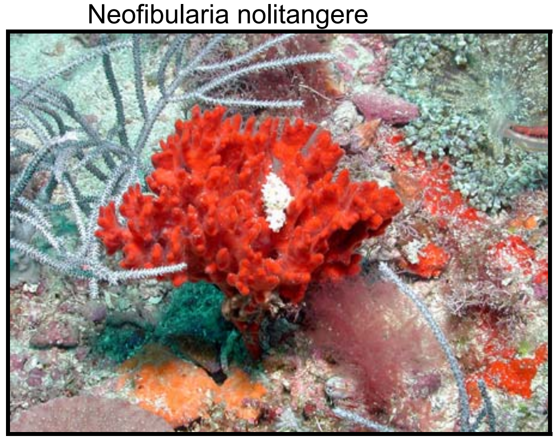
The Florida Middle Grounds Sponges

Order Poecilosclerida
Suborder Myxillina
Family Crambeidae
Monanchora barbadensis

Order Poecilosclerida
Suborder Mycalina
Family Desmacellidae
Neofibularia nolitangere

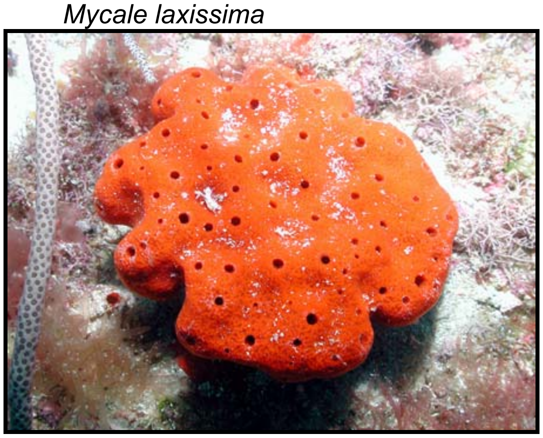


Order Poecilosclerida
Suborder Mycalina
Family Mycalidae
Mycale laxissima

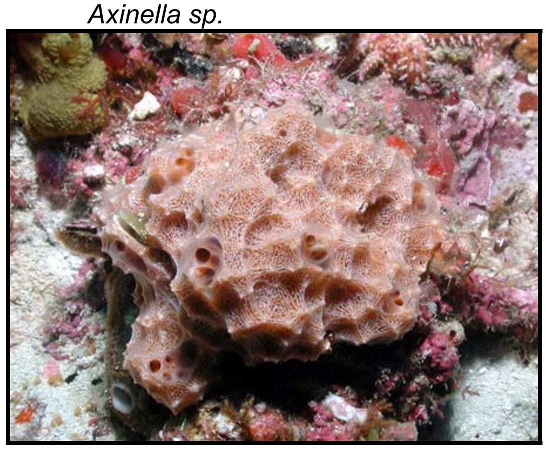


Order Halichondrida

Family Axinellidae
Axinella sp.



Order Halichondrida
Family Axinellidae
Dragmacidon lunaecharta

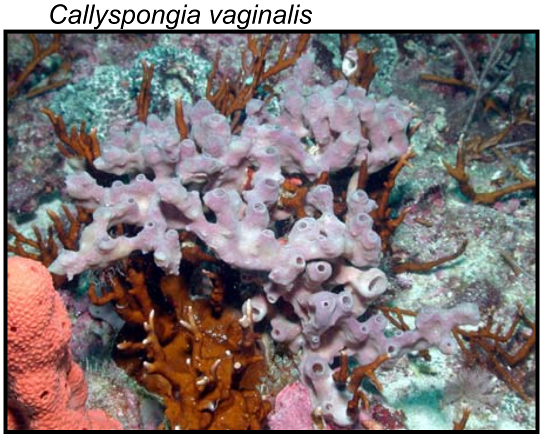


Order Halichondrida
Family Dictyonellidae
Scopalina reutzleri

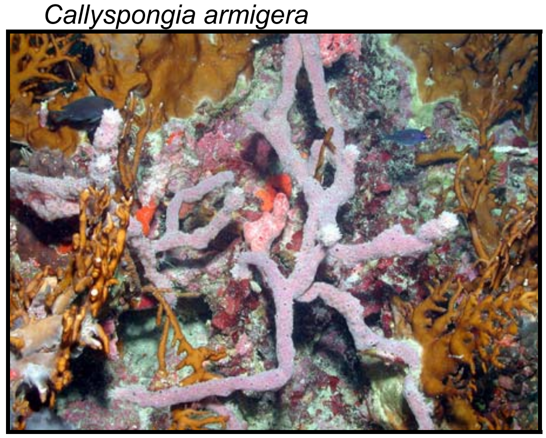
The Florida Middle Grounds Sponges

Order Haplosclerida
Family Callyspongiidae
Callyspongia vaginalis

Order Haplosclerida
Family Callyspongiidae
Callyspongia armigera

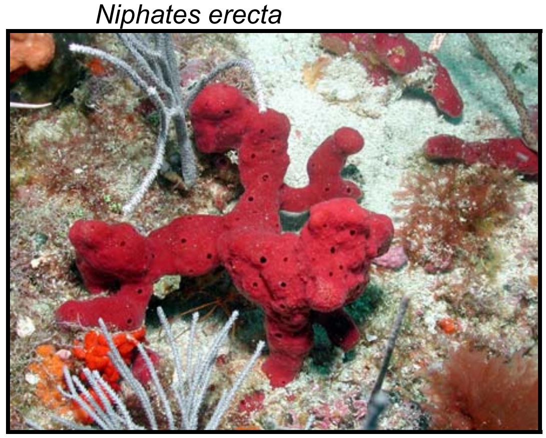


Order Haplosclerida
Family Callyspongiidae
Callyspongia fallax



Order Haplosclerida
Family Niphatidae
Niphates erecta

Order Haplosclerida
Family Niphatidae
Cribrochalina vasculum

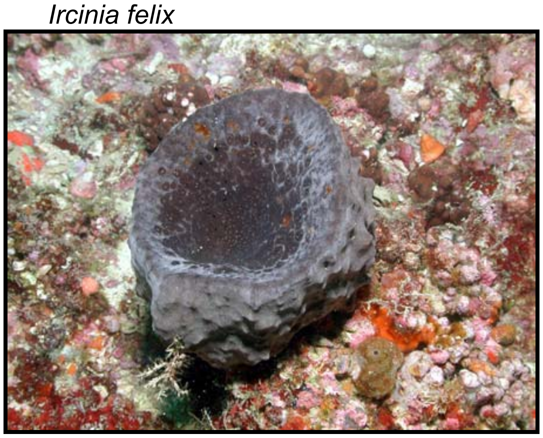


Order Haplosclerida
Family Niphatidae
Amphimedon compressa

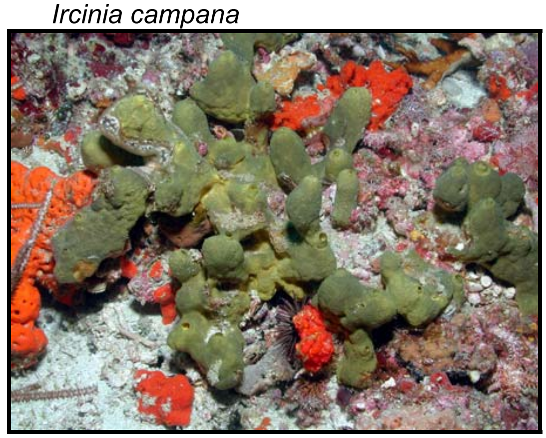
The Florida Middle Grounds Sponges

Order Dictyoceratida
Family Ircinidae
Ircinia felix

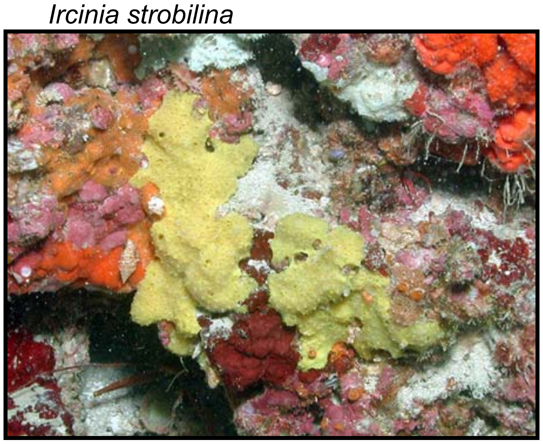
Order Dictyoceratida
Family Ircinidae
Ircinia campana



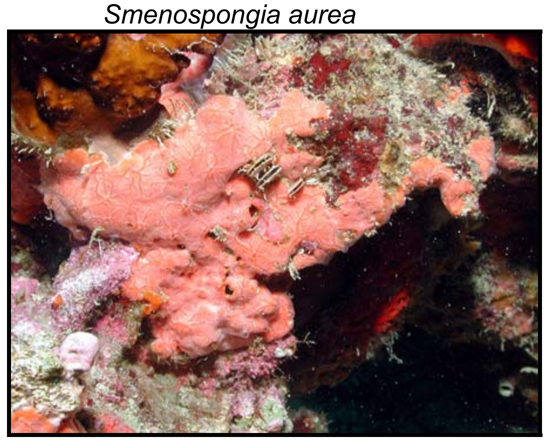
Order Dictyoceratida
Family Ircinidae
Ircinia strobilina



Order Dictyoceratida
Family Thorectidae
Smenospongia aurea



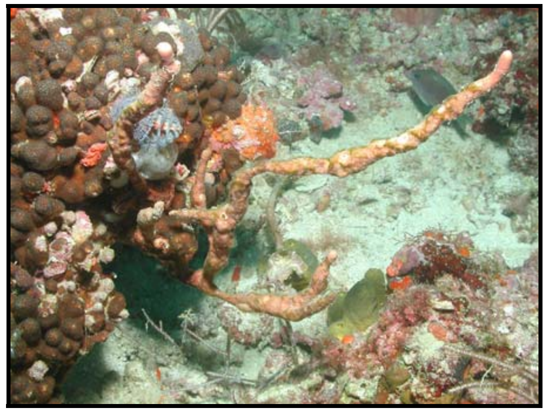
Order Dendroceratida
Family Darwinellidae
Aplysilla sulfurea



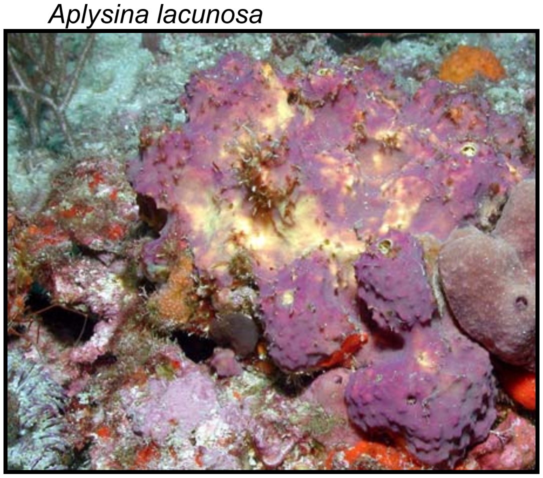
Order Halisarcida
Family Halisarcidae
Halisarca sp.

The Florida Middle Grounds Sponges

Order Verongida
Family Aplysinidae
Aplysina lacunosa



Order Verongida
Family Aplysinidae
Aplysina cauliformis

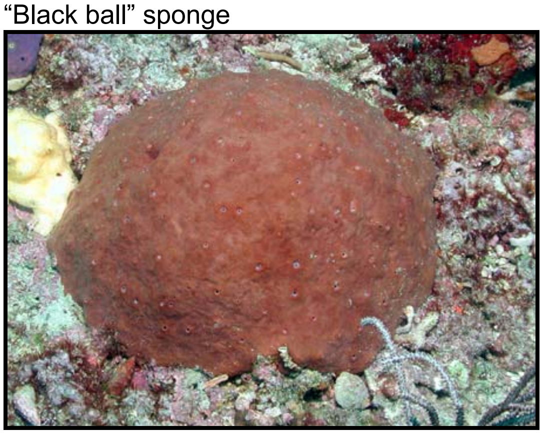


Order Verongida
Family Pseudoceratinidae
Pseudoceratina crassa

The Florida Middle Grounds Sponges

Unidentified
"Black ball" sponge

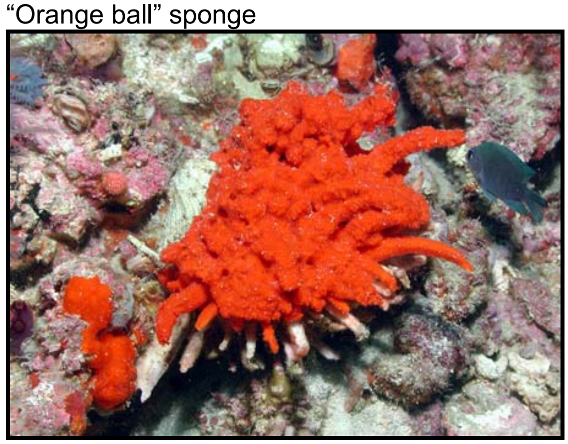
Unidentified
"Geodia sp. ?"



Unidentified
"Hard orange" sponge

Unidentified
"Orange ball" sponge

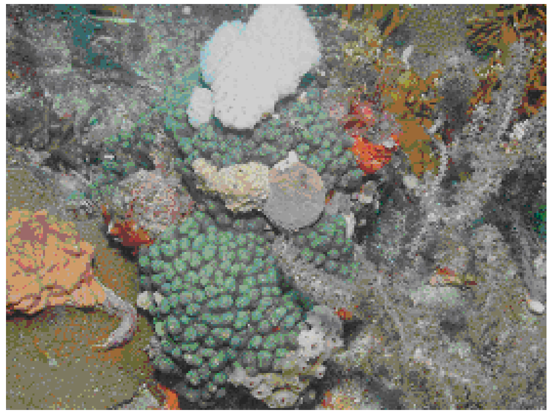
Unidentified
"Purple encrusting" sponge



Unidentified
"Orange encrusting" sponge

The Florida Middle Ground Stony Corals

Madracis decactis (upper right)



Madracis decactis

Dichocoenia stokesii

Dichocoenia stokesii (two color morphs)

Dichocoenia stokesii (two color morphs)

Millepora alcicornis

The Florida Middle Ground Stony Corals

	
Oculina diffusa (encrusted by *Millepora alcicornis* on left)	*Porites divaricata*

Acanthuridae – surgeonfishes

Acanthurus chirurgus doctorfish

The Florida Middle Ground Fishes

Apogonidae – cardinalfishes

Apogon maculatus flamefish

Apogon pseudomaculatus Two spot cardinalfish

The Florida Middle Ground Fishes

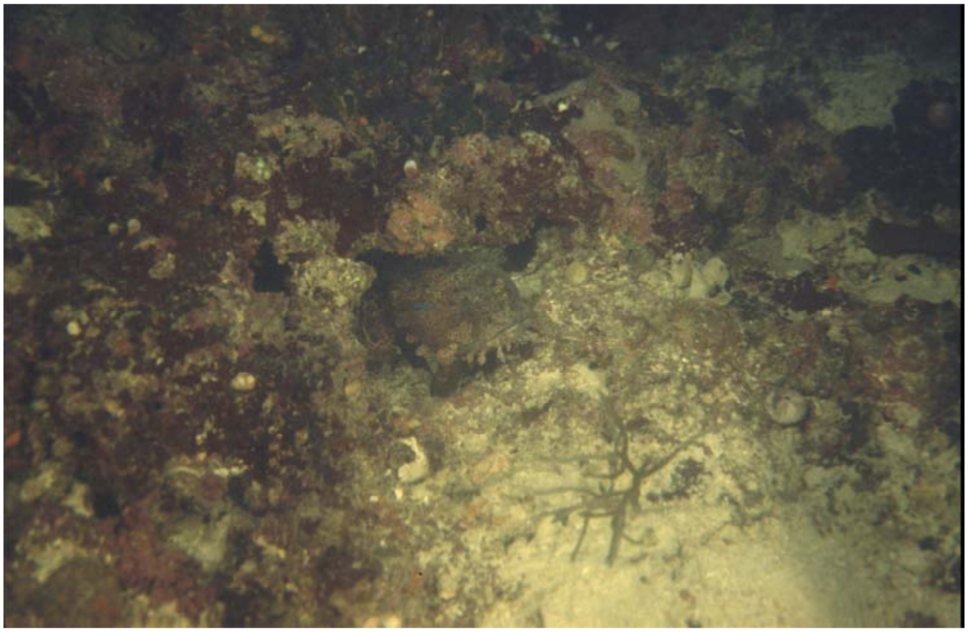
Balistidae – leatherjackets

Balistes capriscus gray triggerfish

Monacanthidae – filefishes

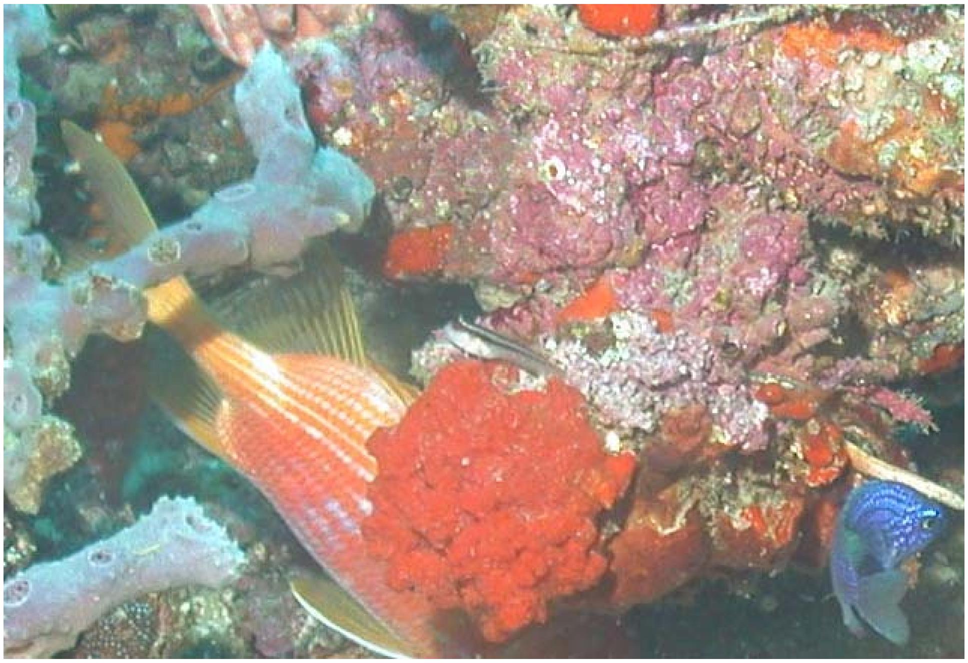
Cantherhines macrocerus whitespotted filefish

Batrachoididae – toadfishes



Opsanus pardus leopard toadfish

Blenniidae – combtooth blennies

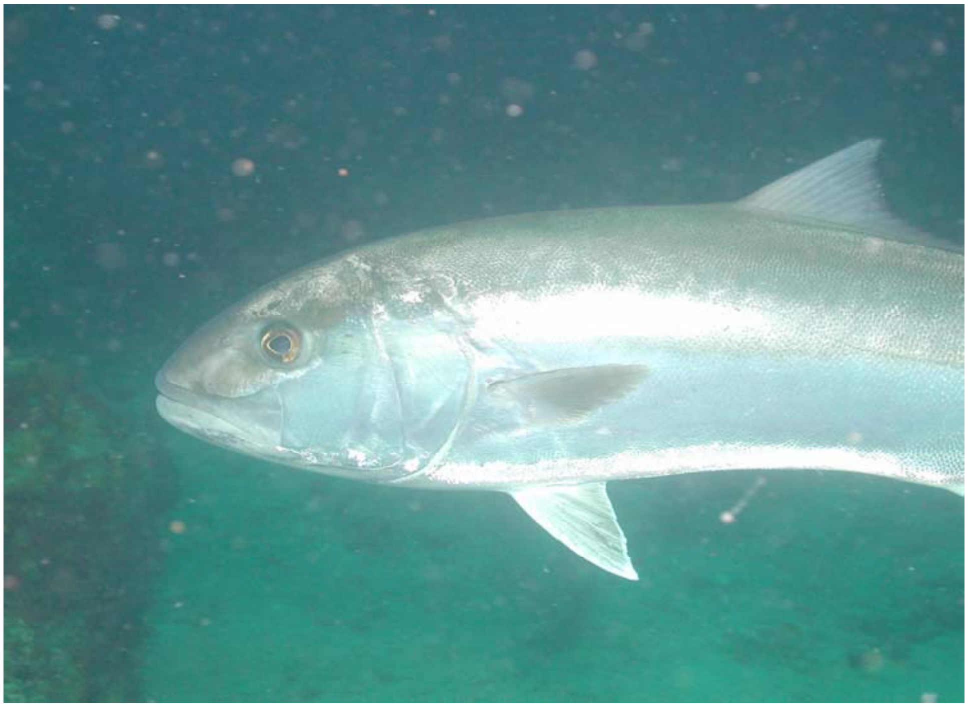


Parablennius marmoreus seaweed blenny (striped phase)

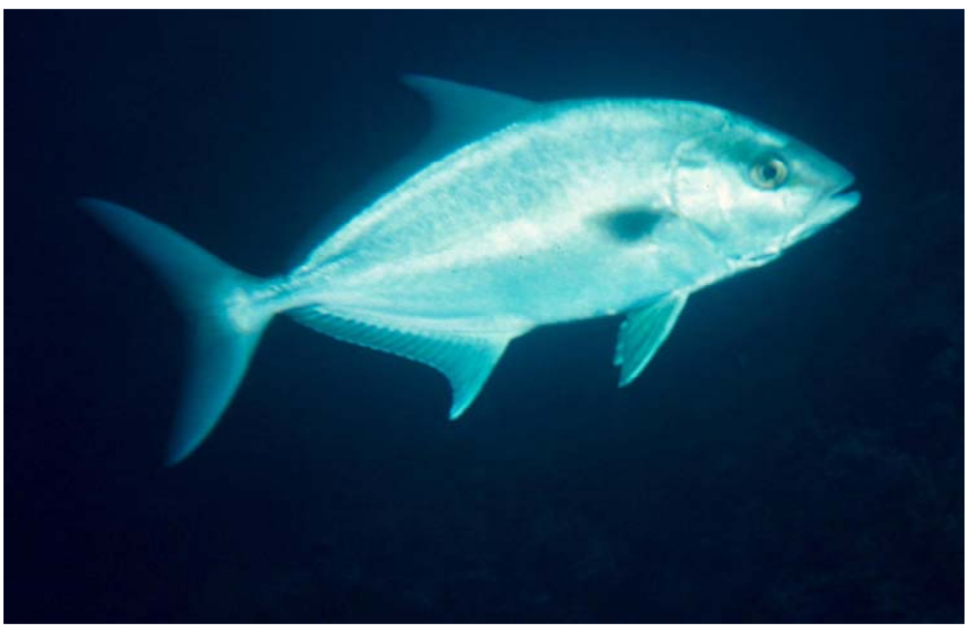
Parablennius marmoreus seaweed blenny (yellow phase)

The Florida Middle Ground Fishes

Carangidae – jacks



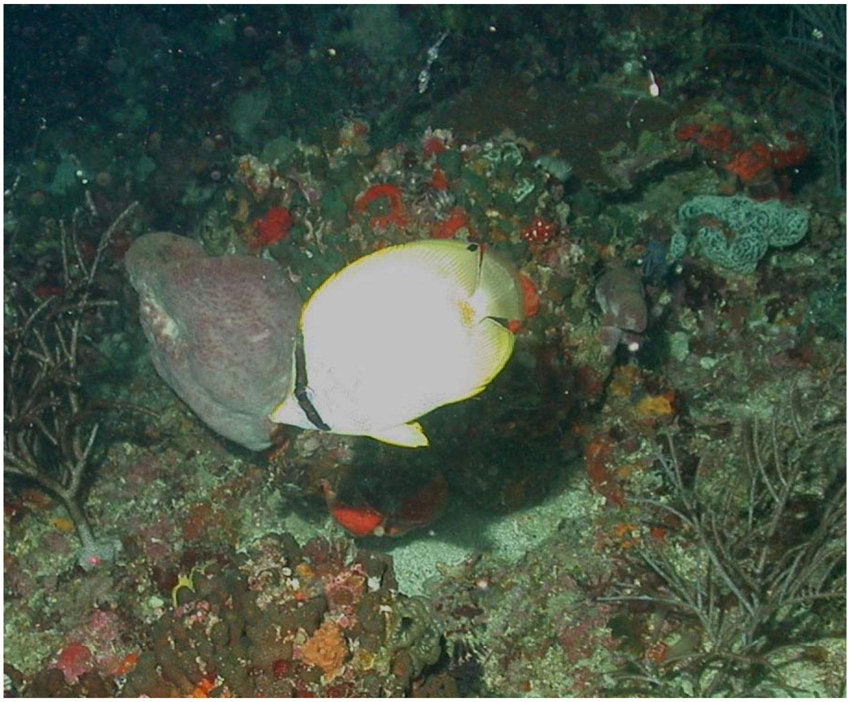
Seriola dumerili greater amberjack



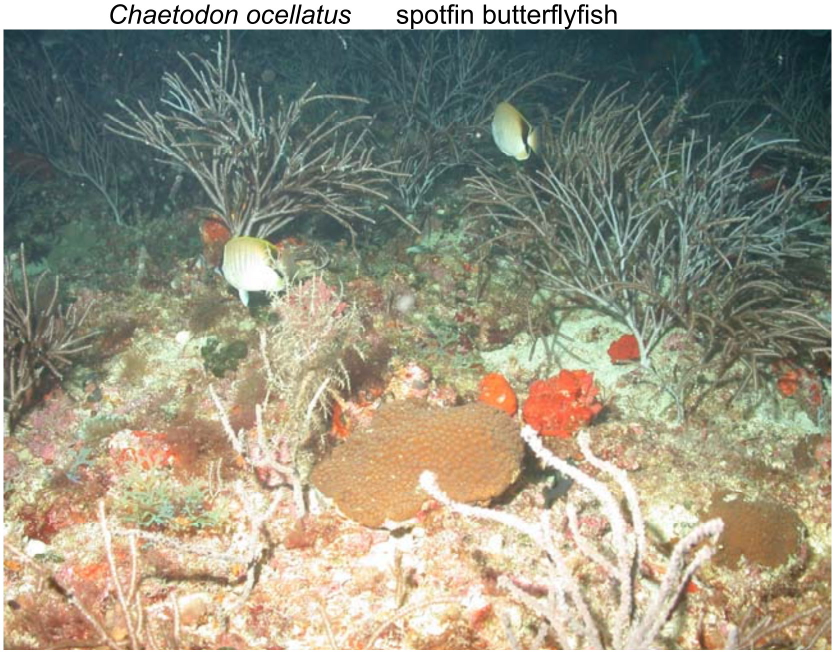
Seriola rivoliana almaco jack

The Florida Middle Ground Fishes

Chaetodontidae – butterflyfishes



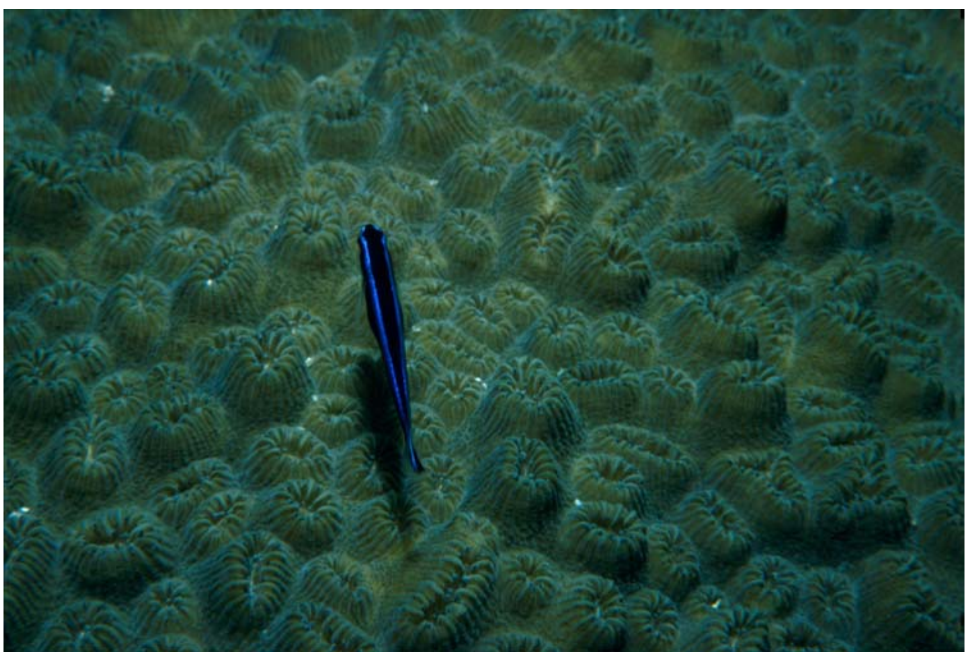
Chaetodon ocellatus spotfin butterflyfish



Chaetodon sedentarius bank butterflyfish

Gobiidae – gobies

Coryphopterus puntipectophorus spotted goby



Elacatinus oceanops neon goby

The Florida Middle Ground Fishes

Gobiidae – gobies

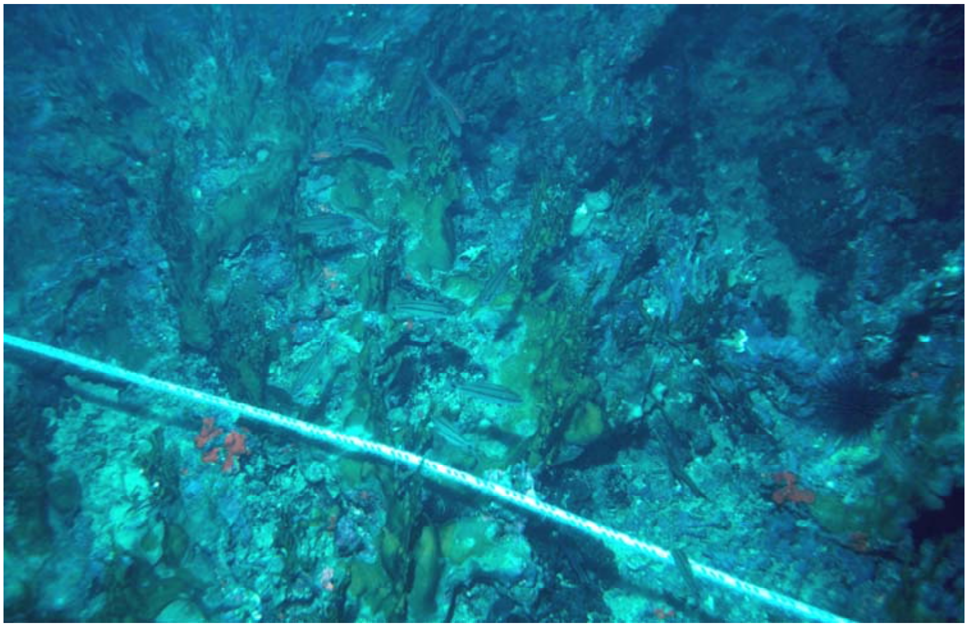
Elacantinus xanthiprora yellowprow goby

Microdesmidae – dartfishes

Ptereleotris calliura blue dartfish

The Florida Middle Ground Fishes

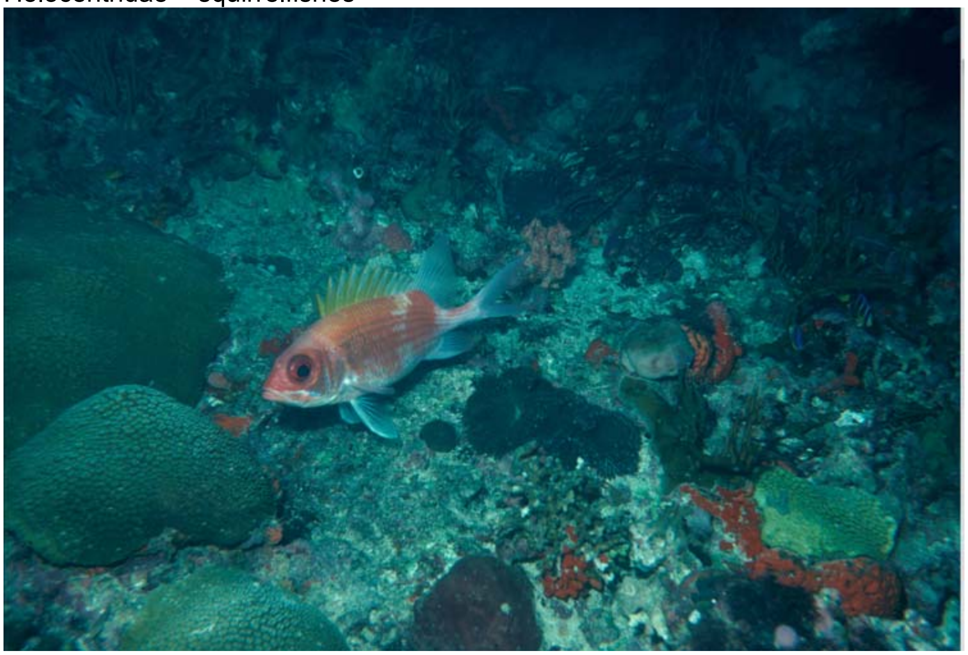
Haemulidae – grunts



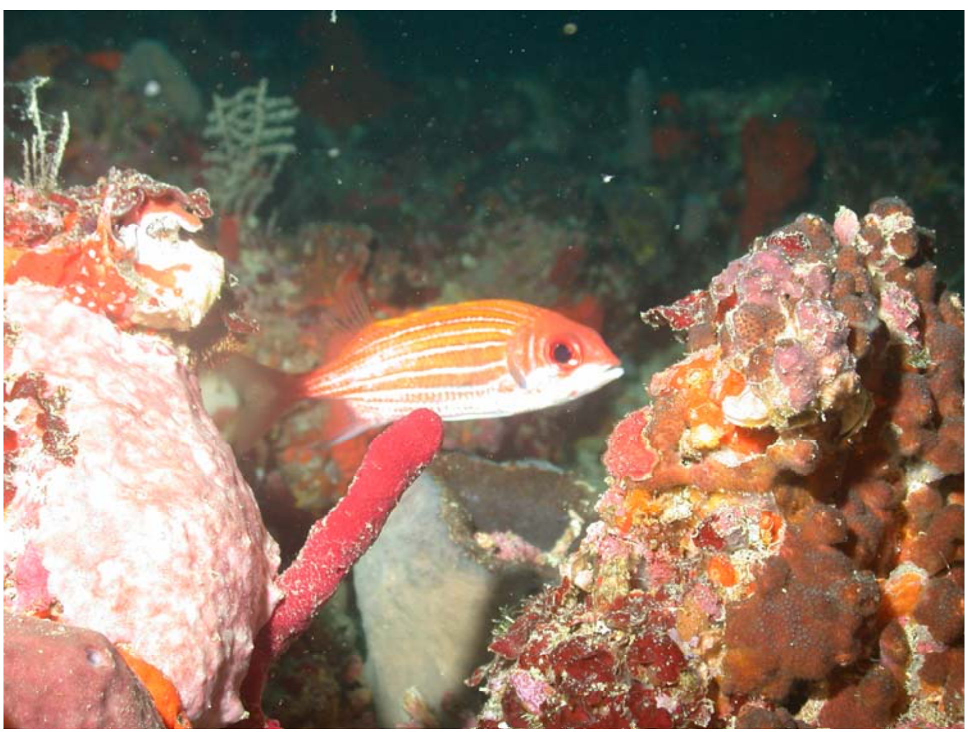
Haemulon aurolineatum tomtate

The Florida Middle Ground Fishes

Holocentridae – squirrelfishes



Holocentrus adscensionis squirrelfish



Sargocentron bullisi deepwater squirrelfish

The Florida Middle Ground Fishes

Labridae – wrasses

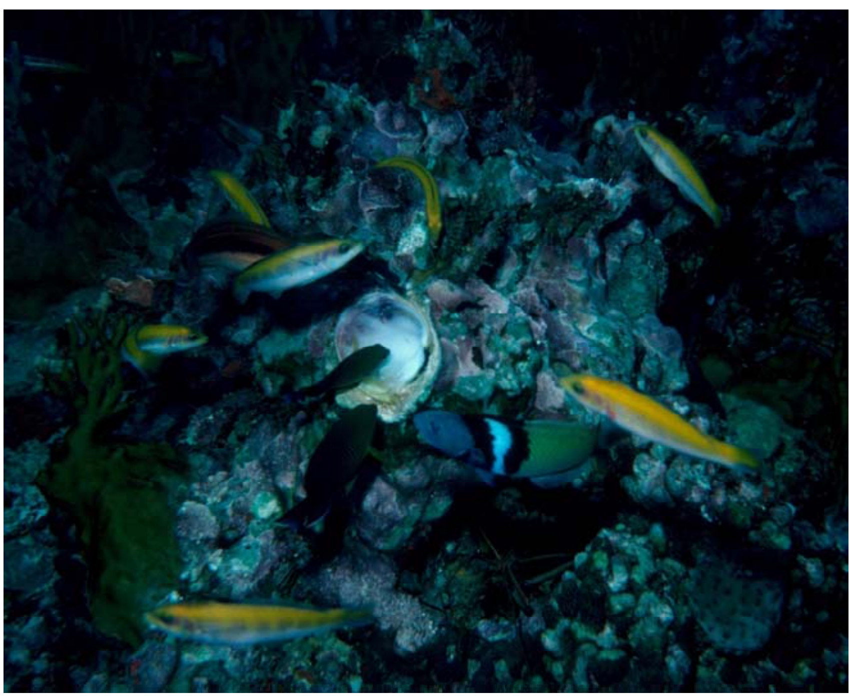
Bodianus rufus Spanish hogfish

Halichoeres bivittatus slippery dick (initial phase)

The Florida Middle Ground Fishes

Labridae – wrasses

Halichoeres caudalis painted wrasse



*Thalassoma bifasciatum*bluehead (initial and terminal phases)

Labridae – wrasses

Lachnolaimus maximus hogfish (terminal phase)

Lachnolaimus maximus hogfish (initial phase)

The Florida Middle Ground Fishes

Lutjanidae – snappers

Lutjanus griseus gray snapper

Lutjanus campechanus Red snapper[2]

[2] Photo taken in the Madison Swanson Marine Reserve on the West Florida Shelf

The Florida Middle Ground Fishes

Ophichthidae – snake eels

Myrichthys breviceps sharptail eel

Opistognathidae – jawfishes

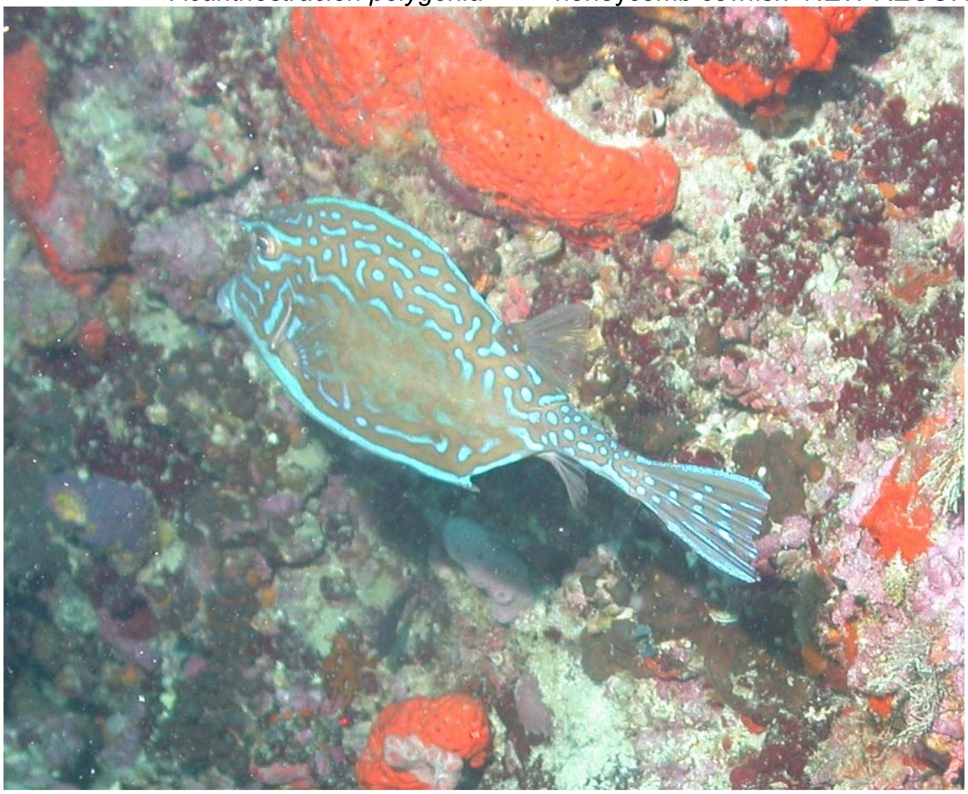
Opistognathus aurifrons yellowhead jawfish

Priacanthidae – bigeyes

Pristygenys alta short bigeye

Ostraciidae – boxfishes

Acanthostracion polygonia honeycomb cowfish NEW RECORD



Acanthostracion quadricornis scrawled cowfish

Pomacanthidae – angelfishes

Holacanthus bermudensis blue anglefish

Holacanthus bermudensis blue angelfish (juvenile)

The Florida Middle Ground Fishes

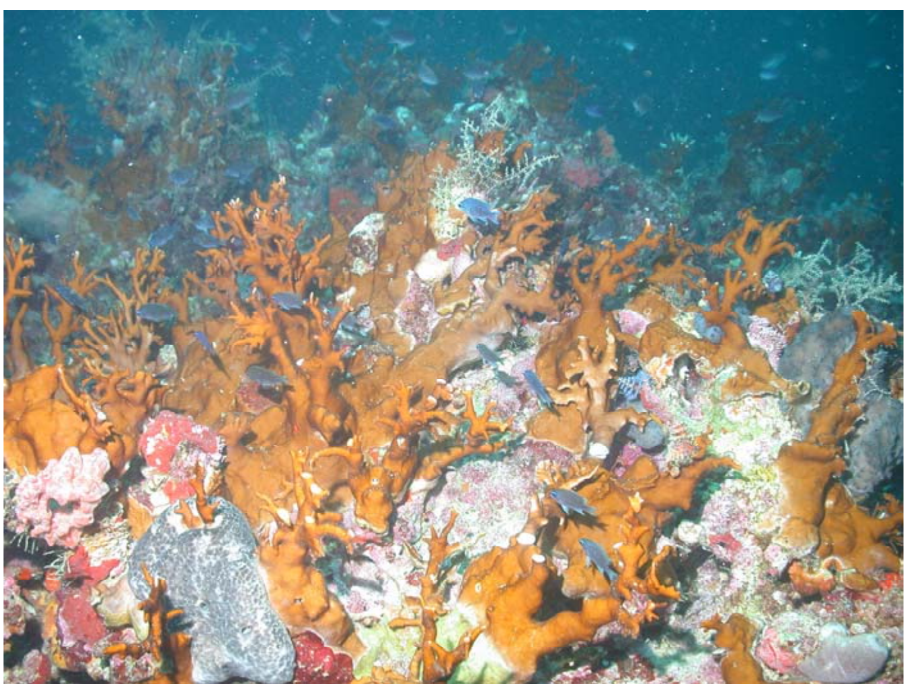
Holacanthus tricolor rock beauty

Pomacanthus arcuatus gray angelfish

The Florida Middle Ground Fishes

Pomacentridae – damselfishes

Chromis enchrysura yellowtail reeffish



Chromis scotti purple reeffish

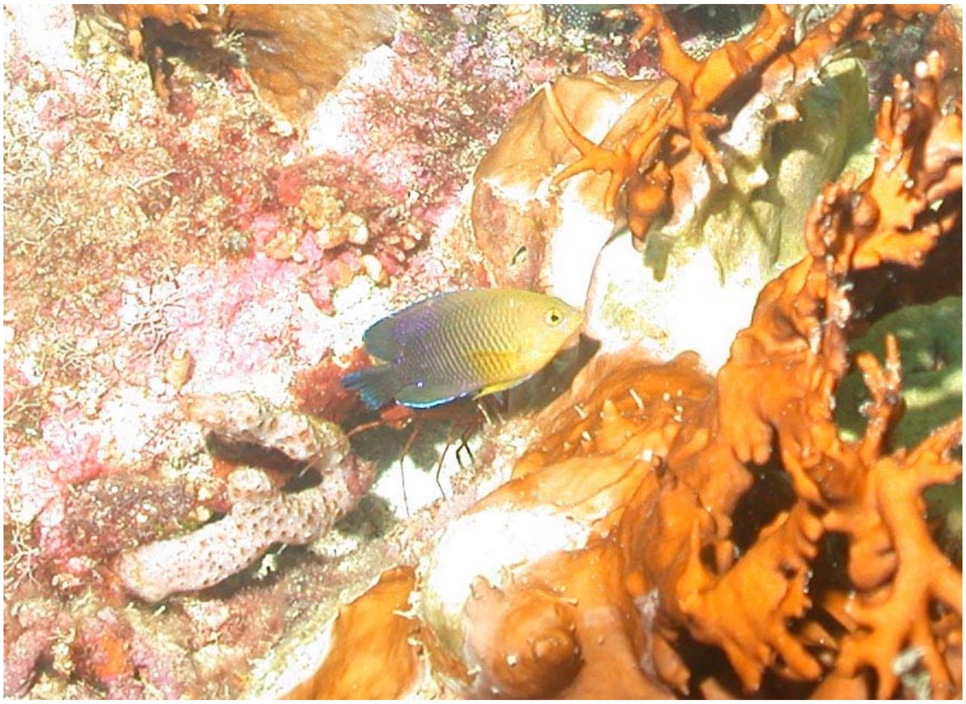
The Florida Middle Ground Fishes

Pomacentridae – damselfishes

Chromis scotti purple reeffish (dark phase and juvenile)

Chromis scotti purple reeffish (mottled phase)

Pomacentridae – damselfishes

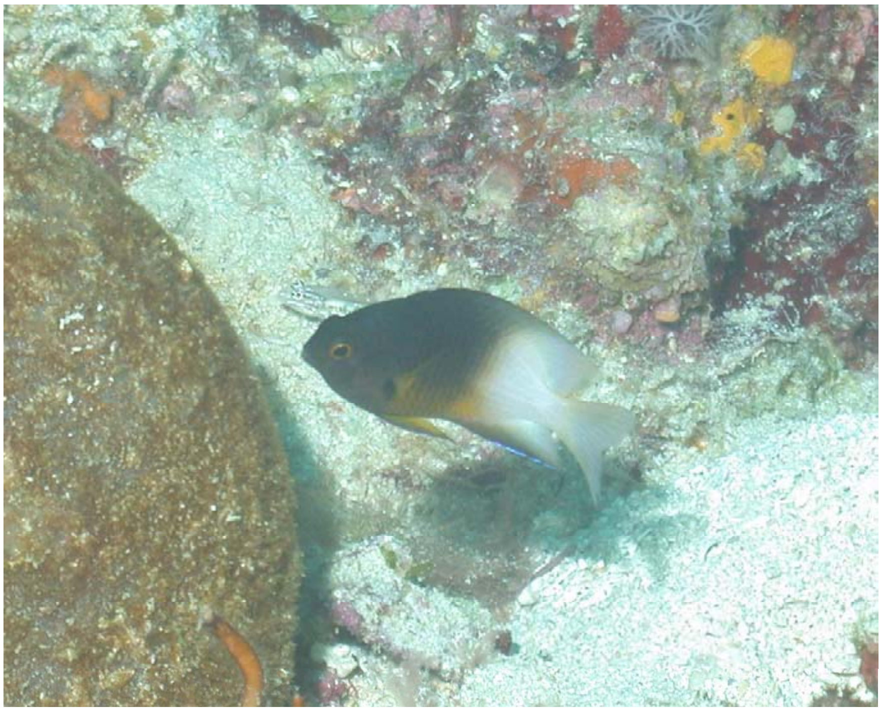


Stegastes variabilis cocoa damselfish (adult)

Stegastes variabilis cocoa damselfish (juvenile)

The Florida Middle Ground Fishes

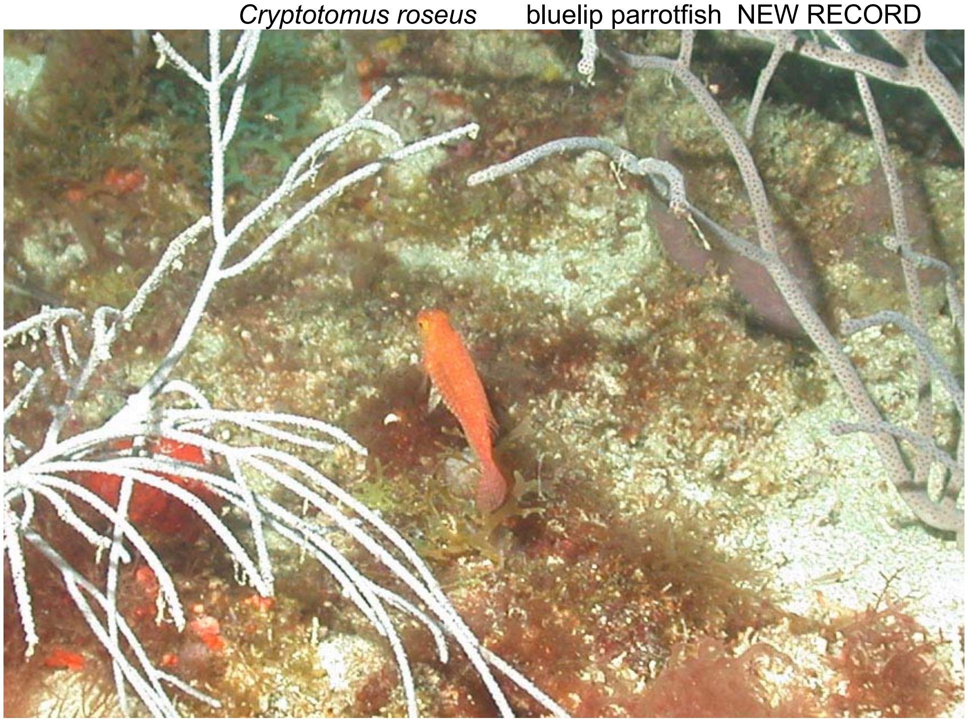
Pomacentridae – damselfishes



Stegastes partitus bicolor damselfish

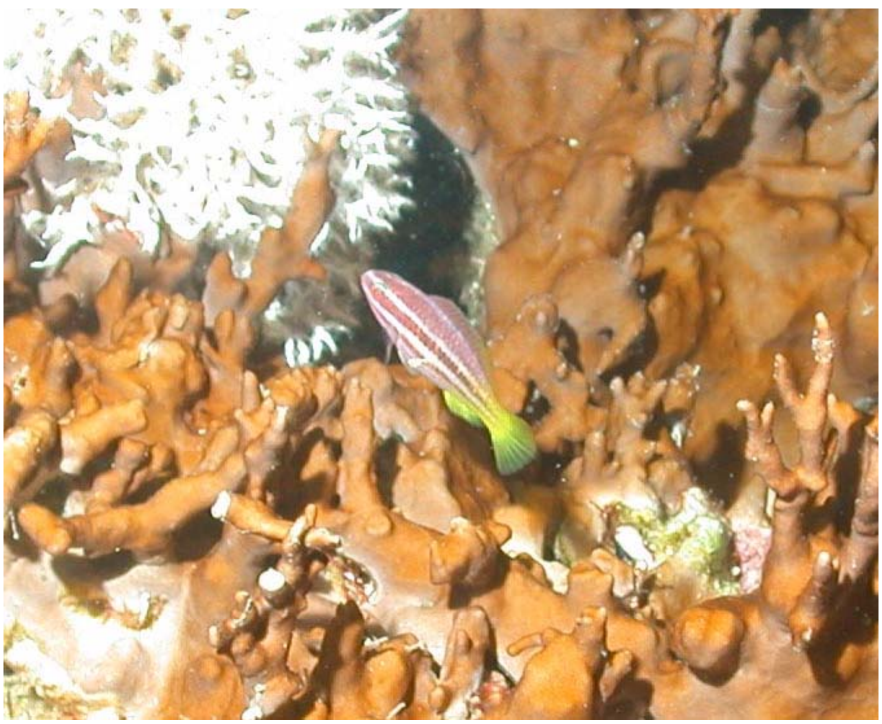
Scaridae – parrotfishes

Cryptotomus roseus bluelip parrotfish NEW RECORD



Sparisoma atomarium greenblotch parrotfish (initial phase)

Scarus cf. *iseri* striped parrotfish (terminal phase)



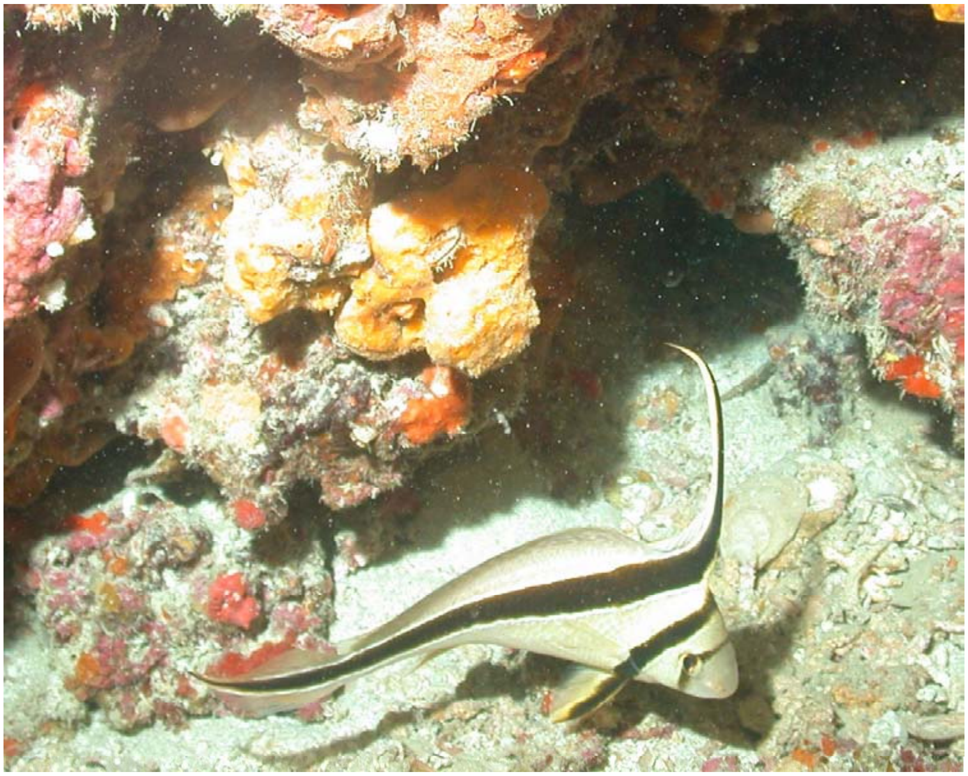
Scarus cf. *iseri* striped parrotfish (initial phase)

Sparisoma atomarium greenblotch parrotfish (terminal phase)

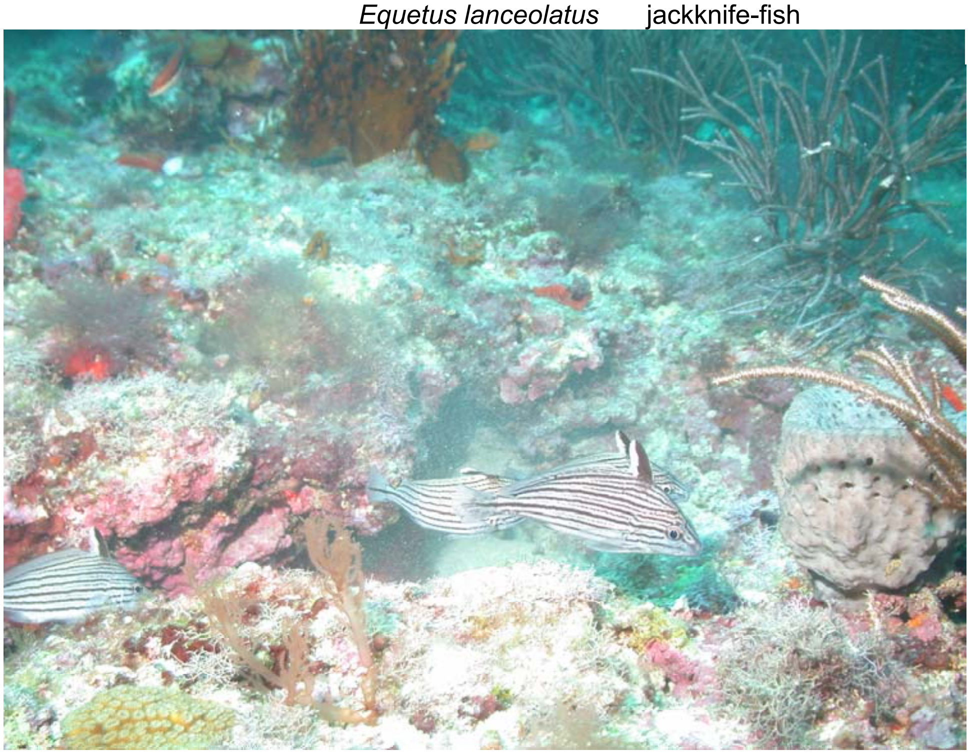
Sparisoma aurofrenatum greenblotch parrotfish (initial phase)

The Florida Middle Ground Fishes

Sciaenidae – drums



Equetus lanceolatus jackknife-fish



Pareques umbrosus cubbyu (light phase)

Sciaenidae – drums

Pareques umbrosus cubbyu (dark phase)

Scorpaenidae – scorpionfishes

Scorpaena plumieri spotted scorpionfish

The Florida Middle Ground Fishes

Serranidae – sea basses

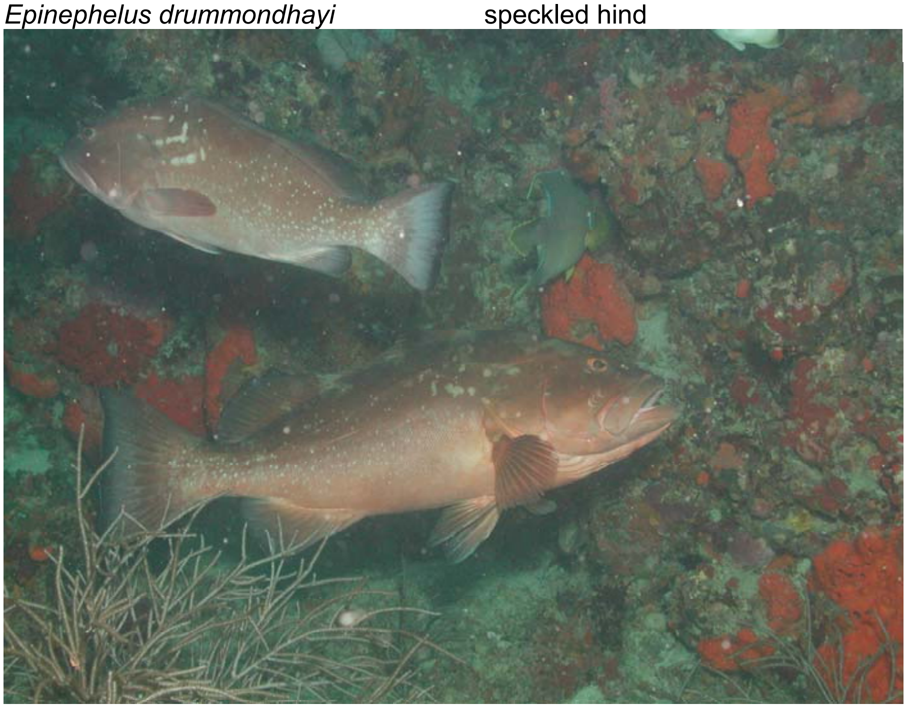
Centropristis ocyurus bank sea bass

*Cephalopholis cruentata*graysby

The Florida Middle Ground Fishes

Serranidae – sea basses

Epinephelus drummondhayi speckled hind

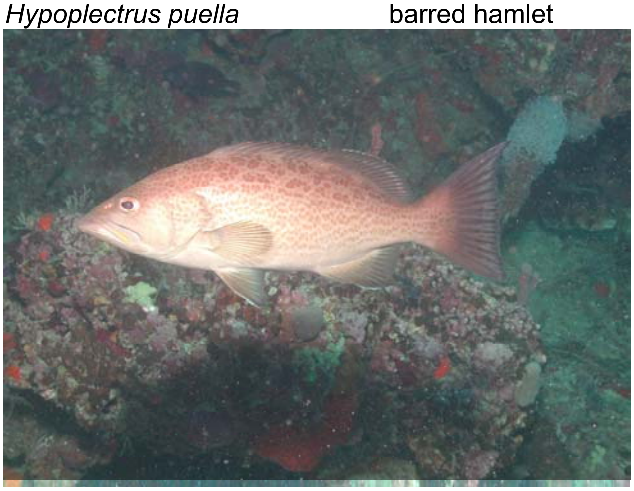


Epinephelus morio red grouper

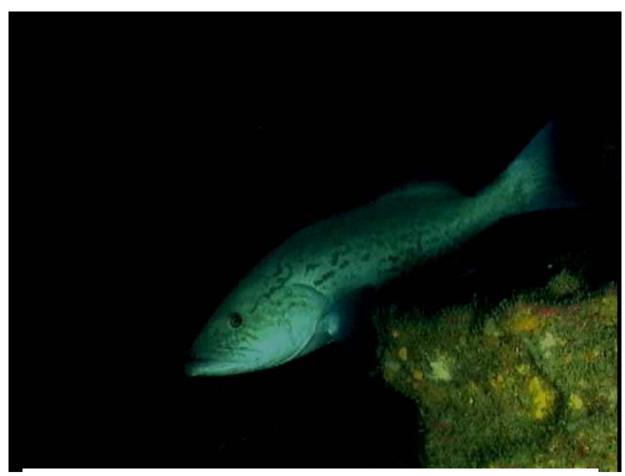
The Florida Middle Ground Fishes

Serranidae – sea basses

Hypoplectrus puella barred hamlet



Mycteroperca phenax scamp



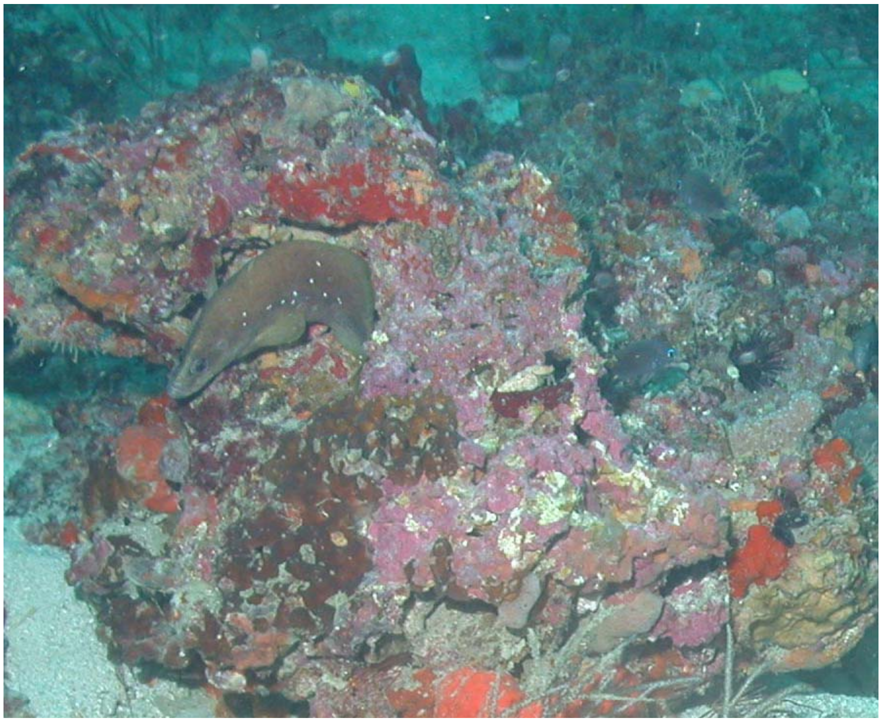
Courtesy of National Geographic

Mycteroperca microlepis[3] gag

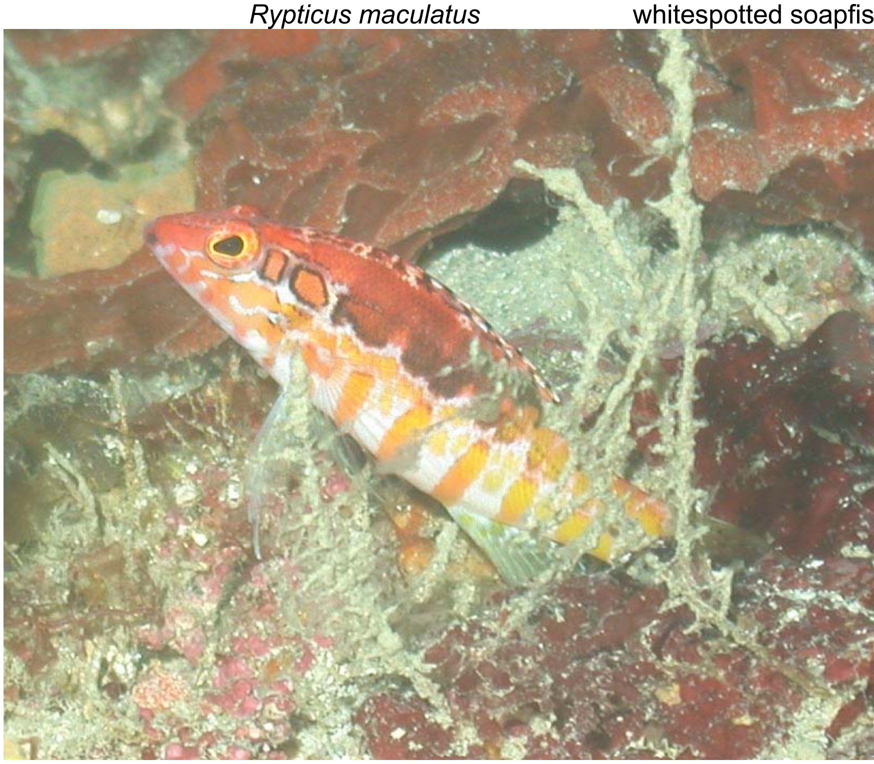
[3] Photographed at Steamboat Lumps, nearly due east of the Florida Middle Ground

The Florida Middle Ground Fishes

Serranidae – sea basses



Rypticus maculatus whitespotted soapfish



Serranus annularis orangeback bass

The Florida Middle Ground Fishes

Serranidae – sea basses

Serranus phoebe tattler

Serranus phoebe tattler

The Florida Middle Ground Fishes

Sparidae – porgies

Calamus nodosus Knobbed porgy[4]

Pagrus pagrus Red Porgy[1]

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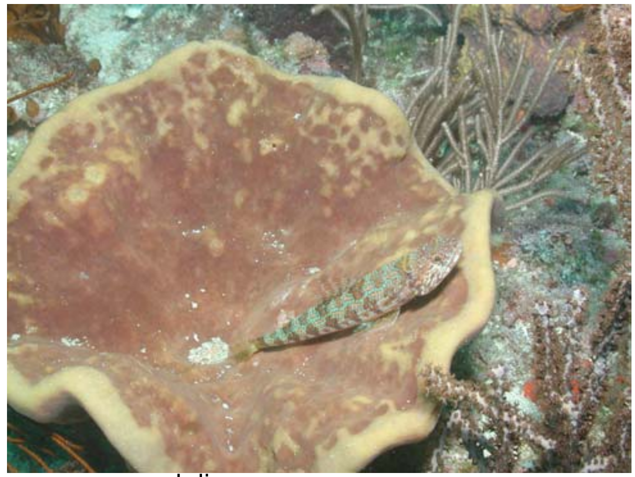
[4] photographed in the Madison Swanson Marine Reserve on the West Florida Shelf

The Florida Middle Ground Fishes

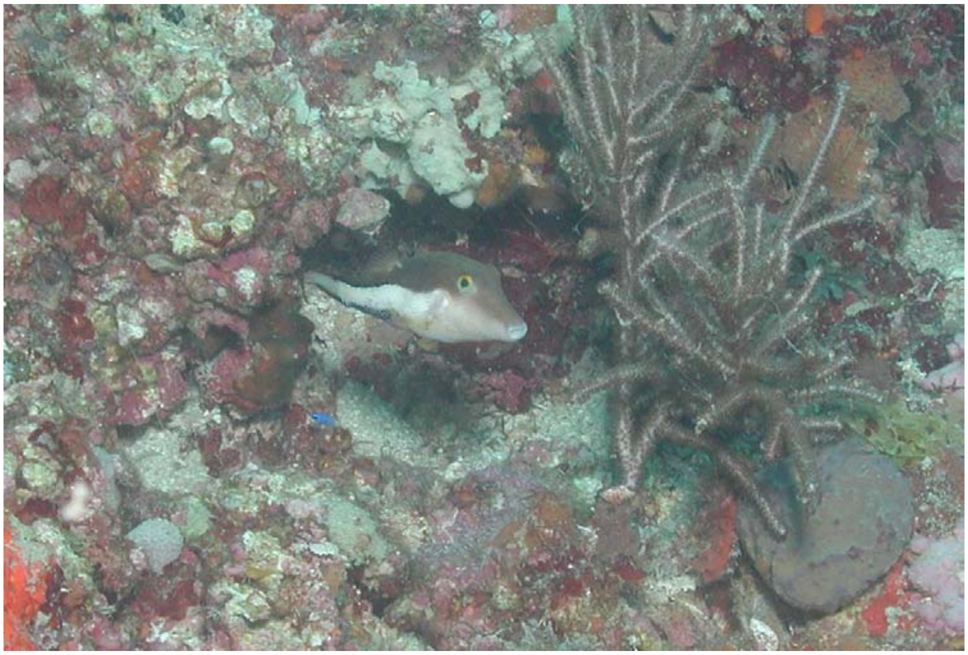
Synodontidae – lizardfishes



Synodus intermedius sand diver

Synodus synodus red lizardfish NEW RECORD

Tetraodontidae – puffers



Canthigaster rostrata sharpnose puffer

Sphoeroides spengleri bandtail puffer

Diodontidae – porcupinefishes

Diodon holocanthus balloonfish

Appendices

The Florida Middle Grounds

Appendix A. Algal samples collected in The Florida Middle Grounds Habitat Area of Particular Concern, May 2003, and archived in the Smithsonian Institution.

Sta. 147	21-May-03
DML63901	*Kallymenia westii*
DML63902	*Halymenia floridana*
DML63903	*Champia salicornides*
DML63904	*Trichogloea herveyi*
DML63905	*Dictyota menstrualis*
DML63906	*Sporolithon episporum*
DML63907	*Porolithon pachydermum*
DML63908	*Lithothamnion sp.*
DML63910	*Gelidium sp.*
Sta. 247	25-May-03
DML63911	*Udotea dixonii*
DML63912	*Codium coralinianum*
DML63913	*Codium ithmocladum*
DML63914	*Codium intertextum*
DML63915	*Halimeda discoidea*
DML63916	*Dictyota menstrualis*
DML63917	*Trichogloea herveyi*
DML63918	*Champia salicornoides*
DML63919	*Mesohyllum mesomorphum & Jania adhaerens*
DML63920	*Lithophyllum congestum*
Sta. 251	25-May-03
DML63921	*Botrycladia pyriformis*
DML63922	*Udotea dixonii*
DML63923	*Halimeda dixonii*
DML63924	*Dictyota menstrualis*
DML63925	*Lithothamnion ruptile*
DML63926	*Champia salicornoides*
DML63927	*Champia parvula*
DML63928	*Champia salicornoides*
DML63929	*Kallymenia sp.*
DML63930	*Halymenia floridana*
DML63931	*Chrysymenia enteromorpha*
Sta. 151	26-May-03
DML63932	*Colpomenia sinuosa*
DML63933	*Rhiplia sp.*
DML63934	*Halymenia floridana*
DML63935	*Udotea verticulosa*
DML63936	*Botrycladia pyriformis*
DML63937	*Kalymenia westii*
DML63938	*Udotea verticulosa*
DML63939	*Chrysymenia enteromorpha*
DML63940	*Champia salicornoides*
DML63941	*Dictyota pulchella*
	Goliath Grouper Rock- 27 May 03
DML63942	*Udotea dixonii*
DML63943	*Porolithon pachydermum*
	Fisherman's Hole 27 May 03
DML63944	*Dictyota menstrualis*
DML63945	*Chrysymenia enteromorpha*
DML63946	*Chrysymenia sp*.
DML63947	*Chrysymenia enteromorpha*
DML63948	*Udotea dixonii*

Appendix B. List of sponge species collected from the Florida Middle Grounds in the 1970s. The list is incomplete because of the poor state of sponge systematics at the time. Drawn from Hopkins (*et al.* 1977, 1981c, Hopkins 1981b). C = common

Species	Abundance
Agelas dispar[1]	C
Axinella polycapella	
Geodia gibberosa	
Callyspongia vaginalis	C
Callyspongia B	
Callyspongia fallax	
Cinachyra sp.	C
Chocolate cake sponge	
Jaspid sponge	
Jaspid with pink sponge	
Erylus sp	
Niphates erecta	
Haliclona/Halichondria?	
Haliclona rubens	C
Anthosigmella varians	
Ircinia	
Ircinia campana	C
Ircinia fasciculata	C
Ircinia strobilinia	C
Ircinia A	
Placospongis sp	C
Pseudoceratina crassa	C
Aiolochrola crassa	
Spheciospongia vesparia	C
Monanchora barbadensis	
Mycale angulosa	C
Anthosigmella varians	
Neofibularia nolitangere	C
Vergongia cauliformes	C
Verongia fistularis	C
Verongia longissima	C
Brown sponge	
Sponge A'	
Sponge E	
Sponge F	
Sponge I	

[1] This species is the only that appeared historically to be restricted in zonation to the reef face at 30-32 m; all other species appeared well distributed over the depth range

Appendix C. Ichthyofauna occurrence, abundance, and frequency of occurrence in The Florida Middle Ground Habitat Area of Particular Concern documented from twelve ROV dives, May 2003. Sampling sites are described in Tables 2 and 3. SH – Sink Hole, MW – Midway, DS – Deep South, and GGR – Goliath Grouper Rock. At the Sink Hole site, data are separated into reef (r) and sand (s) transects. Abundance is based on transect data only. Observation outside of transects are listed as P.

	Sampling Sites													TOTAL	Rank	Freq.
	147	047	151	251a	247	SH	SH	251b	MW	151	491/492	DS	GGR			
Scientific Name																
Acanthostracion quadricornis		1								P				1	**50**	2
Acanthostracion spp.	1					P		1			1			3	**41**	4
Acanthurus bahianus						1		2						3	**42**	2
Acanthurus chirurgus					5	2				P	1		P	8	**32**	5
Apogon spp.												1		1	**51**	1
Balistes capriscus						P		P	P				P	0		4
Calamus nodosus	P	1	1		P	P		2	P	2		1	P	7	**34**	10
Calamus spp.		P												0		1
Cantherhines macrocerus			P											0		1
Canthigaster jamestyleri									1					1	**52**	1
Canthigaster rostrata			1								1			2	**45**	2
Carcharhinidae			1											1	**53**	1
Centropristis ocyurus						P	3	1	4		P	10	P	18	**19**	7
Cephalopholis cruentata	1	4	5	1	19				1	P	1		P	32	**14**	9
Chaetodon ocellatus	1	3	P	2	2	1				P	2	1	P	12	**27**	10
Chaetodon sedentarius	P	P	P		8			1	P		P	1	P	10	**29**	9
Chromis enchrysura						263			12	1		81	P	357	**3**	5
Chromis scotti	105	94	559	119	447	227		283	159	358	1426	25	P	3802	**1**	12
Coryphopterus spp.	1											5		6	**38**	2
Cryptotomus roseus	1		2			2				2	1		P	8	**33**	6
Diplectrum sp.									P		P			0		2
Elacantinus oceanops											1			1	**54**	1
Elacatinus xanthiprora								1						1	**55**	1

Appendix C, continued

Scientific Name	147	047	151	251a	247	SH	SH	251 b	MW	15 1	491/492	DS	GGR	TOTAL	Rank	Freq.
							Sampling Sites									
Epinephelus adscensionis					P									0		1
Epinephelus drummondhayi										P				0		1
Epinephelus morio	P	1	2		4	2		1	P	2	1	2	P	15	**22**	11
Equetus lanceolatus									P					0		1
Gobiidae 1		4			4	6			13	1		5		33	**12**	6
Gobiidae 2								6	13					19	**18**	2
Gymnothorax moringa											P			0		1
Haemulon aurolineatum					7									7	**35**	1
Haemulon plumierii	P				1									1	**56**	2
Halichoeres bathyphilus												9		9	**30**	1
Halichoeres caudalis						16		5	4	5	2			32	**14**	5
Halichoeres cf. *bivittatus*	3	9	34	3	37	117		212	16	37	34	2	P	504	**2**	12
Halichoeres garnoti	P													0		1
Holacanthus bermudensis	3	2	11	3	10	3		5	3		12	6	P	58	**7**	11
Holacanthus tricolor					1					13				14	**23**	2
Holocentrus adscensionis	9		P	1	8	2		P	P	P	1	1	P	22	**16**	11
Hypoplectrus puella	2	9	5	1	2	6		7	6	5	11	1	P	55	**9**	12
Labridae								12	12	38		3		65	**6**	4
Lachnolaimus maximus		1	P								1		P	2	**46**	4
Lutjanus campechanus										1			P	1	**57**	2
Lutjanus griseus	14	2	10		22			7	P	2			P	57	**8**	8
Mycteroperca phenax		5	4	7	9	4		1	P	3	P		P	33	**12**	10
Myripristis jacobus					1									1	**58**	1
Nicholsina usta						3								3	**43**	1
Opistognathus aurifrons												17	P	17	**20**	2
Osteichthyes (unidentified fish)						9								9	**31**	1
Pagrus pagrus												P		0		1
Parablennius marmoreus											2			2	**47**	1

Appendix C, Continued

	Sampling Sites															
	147	047	151	251	247	SH	SH	251	MW	151	491/492	DS	GGR	TOTAL	Rank	Freq.
Pareques umbrosus					6									6	**39**	1
Pristigenys alta	P		P		P			1	1			P	P	2	**48**	7
Ptereleotris calliura					2	27	4	8	2	1	P	3		47	**11**	8
Sargocentron bullisi									2					2	**49**	1
Scaridae								4	3					7	**36**	2
Scarus cf. *iserti*		2	6		5	5		7		20	37		P	82	**5**	8
Seriola dumerili			P		13									13	**26**	2
Seriola rivoliana			P		49									49	**10**	2
Serranidae									1					1	**61**	1
Serranus annularis										P				0		1
Serranus notospilus												1		1	**59**	1
Serranus phoebe									5			6		11	**28**	2
Serranus tigrinus											1			1	**60**	1
Sparisoma atomarium	1	6	1						P	2	2	2	P	14	**24**	8
Sparisoma aurofrenatum	P		2		1			1		1	2		P	7	**37**	7
Sphyraena barracuda					1									1	**62**	1
Stegastes partitus	P	1		1	1	6			1	2	9	1	P	22	**16**	10
Stegastes variabilis	5	13	17	2	17	10		28	10	12	36		P	150	**4**	11
Synodus intermedius	1	P			P	1		2	2		5	5	P	16	**21**	9
Synodus spp.		2							2			2		6	**40**	3
Thalassoma bifasciatum	1		1					1		4	7			14	**25**	5
Xyrichtys novacula							3							3	**44**	1
No. Individuals	149	160	662	140	682	713	10	599	273	512	1597	191		5688		
No. Taxa	15	18	17	10	26	21	3	24	22	21	24	24		72		
No. Taxa Outside Transects	8	3	8	0	4	4	0	2	10	7	6	1	27			
Shannon-Weiner Diversity	1.24	1.71	0.77	0.72	1.56	1.68	1.09	1.47	1.79	1.29	0.59	2.19				
Evenness	0.46	0.59	0.27	0.31	0.48	0.55	0.99	0.46	0.58	0.42	0.18	0.69				

Appendix D. Abundance and frequency of occurrence for reef fish taxa in 2003 ROV digital still images by location at the Florida Middle Ground Habitat Area of Particular Concern, May 2003. N =the number of images analyzed at each sampling site. DS = depp south, GGR = goliath grouper rock, MW = Midway, SH = Sink Hole. Numerical sites were visited historically by Hopkins et al (1981).

							Sampling sites									
		047	147	151_1	151_2	247	251_1	251_2	491/492	DS	GGR	MW	SH	Total	Rank	Freq.
Taxon	N	107	12	127	129	234	30	177	273	117	103	153	55	1517		
Acanthostracion polygonius					1									1		1
Acanthostracion quadricornis								1						1		1
Acanthostracion spp.									2					2		1
Acanthurus bahianus						1								1		1
Acanthurus chirurgus		1			2	2		1						6		4
Apogon maculatus									1					1		1
Apogon pseudomaculatus					3							2		5		2
Apogon spp.					1									1		1
Balistes capriscus											1			1		1
Calamus nodosus		1					1	4	3	1	3			13		6
Calamus spp.						1							1	2		2
Cantherhines macrocerus				2										2		1
Cantherhines pullus									2					2		1
Canthigaster rostrata				1					4	1				6		3
Centropristis ocyurus				1	1				4	1				7		4
Cephalopholis cruentata		1		2		9		2	1		2			17	**19**	6
Chaetodon ocellatus		5			5	1			4	1	2			18	**18**	6
Chaetodon sedentarius		2		1					1					4		3
Chromis enchrysura		4		1	7			16	2	106	1	6	33	176	**4**	9
Chromis scotti		115	9	169	117	186	29	180	442	6	147	56	36	1492	**1**	12
Coryphopterus glaucofraenum		1		1	2	2	1	4	7	2	1	25	1	47	**11**	11
Coryphopterus punctipectophorus		12	2	3	7	7		13	2	15		22		83	**8**	9
Cryptotomus roseus				2	4	4		5	2		1	2	1	21	**16**	8
Dactyloscopidae										1				1		1
Diodon holocanthus					1									1		1
Diplectrum sp.					1							3		4		2
Elacatinus oceanops				1	1	7		3	3			1		16	**20**	6
Elacatinus xanthiprora				1						3				4		2
Epinephelus adscensionis							1							1		1
Epinephelus morio		2		1	2	3	1	4		2	4	4		23	**14**	9

Appendix D, continued

Taxon	047	147	151-1	151-2	247	251-1	251-2	491/492	DS	GGR	MW	SH	Total	Rank	Freq.
	Sampling sites														
N =	107	12	127	129	234	30	177	273	117	103	153	55	1517		
Equetus lanceolatus				1							5		6		2
Gobiidae 1	2	1			5	1							9		4
Haemulon plumierii								1					1		1
Halichoeres bathyphilus					3				11				14		2
Halichoeres caudalis				2			2				3		7		3
Halichoeres cf. *bivittatus*	1	2	21	23	55	2	68	22	6	12	20	27	259	**3**	12
Holacanthus bermudensis	11		2	6	4		2	19	3	4		1	52	**10**	9
Holacanthus tricolor					1								1		1
Holocentrus adscensionis					3	2	5	1					11		4
Holocentrus rufus							1						1		1
Hypoplectrus puella	2		2	4	3			4	4	2	1		22	**15**	8
Labridae				1									1		1
Labrisomus sp.									1				1		1
Lachnolaimus maximus								1		5			6		2
Lutjanus campechanus										2			2		1
Lutjanus griseus	28			8	17		13	6		4			76	**9**	6
Malacoctenus triangulatus					1								1		1
Mycteroperca phenax					4	2	1	3					10		4
Nicholsina usta											1		1		1
Opistognathus aurifrons	1			1	3			3	13	8	6	9	44	**12**	8
Opistognathus lonchurus											1		1		1
Pagrus pagrus									3				3		1
Parablennius marmoreus	10		8	2	55	1	4	15	3	1	15		114	**7**	10
Pareques umbrosus					4		5				3		12		3
Priacanthus arenatus							1						1		1
Pristigenys alta			1				2		9				12		3
Ptereleotris calliura				24	6		23	12	9	9	15	37	135	**6**	8
Rypticus maculatus					1		2						3		2
Sargocentron bullisi								1			6		7		2
Scarus cf. *iserti*	8		40	39	24	17	35	71		25		3	262	**2**	9

Appendix D, continued

Taxon	047	147	151-1	151-2	247	251-1	251-2	491/492	DS	GGR	MW	SH	Total	Rank	Freq.
	Sampling sites														
N	107	12	127	129	234	30	177	273	117	103	153	55	1517		
Scaridae							1						1		1
Seriola dumerili					4								4		1
Seriola rivoliana					32								32	**13**	1
Serranus annularis				2				1	6		1		10		4
Serranus phoebe								7	5		3		15		3
Serranus subligarius				1									1		1
Sparisoma atomarium	5		3	1	1	1		6	2	1			20	**17**	8
Sparisoma aurofrenatum			2		2		1	4		1		1	11		6
Stegastes partitus				1				9				1	11		3
Stegastes variabilis	12		20	16	25	6	17	29		13	8	10	156	**5**	10
Syngnathidae									1				1		1
Synodus intermedius	2				1		2	1	5	1	3		15		7
Synodus spp.									1				1		1
Thalassoma bifasciatum			2	1	4	3	1	3					14		6
Xyrichtys novacula												2	2		1
No. of Taxa	21	4	23	32	34	14	30	36	27	23	24	14	75		

Appendix E. Ichthyofauna identified from SCUBA video and still images at The Florida Middle Ground Habitat Area of Particular Concern, May 2003. FR = fish Rock, GGR = goliath grouper rock. P = present.

	Sampling Sites							
Taxon	147	151	247	251	491	FR	GGR	Frequency
Acanthurus bahianus			P	P	P	P		4
Acanthurus chirurgus				P		P		2
Acanthurus spp.	P		P			P	P	4
Balistes capriscus	P						P	2
Calamus nodosus	P		P	P	P	P	P	6
Cephalopholis cruentata	P		P	P		P	P	5
Chaetodipterus faber						P		1
Chaetodon ocellatus			P	P	P	P		4
Chaetodon sedentarius	P	P	P	P		P	P	6
Chromis scotti		P	P	P	P	P	P	6
Elacatinus oceanops					P			1
Epinephelus adscensionis			P	P	P			3
Epinephelus morio	P	P	P	P	P	P		6
Gymnothorax moringa		P						1
Haemulon plumierii	P							1
Halichoeres cf. *bivittatus*		P	P	P				3
Halichoeres garnoti						P		1
Holacanthus bermudensis	P	P	P	P	P	P	P	7
Holocentrus adscensionis	P		P	P	P			4
Holocentrus spp.		P	P	P		P	P	5
Hypoplectrus puella	P	P	P		P	P	P	6
Lachnolaimus maximus				P	P			2
Lutjanus griseus	P		P	P	P	P		5
Mycteroperca microlepis			P			P		2
Mycteroperca phenax		P	P	P	P	P		5
Mycteroperca spp.	P		P	P				3
Pareques umbrosus	P					P	P	3
Pseudupeneus maculatus			P			P		2
Ptereleotris calliurus		P				P		2
Scarus cf. *iserti*	P	P	P	P	P	P	P	7
Seriola dumerili			P	P				2
Seriola rivoliana			P					1
Sparisoma aurofrenatum	P					P		2
Stegastes partitus		P	P					2
Stegastes variabilis		P	P	P				3
Synodus spp.		P						1
Thalassoma bifasciatum	P	P		P	P			4
No of Taxa	16	15	24	21	15	22	11	37

Appendix F. Checklist of fishes from The Florida Middle Grounds from historical and current studies. A = abundant C = common F = frequent O = occasional R = rare X = present. *New record this study.

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Carcharhinidae - requium sharks										
Carcharhinus falciformis	silky shark	X				R				
Carcharhinus leucus	bull shark	X								
Carcharhinus sp.	shark									X
Galeocerdo cuvier	tiger shark	X				R				
Sphyrindae										
Sphyrna sp.	hammerhead									X
Dasyatidae – stingrays										
Dasyatis americana	southern stingray					R				
Myliobatidae - eagle rays										
Rhinoptera bonasus	cownose ray					R				
Mobulidae - manta ray										
Manta birostris	giant manta	X				R				
Muraenidae – morays										
Gymnothorax funebris	green moray					R				
Gymnothorax moringa	spotted moray	F	X			O	X			X
Gymnothorax nigromarginatus	blackedge moray	X				R				
Muraena retifera	reticulated moray	X								
Ophichthidae - snake eels										
Ahlia egmontis	key worm eel	X				R				
Bascanichthys scuticaris	whip eel					R				
Callechelys guineensis	shorttail snake eel					R				
Echiophis intertinctus	spotted spoon-nose eel					R				
*Myrichthys breviceps**	sharptail eel									
Myrophis punctatus	speckled worm eel	X				R				
Ophichthus gomesii	shrimp eel	X				R	X			
Ophichthus ophis	spotted snake eel	X								
Ophichthus puncticeps	palespotted eel					R				
Congridae - conger eels										
Rhynchoconger flavus	yellow conger						X			
Paraconger caudilimbatus	margintail conger	X				R				

Appendix F, continued

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Engraulidae – anchovies										
Engraulis eurystole	silver anchovy	X								
Clupeidae – herrings										
Etrumeus teres	round herring	X				R				
Jenkinsia sp.	dwarf herring					R				
Sardinella aurita	Spanish sardine	X				R	X			
Synodontidae – lizardfishes										
Synodus intermedius	sand diver	O				F	X	R		X
Synodus saurus	bluestripe lizardfish	R								
*Synodus synodus**	red lizardfish									X
Bythitidae - live bearing brotula										
Ogilbia sp.	brotula					R				
Bregmacerotidae – codlets										
Bregmaceros cantori	Striped codlet	X								
Phycidae - phycid hakes										
Urophycis floridana	southern hake	X				O		R		
Batrachoididae – toadfishes										
Opsanus pardus	leopard toadfish	F				F	X			
Antennariidae – frogfishes										
Antennarius ocellatus	ocellated frogfish	O								
Ogcocephalidae – batfishes										
Ogcocephalus cubifrons	polka-dot batfish	R				R				
Mugilidae – mullet										
Mugil cephalus	striped mullet	X				R				
Belonidae – needlefishes										
Strongylura marina	Atlantic needlefish					R				
Tylosurus crocodilus	houndfish	X				O				

Appendix F, continued

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Exocoetidae – flyingfishes										
Cheilopogon exsiliens	bandwing flyingfish	X				R				
Cheilopogon melanurus	Atlantic flyingfish	X								
Hirundichthys rondeleti	blackwing flyingfish	X								
Parexocoetus brachypterus	sailfin flyingfish	X				R				
Hemiramphidae – halfbeaks										
Euleptorhampus velox	flying halfbeak	X				R				
Hemiramphus brasiliensis	ballyhoo	X				R				
Hyporhamphus unifasciatus	Atlantic silverstripe halbeak					R				
Holocentridae – squirrelfishes										
Holocentrus adscensionis	squirrelfish	F	X	X		C	X	O		X
Holocentrus rufus	longspine squirrelfish									X
Myripristis jacobus	blackbar soldierfish	O				R				X
Sargocentron bullisi	deepwater squirrelfish	R	X			R	X	R		X
Syngnathidae - pipefishes										
Cosmocampus albirostris	whitenose pipefish					R				
Hippocampus erectus	lined seahorse					R		R		
Syngnathus springeri	bull pipefish					R			X?	
Aulostomidae – trumpetfishes										
Aulostomus maculatus	Atlantic trumpetfish	R					X			
Scorpaenidae – scorpionfishes										
Scorpaena brasiliensis	barbfish	O				R				
Scorpaena plumieri	spotted scorpionfish	O	X				X?			X
*Scorpaenodes tredecimspinosus**	deepreef scorpionfish									
Serranidae - sea basses										
Bathyanthias mexicanus	yellowtail bass						X			
Centropristis ocyurus	bank seabass	O	X	X		O	X	F		X
Cephalopholis cruentata	graysby	O	X			F	X	O	O	X
Cephalopholis fulva	coney	R								

Appendix F, continued

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	Dennis et al. 2004
Serranidae (continued)										
Diplectrum formosum	sand perch	O					X			X?
Epinephelus adscensionis	rock hind	O	C			F	X			X
Epinephelus drummondhayi	speckled hind	R	R							X
Epinephelus guttatus	red hind	O	O			R	X	R		
Epinephelus itajara	goliath grouper	O				R				
Epinephelus morio	red grouper	F	F			C	X	R	O	X
Hypoplectrus puella	barred hamlet	O	O			A	X	F	O	X
Liopropoma eukrines	wrasse basslet					R	X	R		
Mycteroperca bonaci	black grouper	R	R							
Mycteroperca interstitialis	yellowmouth grouper	R				R	X			
Mycteroperca microlepis	gag	C	A	X		C	X	O		X
Mycteroperca phenax	scamp	C	C	X		C	X	F		X
Mycteroperca venenosa	yellowfin grouper	R								
Paranthias furcifer	Atlantic creole fish	R				R	X			
Rypticus maculatus	whitespotted soapfish	O				O		O		X
*Serranus annularis**	orangeback bass									X
*Serranus notospilus**	saddle bass									X
Serranus phoebe	tattler					R	X			X
Serranus subligarius	belted sandfish	F	R			O		R		X
Serranus tabacarius	tobaccofish	R					X			
Serranus tigrinus	harlequin bass	R								X
Opistognathidae – jawfishes										
Opistognathus aurifrons	yellowhead jawfish	F	O			R	X	R		X
*Opistognathus lonchurus**	moustache jawfish									X
Priacanthidae – bigeyes										
*Priacanthus arenatus**	bigeye									X
Pristigenys alta	short bigeye	O				O	X	R	O	X

Appendix F, continued

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Apogonidae – cardinalfishes										
Apogon binotatus	barred cardinalfish	R								
Apogon maculatus	flamefish	R				F		R		X
Apogon pseudomaculatus	twospot cardinalfish	F	C			C		O		X
Astrapogon alutus	bronze cardinalfish				X	O				
Phaeoptyx pigmentaria	dusky cardinalfish					F				
Phaeoptyx xenus	sponge cardinalfish	F					X			
Malacanthidae – tilefishes										
Malacanthus plumieri	sand tilefish	X								
Echeneidae - sharksucker										
Echeneis neucratoides	whitefin sharksucker	X				R				
Rachycentridae - cobia										
Rachycentron canadum	cobia	X				R				
Coryphaenidae - dolphin										
Coryphaena hippurus	dolphinfish	X				R				
Carangidae – jacks										
*Caranx bartholomaei**	yellow jack									
Caranx crysos	blue runner	X				R	X			
Caranx ruber	bar jack	X								
Decapterus punctatus	round scad	X				R	X			
Elagatis bipinnulata	rainbow runner					R	X			
Seriola dumerili	greater amberjack	X	O			C	X	C		X
Seriola fasciata	lesser amberjack									
Seriola rivoliana	almaco jack	X				R	X			X
*Seriola zonata**	banded rudderfish									
Trachurus lathami	rough scad	X								

Appendix F, continued

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Lutjanidae – snappers										
Lutjanus campechanus	red snapper	F	R			O				X
Lutjanus cyanopterus	cubera snapper	R								
Lutjanus griseus	gray snapper	C				C	X	F		X
Lutjanus synagris	lane snapper	R								
Ocyurus chrysurus	yellowtail snapper	R	X							
Rhomboplites aurorubens	vermilion snapper	O					X			
Haemulidae – grunts										
Haemulon aurolineatum	tomtate	F				F	X	O		X
Haemulon plumierii	white grunt	O				O	X	O		X
Sparidae – porgies										
Archosargus probatocephalus	sheepshead									
Calamus bajonado	jolthead porgy	R	X			R				
Calamus calamus	saucereye porgy									
Calamus nodosus	knobbed porgy	F				C	X	F		X
Calamus proridens	little-head porgy	O	O							
Pagrus pagrus	red porgy	C				C	X	F		X
Sciaenidae – drums										
Equetus lanceolatus	jackknife fish	O	O			F	X	R		X
Pareques umbrosus	cubbyu	F		X		C	X	F	O	X
Mullidae – goatfishes										
*Mulloidichthys martinicus**	yellow goatfish									
Mullus auratus	red goatfish	R								
Pseudupeneus maculatus	spotted goatfish						X			X
Chaetodontidae –butterflyfishes										
Chaetodon capistratus	foureye butterflyfish	R								
Chaetodon ocellatus	spotfin butterflyfish	O	O			F	X	O		X
Chaetodon sedentarius	reef butterflyfish	O	R			F	X	O		X

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Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Pomacanthidae - angelfishes										
Centropyge argi	cherubfish	R	R				X			
Holacanthus bermudensis	blue angelfish	C	C	X		A	X	C		X
Holacanthus ciliaris	queen angelfish	R	R							
*Holacanthus tricolor**	rock beauty									X
Pomacanthus arcuatus	gray angelfish	F	O			F	X			
Pomacanthus paru	French angelfish	R	R							
Kyphosidae - sea chubs										
Kyphosus sectatrix	Bermuda chub					O				
Pomacentridae – damselfishes										
Chromis cyanea	blue chromis	R	O							
Chromis enchrysura	yellowtail reeffish	F		X		F	X	F	C	X
Chromis scotti	purple reeffish	A	X	X		A	X	A	A	X
Stegastes partitus	bicolor damselfish	F	C			O	X	R	O	X
*Stegastes planifrons**	threespot damselfish									
Stegastes variabilis	cocoa damselfish	F	O	X	X	A	X	C	C	X
Labridae – wrasses										
Bodianus rufus	Spanish hogfish	R				R	X			X
Bodianus pulchellus	spotfin hogfish					R				
Clepticus parrae	creole wrasse						X			
Halichoeres bathyphilus	greenband wrasse									X
Halichoeres cf. *bivittatus*	slippery dick	C	C	X		A	X	A		X
Halichoeres caudalis	painted wrasse	C				F		R		X
Halichoeres garnoti	yellowhead wrasse					R				X
Halichoeres pictus	rainbow wrasse					R		R		
Lachnolaimus maximus	hogfish	O	O			C	X	F		X
Thalassoma bifasciatum	bluehead	O	O			R	X			X
Xyrichtys novacula	pearly razorfish	O	R							X

Appendix F, continued.

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Scaridae - parrotfishes										
*Cryptotomus roseus**	bluelip parrotfish									X
Nicholsina usta	emerald parrotfish	O					X			X
Scarus cf. *iseri*	striped parrotfish	F	O	X		F	X	C	C	X
Sparisoma atomarium	greenblotched parrotfish			X						X
Sparisoma aurofrenatum	redband parrotfish	R					X			X
Sparisoma radians	bucktooth parrotfish	R								
Uranoscopidae - stargazers										
Kathetostoma albigutta	lancer stargazer					R				
Dactyloscopidae - sand stargazers										
Dactyloscopus tridigitatus	sand stargazer									X
Labrisomidae - labrisomids										
Labrisomus haitiensis	longfin blenny	O	X			O		R		X?
*Malacoctenus triangulatus**	saddled blenny									X
Starksia ocellata	checkered blenny				X	C		R		
Chaenopsidae - pikeblennies										
Emblemaria atlantica	banner blenny				X	F		O		
Emblemaria piratula	pirate blenny				X	R				
Blenniidae - combtooth blennies										
Hypleurochilus bermudensis	barred blenny				X					
*Hypleurochilus caudovittatus**	zebratail blenny									X
Parablennius marmoreus	seaweed blenny	F	C		X	A	X	C		X
Gobiesocidae - clingfishes										
Gobiesox strumosus	skilletfish				X	R				
Gobiidae – gobies										
Coryphopterus glaucofraenum	bridled goby	F				A	X	X		X
Coryphopterus punctipectophorus	spotted goby		C			A		X		X
Evermannichthys spongicola	sponge goby				X	R				
Elacatinus oceanops	neon goby	C	X	X		A	X	C		X

Appendix F, continued.

Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This Study
Gobiidae (continued)										
Elacatinus xanthiprora	yellowprow goby	O	R	X	X	C	X	C		X
Gobulus myersi	paleback goby					F				
Lythrypnus elasson	dwarf goby					F				
Lythrypnus nesiotes	island goby				X	C				
Psilotris celsus	highspine goby				X	F				
Risor ruber	tusked goby					O				
Microdesmidae - dartfishes										
Ptereleotris calliura	blue dartfish	F				C		C		X
Ephippidae - spadefish										
Chaetodipterus faber	Atlantic spadefish	R					X			X
Acanthuridae - surgeonfishes										
Acanthurus bahianus	ocean surgeonfish						X			X
Acanthurus chirurgus	doctorfish	O	R				X			X
Acanthurus coeruleus	blue tang						X			
Sphyraenidae – barracudas										
Sphyraena barracuda	great barracuda					F	X			X
Scombridae - mackerel										
Scomber japonicus	chub mackerel					R				
Scomberomorus cavalla	king mackerel	X				R	X			
Balistidae - leatherjackets										
Balistes capriscus	gray triggerfish	F	R			C	X	F		X
Monacanthidae - filefishes										
Aluterus schoepfii	orange filefish					R	X			
Aluterus scriptus	scrawled filefish					R				
*Cantherhines macrocerus**	whitespotted filefish									X
Cantherhines pullus	orangespotted filefish						X			X
Monacanthus ciliatus	fringed filefish					R				
Stephanolepis hispidus	planehead filefish	O				R	X			
Stephanolepis setifer	pygmy filefish	O								

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Scientific Name	Common Name	Smith et al. 1975	Smith 1976	Hopkins et al. 1977	Livingston 1979	Hopkins et al. 1981	Tyler 1983	Clarke 1986	Shipp et al. 1986	This study
Ostraciidae - boxfishes										
*Acanthostracion polygonia**	honeycomb cowfish									X
Acanthostracion quadricornis	scrawled cowfish	O				R	X			X
Tetraodontidae - puffers										
*Canthigaster jamestyleri**	goldface toby									X
Canthigaster rostrata	sharpnose puffer	O				O	X	O		X
Sphoeroides spengleri	bandtail puffer	O				O	X	R		
Diodontidae - porcupinefishes										
Chilomycterus schoepfii	striped burrfish					O	X			
*Diodon holocanthus**	balloonfish									X
	No. Taxa	125	46	14	12	125	77	51	11	84