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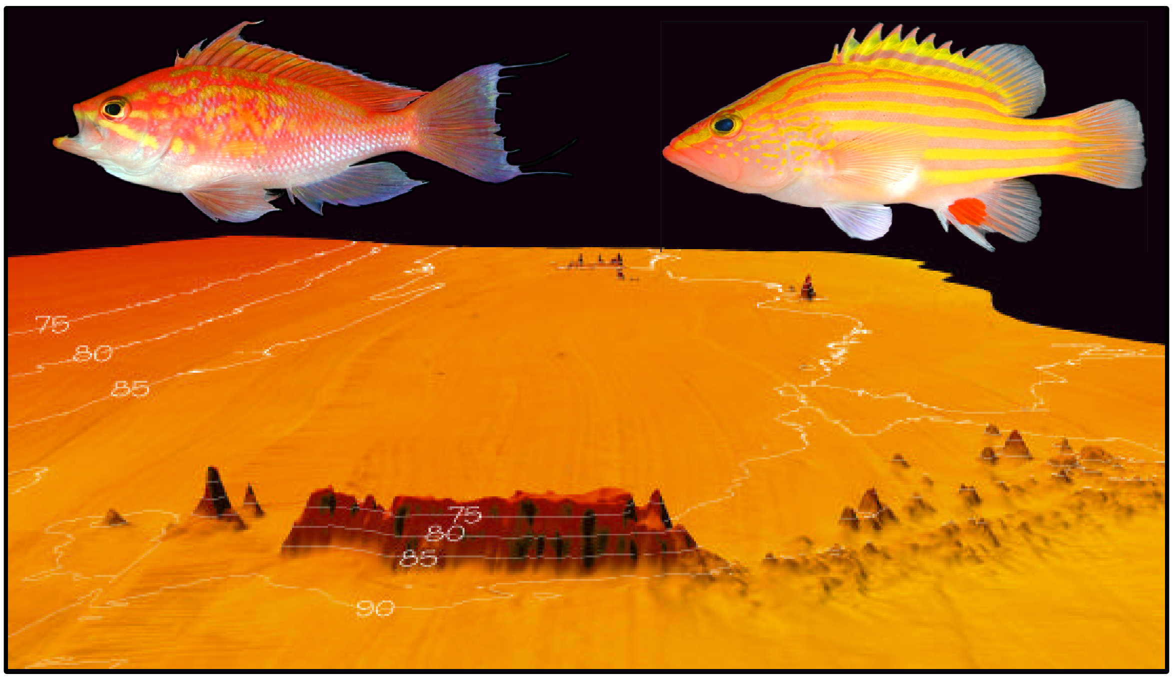
Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program

Community Structure and Trophic Ecology of Fishes on the Pinnacles Reef Tract



U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Community Structure and Trophic Ecology of Fishes on the Pinnacles Reef Tract

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June 2002

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U.S. Department of the Interior
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PROJECT COOPERATION

This study was undertaken to meet information needs identified by the U.S. Geological Survey (USGS), Outer Continental Shelf Ecosystem Program in concert with the Minerals Management Service (MMS).

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The following datasets are available as read-only files on the Florida Caribbean Science Center Website at http://www.fcsc.usgs.gov/index.html:
Located in: Pinnacles Tech Report/
- Pinnacles Master Station Log.xls
- Pinnacles Master Specimen Log.xls
- USGS Technical Report 2001-0008.doc
- USGS Technical Report 2001-0008.pdf

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EXECUTIVE SUMMARY

Topographic prominences form reef-like features along the outer continental shelf (OCS) edge and continental slope of the southeastern United States and Gulf of Mexico. An extensive set of reef features, known as the Pinnacles Reef Tract, occurs off Mississippi and Alabama at depths between 60 and 110 m. In this area recent research has focused largely on distribution of reef structures, their geology and physical characteristics, and processes relating to their origin. Community ecology studies have been limited in scope, confined mainly to distribution of sessile megafaunal and incidental observations of fishes. This study's goal was to determine patterns of fish community structure and trophic relationships on Pinnacles reef and reef-associated biotopes. We examined variation in hard-bottom reef fish assemblages with reef topography and geographic location, to identify faunal differentiation associated with reef profile, biotopes, area, and depth. In addition, trophodynamic investigations were undertaken using food habits and food web structure of Pinnacles Reef Tract fishes. Analysis of food web structure was used to identify the relative importance of resident reef fishes (autochthonous) versus off-reef trophic resources (allochthonous). This study was a component of the overall Minerals Management Service (MMS) Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program (NEGOM-CMEP), designed to compliment other synoptic programs. It focused on hard-bottom features that serve as essential fish habitat for reef fishes on the OCS in areas of oil and gas development.

Ten sites within the combined Mississippi-Alabama Marine Ecosystems Study and Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study (MAMES/MASPHTHMS) area were visited on the initial cruise. An additional eight study sites were visited on subsequent cruises. High Resolution Multi-Beam Swath bathymetric maps were completed in the Pinnacles Reef Tract to provide detailed maps of the geomorphology of study reefs. These high-resolution images have been used to guide subsequent sampling. The combined sampling effort for all cruises comprised 326 stations, apportioned into 112 angling, 63 trap, 22 bottom trawl, 58 remotely operated vehicle (ROV), 15 dredge/core/grab, and 37 plankton stations, with a small number of stations representing bottom surveys, CTD casts, light meter deployments, and exploratory sampling gear. All sampling combined returned over 6,000 specimens for food habits analyses, taxonomic verification and documentation, and subsequent life history analyses. Shipboard photographs documenting 113 fish species were obtained. ROV surveys resulted in about 85 hours of reef and reef-associated biotope observations and were used for analysis of resident fish fauna.

The results of this study have expanded the number of fishes documented from the Pinnacles Reef Tract, and is the first extensive collection of deep (greater than 60 m) reef fishes made in this region, and possibly worldwide. Of the 159 species documented from collected specimens or via videotape, 88 were identified from ROV censuses, and 70 can be classified as obligate reef-fishes belonging to the Caribbean reef-fish fauna. Such obligate reef fishes have life histories tied to three-dimensional hard-bottom habitats, and would not otherwise be found on the OCS open shelf. An additional 32 species are facultative reef associates that range broadly over OCS habitats, but occur on reef habitat,

when available. ROV surveys revealed the dominance of planktivorous reef fishes on high profile reef features. Anthiine fishes (small planktivorous seabasses) numerically dominate the deep reef fish community, and may serve as a keystone species by foraging in the water column and transferring energy to the deep reef ecosystem. The diurnal nature of the fauna is evident in that the total number of individuals was significantly lower at night especially on shallow reefs. While small diurnal planktivores are considered to be an important link between open water plankton and the reef, nocturnal planktivores may play a relatively important role in the overall energetics of the reef community. Based on ROV analysis of fish faunal composition, species richness and relative abundance of reef fishes differs among biotopes (reef top, reef crest, reef face, reef base, talus zone, and sand flats). Cluster analysis grouped reefs by depth trend and relief.

At least 250 reef-associated fishes have been documented from offshore banks, reefs, and other hard-bottom habitats in the northern Gulf of Mexico based on previous literature. The suite of primary reef fishes inhabiting the Pinnacles Reef Tract represents a depauperate, winnowed fraction of the Caribbean reef-fish fauna. It can be hypothesized that the known Pinnacles reef fish diversity is diminished relative to the Caribbean due to: 1) distance from the source fauna, 2) depth limitation, 3) temperature limitation, 4) habitat limitation due to turbidity, 5) trophic limitations, 6) fishing pressure, or 7) incomplete sampling. Environmental conditions per se do not appear to control reef fish distribution in the area. Based on the analysis presented here the lack of a full range of reef habitats, such as coral and coralline algae dominated communities, is the greatest influence on taxonomic structure. In addition, heavy fishing pressure may have substantially altered the reef fish community. Trophic structure can assist in evaluation of overfishing of large predators and the associated shift in the reef fish community. The numerical dominance by small and medium planktivorous reef fish taxa in shelf-edge reef communities in the Pinnacles Reef Tract has likely been magnified by removal of piscivores through recent increases in commercial fishing activity in this region.

Trophodynamic investigations undertaken in the present study include feeding habits and food web structure of Pinnacles Reef Tract fishes. Defining trophic pathways is the key to developing an understanding of the ecological framework in the reef fish community. Analysis of food web structure also identifies relative importance of resident reef fishes versus off-reef trophic resources such as adjacent soft-substrate and pelagic prey in the diet of large predatory fishes, predator-prey relationships among fishes and invertebrates, and may also identify potential pathways of energy transfer from fishes to the benthic invertebrate assemblage through the release of fecal material.

A food web model was developed for the Pinnacles fish community, based on numerical contribution of prey to the diet of each predator. Over 1000 individuals were examined for food habits, with approximately 50% containing prey items. Fish were assigned to feeding guilds based on stomach contents to identify similarity in prey resources among species, sources of prey, and overall patterns in trophic structure. The numerically dominant species (greater than 80% of the individuals observed by ROV) on high profile reefs, roughtongue bass and red barbier, have diets dominated by calanoid copepods, gastropod larvae, and a variety of other pelagic mesoplankton. The generalized carnivore guild was represented by numerous taxa including tattler and a variety of serranids, scorpaenids, muraenids, and holocentrids. This guild contains the most taxa of deep reef fishes, although individual species are not as numerically abundant as planktivores and benthic carnivores in reef communities.

Anthiine fishes may serve as a keystone predator by foraging in the water column and transferring energy to the deep reef ecosystem. Anthiines in turn become prey for a variety of reef predators. Dense populations of Pinnacles fishes appear to exceed levels that could be supported solely by locally produced prey resources. Fishes on deep reefs must therefore be "subsidized" by passive transport of prey from surrounding benthic or pelagic habitats on water currents, or via active feeding migrations of predators to adjacent areas of the water column or the underwater landscape. Large predators, including greater amberjack and red snapper, utilize prey from pelagic, reef, and soft-bottom habitats and provide pathways of energy transfer.

The numerical dominance of planktivorous reef fish taxa in shelf-edge reef communities and vermilion snapper in our hook and line samples in the Pinnacles Reef Tract have likely been magnified by removal of piscivores through recent increases in commercial fishing activity in this region and historical fishing practices throughout the northwestern Gulf of Mexico since the mid 1800's. While our observations of trophic structure in the deep reef community closely resemble those observed in the Indo-Pacific, the reef fish community structure may have been greatly altered by human activity through fishing during the past century.

Fishes and invertebrates have been characterized at the Pinnacles Reef Tract by three major studies and all major reef features have been precisely mapped. This area may be the most well-known deep hard bottom area in the world. Thus we postulate that the majority of the reef fish species that occur at depths between 60 and 110 m are now documented. Yet due to the large area and diversity of habitat further scientific inquiry will continue to add to our knowledge of the fish fauna. Our present knowledge of the Pinnacles ichthyofauna can be used to characterize the fundamental taxonomic composition and trophic structure of deep reef-fish communities throughout southeastern United States and Gulf of Mexico OCS areas and therefore be useful in assessing future anthropogenic impacts on faunal structure.

CHAPTER 1

COMMUNITY STRUCTURE OF PINNACLES REEF TRACT FISHES

BACKGROUND AND INTRODUCTION

Topographic prominences form reef-like features along the continental shelf edge and continental slope of the southeastern United States and Gulf of Mexico. Such reefs have been known in the northern Gulf for over 70 years (Trowbridge 1930, Shepard 1937, Ludwick and Walton 1957, Moore and Bullis 1960). Shepard (1937) discussed the distribution of salt domes throughout the northwestern Gulf of Mexico based on fathometer surveys conducted by the U. S. Coast and Geodetic Survey in 1936, and Goedicke (1955) applied the term "pinnacles" to describe outer shelf features in the northern Gulf, including East and West Flower Garden Bank. Subsequently, Ludwick and Walton (1957) followed suit, using the term pinnacles to refer to steep-sided reef-like structures on the outer shelf in the northeastern Gulf. Historically, the term pinnacles included the entire class of reef structures rising from the open shelf, whether the top of the structure is spire-like, flat, or ragged, and regardless of the areal size or height of the overall structure (**Fig. 1.1**).

Shelf-edge prominences, including northeastern Gulf pinnacles, include structures of very heterogeneous origins (Gittings et al. 1992a, Gardner et al. 2001). West of the Mississippi, many shelf-edge banks are formed by the extrusion of salt domes (diapirs) from the surrounding seafloor, and are either capped with contemporary communities of reef-building organisms such as scleractinian corals, or are characterized by exposed carbonate rocks that are colonized by a diverse assemblage of sessile invertebrates (Rezak et al. 1985, Gittings et al. 1992a, Hardin et al. 2001). In the western Gulf off south Texas, shelf-edge prominences are non-diapiric drowned fossil coral-algal reefs (Rezak et al. 1985). East of the Mississippi, relatively few diapiric structures occur and are primarily located along the western portion of the Mississippi-Alabama shelf (Gittings et al. 1992a).

Most shelf-edge (60 to 110 m) features in this region appear to be non-diapiric, drowned, or fossil reefs initially formed during low sea level stands during the Pleistocene, and colonized by invertebrate communities [Continental Shelf Associates (CSA) 1992, Sager et al. 1992, Gittings et al. 1992a, Hancock 1997, Continental Shelf Associates and Texas A&M University (CSA & TAMU) 2001, Gardner et al. 2001]. Hard-substrate features supporting reef-like communities also occur on slide scar features that are exposed by slumping of the upper continental slope (Gardner et al. 2001) or on banks built by ahermatypic corals such as *Lophelia pertusa* (Linnaeus 1758) (Moore and Bullis 1960, Rogers 1999).

With few exceptions (e.g., Flower Garden Banks) outer continental shelf (OCS) reefs throughout the northern Gulf of Mexico lie in waters that are either too deep for sufficient light penetration, or seasonally too cold or too turbid to support hermatypic corals and

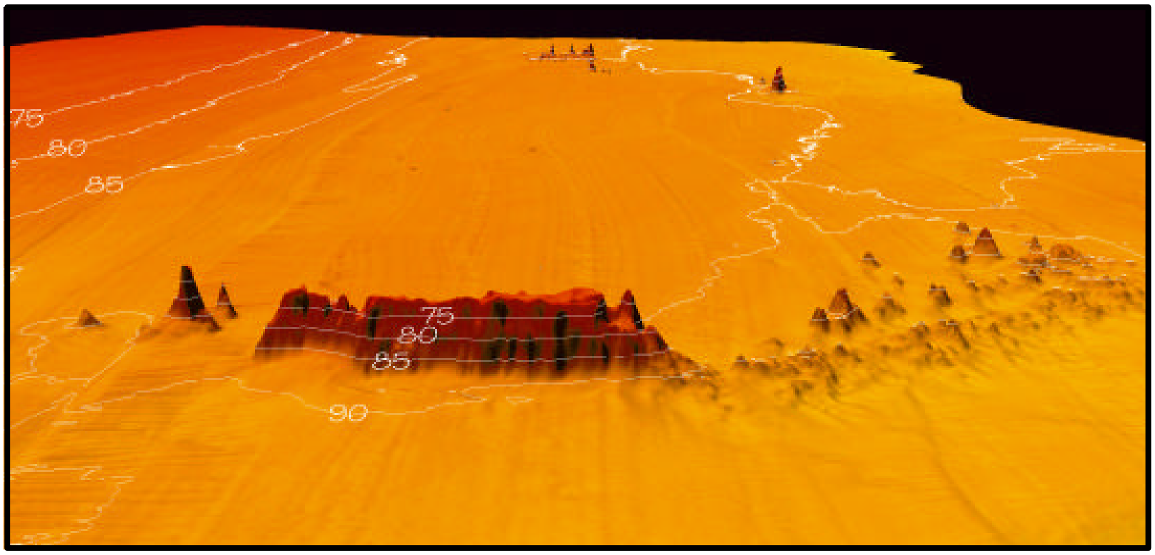

Figure 1.1. Oblique view of the Alabama Alps study site and 36 Fathom Ridge area along the Pinnacles Reef Tract, showing the variability in outer shelf reef morphology (map provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 10X. Isobaths in meters.

most forms of algae (Rezak et al. 1985). In the northeastern Gulf, OCS deep reefs (>60 m) are predominantly fossil structures that do not harbor hermatypic corals, extensive coralline or leafy algae communities (CSA 1992, Gittings et al. 1992a, Sager et al. 1992, Hancock 1997, CSA and TAMU 2001). There appears to be considerable production of biogenic debris by benthic organisms that colonize these reefs, as evidenced by coarse composition of sediment and high acoustic backscatter samples near features (Sager et al. 1992, Sager and Schroeder 2001, Gardner et al. 2002, Gardner et al. 2001). Moreover, many topographic features display evidence of extensive historical subaerial erosion (i.e., flattening of reef tops at lower sea level stages) and submarine sculpturing by scouring and bioerosion (resulting in the formation of basal undercuts, hollows and caves). Although the major coral reef builders are absent in pinnacle megafaunal communities, some biological deposition continues due to growth of ahermatypic corals, bryozoans, calcareous worms, and other calcium depositing and cementing organisms on the surface of these features (Sager et al. 1992, Hancock 1997, CSA and TAMU 2001).

Reef communities of the OCS have been comprehensively studied in the northwestern Gulf (Bright et al. 1984, Rezak et al. 1990, Gittings et al. 1992b, Gittings and Hickerson 1998). However, assessment of fish community structure has been primarily taxonomic and qualitative (Bright and Cashman 1974, Rezak et al. 1985), or semi-quantitative (Dennis and Bright 1988a). Long-term monitoring on the Flower Garden Banks has concentrated on corals, with limited attention to quantitative assessment of fish populations (Gittings et al. 1992b).

Early investigations on the distribution of OCS reefs in the northeastern Gulf began in the middle of the 20th century. Relative to the technology of the time, the pioneering research of Ludwick and Walton (1957) was remarkable in its scope and breadth, laying the foundation for most subsequent geological and biological research on OCS deep reefs in the Gulf of Mexico. Using single-beam acoustic transects, Ludwick and Walton mapped the location of OCS pinnacles all along the northern Gulf from the Mississippi Delta to Port St. Joe, Florida. They produced the first bathymetric chart of the zone of pinnacles and reconstructed basal topography underlying the pinnacles. They measured physical and chemical seawater properties, mapped sediments and foraminiferal populations, and identified the major biological contributors to fossil reef formation from dredged reef rock. Ludwick and Walton also identified living sessile macrofauna and provided the first underwater photographs of pinnacles epifauna and bottom morphology.

Subsequent to Ludwick and Walton's work, major study programs of the Mississippi-Alabama Pinnacles Reef Tract (referred to hereafter as Pinnacles Reef Tract) have proceeded under the auspices of the Minerals Management Service (MMS) including the Mississippi-Alabama Marine Ecosystems Study (MAMES) (Laswell et al. 1990, Brooks 1991), Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study (MASPTHMS) (CSA 1992), and Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program (NEGOM-CMEP) (CSA and TAMU 2001). These studies have conducted bathymetric and habitat reconnaissance, side-scan mapping, oceanographic, physical, and biological characterization and monitoring of pinnacle features and their hard-bottom communities. These investigations have provided the site locations, bathymetric charts, physical background, and macrofaunal framework for this study of pinnacle reef fish communities (**Figs. 1.2, 1.3**). Our community structure study complements work accomplished simultaneously under the NEGOM-CMEP program.

In the northeastern Gulf, recent research on OCS reefs has focused largely on distribution of reef structures, their geology and physical characteristics, and processes relating to their origin (Brooks 1991; CSA 1992, Sager et al. 1992, Sager and Schroeder 2001). Community ecology studies have been limited in scope, confined mainly to distribution of sessile megafaunal invertebrates (Gittings et al. 1992a, CSA and TAMU 2001), and incidental observations of fish communities (Shipp and Hopkins 1978; Gittings et al. 1991, Thompson et al. 1999). Snyder (2001) investigated some aspects of reef fish community structure (taxonomic diversity, habitat association) during the NEGOM-CMEP program.

The present study affords a more comprehensive evaluation of community structure, biotope affinities, and trophic ecology of the Pinnacles Reef Tract fish fauna. Here we examine variation in hard-bottom reef fish assemblages with reef topography and geographic location, to identify faunal differentiation associated with reef profile, biotopes, area, and depth. We also identify food habits and trophic structure of Pinnacles fishes (Chapter 2). The present study led to the initiation of important high-resolution multi-beam swath bathymetry of Pinnacles habitat/topography as is depicted in the study sites description.

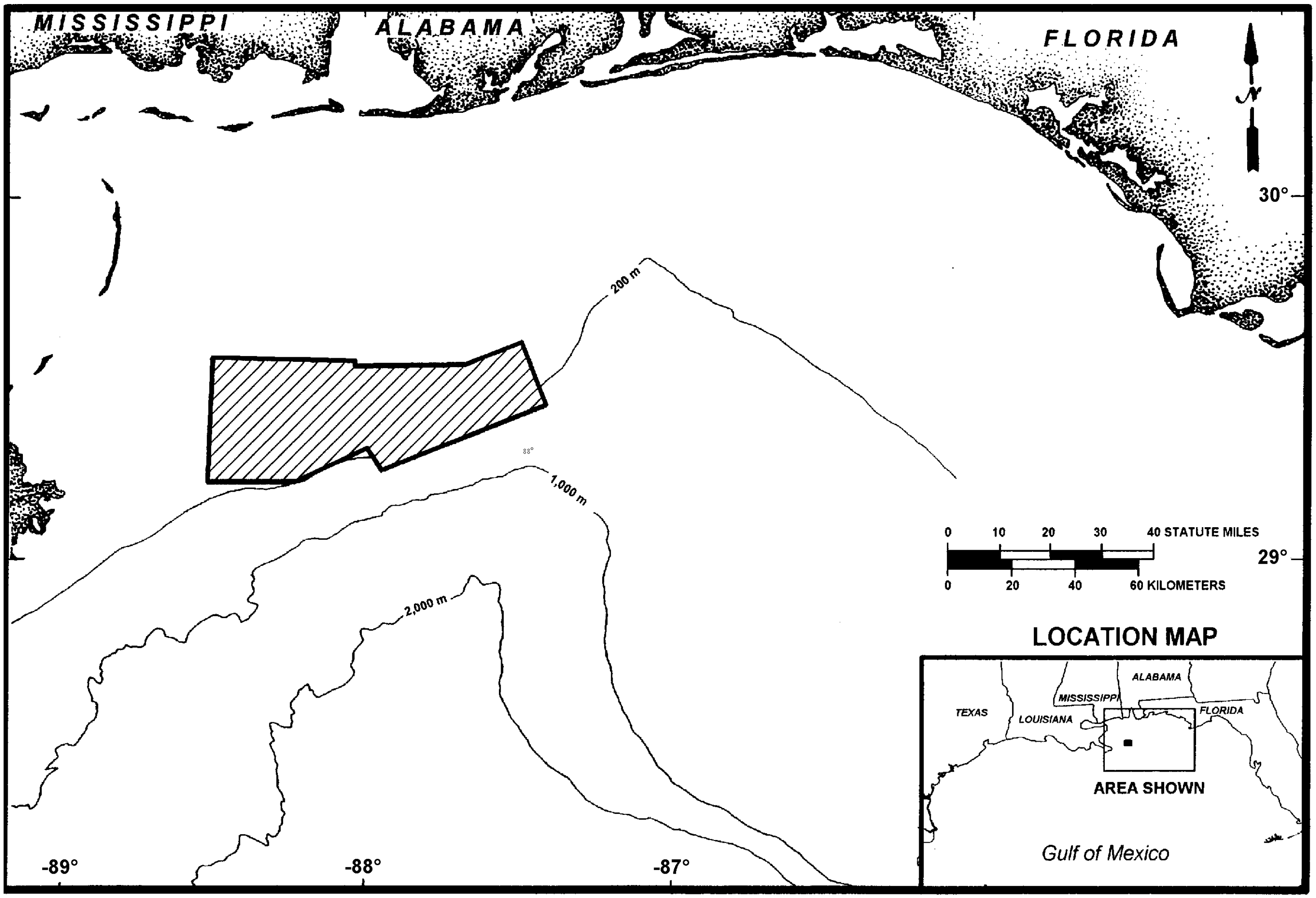

Figure 1.2. Northeastern Gulf of Mexico outer continental shelf with polygon marking the combined MMS MAMES and MASPTHMS study areas, enclosing the Pinnacles Reef Tract, including NEGOM-CMEP and USGS study sites (adapted from CSA and TAMU 2001).

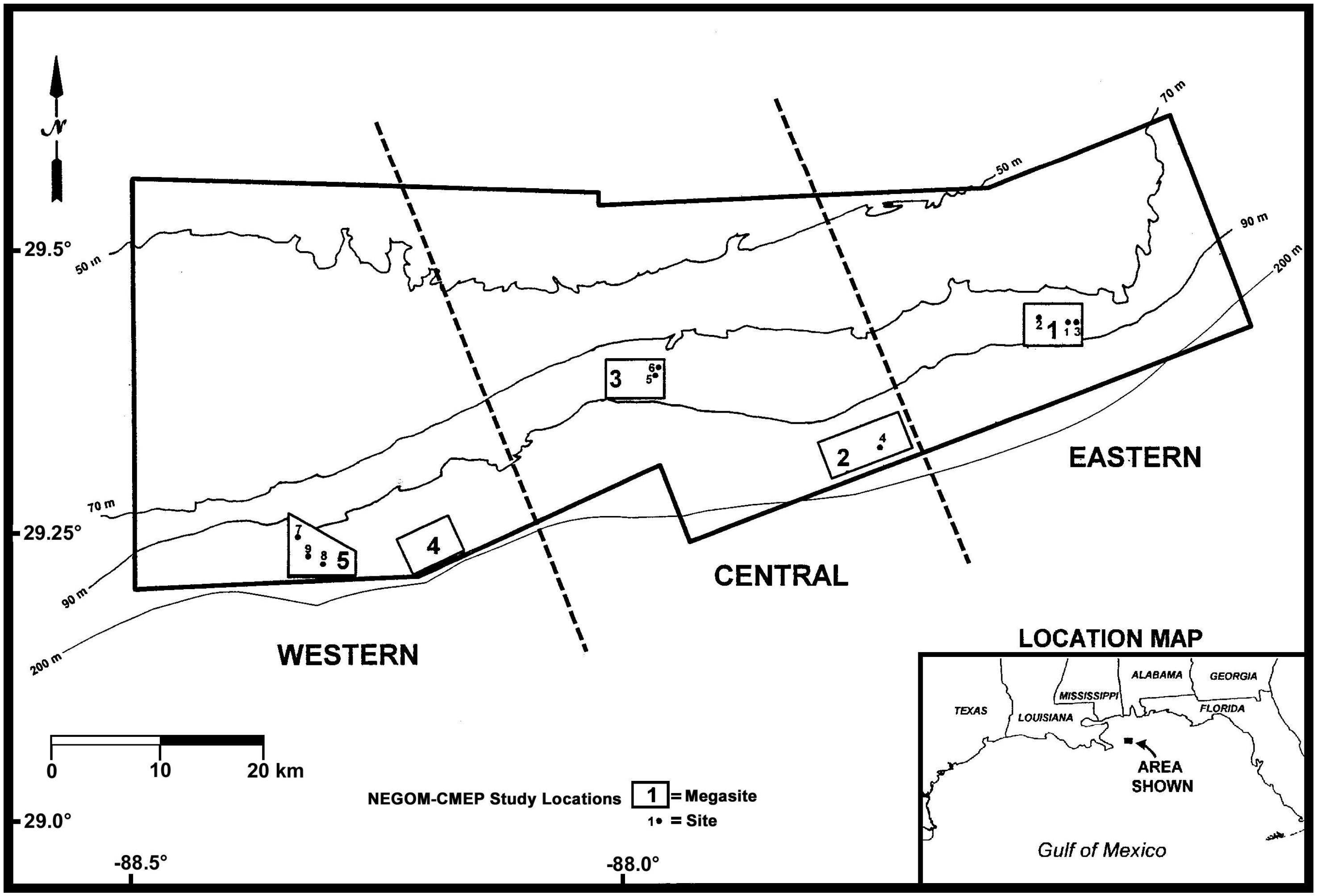

Figure 1.3. Locations of NEGOM-CMEP megasites (large numerals) and monitoring sites (small numerals) (adapted from CSA and TAMU 2001).

OBJECTIVES

A component of the overall NEGOM-CMEP Program, this study was designed to investigate aspects of fish community structure and compliment other synoptic programs. The study focused on hard-bottom features that serve as essential fish habitat for reef fishes on the OCS in areas of oil and gas development. The overall goal was to determine patterns of fish composition, community structure, and trophic relationships on Pinnacles reef and reef-associated biotopes. Project objectives were as follows:

- Using a broad range of sampling and video methods, qualitatively define taxonomic composition of fishes associated with steep-sided, reef-like, hard-bottom structures comprising the Pinnacles Reef Tract of the northeastern Gulf of Mexico.

- Quantitatively define species composition, abundance, dominance rank order, and species richness of fishes according to reef type, relief, and biotope. In addition, the fish fauna of the near reef zone and surrounding soft bottom area were also characterized.

- Define food habits and tropic structure of Pinnacles reef fishes (Chapter 2).

Study Sites

Bathymetric charts produced during the MAMES (Laswell et al. 1990, Brooks 1991), MASPTHMS (CSA 1992), and NEGOM-CMEP programs (CSA and TAMU 2001) were used to locate areas of interest during the initial USGS reconnaissance cruise in 1997. Ten potential sites within the combined MAMES/MASPHTHMS polygon were visited on the initial cruise (**Table 1.1, Fig. 1.4**). An additional eight study sites were visited on subsequent cruises. During May/June 2000, High Resolution Multi-Beam Swath (HRMBS) bathymetric maps were completed in the Pinnacles Reef Tract to provide detailed maps of the geomorphology of study reefs (Gardner et al. 2000, Gardner et al. 2001, Gardner et al. 2002). High-resolution images resulting from that survey are included in this report, and were used to guide subsequent sampling.

Many of the sites for this study were selected within NEGOM-CMEP megasites to make use of data collected there by other investigators (**Figs. 1.3, 1.4**). Study reefs were selected from both the shallow reef trend (65-80 m) and deep reef trend (85-110 m). Eight main study reefs (five shallow, three deep) selected for fish community structure and trophodynamics study are described below:

1) **Roughtongue Reef** [1] - is a roughly elliptical (400 m major base diameter), high profile, flat-top structure with steep vertical sides (**Figs. 1.5A, 1.6**). The reef lies within NEGOM-CMEP Megasite 1 in the eastern part of the study area, in Destin Dome Lease Blocks 532 and 533, and corresponds to NEGOM-CMEP Site 1 (CSA and TAMU 2001) (**Fig. 1.3**). The general area containing this and the next two target reefs has historically

[1] names were designated by USGS for convenient reference and are not official geographic names

Table 1.1. Summary of USGS Pinnacles Reef Tract study locations. Geographic coordinates indicate general reef location.

Reef Name	Latitude (N) DD	Longitude (W) DD	Base Depth (m)	Crest Depth (m)	Max Relief (m)	Relief Category	Reef Area (ha)	Corresponding NEGOM-CMEP Location
Alabama Alps	29.2518	88.3373	88	72	16	High	20.0	Megasite 5, Site 7
Cat's Paw Reef	29.4396	87.5870	78	64	14	High	23.9	Megasite 1
Corkscrew Reef	29.4426	87.5445	78	66	12	High	13.8	none
Double Top Reef	29.3920	87.9830	80	68	12	High	3.0	Megasite 3
Far Tortuga	29.5571	87.4616	70	66	4	Intermediate	74.8	none
Ludwick and Walton Pinnacle 1	29.3268	87.7715	110	100	10	High	9.0	Megasite 4
L&W Pinnacle 2	29.3273	87.7680	110	100	10	High	7.0	Megasite 2, Site 4
L&W Pinnacle A	29.3428	87.7406	106	100	6	High	5.2	Megasite 2
L&W Pinnacle B	29.3386	87.7546	104	98	6	High	11.0	Megasite 2
L&W Pinnacle C	29.3400	87.7466	110	102	8	High	6.7	Megasite 2
L&W Pinnacle D	29.3350	87.7591	104	100	4	Intermediate	2.5	Megasite 2
L&W Pinnacle H	29.3265	87.7625	110	104	6	High	5.3	Megasite 2
NEGOM-CMEP Site 5	29.3938	87.9810	80	68	12	High	0.7	Megasite 3, Site 5
Patch Reef Field	29.4415	87.6915	71-77	69-75	3	Low	1000.0	none
Porgy Reef	29.4371	87.6180	78	68	10	High	19.4	Megasite 1
Roughtongue Reef	29.4415	87.5785	78	64	14	High	15.4	Megasite 1, Site 1
Scamp Reef	29.3250	87.7765	110	100	10	High	4.6	Megasite 2
Shark Reef	29.3965	88.0193	77	74	3	Low	1.2	Megasite 3
Solitary Mound 1	29.4558	87.6641	71	66	5	Intermediate	0.8	none
Solitary Mound 2	29.4643	87.6320	72	64	8	High	12.6	none
Triple Top Reef	29.3978	87.9915	76	68	8	High	3.6	Megasite 3
Yellowtail Reef	29.4403	87.5751	68	60	8	High	13.9	Megasite 1

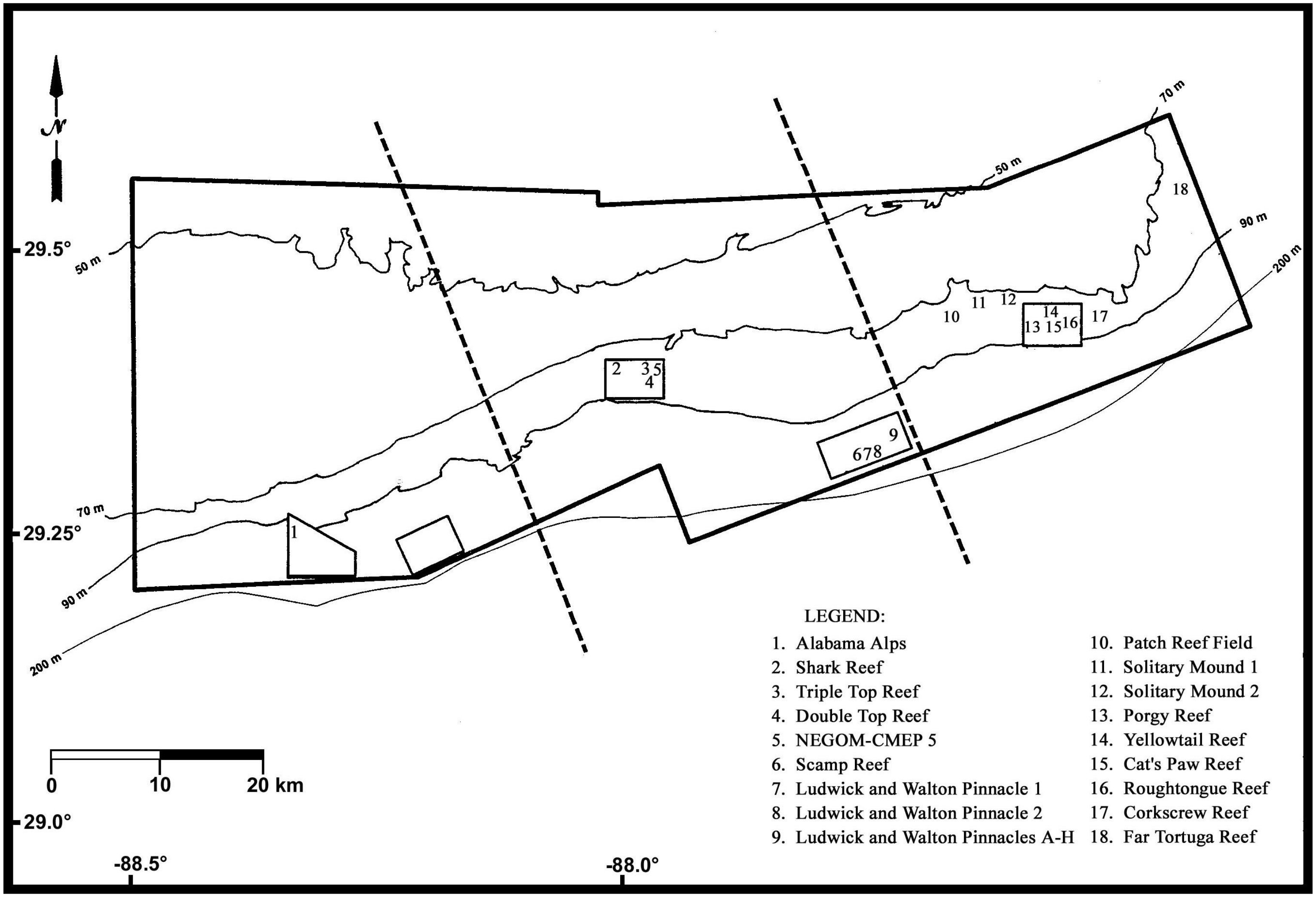

Figure 1.4. USGS Pinnacles Reef Tract study sites in relation to NEGOM-CMEP megasites (open boxes) (adapted from CSA and TAMU 2001).

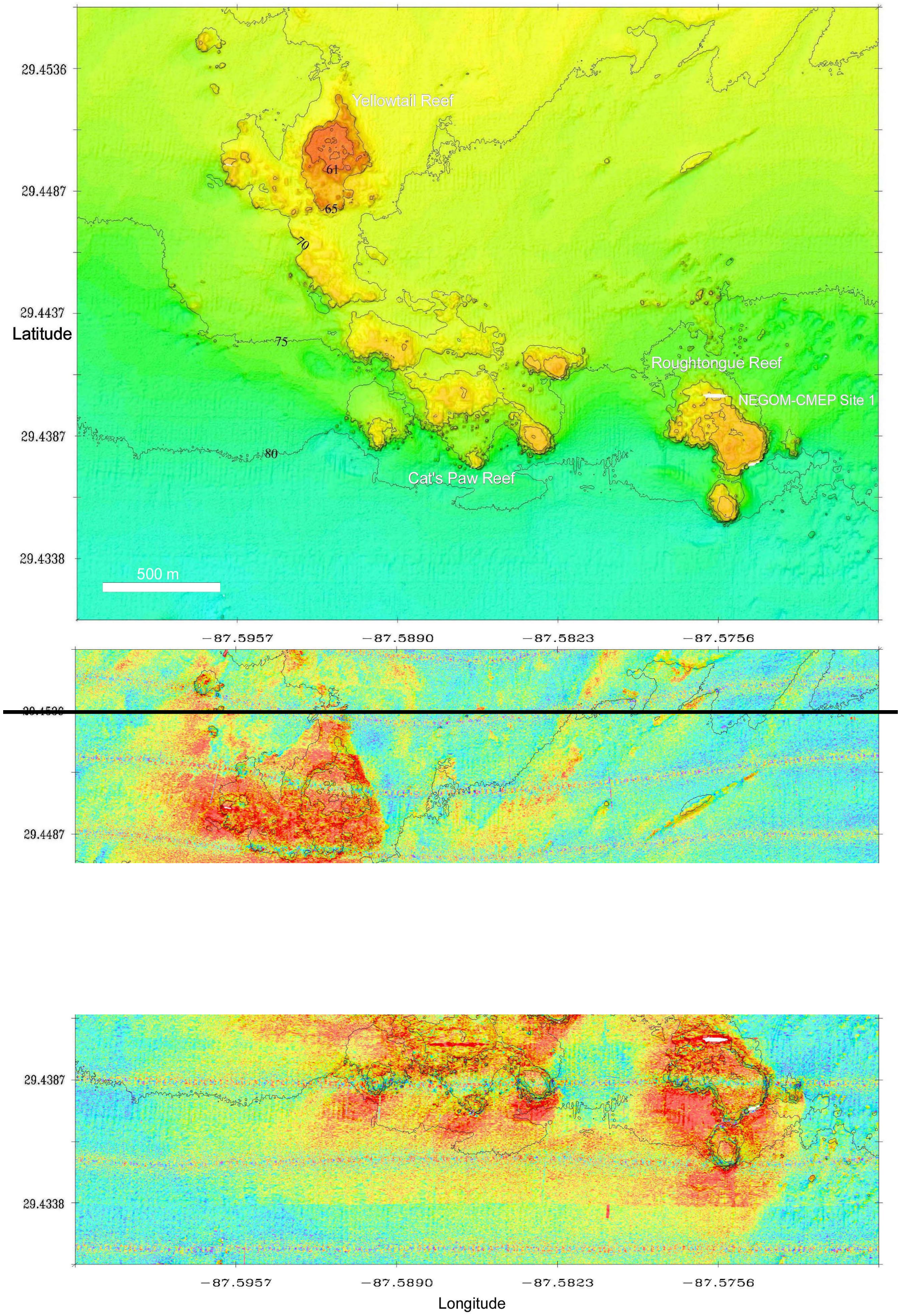

Figure 1.5. **A**. High-resolution multi-beam swath bathymetry for 40 Fathom Fishing Ground area with study sites. **B**. Acoustic backscatter for same area differentiating sediment type. Horizontal lines are due to sampling artifacts. Red indicates high backscatter and blue low backscatter (provided by J. Gardner, USGS, Menlo Park, CA). Isobaths in meters.

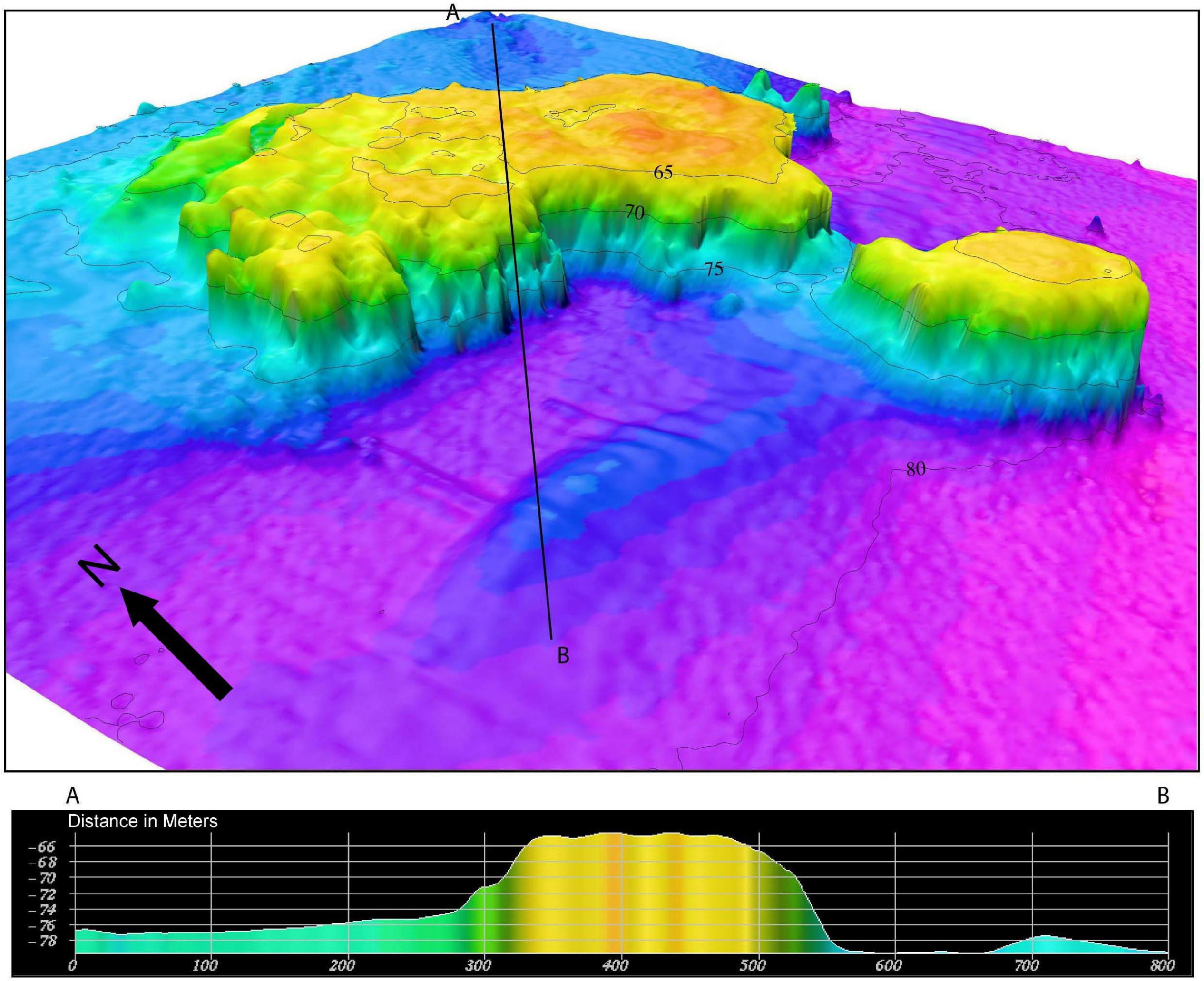

Figure 1.6. High-resolution multi-beam swath bathymetry for Roughtongue Reef study site (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 9X. Transect line drawn from point A to B depicts reef in cross-section. Isobaths in meters.

been called the 40 Fathom Fishing Ground by fishermen, and in the MAMES program this area is referred to as the Eastern Delta Mounds (CSA and TAMU 2001). Roughtongue Reef belongs to the shallow pinnacle trend, with a base depth of 80 m (**Fig. 1.6**). Extensive areas of accumulated sediments occur on the reef flat top and a diverse, dense invertebrate assemblage occurs throughout the interior (Hardin et al. 2001). Vertical rock faces, boulders, and rock outcrops occurring along the sides and surrounding the feature display eroded surfaces, and typically have lower invertebrate densities, dominated by the solitary coral *Rhizopsammia manuelensis* Chevalier 1966 and other small ahermatypic species (Hardin et al. 2001). Attached to the main reef is a smaller mound immediately to the south. The reef is surrounded by an extensive area of high acoustic backscatter resulting from coarse reef-derived sediment or hard substrates (**Fig. 1.5B**, red area). The USGS designated name refers to the common name for the small planktivorous serranid, *Pronotogrammus martinicensis*, the roughtongue bass, which is extremely abundant on this reef.

2) **Cat's Paw Reef** is a group of six small, medium to high profile, flat-topped mounds, arranged in the pattern of a "cat's paw" print, with 5-10 m relief (**Figs. 1.5, 1.7**). This cluster of mounds lies about 1000 m west of Roughtongue Reef in the 40 Fathom Fishing Ground, NEGOM-CMEP Megasite 1 area (**Figs. 1.4, 1.5, 1.7**) and is within Destin Dome Lease Block 532. Individual reef formations within the feature have flat top communities present with limited sediment cover, highly eroded and sculpted rock surfaces with vertical faces along edges of features. Small soft corals are abundant on horizontal surfaces, solitary coral colonies (including *R. manuelensis*), with spiral sea whips, antipatharians, and crinoids also common. Coarse sand substratum was present around reef features, and silt was not evident on sediment surfaces.

3) **Yellowtail Reef**, a single, elliptical (200 m base diameter), high-profile, flat-top structure, that reaches the shallowest crest depth (60 m) of all study sites (**Table 1.1, Fig. 1.8**). This structure also belongs to the 40 Fathom Fishing Ground group, and lies within NEGOM-CMEP Megasite 1 (**Fig. 1.5A**) within Destin Dome Lease Block 532. It forms the northwestern end of a reef arc, with Cat's Paw Reef at the center, and Roughtongue Reef lying at the southeastern end. Like other reef features in the group, an extensive flat top area is present, characterized by accumulated sediments and a dense invertebrate assemblage dominated by octocorals, antipatharians, sponges, and coralline algae. Rock outcrops characterize the northern extent of the feature, and these areas are heavily colonized by sessile invertebrates and coralline algae. The USGS designated name refers to the yellowtail reeffish, *Chromis enchrysura*, which is particularly abundant on this reef.

4) **Double Top Reef** is a horseshoe shaped (100 m base diameter), high profile structure that consists of multiple flat-top mounds with steep vertical sides (**Figs. 1.9, 1.10**). This structure lies within NEGOM-CMEP Megasite 3 (**Figs. 1.3, 1.4**) in the central part of the study area, in Main Pass Lease Block 223. A secondary mound attached to the northeast corresponds to NEGOM-CMEP Site 5 (**Fig. 1.9**). In the MAMES program this general area is referred to as the Near Shoreline Ridge (Brooks 1991). Double Top Reef belongs to the shallow pinnacle trend in the northeastern Gulf, and also includes a similarly-shaped series of mounds in the study area referred to as Triple Top Reef, and an adjacent, low profile

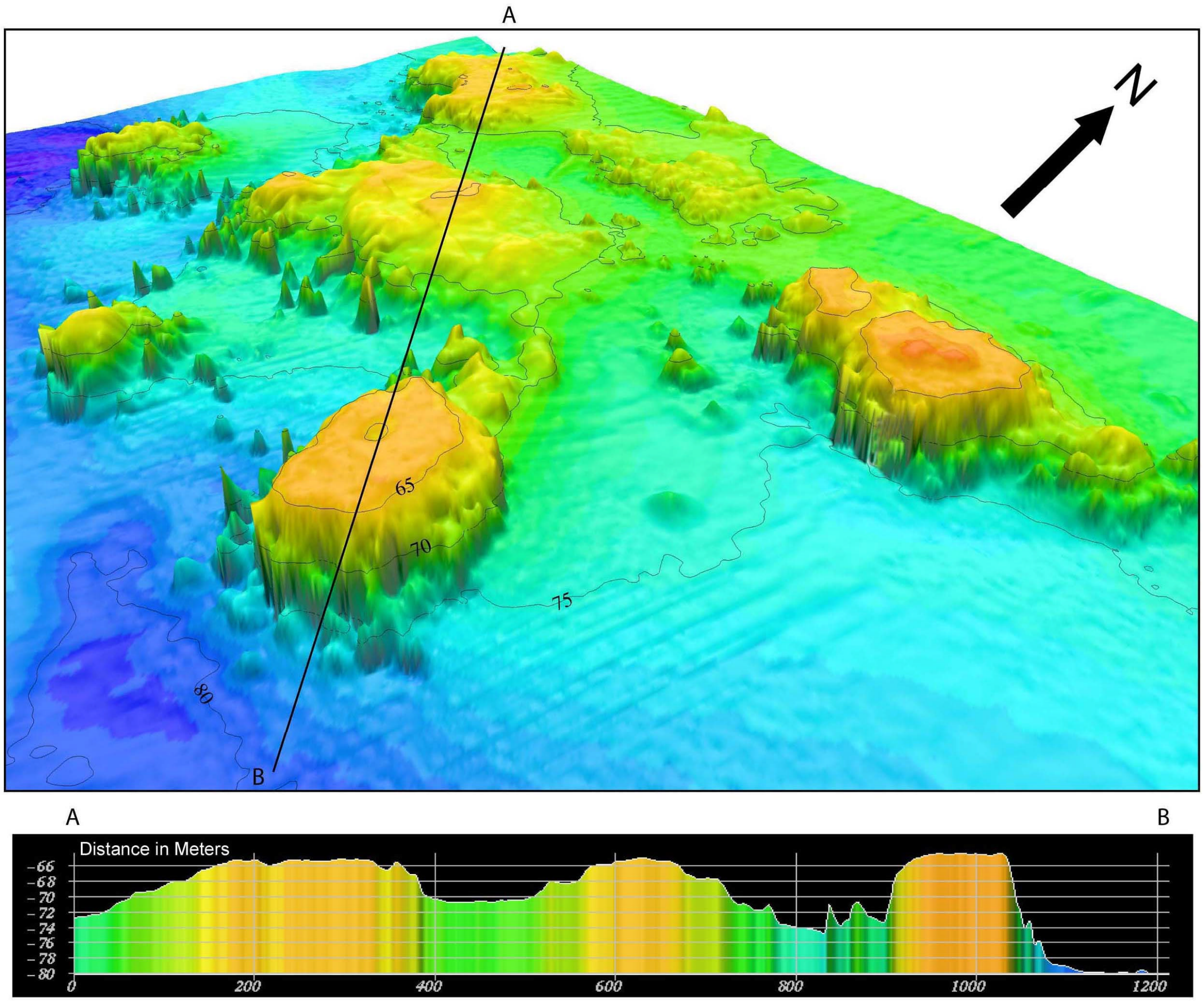

Figure 1.7. High-resolution multi-beam swath bathymetry for Cat's Paw Reef study site (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 9X. Transect line drawn from point A to B depicts reef in cross-section. Isobaths in meters.

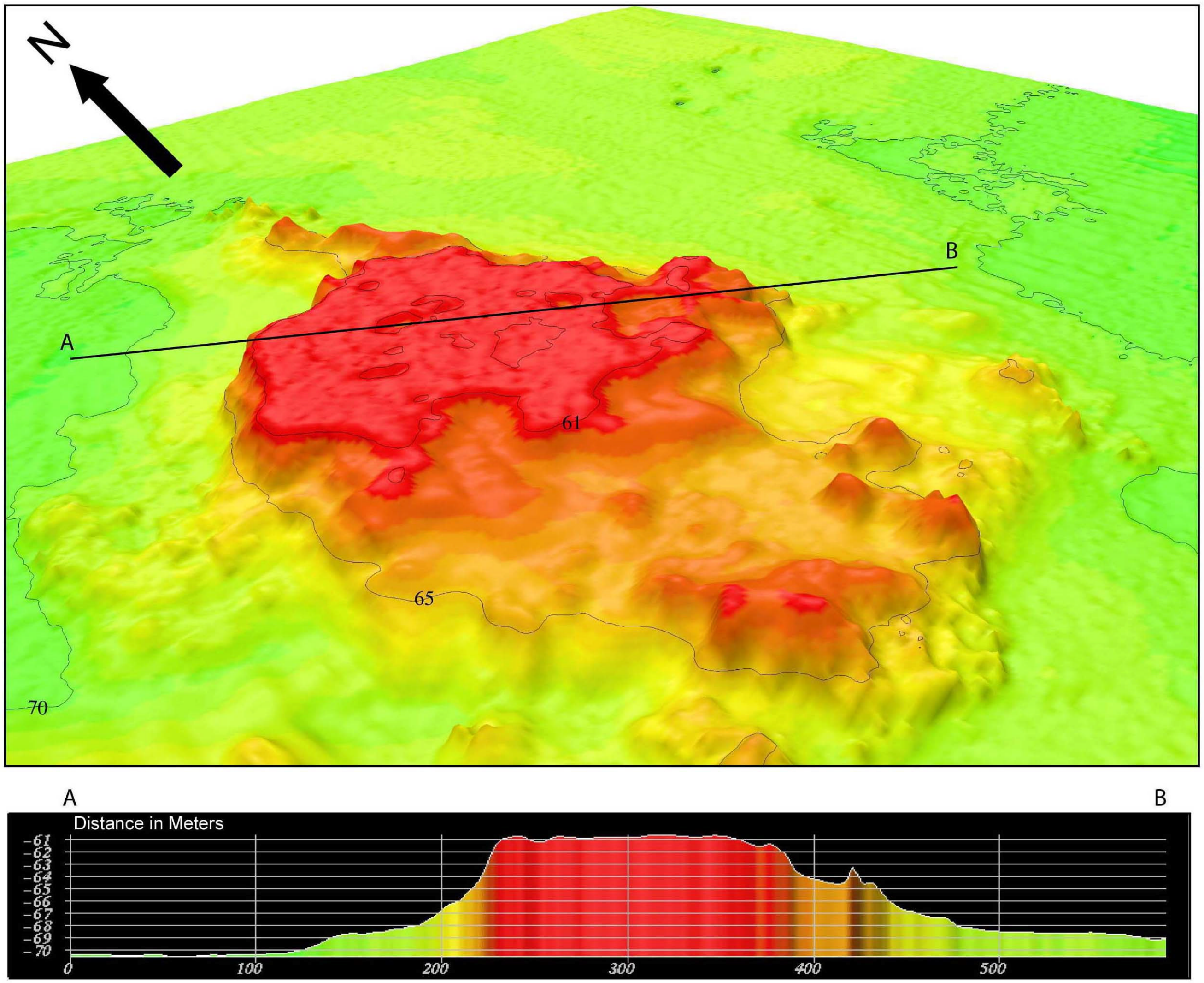

Figure 1.8. High-resolution multi-beam swath bathymetry for Yellowtail Reef study site (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 9X. Transect line drawn from point A to B depicts reef in cross-section. Isobaths in meters.

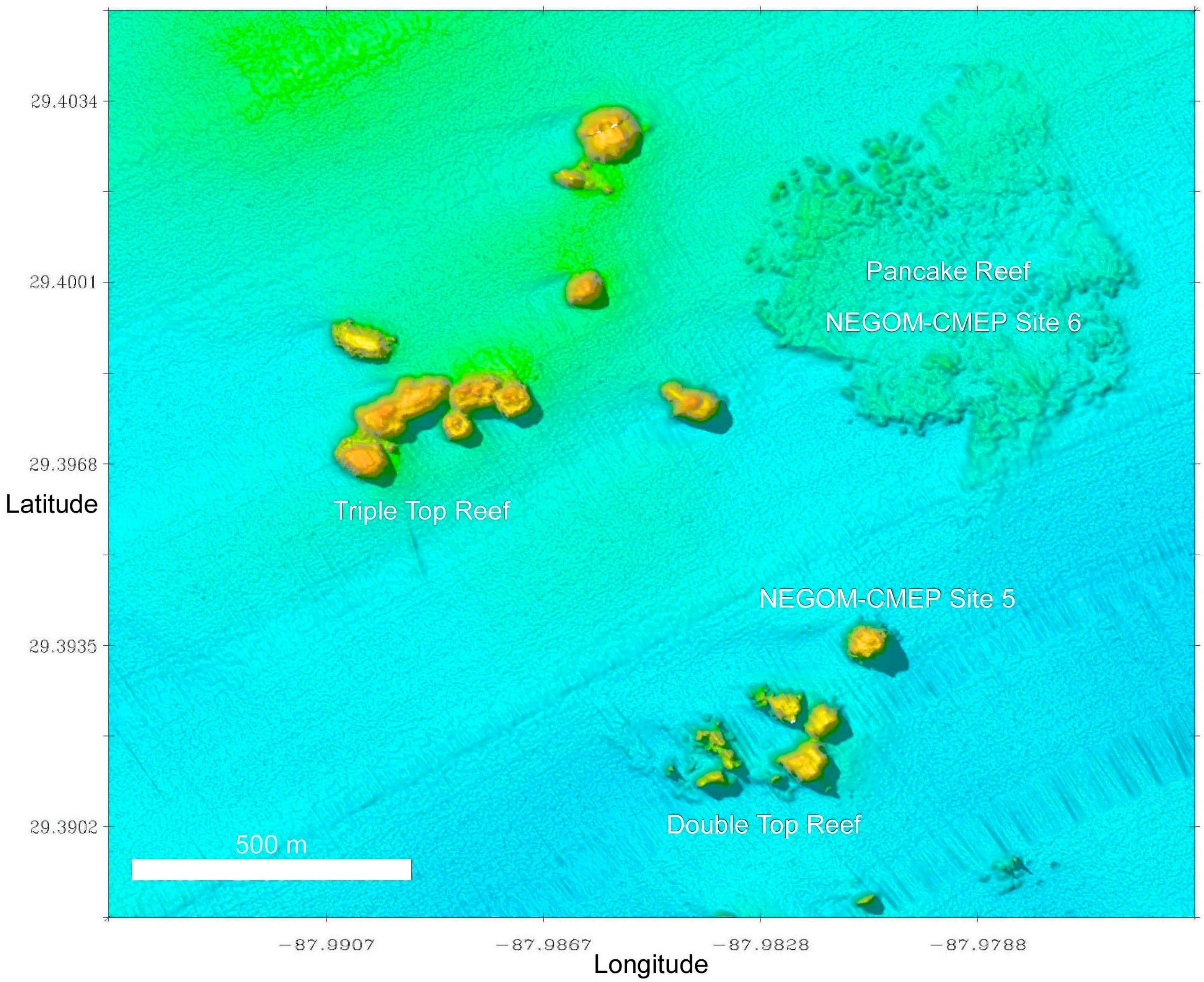

Figure 1.9. High-resolution multi-beam swath bathymetry for Near Shoreline Ridge area with study sites (provided by J. Gardner, USGS, Menlo Park, CA).

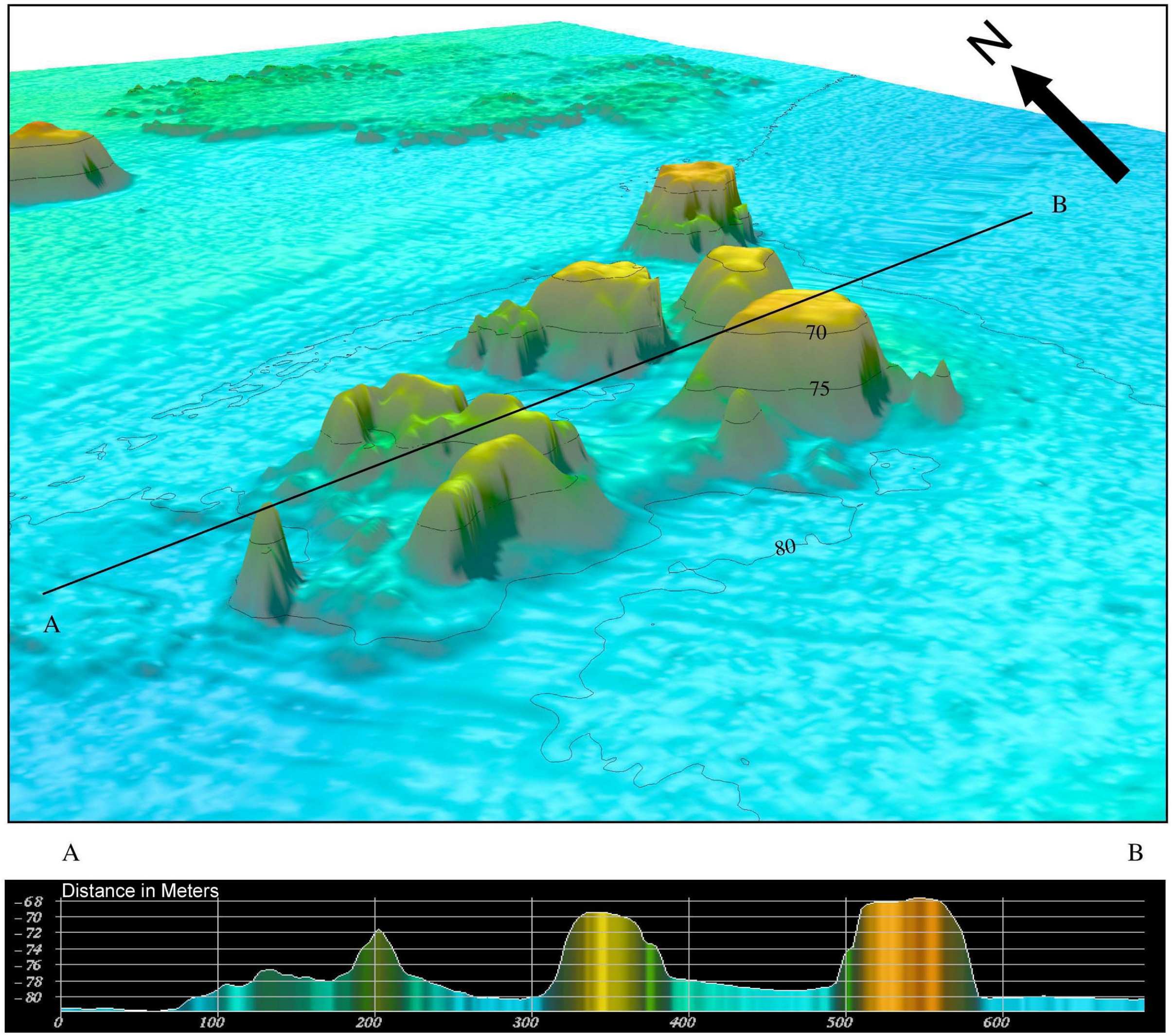

Figure 1.10. High-resolution multi-beam swath bathymetry for Double Top Reef study site (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 9X. Transect line drawn from point A to B depicts reef in cross-section. Isobaths in meters.

feature referred to as Pancake Reef that corresponds to NEGOM-CMEP Site 6 (**Fig. 1.9**). These features also have flat top communities characterized by high sediment cover and dense invertebrate assemblages dominated by octocorals and antipatharians, with few solitary corals. Vertical rock walls and overhangs are dominated by *R. manuelensis* and other solitary corals, and are highly sculpted and eroded. The USGS designated names refer to the topography of these reef structures. Double Top Reef and Triple Top Reef are not NEGOM-CMEP study sites.

5) **Alabama Alps** is a long, narrow, north-south aligned, high profile mound approximately 1000 m in length (**Figs. 1.11, 1.12**). This structure lies within NEGOM-CMEP Megasite 5 in the western part of the study area, in Main Pass Lease Block 286, and corresponds in part to NEGOM-CMEP Site 7. In the MASPTHMS program this same area is referred to as Lagniappe Delta Shallow, and has historically been called the 36 Fathom Ridge by fisherman. Alabama Alps forms the northwestern terminus of a long northwest to southeast-aligned ridge and pinnacle arc paralleling the shelf edge (**Fig. 1.1**), and belongs to the shallow pinnacle trend of the northeastern Gulf. The top of this feature has sections of relatively flat terrain with scattered sections of sediment cover, particularly in the southern portion of the feature (**Figs. 1.11, 1.12**). Invertebrate assemblages on the flat sections are dominated by octocorals, antipatharians, and sponges (Hardin et al. 2001). The sides of the feature range from vertical walls to large attached monoliths where the solitary coral *R. manuelensis* is the dominant sessile invertebrate with crinoids, antipatharians, coralline algae, sponges, and other solitary corals present (Hardin et al. 2001). The USGS designated name refers to the precipitous terrain, particularly the near-vertical west-face scarp of the structure, and its position off the state of Alabama.

6) Ludwick and Walton Pinnacle 1 is the central member of a group of five medium to high-profile, spire-top, shelf-edge structures with 10 m maximum relief and a base depth of 110 m. This group belongs to the deep shelf-edge pinnacle trend in the northeastern Gulf (**Fig. 1.13**). These pinnacles form a short east-west aligned arc on the shelf-slope break, bordering the northern edge of a massive shelf-edge slump feature. Pinnacle 1 is one of those profiled and contoured by Ludwick and Walton (1957). It lies within the MAMES Western Delta Mounds area, NEGOM-CMEP Megasite 2 and within Destin Dome Lease Block 661. A fairly uniform coverage of coarse sand, rock fragments, shell fragments, and other calcareous debris surrounds the base of feature with occasional small rocky reef outcrops and patch reefs encrusted with *R. manuelensis*, octocorals, antipatharians, and crinoids. Emergent rocky features with vertical walls, rock ridges, and rock arches are distributed across the reef. Vertical rock faces have highly eroded surfaces, and are densely covered with *R. manuelensis*, with low coverage of other solitary corals, octocorals, sponges, and antipatharians.

7) Ludwick and Walton Pinnacle 2 is another of the deep shelf-edge pinnacle group. This structure, lying immediately to the east of Pinnacle 1, also was profiled and contoured by Ludwick and Walton (1957). It also lies within the MAMES Western Delta Mounds area, NEGOM-CMEP Megasite 2, and Destin Dome Lease Block 661. The

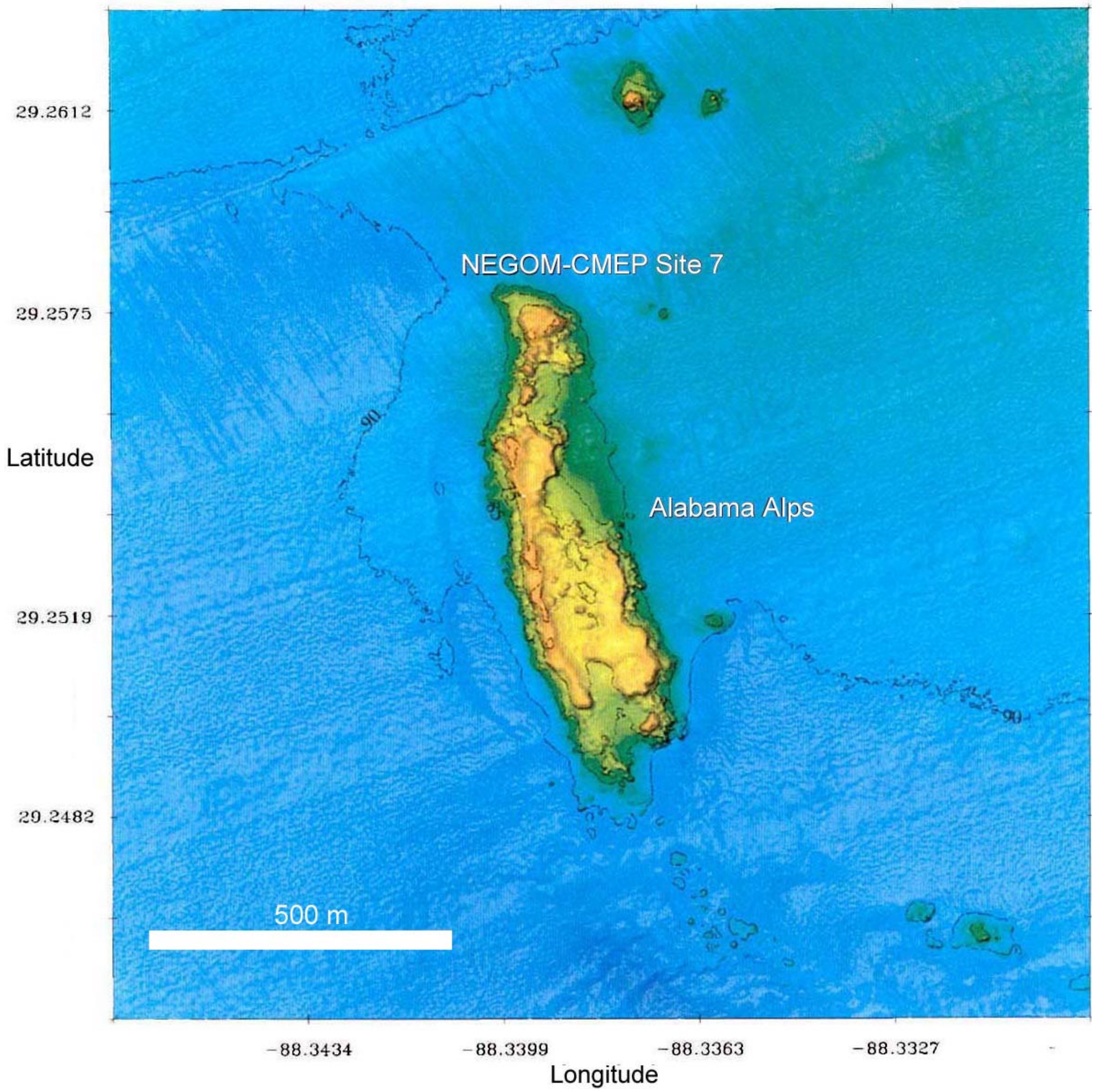

Figure 1.11. High-resolution multi-beam swath bathymetry for 36 Fathom Ridge area with study sites (provided by J. Gardner, USGS, Menlo Park, CA). Isobaths in meters.

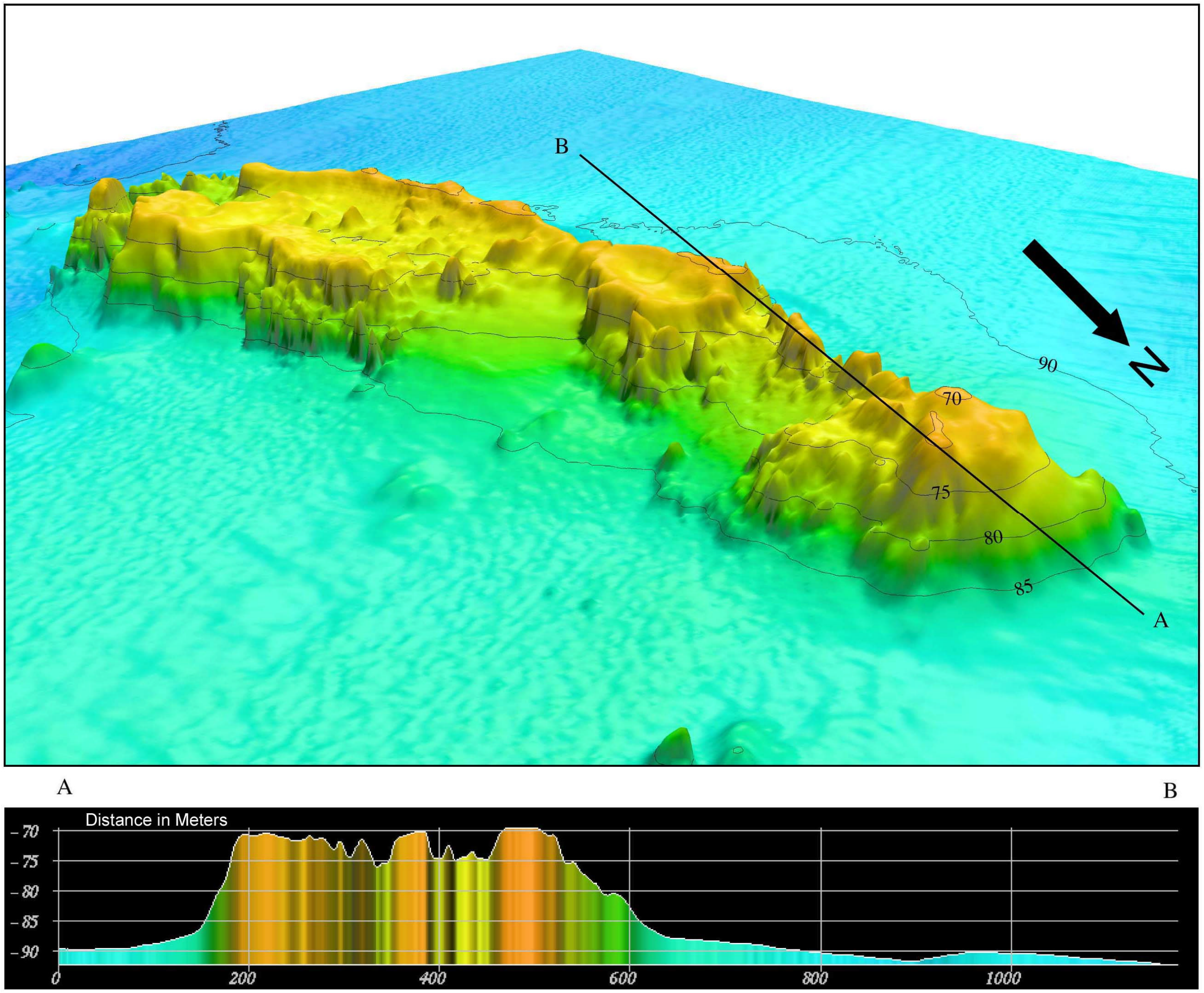

Figure 1.12. High-resolution multi-beam swath bathymetry for Alabama Alps study site (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 9X. Transect line drawn from point A to B depicts reef in cross-section. Isobaths in meters.

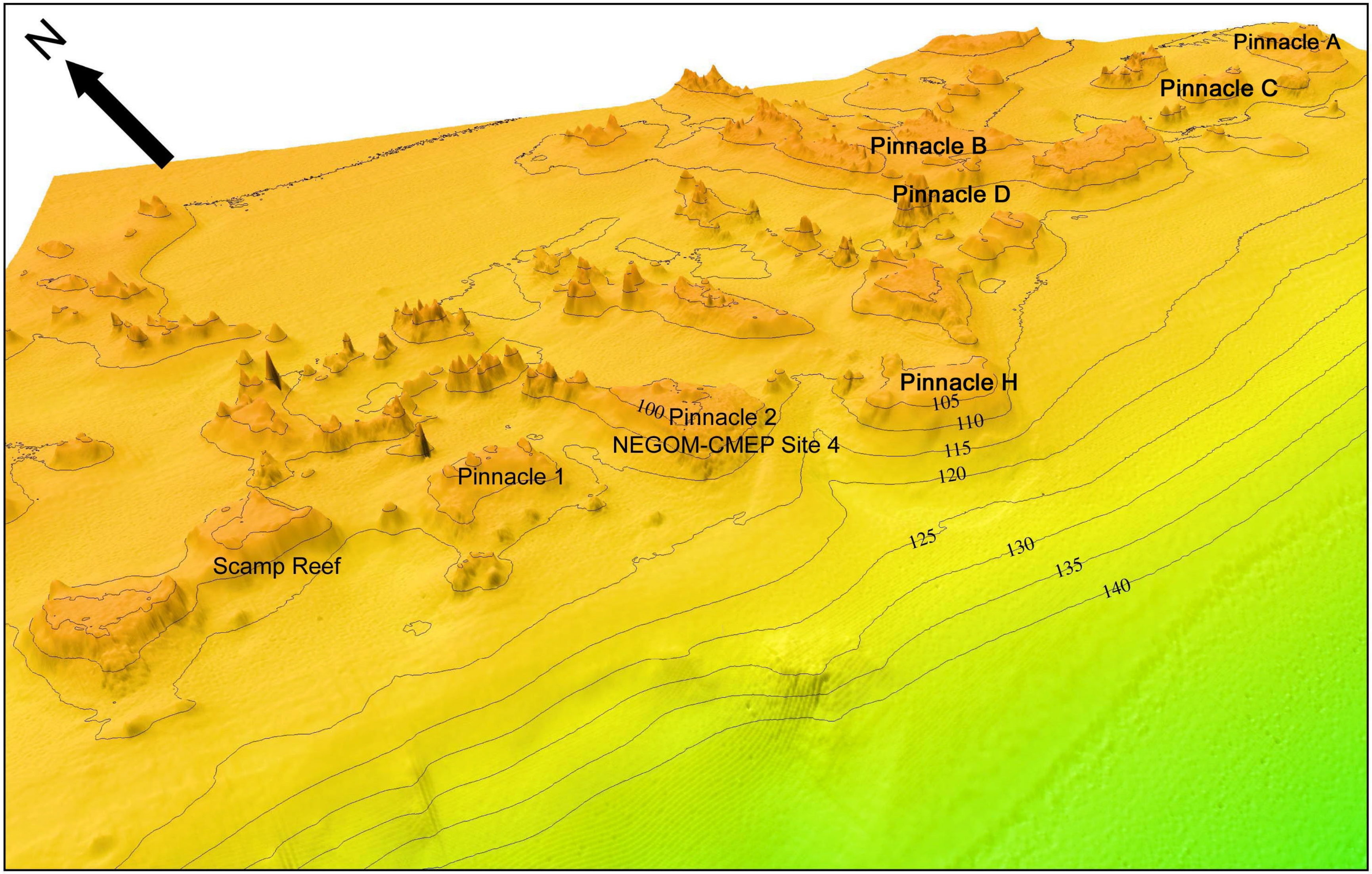

Figure 1.13. High-resolution multi-beam swath bathymetry for Ludwick and Walton Pinnacles area with study sites (provided by J. Gardner, USGS, Menlo Park, CA). Vertical exaggeration = 10X. Distance from east to west = 6 km. Isobaths in meters.

feature is a broad mound that gradually slopes from the center, and is characterized by low relief hardbottom interspersed with a sediment veneer (Hardin et al. 2001). Scattered across the surface are individual rocky features reaching heights of 3 m. The elevated rocky features were colonized by dense populations of *R. manuelensis*, other solitary corals, octocorals, crinoids, and basket stars, while low relief hard bottom regions were characterized primarily by octocorals, antipatharians, and crinoids (Hardin et al. 2001). This pinnacle corresponds to NEGOM-CMEP Site 4.

8) Scamp Reef is a member of the Ludwick and Walton Pinnacles deep shelf-edge group with a precipitous southern reef face (**Fig. 1.13**). This structure, lying immediately to the west of Pinnacle 1, also was profiled and contoured by Ludwick and Walton (1957). It lies within the MAMES Western Delta Mounds area, NEGOM-CMEP Megasite 2 (**Fig. 1.4**), and within Viosca Knoll Lease Block 654. This feature has extensive vertical rock outcrops with profiles in excess of 5 m. Spectacular arches, overhangs and rugged topography occur along the southern face of the reef, with exposed rock colonized by *R. manuelensis,* antipatharians, crinoids, octocorals, and ahermatypic coral colonies. The USGS name Scamp Reef refers to the abundance of the scamp grouper, *Mycteroperca phenax*, that reside at this site.

9) Other Study Sites. Additional study sites were visited during single occasions on reconnaissance cruise 97-01 or subsequent research cruises, but were not intensively sampled during this project (**Fig. 1.4**). The majority of these sites are located in the eastern part of the study area, and are within or adjacent to CMEP Megasite 1.

Porgy Reef is a broad, gradually sloping mound, approximately 500 m in diameter, located west of Roughtongue Reef, and within the boundary of Megasite 1. Silty sand substrates surround the reef, and the interior of the feature is composed of sculpted rock outcrops. No visible sediments were accumulated on the reef interior, and a flat top invertebrate community was absent. Invertebrate assemblages were dominated by *R. manuelensis*, corkscrew sea whips, antipatharians, octocorals, and crinoids on exposed rock surfaces.

Shark Reef is an elongate, east to west oriented, low profile reef feature approximately 250 m in length, located within CMEP Megasite 3, west of Double Top Reef and Triple Top Reef study sites. A well-developed invertebrate community was present on vertical walls and overhangs with small brown solitary corals and *R. manuelensis* abundant. Horizontal surfaces were heavily silted, and many sessile invertebrates appeared to be dead, with basal parts remaining but few living colonies visible. Pencil urchins were common on silted reef surfaces.

Solitary Mound 1 and **Solitary Mound 2** are located to the northwest of Megasite 1. Solitary Mound 1 is a gently sloping mound of intermediate height less than 100 m in diameter. A coarse sand substratum surrounds the reef features, and rock surfaces are extremely eroded/sculpted. Large rocky caverns and depressions occur on the sides of the reef with *R. manuelensis*, stony corals, with numerous corkscrew sea whips and crinoids on the reef crest, and crinoids and soft corals common on vertical rock surfaces. Rocky outcrops around the base of the feature are colonized by *R. manuelensis*, octocorals, and long-spined urchins. Solitary Mound 2 is part of an intermittent ridge, and is an elongate feature approximately 800 m in length. This feature has a well-developed reef flat top with extensive sand and silt cover, where large red soft corals and other octocorals were abundant. Small rocky outcrops were present along the interior of the feature, along with numerous pits in the accumulated sediments.

Patch Reef Field is located to the east of Megasite 1 and is described in detail by Gittings et al. (1991). It is an area with numerous, low profile hard bottom outcroppings. Reef features in this area are only 2 to 3 m in maximum profile. Sessile invertebrates are relatively common on rock surfaces. At higher elevations, the reef community resembles larger features, with abundant solitary corals, octocorals, antipatharians, and sponges. Eroded, sculpted reef faces are encrusted with *R. manuelensis* and other solitary corals on overhangs, and corkscrew sea whips and antipatharians are common along the top and sides of rock outcroppings. As noted by Gittings et al. (1991), a thin layer of silt was present on reef surfaces, and many areas of the reef base, reef face, and small patch reefs were heavily silted. Flocculent silt was also present in the near-bottom water column. Most of the footage on this dive was over open sand bottom, with many small individual patch reefs encountered during the dive, as also observed by Gittings et al. (1991).

Far Tortuga Reef is the site farthest east in this study and is a broad, gradually sloping reef of intermediate profile, approximately 800 m in diameter. Scattered rock outcrops on the feature have typical invertebrate assemblages, with small octocorals and antipatharians abundant on rock surfaces, and *R. manuelensis,* crinoids and sponges also common. The reef feature was composed of relatively small, low profile outcrops interspersed with sandy patches, with a silt veneer over coarse sand around the reef outcrops. High profile formations or a flat-top community were not encountered.

Corkscrew Reef is a series of three high profile, gradually sloping mounds, each approximately 300 m in diameter that are located directly to the east of Megasite 1 (**Table 1.1**). This site is characterized by coarse sand with low silt surrounding the reef, and coarse sand on the reef. Reef surfaces were highly eroded, sculpted rock faces with *R. manuelensis* and large solitary corals on surfaces. Patchy rock outcrops with low invertebrate cover and abundant corkscrew sea whips and antipatharians on the top of reef features. No well-developed flat top community was visible at this site, with the rocky crests of reef features harbored dense assemblages of corkscrew sea whips and other antipatharians.

Ludwick and Walton Pinnacles A-D, H includes a number of additional sites distributed throughout the Ludwick and Walton deep shelf-edge pinnacles tract, ranging from 200 to 1000 m in diameter (**Fig. 1.13, Table 1.1**). Reefs along the Ludwick and Walton Pinnacles tract are surrounded by sand and silt substrate at the base of the feature, with elevated highly sculpted and eroded rock surfaces and extensive caves and depressions. Dominant invertebrates on the deep pinnacles are *R. manuelensis*, other solitary corals, octocorals, antipatharians, and crinoids. Invertebrate density is highest on vertical surfaces and rocky crests. Flat top reef communities with accumulated sediments and dense invertebrate assemblages characteristic of high profile shallow reefs were not observed at any of these sites.

METHODS

Cruise Activities

The initial reconnaissance and sampling cruise USGS 97-01 was conducted on the R/V SUNCOASTER 4-13 August 1997 (92 stations). The remaining six USGS-funded cruises (234 stations) were completed on the R/V TOMMY MUNRO (**Table 1.2**). The combined sampling effort for all cruises comprised 326 stations, apportioned into 112 angling, 63 trap, 22 bottom trawl, 58 remotely operated vehicle (ROV), 15 dredge/core/grab, and 37 plankton stations, with a small number of stations representing bottom surveys, CTD casts, light meter deployments, and exploratory sampling gear (**Table 1.2**). All sampling combined returned over 6,000 specimens for food habits analyses, taxonomic verification and documentation, and subsequent life history analyses. Shipboard photographs documenting 113 species were obtained. ROV tapes resulted in about 85 hours of observation of reef and reef-associated biotopes and the resident fish fauna for analysis.

Sampling was conducted during all seven research cruises spanning the time interval of 1997-2000 (**Table 1.2**). Positions for all sampling sites were determined by Differential Global Positioning System (DGPS) and charts were provided by CSA-TAMU collaborators. Sampling conducted during the 2000-01 cruise was further georeferenced using digital maps of HRMBS topography and vessel position tracked in ArcView software to display station location (**Fig. 1.14**). Operations were conducted continuously 24 hours per day.

Hook and Line Angling

During all cruises, demersal and pelagic fishes from hard-bottom reefs were obtained using hook and line angling with bait and large hooks (for macro-carnivores) and angling with unbaited, multi-hook “Sabiki” jigs (for planktivores and micro-carnivores) (**Fig. 1.15**). Sabiki jigs are constructed of a variety of small hook sizes (5 to 20 mm in length) with added strips of iridescent film to imitate shrimps or other small planktonic organisms, and each pre-packaged unit contains from 4 to 7 hooks. Sabiki jigs were deployed using 142 to 340 g lead sinkers, depending upon water depth and currents, and were successfully used to collect fishes to 110 m depth. Fishes were primarily collected during daylight hours, as the majority of individuals captured using this technique were visual planktivores.

Traps

A variety of sizes and mesh traps including large (1.8 m X 1.5 m X 0.6 m) chevron traps with 25 mm X 12 mm mesh to box traps (1.2 m X 1.2 m X 0.6 m) of 25 mm hexagonal wire were used to obtain fish specimens to confirm visual identification and sample cryptic taxa not easily observed by the ROV. Some traps were equipped with 3 or 6 mm Vexar mesh liner to retain small specimens. Traps were deployed in trap lines made up of two to four traps. Also attached to these lines were smaller collection devices such as minnow traps, PVC bundles, and bottles in an attempt to attract and capture small shelter seeking fishes.

Trawls

A 4.9 m semi-balloon trawl with a 3.8 cm mesh body and a 0.6 cm mesh liner was used to collect bottom fishes near reefs at 13 stations and a 7.6 m semi-balloon trawl with a 3.8 cm mesh body and a 0.6 cm mesh liner at five stations. Both trawls were equipped with a "Texas" roller rig made up of 7.6 cm rubber disks on a chain in front of the head rope to reduce hangs on reef structures.

Specimen Disposition

In-situ collections provided voucher specimens to verify and document species identifications, and material for food habits studies. On board the research vessel, individual voucher fish specimens were carefully preserved, pinned out to display coloration and diagnostic features, and photographed using digital and 35 mm cameras on a water bath light table (Randall 1961). Photographs were taken by D. Weaver, W. Smith-Vaniz, and J. Caruso. Specimens were preserved in 10% buffered formalin or frozen in the field, and later transferred to 70% ethanol in the laboratory. Selected voucher specimens were catalogued in the National Museum of Natural History (NMNH) and Florida Museum of Natural History (FMNH) ichthyology collections. The remaining voucher material, metadata, and voucher photographs are maintained at the Florida Caribbean Science Center (FCSC).

Other gears

Additional shipboard activities included plankton sampling to document pelagic prey availability to the deep reef fish community, and collection of physicochemical parameters of the water column. These data will be reported elsewhere.

ROV Methodology

Collection of specimens was complemented by use of ROVs to conduct habitat reconnaissance and document faunal composition via color video camera. All dives were recorded to videotape for subsequent laboratory analyses. A Phantom DS4 ROV, equipped with a color video camera, was the primary system used for in-situ observations. Three different Phantom ROVs were employed during the seven Pinnacles research cruises. United States Navy (97-01) and NMFS (99-03) ROVs were operated by NMFS Mississippi Laboratories during the first three years of the program, and the NOAA/NURP Phantom DS4 was operated by NURC-UNCW on the remaining cruises. Due to technical difficulties and image quality, only ROV data from cruises 97-01, 99-03, and 2000-01 were used for quantitative purposes (Appendix A). ROV observations were used to define and compare fish faunal composition at each main target study reef by depth, reef height (high, medium and low profile), and biotope.

Table 1.2. Summary of research activities conducted from 1997-2000. Number of stations listed by study site and sampling gear.

Cruise No. Date	Sampling Gear	Main Study Sites: Alabama Alps	Cat's Paw Reef	Double Top Reef	Roughtongue Reef	Triple Top Reef	Yellowtail Reef		Other Study Sites: Patch Reef Field	Corkscrew Reef	CMEP- Site 5	Far Tortuga Reef	L & W Pinnacle 1	L & W Pinnacle 2	L & W Pinnacles A-H	Scamp Reef	Porgy Reef	Shark Reef	Solitary Mound 1	Solitary Mound 2
	ROV Day		1	2	4	1	5		1	1		1						2	1	
	ROV Night				1		1										1			1
	Angling AM				2		4													
	Angling PM			2	3		1		1	1		1					2		1	
97-01	**Angling Night**				2	1	1										1	1		1
4-13 Aug 1997	**Plankton**																			
	Traps				2	1	1		1									1		
	Trawls			2		1	1		1											2
	CTD			1	2	1	1					1								
	ROV Day																			
	ROV Night																			
	Angling AM			1	4				1											
	Angling PM			1	1		2													
98-02	**Angling Night**				1		1													
8-10 Oct 1998	**Plankton**																			
	Traps				3	3														
	Trawl																			
	CTD																			
	ROV Day																			
	ROV Night																			
	Angling AM	3	2		2															
	Angling PM	1	1		1		1													
99-01	**Angling Night**				1															
18-23 Feb 1999	**Plankton**	5	1		1															
	Traps	4	1		1															
	Trawl																			
	CTD																			

Table 1.2. (continued).

Cruise No. Date	Sampling Gear	Alabama Alps	Cat's Paw Reef	Double Top Reef	Roughtongue Reef	Triple Top Reef	Yellowtail Reef	Patch Reef Field	Corkscrew Reef	CMEP- Site 5	Far Tortuga Reef	L & W Pinnacle 1	L & W Pinnacle 2	L & W Pinnacles A-H	Scamp Reef	Porgy Reef	Shark Reef	Solitary Mound 1	Solitary Mound 2
		Main Study Sites						**Other Study Sites**											
99-02 30 May- 4 June 1999	ROV Day				1		1												
	ROV Night																		
	Angling AM	2	2	2			2									2			
	Angling PM	1	3	2	1		1									1		1	
	Angling Night		1		1							1							
	Plankton	2	4	2	2		4									1			
	Traps	4	4		6	4						1							
	Trawl																		
	CTD																		
99-03 20-22 Aug 1999	ROV Day	2			1		2						2						
	ROV Night	1										1							
	Angling AM	1					1												
	Angling PM	3																	
	Angling Night	1																	
	Plankton	2					1												
	Traps		1																
	Trawl				1														
	CTD	1			1		1						1						

Table 1.2. (continued).

Cruise No. Date	Sampling Gear	Alabama Alps	Cat's Paw Reef	Double Top Reef	Roughtongue Reef	Triple Top Reef	Yellowtail Reef		Patch Reef Field	Corkscrew Reef	CMEP- Site 5	Far Tortuga Reef	L & W Pinnacle 1	L & W Pinnacle 2	L & W Pinnacles A-H	Scamp Reef	Porgy Reef	Shark Reef	Solitary Mound 1	Solitary Mound 2
		Main Study Sites							**Other Study Sites**											
	ROV Day	2					3				1				1	1				
	ROV Night	1													1	1				
	Angling AM	1			3		3				1				1					
	Angling PM	2			1		3								1	1				
2000-01	Angling Night				1		1													
5-10 Mar 2000	Plankton	2			1		1													
	Traps	6			2		7							1	5					
	Trawl	4																		
	CTD																			
	ROV Day				1		2													
	ROV Night																			
	Angling AM				1		1													
	Angling PM						1													
2000-02	Angling Night																			
5-6 Sept 2000	Plankton				1		1													
	Traps																			
	Trawl																			
	CTD																			

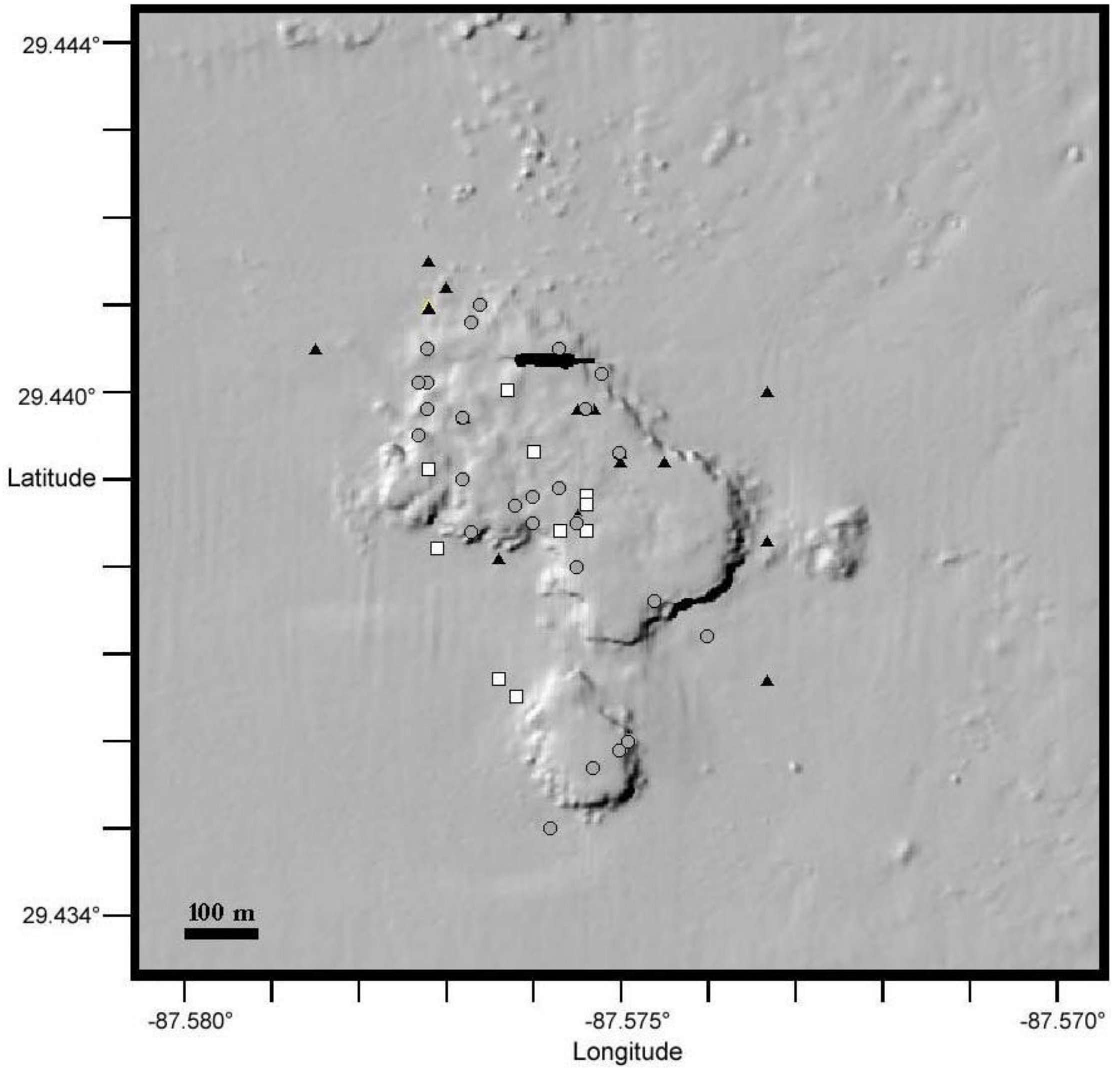

Figure 1.14. Distribution of sampling effort at Roughtongue Reef (NEGOM-CMEP Site 1) for cruises 97-01 through 2000-01. Each symbol represents the position of the research vessel during sampling gear deployment. Gray circles-angling, black triangles-traps, open squares-ROV dives.

Figure 1.15. Sabiki jigs used to collect small reef fishes during this study, including *Pronotogrammus martinicensis* (top and middle) and *Hemanthias vivanus* (bottom).

Transecting methodology were drawn from those previously employed in ROV/submersible/camera sled studies that have shown that videotape analysis of large mobile demersal fishes requires a moving image and a low oblique perspective to capture diagnostic features of morphology and coloration (Grassle et al. 1975, Cohen and Pawson 1977, Uzmann et al. 1977, Rice et al. 1979, Parker and Ross 1986, Hecker 1987, Butler et al. 1991, Sulak and Ross 1993, 1996, Adams et al. 1995, Felley and Vecchione 1995). ROV transects were conducted at a constant speed of 0.10-0.15 m/sec across the bottom, with altitude of the ROV held to a maximum of 1.0 m (distance between sea floor and video camera lens, varying somewhat according to terrain). Horizontal swath width was resolved as the lower border of the video frame with the video camera zoom set to full wide-angle, and pan and tilt angles set to about 25° and 20°, respectively. Video was recorded on board the ship on S-VHS or Hi-8 videotape with audio annotation.

In situ collections of small reef fishes were accomplished using a suction sampler fitted to the ROV (**Fig. 1.16**) that dispensed a suspended rotenone solution (co-designed by D. Weaver and L. Horn, UNC-Wilmington). Powdered rotenone (Prentiss, Inc.) was suspended in 3 L of concentrated Ivory Liquid dishwashing detergent, and mixed with 8 L of seawater. Approximately 3 kg of standard table salt and 10 kg of granular sugar was added to increase the specific gravity of the solution to help maintain contact with the bottom. The suspended rotenone was passed through a standard kitchen strainer to remove large clumps, and loaded into the dual reservoir chambers of the sampler. A standard marine bilge pump, encased in an aluminum housing and powered from the surface, was used to dispense the rotenone solution and collect fishes at select reef sites during ROV dives. Fishes were retained in a 5 mm mesh liner fitted inside the first PVC chamber (**Fig. 1.16**).

Videotape Analysis

Videotapes were transferred to S-VHS format and analyzed on a commercial quality S-VHS VCR with variable speed editor/jogger control (slow-motion, frame by frame advance) to facilitate species identification at slow speed advance and enumerate individuals. Videotape analysis was used to quantify fish abundance by taxa and biotope. Incidental observations of pelagic fishes also were recorded and individuals identified. In addition to moving videotape transects, the zoom function of the NURC-UNCW ROV video camera was periodically used to capture close-up images of individuals to facilitate identification during cruises 2000-01 and 2000-02. These still video segments were used to verify species identifications made during transect surveys. All fish species were identified to the lowest possible taxonomic unit, with confirmation from close-up video images and by reference to voucher specimens collected by angling, trapping, or ROV suction sampler.

Habitat Parameters

In addition to defining fish community structure, videotape screening was used to make qualitative notes on the physical habitat and megafaunal invertebrates associated with particular biotopes and fish assemblages. Where appropriate (e.g., high profile, flat

A

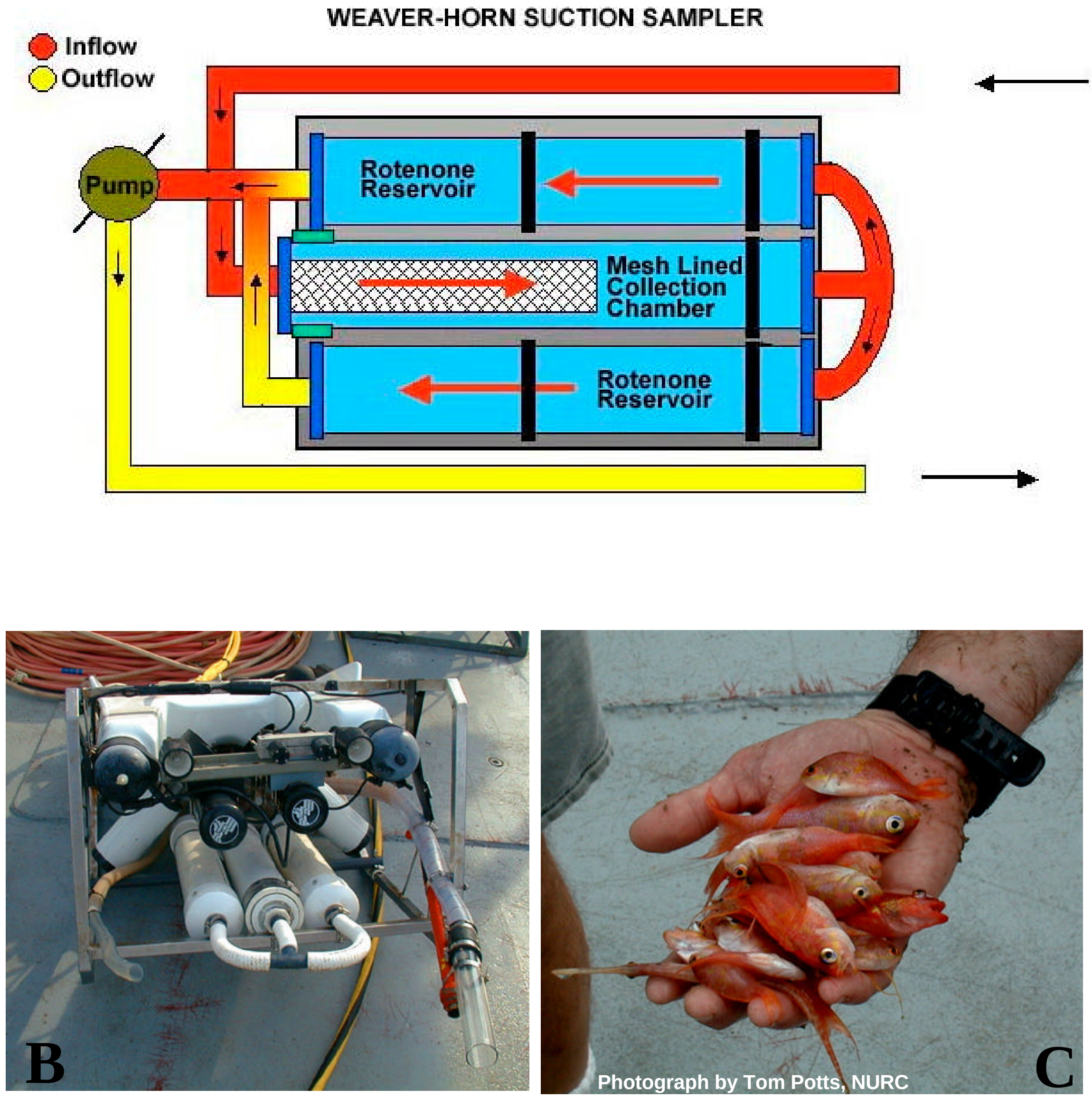

Figure 1.16. **A**. Suction sampler device schematic. **B**. NURC-UNCW Phantom DS4 ROV with suction sampler. **C**. A typical collection of fishes made by the suction sampler.

topped features) fish observed were assigned to one of six biotopes: reef top, reef crest, reef base, reef talus (circum-reef sediment apron), and soft bottom.

Reef Top is referred to as flat reef tops or reef flats by Gittings et al. (1992a) and describes the biotope that develops on large, flat-topped mounds such as Roughtongue Reef, Yellowtail Reef, and CMEP-Site 5. This biotope is identified by extensive pockets of accumulated sediments and rocky debris, interspersed with low profile rock outcrops, ridges, and crevices. Invertebrate assemblages on the reef flat top community exhibit high density and species richness, and are dominated by erect sponges, octocorals (particularly sea fans, including *Nicella* sp.), comatulid crinoids, antipatharians, gorgonocephalid basket stars, bryozoans, and coralline algae (Gittings et al. 1992a, Hardin et al. 2001). Our reef top category corresponds to top interior locations of Hardin et al. (2001) and continuous hard bottom category of Snyder (2001).

Reef Crest biotopes were defined as the interface between the near vertical, rocky reef face and the sediment covered flat top characterized by dense assemblages of invertebrates. Reef crest biotopes typically were characterized by extensive rocky outcrops with small areas of sediment cover and low invertebrate densities. We distinguished the reef crest ecotone from the adjacent flat reef top and vertical reef face biotopes to identify the possible influence of position in the leading edge of water currents on the reef fish community. Our reef crest category corresponds to the top edge location listed by Hardin et al. (2001).

Reef Face as referred to by Gittings et al. (1992a), are rugged, often near-vertical rocky surfaces that characterize the steep-sided edges of large flat-topped features and the steep walls of narrow, spire shaped deep water pinnacles. Reef face communities are characterized by a lower overall density of epifauna than reef tops, with an abundance of ahermatypic corals, including *R. manuelensis*, *Madrepora* sp., and *Madracis*/*Oculina* sp., comatulid crinoids, a variety of octocoral fans, antipatharians including the spiral whip *Stichopathes lutkeni* Brooks, 1889, coralline algae (to about 75 m), and sea urchins (Gittings et al. 1992a, Hardin et al. 2001). This biotope is described as reef side by Hardin et al. (2001) and Snyder (2001).

Reef Base was defined as the ecotone between the steep reef face and the talus zone, where the rugged rocky face of the reef was often undercut and formed small caves and overhangs. This region contained both rocky vertical faces with abundant solitary corals and the coarse sediments and rocky debris/talus resulting from bioerosion occurring on the reef above. This biotope is also identified by Hardin et al. (2001) and Snyder (2001).

Reef Talus (circum-reef sediment apron) is listed as debris fields or rubble flats by Gittings et al. (1991, 1992a). These are flat areas of reef debris and coarse carbonate sediments occurring on the flanks of large, high-relief mounds (Gittings et al. 1992a, Sager and Schroeder 2001). Coarse sediments and debris are produced by shell material resulting from bioerosion, and rock fragments from the main reef. Small rocky outcrops in this biotope are often encrusted with solitary corals, small octocoral fans, and antipatharians (Gittings et al. 1992a, Hardin et al. 2001). The reef talus zone is identifiable on HRMBS maps as the area of highest acoustic backscatter (red) to the south and west of hard bottom features (Gardner et al. 2000) (**Fig. 1.5B**).

Soft Bottom/Sand Plain refers to the relatively flat substrate surrounding reef features, characterized by fine to coarse quartz sand without visible portions of shell hash or rock rubble. These areas are often flat and featureless, but occasionally are contoured by ripples, gentle waves, or numerous excavated burrows, pits, and mounds that add to the topography. Sessile invertebrates in this habitat are limited to occasional small octocorals or antipatharians that attach to buried rock surfaces. Non-reef associated soft bottom is distinguishable in acoustic backscatter maps as areas of lowest backscatter (**Fig. 1.5B**, blue).

Data Analysis

Survey Period and Reef Tract Comparisons

ROV dives were divided into day and night periods, and data from crepuscular periods were excluded from this analysis. A two-way chi-square goodness of fit test was used to compare abundance between survey period and reef tract. A sequential Bonferroni procedure was used to adjust significance values for multiple tests (Sokal and Rohlf, 1995). At five reefs, Alabama Alps, Ludwig & Walton Pinnacles, Scamp, Yellowtail, and Roughtongue Reefs, both day and night data were obtained by ROV. Although sample sizes were small, a paired t-test was used to test day-night differences in total fish abundance, number of taxa, and top six taxa abundance (Sokal and Rohlf, 1995). All data were standardized by effort measured as video survey time in minutes.

Cluster Analysis

We used cluster analysis to help explore and define the structure of fish assemblages among reefs and biotopes. Data were summarized by reef and survey period. Data from Ludwick and Walton Pinnacles 1, 2, A, B and C were combined into a single reef category. Raw counts were standardized by effort expressed as number of fish per minute of video survey time for comparisons among reefs. Survey time was not recorded by biotope so data were double standardized for analysis. Taxa were restricted to those that occurred at two or more sites to reduce the potential effect of bias from rare species (Wolda, 1981). Two measures of similiarity, percent similarity and Morisita, were used for comparison as they emphasize different attributes (Bloom, 1981; Wolda, 1981). An agglomerative hierarchical clustering strategy was used with an unweighted pair-group mean average sorting algorithm to obtain grouping of reefs and taxa (Boesch, 1977). The COMPAH computer program was used to perform the analysis (Gallagher, 1998). Clusters were subjectively divided into groups to facilitate comparisons. We compared cluters from the two similarity measures. If a reef or taxa was found in different groups between clusters it was considered poorly resolved and a weak member of the group; thus not indicative of the group structure.

Percent Similarity

$$\% \ \mathrm{SIM}_{ij} = \sum_{k=1}^{S} \min \left(\frac{x_{ik}}{\sum_{k=1}^{S} x_{ik}} \ , \ \frac{x_{jk}}{\sum_{k=1}^{S} x_{jk}} \right) .$$

where, x_{ik} = *Abund. of species k in sample i.*
S = *Number of species.*

Morisita-Horn Similarity

$$MHS_{ij} = 2 \sum_{k=1}^{S} \frac{x_{ik} \ x_{jk}}{(d_i + d_j) \ N_{i.} \ N_{j.}} .$$

where, S = *Number of species.*
x_{ik} = *Abundance of species k in sample i.*
$N_{i.}$ = *Total individuals in sample i.*

$$d_i = \frac{\sum_{k=1}^{S} x_{ik}^2}{N_{i.}^2} .$$

Both sites (reefs) and taxa were clustered and nodal analysis was performed to enhance the interpretation of the data (Boesch, 1977). The relationship between reefs and taxa groups was measured as constancy, the faithfulness of a taxa group to a particular reef group and fidelity, the degree to which taxa are limited to reef groups. Constancy and fidelity were arbitrarily categorized from high to low to better elucidate relationships between reefs and taxa.

Constancy

$$C_{ij} = \frac{a_{ij}}{(N_i \ N_j)}$$

Fidelity

$$F_{ij} = \frac{(a_{ij} \ ? \ N_j)}{(N_j \ ? \ a_{ij})}$$

where a_{ij} number of occurrences of taxa from taxa group i in site group j.
N_i total number taxa in taxa group i.
N_j total number taxa in taxa group j.

RESULTS

Faunal Composition

The results of this study have expanded the number of fishes documented from the Pinnacles Reef Tract, and is the first extensive collection of deep reef fishes made in this region, and possibly worldwide (**Table 1.3**). Of the 159 species documented (**Table 1.4**) from collected specimens or via videotape, 88 were identified from ROV censuses, and 65 can be classified as obligate reef-fishes belonging to the Caribbean reef-fish fauna. Such obligate reef fishes have life histories tied to three-dimensional, hard-bottom habitats, and would not otherwise be found on the OCS open shelf (**Figs. 1.17-1.19**). An additional 32 species are facultative reef associates that range broadly over OCS habitats, but occur on reef habitat, when available. The remaining species include primarily Carolinian soft-substrate species, including both coastal and shelf-dwelling fishes, along with a small number of pelagic and deep midwater species that were found over reef features with varying frequency and regularity.

Table 1.3. Previous investigations of the ichthyofauna of the Pinnacles Reef Tract, comparing number of reef fishes observed by ROV in each study.

Study	Reef Fish Taxa	Total Fish Taxa	Voucher Specimens?
Darnell, 1991b	39	70	No
Snyder, 2001	49	76	No
This study	65	88	Yes

Table 1.4. List of fishes documented in the Pinnacles Reef Tract from 1997-2000. Scientific and common names follow Robins et al. (1991) except where noted with asterisk. Columns denoted as **PRF** - primary reef fishes, **A** - hook and line angling, **As** - Sabiki angling, **Ro** – ROV observed, **Rc** – ROV collected, **Tp** – Trap, **Tl** – Trawl, and **P** – voucher specimen photograph.

Scientific Name	Common Name	PRF	A	As	Ro	Rc	Tp	Tl	P
Lamnidae - mackerel sharks									
Isurus oxyrinchus	shortfin mako		X						X
Scyliorhinidae - cat sharks									
Scyliorhinus retifer	chain dogfish						X	X	X
Triakidae – houndsharks									
Mustelus canis	smooth dogfish		X		X				X
Mustelus sinsusmexicanus	gulf smoothhound						X		
Carcharhinidae - requiem sharks									
Carcharhinus falciformis	silky shark		X						
Rhizoprionodon terraenovae	Atlantic sharpnose shark		X						
Sphyrnidae – hammerheads									
Sphyrna lewini	scalloped hammerhead		X						
Squatinidae - angel sharks									
Squatina dumeril	Atlantic angel shark							X	X
Rajidae - skates									
Raja eglanteria	clearnose skate							X	
Raja texana	roundel skate							X	X
Muraenidae – morays									
Gymnothorax hubbsi[1]	lichen moray	X				X			X
Gymnothorax kolpos	blacktail moray	X	X		X		X		X
Gymnothorax moringa	spotted moray	X					X		X
Gymnothorax nigromarginatus	blackedge moray						X	X	X
Gymnothorax saxicola	honeycomb moray		X					X	X
Muraena retifera	reticulated moray	X	X				X		X
Ophichthidae - snake eels									
Ophichthus gomesii	shrimp eel				X			X	
Ophichthus puncticeps	palespotted eel						X	X	X
Congridae - conger eels									
Conger oceanicus	conger eel						X		
*Rhynchoconger gracilior**	whiptail conger							X	
Nettostomatidae - duckbill eels									
Hoplunnis diomedianus	blacktail pike-conger				X			X	
Clupeidae - herrings									
Etrumeus teres	round herring							X	
Argentinidae – argentines									
Glossanodon pygmaeus	pygmy argentine							X	
Aulopidae – flagfins									
Aulopus filamentosus	yellowfin flagfin			X					X
Synodontidae - lizardfishes									
Saurida normani	shortjaw lizardfish					X		X	X
Synodus foetens	inshore lizardfish							X	
Synodus intermedius	sand diver	X			X			X	X
Trachinocephalus myops	snakefish							X	X
Myctophidae - lanternfishes					X				
Carapidae - pearlfishes									
Echiodon dawsoni	chain pearlfish		X[2]						

[1]new Gulf of Mexico record
[2]stomach content
*revised nomenclature

Table 1.4. (continued).

Scientific Name	Common Name	PRF	A	As	Ro	Rc	Tp	Tl	P
Ophidiidae - cusk-eels									
Brotula barbata	bearded brotula	X	X		X		X		X
Lepophidium brevibarbe	blackedge cusk-eel				X			X	
Lepophidium jeannae	mottled cusk-eel							X	X
Ophidion beani	longnose cusk-eel							X	
Otophidium omostigmum	polka-dot cusk-eel							X	
Moridae - codlings									
Physiculus fulvus	metallic codling							X	
Bregmacerotidae - codlets									
Bregmaceros cantori	pale codlet				X			X	X
Phycidae* – phycid hakes									
Urophycis floridana	southern hake						X		X
Urophycis regia	spotted hake						X		X
Batrachoididae – toadfishes									
Opsanus pardus	leopard toadfish		X		X		X		X
Porichthys plectrodon	Atlantic midshipman							X	X
Antennariidae – frogfishes									
Antennarius ocellatus	ocellated frogfish				X				
Antennarius radiosus	singlespot frogfish							X	X
Ogcocephalidae – batfishes									
Halieutichthys aculeatus	pancake batfish							X	X
Ogcocephalus corniger	longnose batfish				X			X	X
Ogcocephalus declivirostris	slantbrow batfish							X	X
Holocentridae – squirrelfishes									
Corniger spinosus	spinycheek soldierfish	X		X	X				X
Holocentrus adscensionis	squirrelfish	X		X	X				X
Ostichthys trachypoma	bigeye soldierfish	X			X				
*Sargocentron bullisi**	deepwater squirrelfish	X		X	X				X
Caproidae - boarfishes									
Antigonia capros	deepbody boarfish	X			X				
Syngnathidae - pipefishes									
Hippocampus sp.	seahorse						X[2]		
Aulostomidae – trumpetfishes									
Aulostomus maculatus	trumpetfish	X				X			X
Fistulariidae – cornetfishes									
Fistularia petimba	red cornetfish	X		X	X				X
Scorpaenidae - scorpionfishes									
Pontinus rathbuni	highfin scorpionfish	X		X				X	X
Scorpaena agassizii	longfin scorpionfish							X	X
Scorpaena dispar	hunchback scorpionfish	X	X		X				X
Triglidae – searobins									
Bellator militaris	horned searobin							X	X
Prionotus paralatus	Mexican searobin							X	X
Prionotus roseus	bluespotted searobin							X	X
Prionotus rubio	blackwing searobin							X	X
Prionotus stearnsi	shortwing searobin				X			X	X

PRF – primary reef fish **A –** Angling **As –** Sabiki angling **Ro –** ROV observed **Rc –**ROV collected
Tp – Trap **Tl –** Trawl **P –** Photograph
[2]stomach content
*revised nomenclature

Table 1.4. (continued).

Scientific Name	Common Name	PRF	A	As	Ro	Rc	Tp	Tl	P
Serranidae - sea basses									
Anthias tenuis	threadnose bass	X			X	X			X
Centropristis ocyurus	bank sea bass		X		X		X		X
Centropristis philadelphica	rock sea bass		X		X				X
Epinephelus drummondhayi	speckled hind	X	X				X		X
Epinephelus flavolimbatus	yellowedge grouper		X		X		X		X
Epinephelus niveatus	snowy grouper	X	X		X		X		X
Epinephelus nigritus	warsaw grouper	X					X		X
Gonioplectrus hispanus	Spanish flag	X	X		X				X
Hemanthias leptus	longtail bass	X		X	X				X
Hemanthias vivanus	red barbier	X		X	X	X			X
Liopropoma eukrines	wrasse bass	X		X	X	X			X
Mycteroperca microlepis	gag	X	X		X		X		X
Mycteroperca phenax	scamp	X	X		X		X		X
Paranthias furcifer	creole-fish	X		X	X		X		X
*Pronotogrammus martinicensis**	roughtongue bass	X		X	X	X			X
Rypticus maculatus	whitespotted soapfish	X	X		X				X
Serranus atrobranchus	blackear bass				X			X	X
Serranus notospilus	saddle bass				X			X	X
Serranus phoebe	tattler	X		X	X				X
Grammatidae – basslets									
Lipogramma regia[1]	royal basslet	X			X				
Opistognathidae – jawfishes									
Opistognathus lonchurus	moustache jawfish	X		X	X				X
Priacanthidae - bigeyes									
Priacanthus arenatus	bigeye	X	X		X				X
Pristigenys alta	short bigeye	X	X		X				X
Apogonidae - cardinalfishes									
Apogon pseudomaculatus	twospot cardinalfish	X		X	X				X
Malacanthidae - tilefishes									
Caulolatilus chrysops	goldface tilefish	X	X				X		X
Caulolatilus intermedius	anchor tilefish		X						X
Malacanthus plumieri	sand tilefish	X	X		X		X		X
Pomatomidae - bluefishes									
Pomatomus saltatrix	bluefish		X		X				X
Echeneidae - remoras									
Echeneis naucrates	sharksucker		X						
Carangidae - jacks									
Caranx crysos	blue runner		X						X
Caranx hippos	crevalle jack		X						
Selar crumenophthalmus	bigeye scad		X					X	
Seriola dumerili	greater amberjack	X	X		X		X		X
Seriola fasciata	lesser amberjack		X		X		X		X
Seriola rivoliana	almaco jack	X	X				X		X
Seriola zonata	banded rudderfish		X						X
Trachurus lathami	rough scad			X	X				X

PRF – primary reef fish **A –** Angling **As –** Sabiki angling **Ro –** ROV observed **Rc –**ROV collected **Tp –** Trap **Tl –** Trawl **P –** Photograph

[1]new Gulf of Mexico record

*revised nomenclature

Table 1.4. (continued).

Scientific Name	Common Name	PRF	A	As	Ro	Rc	Tp	Tl	P
Lutjanidae - snappers									
Lutjanus campechanus	red snapper	X	X		X		X		X
Pristipomoides aquilonaris	wenchman		X		X			X	X
Rhomboplites aurorubens	vermilion snapper	X	X	X	X		X		X
Sparidae – porgies									
Calamus leucosteus	whitebone porgy		X				X		X
Calamus nodosus	knobbed porgy	X	X						X
Lagodon rhomboides	pinfish				X		X	X	X
Pagrus pagrus	red porgy	X	X		X		X		X
Stenotomus caprinus	longspine porgy				X			X	X
Sciaenidae - drums									
Cynoscion arenarius	sand seatrout		X						X
Leiostomus xanthurus	spot				X			X	X
Micropogonias undulatus	Atlantic croaker						X	X	X
Pareques iwamotoi	blackbar drum	X			X		X		X
Pareques umbrosus	cubbyu	X			X		X		X
Mullidae - goatfishes									
Mullus auratus	red goatfish							X	X
Upeneus parvus	dwarf goatfish				X			X	X
Chaetodontidae - butterflyfishes									
Chaetodon aya	bank butterflyfish	X			X	X	X		X
Chaetodon ocellatus	spotfin butterflyfish	X			X		X		X
Chaetodon sedentarius	reef butterflyfish	X		X	X		X		X
Pomacanthidae - angelfishes									
Holacanthus bermudensis	blue angelfish	X			X		X		X
Holacanthus ciliaris	queen angelfish	X			X				
Holacanthus tricolor	rock beauty	X			X				
Pomacentridae - damselfishes									
Chromis enchrysura	yellowtail reeffish	X		X	X	X			X
Chromis insolata	sunshinefish	X			X				
Chromis scotti	purple reeffish	X			X				
Labridae - wrasses									
Bodianus pulchellus	spotfin hogfish	X		X	X				X
Decodon puellaris	red hogfish	X		X	X			X	X
Halichoeres bathyphilus	greenband wrasse	X		X	X				X
Uranoscopidae - stargazers									
Kathetostoma albigutta	lancer stargazer							X	X
Blenniidae - combtooth blennies									
Parablennius marmoreus	seaweed blenny	X	X[2]		X				
Gobiidae - gobies									
Coryphopterus punctipectophorus	spotted goby	X			X				
Risor ruber	tusked goby	X							X[3]
Sphyraenidae – barracudas									
Sphyraena borealis	northern sennet		X						X
Gempylidae* - snake mackerels									
Neoepinnula americana	American sackfish				X				
Trichiuridae - cutlassfishes									
Trichiurus lepturus	Atlantic cutlassfish				X			X	X

PRF – primary reef fish **A –** Angling **As –** Sabiki angling **Ro –** ROV observed **Rc –**ROV collected
Tp – Trap **Tl –** Trawl **P –** Photograph
[2]stomach content
[3]box core
*revised nomenclature

Table 1.4. (continued).

Scientific Name	Common Name	PRF	A	As	Ro	Rc	Tp	Tl	P
Scombridae - mackerels									
Acanthocybium solandri	wahoo		X						
Auxis thazard	frigate mackerel			X					
Euthynnus alletteratus	little tunny		X						
Sarda sarda	Atlantic bonita		X						
Scomberomorus cavalla	king mackerel		X		X				
Stromateidae - butterfishes									
Peprilus burti	gulf butterfish				X				
Bothidae - lefteye flounders									
Engyophrys senta	spiny flounder							X	X
Trichopsetta ventralis	sash flounder							X	X
Paralichthyidae* - sand flounders									
Ancylopsetta dilecta	three-eye flounder				X			X	X
Citharichthys cornutus	horned whiff				X			X	X
Cyclopsetta fimbriata	spotfin flounder				X			X	X
Paralichthys squamilentus	broad flounder							X	X
Syacium papillosum	dusky flounder				X			X	X
Achiridae - American soles									
Gymnachirus texae	fringed sole							X	X
Soleidae* - soles									
Symphurus diomedianus	spottedfin tonguefish				X			X	X
Symphurus parvus	pygmy tonguefish							X	
Balistidae - triggerfishes									
Balistes capriscus	gray triggerfish	X	X						X
Monacanthidae* - filefishes									
Monacanthus tuckeri	slender filefish	X		X					X
Ostraciidae - boxfishes									
*Acanthostracion quadricornis**	scrawled cowfish				X				
Tetraodontidae - puffers									
Canthigaster rostrata	sharpnose puffer	X		X	X	X			X
Canthigaster jamestyleri [1]	goldface toby	X		X	X				X
Lagocephalus laevigatus	smooth puffer		X						X
Sphoeroides dorsalis	marbled puffer							X	X
Sphoeroides spengleri	bandtail puffer		X		X				X
Diodontidae - porcupinefishes									
Chilomycterus antillarum	web burrfish	X			X				
Chilomycterus schoepfii	striped burrfish				X				
Diodon holocanthus	balloonfish	X			X				
Molidae – ocean sunfishes									
Mola mola	ocean sunfish				X				

PRF – primary reef fish **A** – Angling **As** – Sabiki angling **Ro** – ROV observed **Rc** –ROV collected
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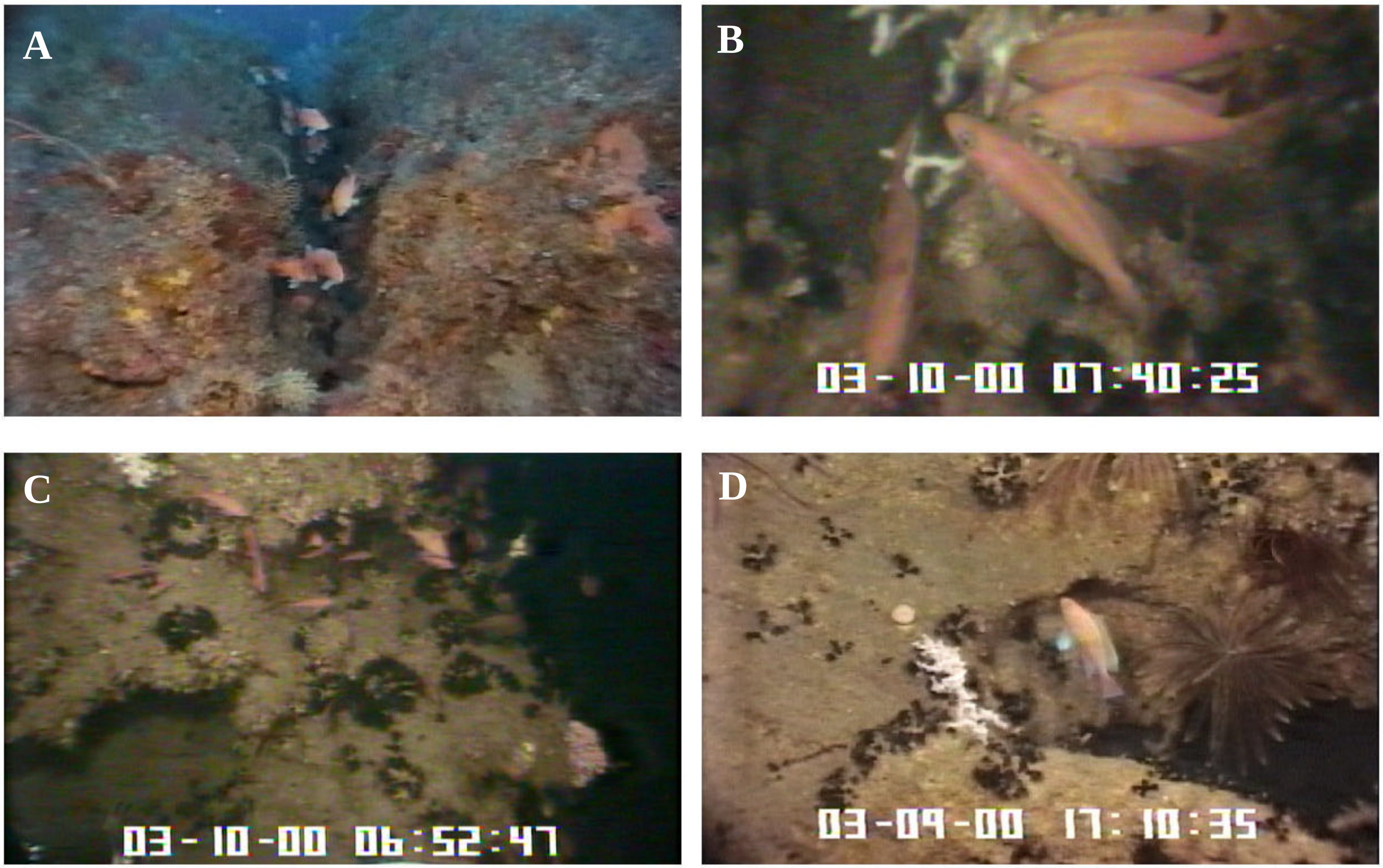


Figure 1.17. Still frames taken from video surveys at the Pinnacles Reef Tract. **A**. *Pronotogrammus martinicensis* school along crevice in reef top at Yellowtail Reef, 63 m. **B**. Close-up of mixed group of *P. martinicensis* and *Hemanthias vivanus* along reef face. **C**. Mixed school of anthiines along reef face at CMEP-Site 5, 75 m. **D**. Single *P. martinicensis* along reef face at Scamp Reef, 105 m. **C** and **D** illustrate invertebrates that dominate the drowned reef community [ahermatypic coral colonies, *Rhizopsammia manuelensis* (black clusters), and crinoids].

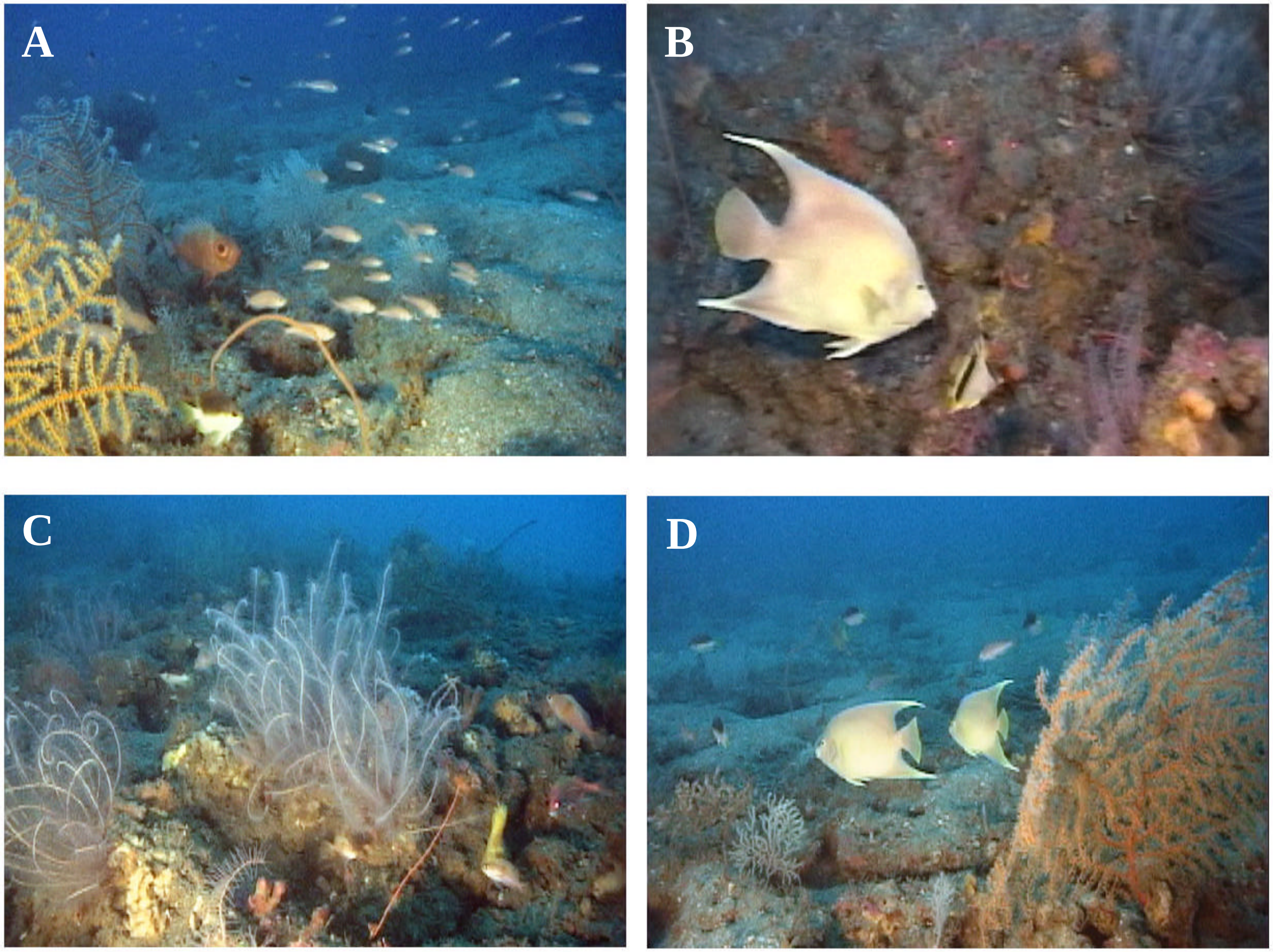


Figure 1.18. Still frames taken from video surveys at the Pinnacles Reef Tract. **A**. Mixed school of *Hemanthias vivanus* and *Chromis enchrysura* with a single *Pristigenys alta* on reef top biotope at Yellowtail Reef, 62 m. **B**. *Holacanthus bermudensis* and *Chaetodon aya* along northern edge of reef top biotope at Yellowtail Reef, 63 m. **C-D**. Reef top biotope with well-developed sessile invertebrate community of gorgonians and crinoids, Yellowtail Reef, 62 m.

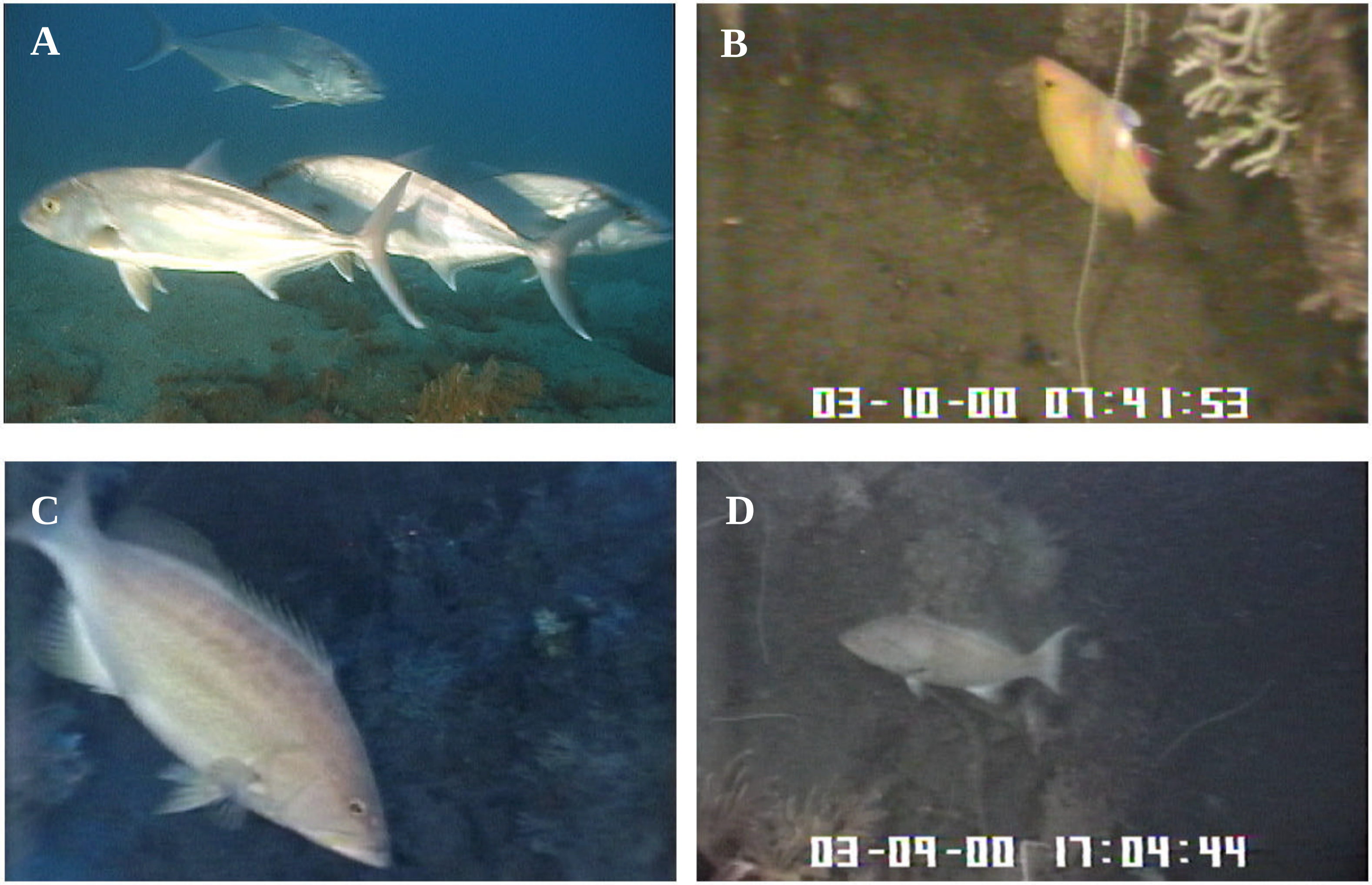


Figure 1.19. Still frames taken from video surveys at the Pinnacles Reef Tract. **A**. *Seriola dumerili* schooling above reef flat top, Yellowtail Reef, 62m. **B**. *Gonioplectrus hispanus* at reef base, CMEP-Site 5, 78 m. **C**. Female *Mycteroperca phenax* on reef face, Scamp Reef, 105 m. **D**. Dominant male *M. phenax* exhibiting grey-head color phase along reef face, Scamp Reef, 105 m.

ROV Survey

Videotape data from only three cruises (USGS 97-01, 99-03 and 2000-01) were of sufficient quality for quantitative analysis of reef fish abundance. Fishes observed during other ROV surveys where visibility was poor, or while collecting fishes using the suction sampler (USGS 2000-01 and 2000-02), were added to the list of species occurring on the Pinnacles Reef Tract but not included in the analysis. Eighty-eight species were identified during ROV surveys, with 17 taxa observed only by this method (**Table 1.4**).

ROV surveys revealed the dominance of planktivorous reef fishes on high profile reef features (**Table 1.5**, Appendix A). Anthiines were the principal taxa observed by day, and communities were dominated by either *Hemanthias vivanus* or *Pronotogrammus martinicensis*, depending on reef location and biotope. Day ROV surveys yielded higher (9719 individuals) overall abundance of fishes than night surveys (2624 individuals) (**Table 1.5**, Appendix A1), indicating most reef species are diurnally active and hide in crevices or burrows at night. About equal numbers of taxa were observed during the day (68) and night (66) though almost twice as much effort was applied during the day. Day surveys had 20 unique taxa, of which none were frequent. Night surveys had 18 unique taxa. Three taxa, *Bregmaceros cantori*, myctophids, and *Trichiurus lepturus,* were common, but not observed on all night dives. These typically non-reef species may make a more substantial contribution to the reefs than previously expected. We compared reef fish abundance by survey period and reef tract simultaneously as these factors might be confounded. Only data from reef habitat were used in this analysis. The chi-square goodness of fit test showed that most taxa had a significant difference in abundance between survey period and reef tract (**Table 1.6**). The diurnal nature of the fauna is evident in that the total number of individuals was significantly lower at night especially on shallow reefs. Seven taxa were significantly more abundant on shallow reefs during the day (**Table 1.6**). Only *Synodus* spp. was significantly lower during the day due to its absence from shallow water reefs. Two taxa, *P. martinicensis* and *Anthias tenuis* were significantly more abundant on deep reefs during the day. Five taxa were most abundant on shallow and six on deep reefs (**Table 1.6**). *Pareques umbrosus* was significantly lower on shallow reefs at night while *Chaetodon aya*, *Decodon puellaris*, and *Serranus phoebe* were lower on deep reefs.

When day/night comparisons were made by reef there was a highly significant difference in total fish abundance between day and night with higher numbers during the day (**Table 1.7**). However, there was no significant difference in number of taxa observed between day and night. Of the top six taxa, four were more abundant during the day but none were significantly so due to the small sample size (**Table 1.7**). *Pronotogrammus martinicensis* tends to lie on the reef surface at night being inactive but visible. In contrast *H. vivanus* hides in crevices at night, thus hidden from the ROV survey. Myctophids, a nocturnally migrating taxon, were significantly more abundant at night overall, as was *T. lepturus*, but due to patchy distributions there was no significant difference among reefs.

Table 1.5. Abundance of top 30 taxa observed in ROV surveys partitioned by survey period (day/night) and reef tract (shallow/deep) for reef habitat.

		Overall	Percent of Total Reef Habitat			
			Day		Night	
Rank	Taxa	No.	Shallow	Deep	Shallow	Deep
1	*Pronotogrammus martinicensis*	5027	25.1	77.3	46.7	27.4
2	*Hemanthias vivanus*	3881	54.4	3.6	15.9	0.3
3	Gobiidae	499	3.9	<0.1	0.4	
4	Myctophidae	335			0.1	23.1
5	*Anthias tenuis*	272	<0.1	8.3		0.8
6	*Chromis enchrysura*	240	3.0	<0.1	3.1	0.1
7	*Trichiurus lepturus*	239				16.5
8	*Pristigenys alta*	231	1.1	1.8	4.6	3.2
9	*Bregmaceros cantori*	179			2.6	9.9
10	*Chaetodon aya*	161	1.2	1.3	2.8	0.7
11	*Halichoeres bathyphilus*	130	1.7	0.3	0.3	0.1
12	*Trachurus lathami*	123	0.3		2.0	5.5
12	*Decodon puellaris*	123	1.0	0.3	0.4	0.1
14	*Pareques umbrosus*	115	1.0	0.7	0.3	1.7
15	*Serranus notospilus*	98				
16	*Serranus phoebe*	84	0.8	0.2	0.9	
17	*Canthigaster rostrata*	83	0.6	0.1	3.1	0.1
18	*Corniger spinosus*	80	0.5	0.5	1.8	0.5
19	*Synodus* spp.	77			0.2	1.2
20	*Liopropoma eukrines*	74	0.8	0.5	0.3	0.2
21	*Scorpaena dispar*	66	0.2	0.3	2.6	0.3
22	*Saurida* spp.	64				
23	*Seriola dumerili*	63	0.1	0.4	0.9	2.1
24	*Chaetodon sedentarius*	45	0.3	0.2	1.7	
25	*Paranthias furcifer*	39	0.6		0.1	
26	*Rhomboplites aurorubens*	36	0.3		1.4	0.1
27	*Apogon pseudomaculatus*	35	0.2	0.0	1.3	0.4
27	*Mycteroperca phenax*	35	0.3	0.3		0.3
29	*Chromis scotti*	29	0.4		0.1	
30	Scorpaenidae	28	0.0	0.3	0.2	1.0
	Total No. Individuals	12343	6574	3145	1175	1449
	No. Taxa	66	60	42	48	43
	No. Unique Taxa		11	5	3	7
	Video Survey Time (min)		689	329	296	313

Table 1.6. Results of chi-square goodness of fit test for reef fish abundance by survey period (day/night) and reef tract (shallow/deep). Significantly higher or lower abundance is indicated by factor.

		Day		**Night**		**Overall**
Rank	**Taxa**	**Shallow**	**Deep**	**Shallow**	**Deep**	***P***
1	*Pronotogrammus martinicensis*		Higher			<0.0001
2	*Hemanthias vivanus*	Higher				<0.0001
3	Gobiidae	Higher				<0.0001
4	Myctophidae				Higher	<0.0001
5	*Anthias tenuis*		Higher			<0.0001
6	*Chromis enchrysura*	Higher				<0.0001
7	*Trichiurus lepturus*				Higher	<0.0001
8	*Pristigenys alta*					ns
9	*Bregmaceros cantori*				Higher	<0.0001
10	*Chaetodon aya*				Lower	0.0005
11	*Halichoeres bathyphilus*	Higher				<0.0001
12	*Trachurus lathami*				Higher	<0.0001
12	*Decodon puellaris*				Lower	<0.0001
14	*Pareques umbrosus*			Lower		0.0003
15	*Serranus notospilus*					ND
16	*Serranus phoebe*				Lower	<0.0001
17	*Canthigaster rostrata*			Higher		<0.0001
18	*Corniger spinosus*					ns
19	*Synodus* spp.	Lower				<0.0001
20	*Liopropoma eukrines*	Higher				<0.0001
21	*Scorpaena dispar*			Higher		<0.0001
22	*Saurida* spp.					ND
23	*Seriola dumerili*				Higher	<0.0001
24	*Chaetodon sedentarius*			Higher		<0.0001
25	*Paranthias furcifer*	Higher				<0.0001
26	*Rhomboplites aurorubens*			Higher		<0.0001
27	*Apogon pseudomaculatus*			Higher		0.0006
27	*Mycteroperca phenax*					ns
29	*Chromis scotti*	Higher				<0.0001
30	Scorpaenidae				Higher	<0.0001
	No. Individuals	Higher	Higher			<0.0001
	No. Taxa			Higher		<0.0001

ns – not significant ND – no data for comparison

Table 1.7. Day-night comparison of selected community parameters and top six taxa (abundance) paired by reef based on ROV data. Sample size equals five. Significant differences are indicated in bold.

	Mean per Minute Video			
	Day	**Night**	**t**	***P***
No. Individuals	16.48	4.00	3.28	**0.01**
No. Taxa	0.36	0.32	0.29	0.39
P. martinicensis	6.35	1.38	1.48	0.11
H. vivanus	5.44	0.24	2.10	0.05
Myctophids	0	0.68	-1.55	0.10
A. tenuis	0.85	0.02	1.00	0.19
Gobiids	0.17	0.01	1.37	0.12
T. lepturus	0	0.33	-1.01	0.18

Taxonomic groups that were not effectively sampled or video documented during the course of the study included juvenile anthiines and gobiids, due to their extremely small size. Gobies were the third most abundant species observed by ROV censuses (**Table 1.5**), and may be represented by a number of species, but only the spotted goby, *Coryphopterus punctipectophorus*, was documented by close-up video during this study (**Table 1.4**).

Biotopes

From ROV analyses of fish faunal composition, we recognize that species richness and relative abundance of reef fishes differs among biotopes [reef zones (including reef top, reef crest, reef face, and reef base), talus zone, and sand flat habitats, **Table 1.8**, **Figs. 1.20-1.23**], and these differences occur across the various study reefs. All reef biotopes are dominated by anthiine serranids, but showed partitioning. *Hemanthias vivanus* was most abundant in reef top and reef crest biotopes while *P. martinicensis* was increasingly abundant on the reef face and reef base (**Table 1.8**). Additional reef fish taxa that numerically dominated reef top and reef crest biotopes included gobiids, the pomacentrid *C. enchrysura*, the priacanthid *Pristigenys alta* and the labrids *Halichoeres bathyphilus* and *D. puellaris*. The reef face biotope was dominated by anthiine serranids. The schooling serranid *Paranthias furcifer*, *D. puellaris*, and the holocentrid *Corniger spinosus* also characterize this biotope. Fishes common on the reef base biotope included species that typically are associated with crevices and holes, including the holocentrid *Ostichthys trachypoma*, the sciaenid *Pareques umbrosus* and the serranid *Liopropoma eukrines*.

Fishes observed on the reef top were represented by more taxa (28) than reef crest, face, and base biotopes (19, 22 and 22, respectively). High species richness is likely due to the diversity of microhabitats available, including rock outcrops, accumulated coarse sand, and dense assemblages of sessile invertebrates such as sponges, gorgonians and antipatharians that form spatially complex structure. The diversity of habitat present on the reef top also presents a wide variety of prey resources that are associated with unconsolidated sediments and a diverse invertebrate assemblage.

A wide range of fishes also frequents the reef top biotope during night hours. Mobile demersal visual piscivores (groupers, snappers) are found on the reef top during evening hours, and schools of amberjack commonly occur on flat-topped features at night. Night ROV surveys also documented the occurrence of soft bottom sciaenids (e.g., *Leiostomus xanthurus*) and carangids (*Trachurus lathami*) utilizing the reef top. Midwater planktivores from the adjacent slope, including *B. cantori*, *T. lepturus*, and lanternfishes (Myctophidae), have been occasionally observed over reef features at night, and were observed in great abundances on deeper sites such as the Ludwick and Walton Pinnacles (Appendix A4).

While reef biotopes were similar in overall species composition, they differed greatly from the talus zone and sand flat (**Table 1.8**, **Figs. 1.22-1.23**). Species assemblages were very similar among reef biotopes (percent similarity>0.40) and dissimilar from the talus zone and sand flat (percent similarity = 0.14) (**Fig. 1.20**). Overall number of taxa was lower in the talus zone (15) and sand flat (16) than reef biotopes. Gobiids were particularly abundant in the circum-reef talus zone (70.1%), with *D. puellaris*, and the serranids *Serranus phoebe* and *S. notospilus* were also dominant (**Table 1.8**, Appendix A). Lizardfishes (*Synodus* spp.) were also common in this biotope.

Table 1.8. Biotope association of Pinnacles Reef Tract fishes based on ROV surveys during Cruise 97-01, combined for all study sites. Numbers of individuals observed at each biotope during videotape analysis, and percent of total, are given. Top five taxa by biotope are indicated in bold.

	REEF TOP		**REEF CREST**		**REEF SLOPE**		**REEF BASE**		**TALUS ZONE**		**SAND FLAT**	
Taxa	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Hemanthias vivanus	**1698**	**58.8**	**314**	**59.7**	**442**	**39.6**	**39**	**8.7**			-	-
Pronotogrammus martinicensis	**618**	**21.4**	**135**	**25.7**	**536**	**48.1**	**308**	**68.8**	1	0.5	4	1.2
Gobiidae	**161**	**5.6**	**27**	**5.1**	10	0.9	5	1.1	**129**	**70.1**	**71**	**20.5**
Chomis enchrysura	**88**	**3.0**	**7**	**1.3**	5	0.4	2	0.4	2	1.1	-	-
Halichoeres bathyphilus	**57**	**2.0**	**9**	**1.7**	-	-	3	0.7	**7**	**3.8**	-	-
Pristigenys alta	43	1.5	1	0.2	8	0.7	2	0.4	1	0.5	-	-
Decodon puellaris	37	1.3	1	0.2	**13**	**1.2**	8	1.8	**18**	**9.8**	**19**	**5.5**
Chaetodon aya	26	0.9	6	1.1	9	0.8	5	1.1	-	-	-	-
Canthigaster rostrata	24	0.8	-	-	2	0.2	-	-	-	-	-	-
Trachurus lathami	19	0.7	-	-	-	-	-	-	-	-	3	0.9
Serranus phoebe	15	0.5	3	0.6	3	0.3	6	1.3	**8**	**4.3**	5	1.4
Liopropoma eukrines	13	0.5	-	-	-	-	**9**	**2.0**	1	0.5	-	-
Scorpaena dispar	12	0.4	3	0.6	4	0.4	3	0.7	2	1.0	2	0.6
Rhomboplites aurorubens	6	0.2	-	-	9	0.8	-	-	-	-	-	-
Parablennius marmoreus	6	0.2	1	0.2	-	-	-	-	-	-	-	-
Sargocentron bullisi	6	0.2	-	-	-	-	-	-	-	-	-	-
Priacanthus arenatus	5	0.2	-	-	-	-	3	0.7	1	0.5	-	-
Pareques umbrosus	5	0.2	-	-	-	-	**26**	**5.8**	-	-	-	-
Mycteroperca microlepis	5	0.2	1	0.2	5	0.4	-	-	-	-	-	-
Chaetodon sedentarius	5	0.2	5	1.0	3	0.3	2	0.4	-	-	-	-
Seriola dumerili	4	0.1	3	0.6	-	-	-	-	-	-	-	-
Holacanthus bermudensis	4	0.1	1	0.2	2	0.2	-	-	-	-	-	-
Corniger spinosus	4	0.1	5	1.0	**12**	**1.1**	6	1.3	-	-	-	-
Serranus notospilus	3	0.1	-	-	-	-	4	0.9	3	1.6	**84**	**24.2**
Centropristis ocyurus	3	0.1	-	-	-	-	1	0.2	-	-	2	0.6
Synodus sp.	2	0.1	-	-	-	-	-	-	**6**	**3.3**	**40**	**11.5**
Lutjanus campechanus	2	0.1	-	-	2	0.2	-	-	-	-	-	-
Mycteroperca phenax	2	0.1	-	-	11	1.0	1	0.2	-	-	-	-
Pontinus rathbuni	-	-	2	0.4	-	-	-	-	1	0.5	-	-
Pagrus pagrus	-	-	1	0.2	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	1	0.2	**15**	**1.3**	-	-	-	-	-	-
Pareques iwamotoi	-	-	-	-	5	0.4	2	0.4	-	-	-	-
Rypticus maculatus	-	-	-	-	2	0.2	-	-	-	-	-	-
Opsanus pardus	-	-	-	-	2	0.2	-	-	-	-	-	-
Gonioplectrus hispanus	-	-	-	-	2	0.2	-	-	-	-	-	-
Ostichthys trachypoma	-	-	-	-	-	-	**11**	**2.5**	-	-	-	-
Hemanthias leptus	-	-	-	-	-	-	1	0.2	-	-	-	-
Unidentified flatfish	-	-	-	-	-	-	1	0.2	-	-	7	2.0
Saurida sp.	-	-	-	-	-	-	-	-	-	-	**62**	**17.9**
Pristipomoides aquilonaris	-	-	-	-	-	-	-	-	-	-	7	2.0
Hoplunnis sp.	-	-	-	-	-	-	-	-	-	-	7	2.0
Syacium papillosum	-	-	-	-	-	-	-	-	-	-	6	1.7
Upeneus parvus	-	-	-	-	-	-	-	-	-	-	3	0.9
Bregmaceros cantori	-	-	-	-	-	-	-	-	1	0.5	2	0.6
Ancylopsetta dilecta	-	-	-	-	-	-	-	-	1	0.5	-	-
Other taxa	13	0.5	-	-	13	1.2	-	-	2	1.0	22	6.6
Totals	**2886**	**100.0**	**526**	**100.0**	**1115**	**100.0**	**448**	**100.0**	**184**	**100.0**	**346**	**100.0**

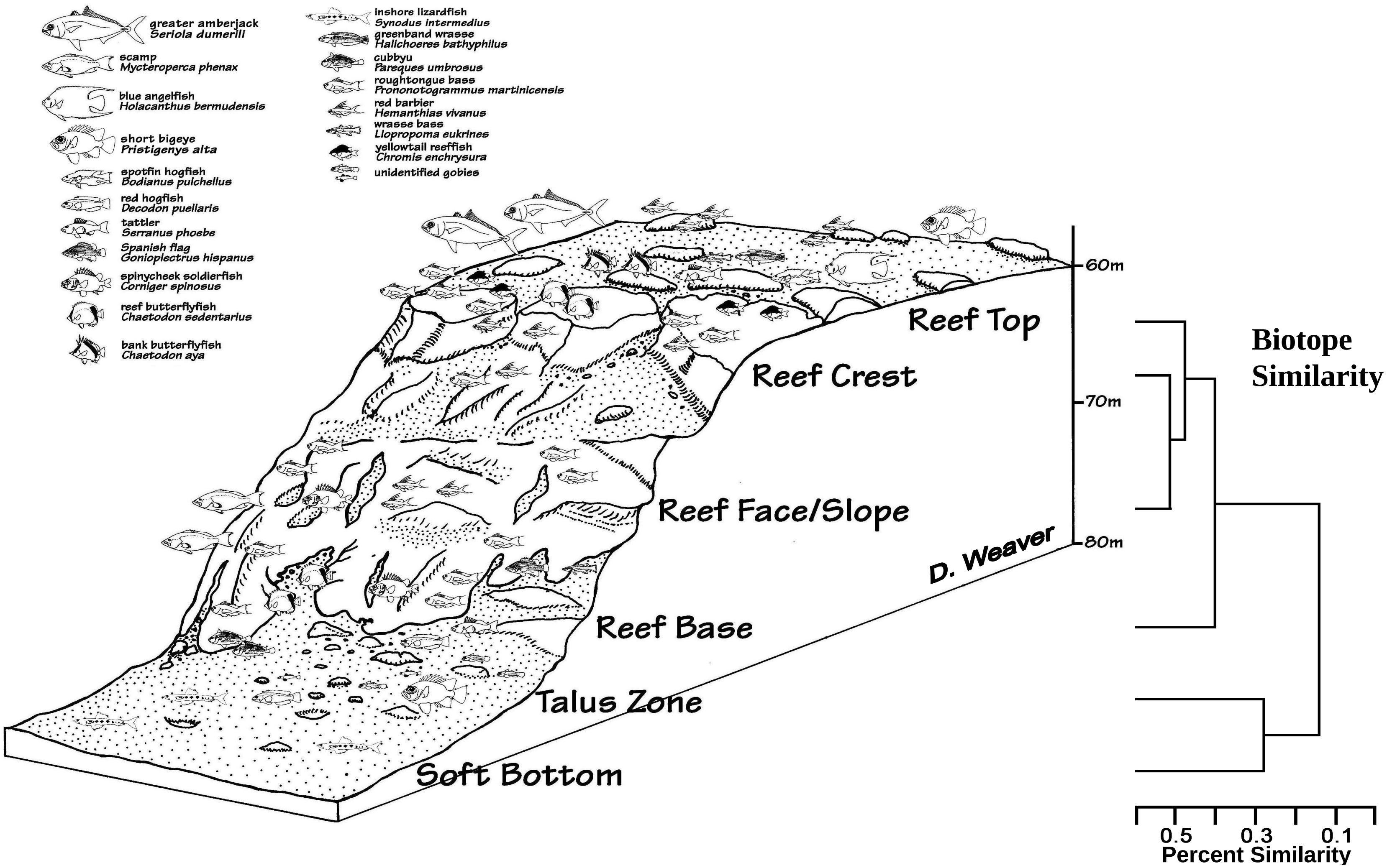


Figure 1.20. Typical ichthyofauna contributing to community structure on the Pinnacles Reef Tract, northeastern Gulf of Mexico, based on ROV data. Cluster diagram shows relationship among biotopes.

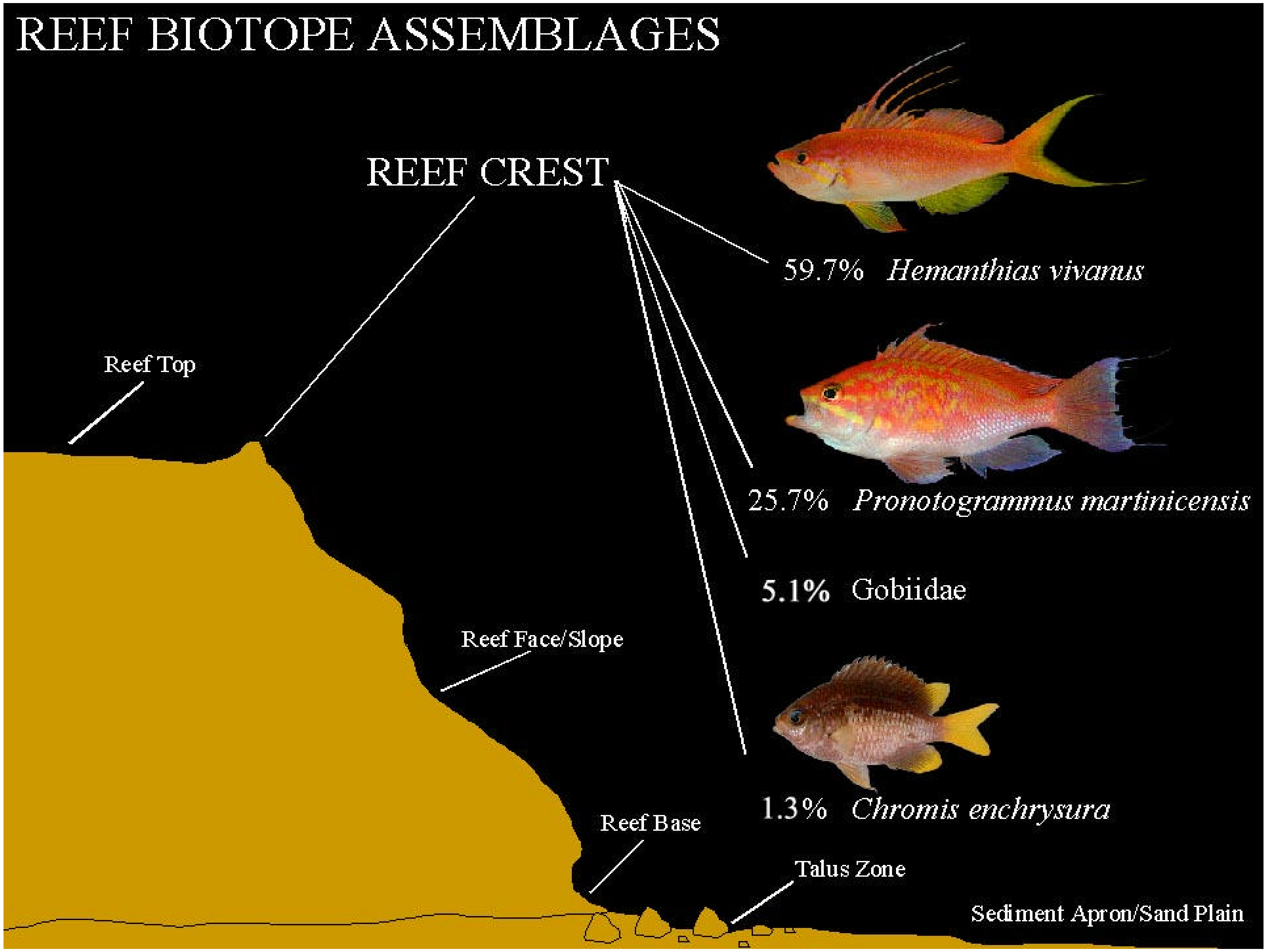


Figure 1.21. Pinnacles Shallow Reef Tract fish faunal composition for reef crest biotope.

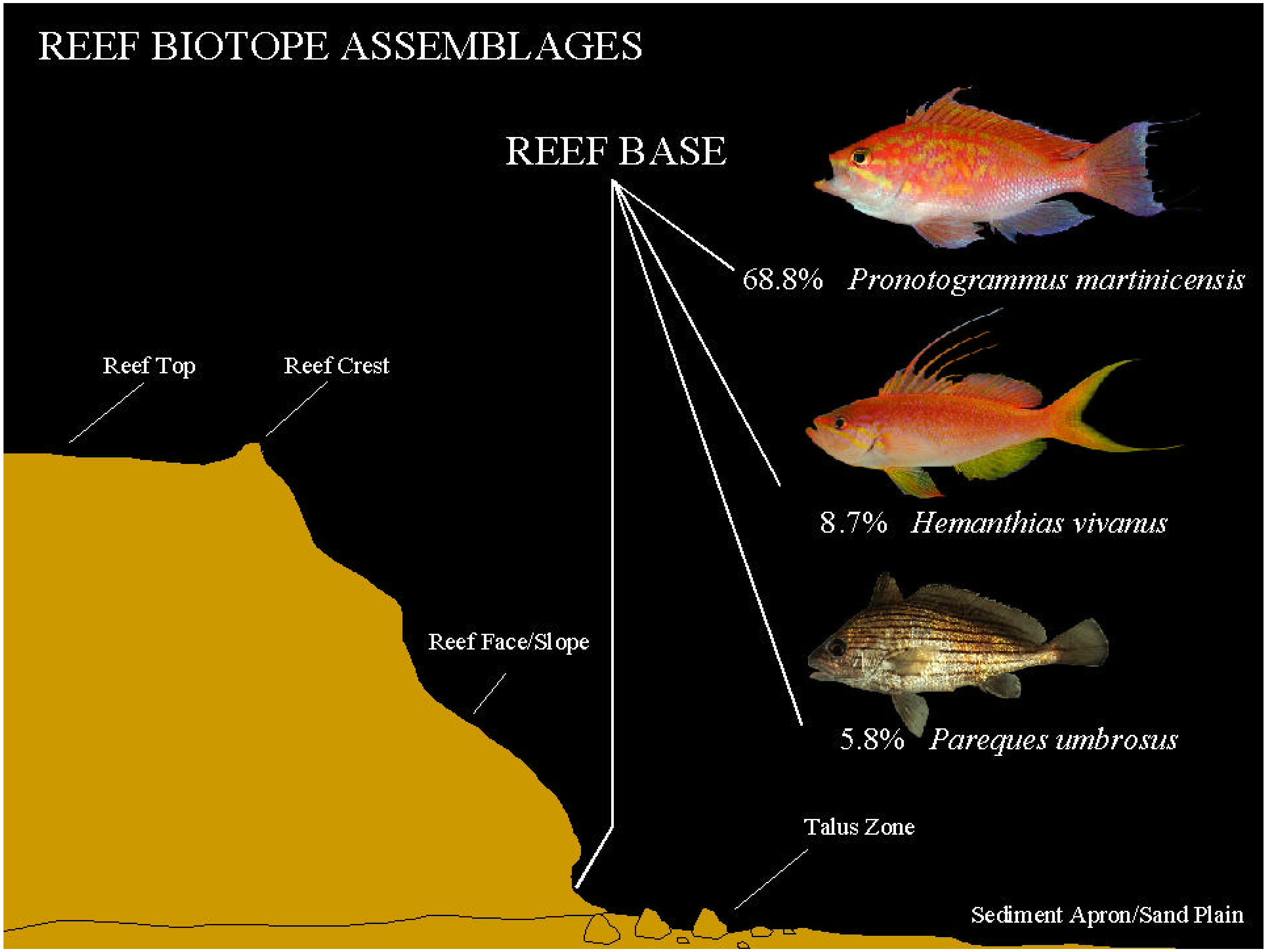


Figure 1.22. Pinnacles Shallow Reef Tract fish faunal composition for reef base biotope.

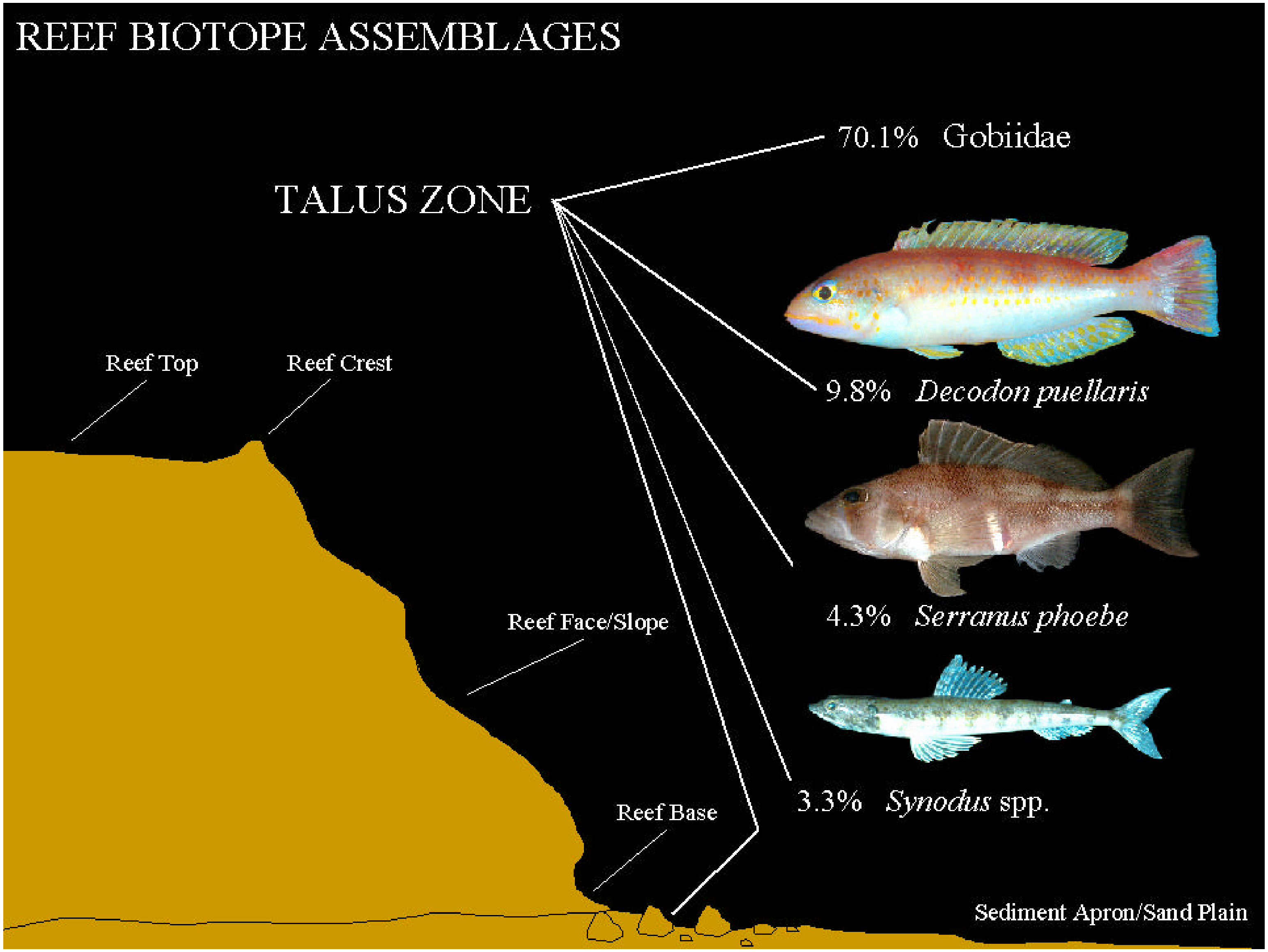


Figure 1.23. Pinnacles Shallow Reef Tract fish faunal composition for talus zone biotope.

Sand flats were also dominated by gobies, with the small serranid *S. notospilus*, lizardfishes (*Synodus* spp. and *Saurida* spp.), *D. puellaris* and flatfishes also common (**Table 1.8**). Anthiine serranids were either absent (*H. vivanus*) or in low abundance (*P. martinicensis*) at these biotopes.

Reef Groups and Species Associations

Fish assemblages from ROV data were compared among reefs using cluster analysis. Five groups of reefs were resolved at a 0.30 similarity level (**Fig. 1.24**). **Table 1.9** compares reef type and community parameters among these groups. Taxa clustering resulted in eight groups at a 0.12 similarity level (**Fig. 1.25**).

Site groups 3 to 5 separate reefs with distinctive faunal compositions. Deeper reef night samples formed the most unique cluster (Site Group 5) with high constancy (faithfulness to a reef group) of Taxa Group G such as myctophids, *T. lepturus*, *B. cantori*, and *T. lathami* (**Fig. 1.25**). The Yellowtail Reef night survey was exceptional in the high constancy with Taxa Group G and very low abundance of *P. martinicensis.* This species is found on the bottom at night and was regularly seen during the night at other sites. Its low abundance at Yellowtail Reef may be due to the low relief of the area surveyed at night. Far Tortuga and Shark Reef (Site Group 3), both large mounds with gentle, silted slopes and no high vertical faces, shared high abundance of gobies and *D. puellaris*.

Site Group 2 contained most of the high relief shallow reef trend sites with the exception of Solitary Mounds. This site group had high constancy with Taxa Groups B and F the largest suite of taxa and strong fidelity (the degree to which taxa are limited to a reef group) with Taxa Group F that included the common taxa, *H. vivanus* and *P. martinicensis* (**Fig. 1.26**). Solitary Mounds fit with this group due to its high abundance of *C. enchrysura*. Site Group 2 reefs on average had high abundances and low species richness (**Table 1.9**).

Site Group 1 sites included deep reefs, night surveys of high diversity shallow water sites, and shallow low relief sites. This indicates that the deep reef fauna is most closely related to the nocturnal fauna of the shallow reef tract. No taxa group had high constancy for this site group, but there was strong fidelity with Group F taxa (**Fig. 1.26**). The low abundance of Taxa Group B, especially *C. enchrysura* and *D. puellaris*, in Site Group 1 differentiates it from Site Group 2. Alabama Alps day and night surveys were very similar (percent similarity = 0.83) sharing 32% (20) of the taxa. In particular *A. tenuis*, *P. umbrosus*, and *S. dumerili* contributed to this similarity. Cat's Paw and Corkscrew Reefs were not well resolved moving among clusters depending on similarity measure employed.

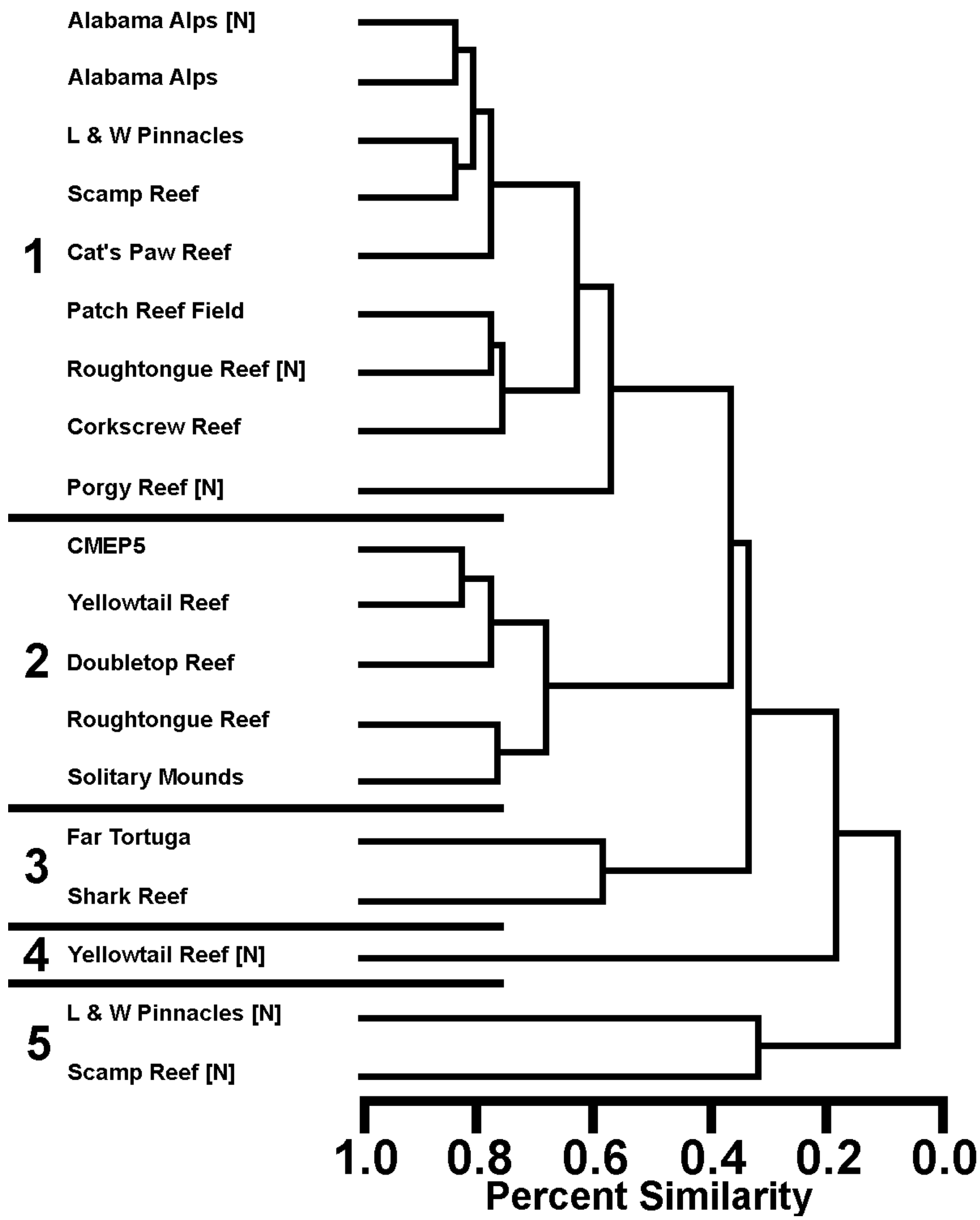


Figure 1.24. Cluster of reef sites using percent similarity and unweighted pair-group mean average combinatorial strategy. [N] designates night dives.

Table 1.9. Summary statistics for ROV data by site group based on cluster analysis. [N] denotes night dives at these sites.

Site Group	Reef	Reef Trend	Relief	Survey Time (min)	Total No. Fish	Total No. Taxa	Mean No. Fish*	Mean No. Taxa*
1								
	Alabama Alps [N]	Deep	High	97.0	482	28	4.97	0.06
	Alabama Alps	Deep	High	61.2	1697	25	27.75	0.01
	Ludwick & Walton Pinnacles[1]	Deep	High	244.8	1088	32	4.44	0.03
	Scamp Reef	Deep	High	23.3	360	16	15.44	0.04
	Cat's Paw Reef	Shallow	High	27.4	81	7	2.96	0.09
	Patch Reef Field	Shallow	Low	58.6	85	12	1.45	0.14
	Roughtongue Reef [N]	Shallow	High	200.2	966	41	4.83	0.04
	Corkscrew Reef	Shallow	High	40.9	363	24	8.88	0.07
	Porgy Reef [N]	Shallow	High	58.5	130	14	2.22	0.11
2								
	CMEP5	Shallow	High	11.3	580	21	51.42	0.04
	Yellowtail Reef	Shallow	High	171.6	2535	40	14.77	0.02
	Double Top Reef	Shallow	High	106.2	354	16	3.33	0.05
	Roughtongue Reef	Shallow	High	90.9	1516	29	16.69	0.02
	Solitary Mounds[2]	Shallow	Intermediate	79.6	584	25	7.34	0.04
3								
	Far Tortuga	Shallow	Intermediate	23.5	72	11	3.06	0.15
	Shark Reef	Shallow	Low	78.6	103	17	1.31	0.17
4								
	Yellowtail Reef [N]	Shallow	High	37.2	79	24	2.12	0.30
5								
	Ludwick & Walton Pinnacles[3] [N]	Deep	High	146.2	766	25	5.24	0.03
	Scamp reef [N]	Deep	High	69.9	200	20	2.86	0.10

[1]includes Pinnacles 1, A, B, and C. [2]includes Mounds 1 and 2. [3]includes Pinnacles 1 and A. ***per minute video

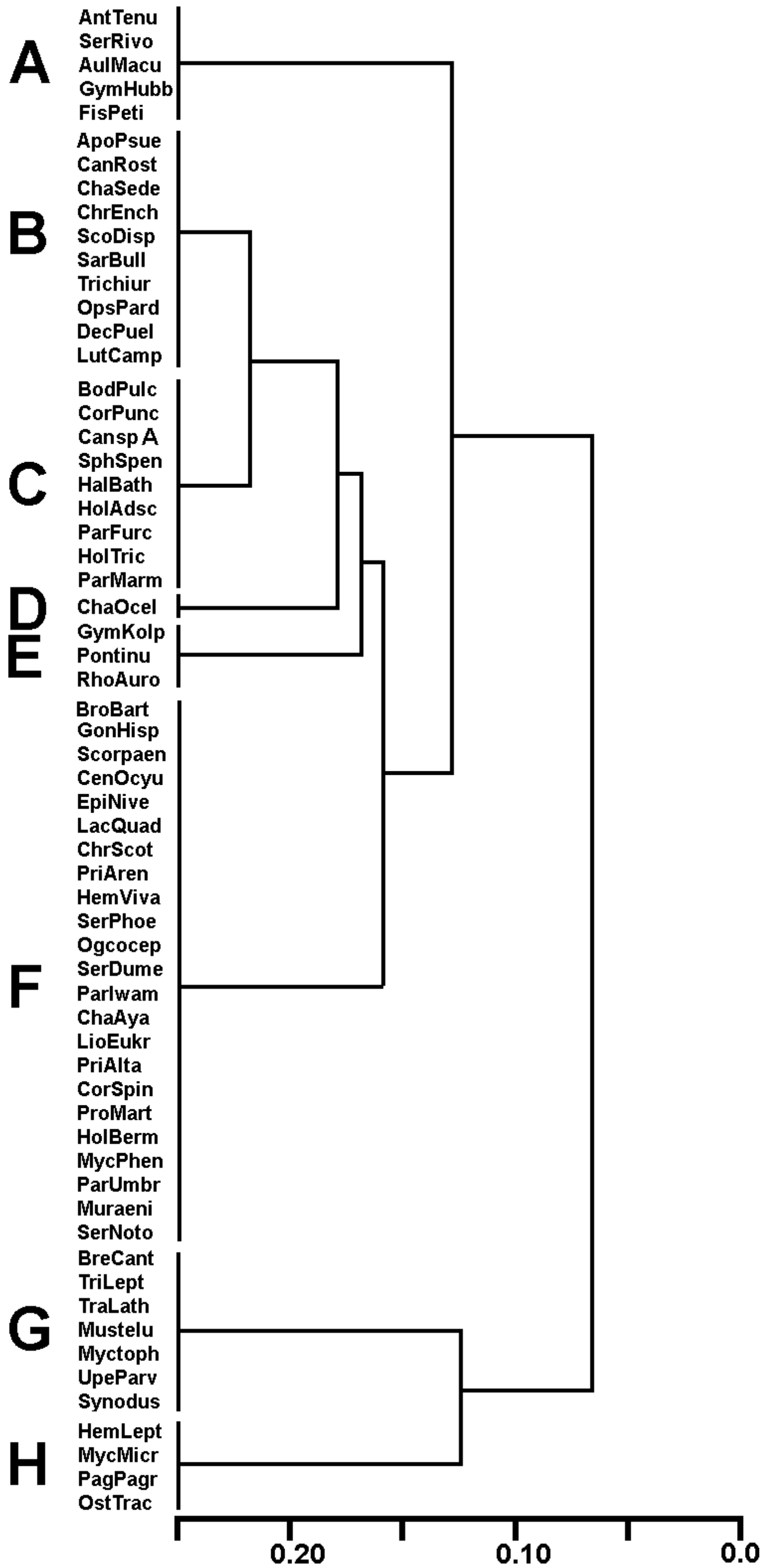
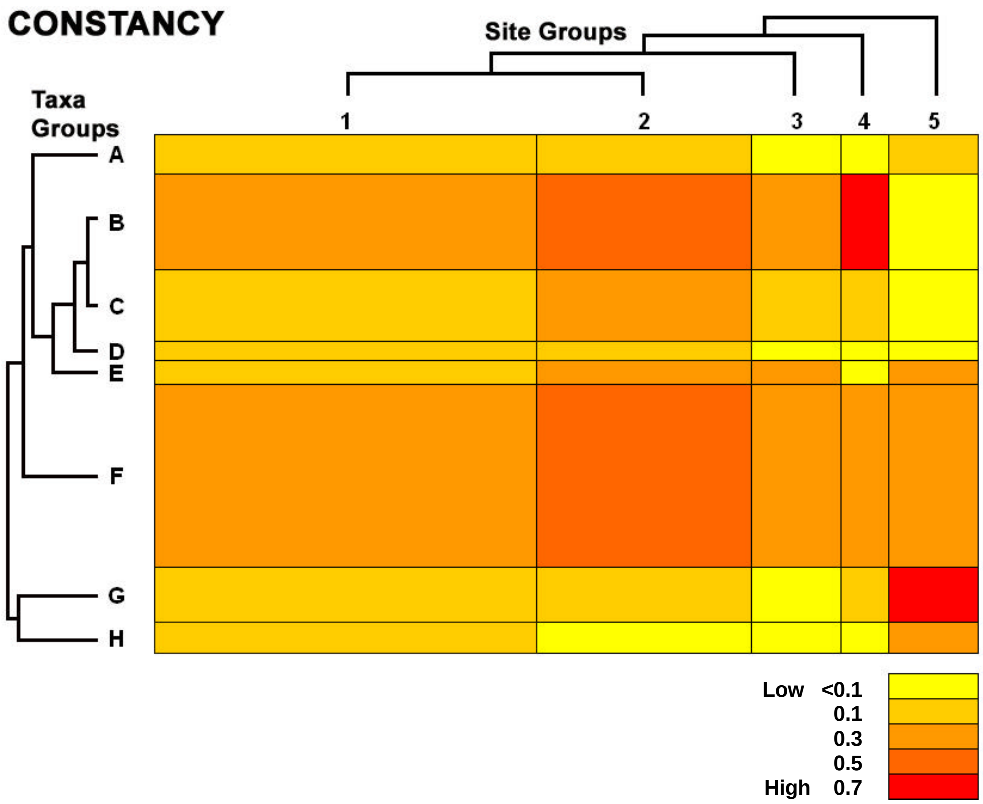


Figure 1.25. Cluster analysis of taxa using percent similarity and unweighted pair-group mean average combinatorial strategy. Clusters were truncated at the group level. Taxa are represented by code, first three letters of genera plus four letters of species name, or first seven letters for genus and higher taxa.



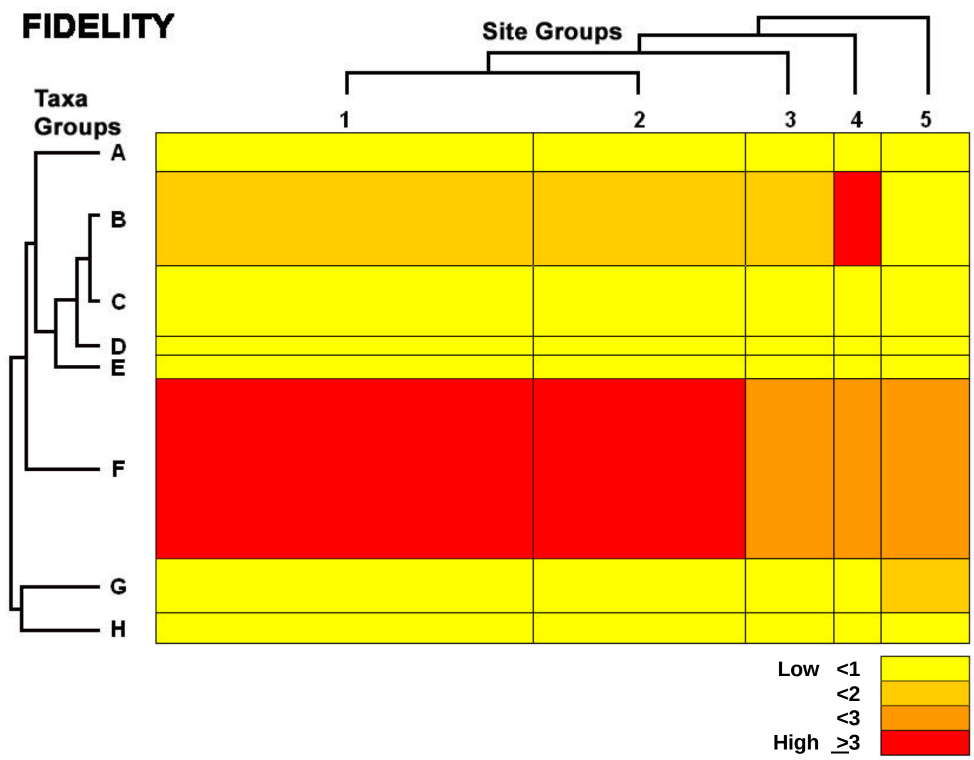


Figure 1.26. Constancy and fidelity for site and taxa groups defined by cluster analysis. Size of cells is related to number of taxa or sites in each group.

Angling

Various remote sampling gears are effective for different groups of taxa. Whereas underwater video documents the fauna much more holistically, some taxa are attracted to or repelled by the ROV light. In addition, cryptic and burrowing species are underrepresented. We used several additional gears types to compliment the ROV survey and enhance our knowledge of the system. Sixty-nine species were taken by hook and line (**Table 1.4**). The gear contributed substantially to our knowledge of community composition, as 21 species were only taken by this gear (particularly sharks, jacks, and mackerels). The numerically dominant taxa collected by baited hook and line are similar to previous surveys (CSA 1992), as *R. aurorubens* and *P. pagrus* were the most frequently caught large predators in both studies (**Table 1.10**). The numerical dominance of *R. aurorubens* and *P. pagrus* also was reported by Grimes et al. (1982) for shelf-edge reefs of the Carolinas. Hook and line sampling was important in estimating large predator abundance, since many of the larger predators are either attracted to the lights of the ROV (carangids, large serranids) or repelled (*R. aurorubens*, *P. pagrus*) during visual surveys biasing abundance estimates. While *R. aurorubens* and *P. pagrus* dominated hook and line samples, they were rarely observed during fish surveys, and typically swim away from the lights when encountering the ROV. We know from comparison of video survey and angling collections that the latter provide an incomplete and highly biased picture of faunal composition, particularly when using standard hook and line angling gear with large, baited hooks.

Traps

Traps collected 38 fish taxa with six species- *Conger oceanicus*, *Epinephelus nigritus*, *Gymnothorax moringa*, *Hippocampus* sp. (stomach contents), *Urophycis floridana*, and *U. regia* - unique to the gear (**Table 1.4**). Of the common taxa, the gear added substantially to the collections of *Pareques* spp., *Brotula barbata*, and eels such as *Muraena retifera* and *Gymnothorax kolpos* (**Table 1.11**). Traps are most effective samplers of cryptic and burrowing species and fish that locate prey by chemosensory means (e.g., eels).

Trawls

Trawls could only be deployed on low relief bottom and thus sampled near-reef sand flat biotope. Fifty-five taxa were collected (**Table 1.4**) with 27 unique to the gear. The faunal separation of the reef and flat bottom communities can be seen in the increased importance of ophidiids (cusk eels), triglids (sea robins), and flatfish (Bothidae and Paralichthyidae) in the trawl catch (**Table 1.12**). *Saurida* spp. and *Serranus notospilus* were dominate in the trawl catch and in ROV surveys on surrounding bottom. Few gobies were taken by the trawl due to mesh size and their propensity to rapidly flee to nearby burrows. Trawls were the only method effective in sampling juvenile *D. puellaris* and *S. notospilus.*

Table 1.10. Abundance of top 15 predatory fishes caught by baited hook and line angling from 1997-2000.

Rank	Species	No.	Percent
1	*Rhomboplites aurorubens*	450	60.4
2	*Pagrus pagrus*	114	15.3
3	*Lutjanus campechanus*	94	12.6
4	*Seriola dumerili*	22	3.0
5	*Centropristis ocyurus*	9	1.2
6	*Caulolatilus chrysops*	9	1.2
7	*Malacanthus plumieri*	7	0.9
8	*Opsanus pardus*	6	0.8
9	*Paranthias furcifer*	4	0.5
10	*Mycteroperca phenax*	4	0.5
11	*Seriola rivoliana*	3	0.4
12	*Mycteroperca microlepis*	3	0.4
13	*Muraena retifera*	3	0.4
14	*Epinephelus niveatus*	3	0.4
15	*Epinephelus flavolimbatus*	3	0.4
Total		**745**	**100**

Table 1.11. Abundance of top 15 fish taxa caught in traps from 1997-2000.

Rank	Species	No.	Percent
1	*Rhomboplites aurorubens*	233	34.9
2	*Pagrus pagrus*	126	18.9
3	*Pareques umbrosus*	71	10.6
4	*Centropristis ocyurus*	42	6.3
5	*Lutjanus campechanus*	33	4.9
6	*Brotula barbata*	31	4.6
7	*Seriola dumerili*	15	2.2
8	*Muraena retifera*	15	2.2
9	*Gymnothorax saxicola*	14	2.1
10	*Mycteroperca phenax*	13	1.9
11	*Micropogonias undulatus*	10	1.5
12	*Mycteroperca microlepis*	7	1.0
13	*Gymnothorax kolpos*	7	1.0
14	*Pareques iwamotoi*	5	0.7
15	*Holacanthus bermudensis*	5	0.7
Total		**668**	**100**

Table 1.12. Abundance of top 15 fish taxa caught by trawl from 1997.

Rank	Species	No.	Percent
1	*Saurida* spp.	140	14.0
2	*Serranus notospilus*	122	12.2
3	*Prionotus paralatus*	79	7.9
4	*Pristipomoides aqualonaris*	76	7.6
5	*Stenotomus caprinus*	72	7.2
6	*Syacium papillosum*	70	7.0
7	*Prionotus stearnsi*	47	4.7
8	*Serranus atrobranchus*	43	4.3
9	*Centropristis philadelphica*	37	3.7
10	*Synodus* spp.	36	3.6
11	*Citharichthys cornutus*	34	3.4
12	*Ophidion holbrooki*	27	2.7
13	*Trichopsetta ventralis*	20	2.0
14	*Lepophidium brevibarbe*	20	2.0
15	*Halieuthichthys aculeatus*	18	1.8
Total		**998**	**100**

DISCUSSION

Within the depth range of the Pinnacles reef tract (60-110 m), previous studies in the northeastern Gulf have indicated that the fish fauna includes components of the Pan-Caribbean reef fish fauna, the Carolinian inshore shelf fauna, and the soft-bottom deep-water outer shelf/upper slope fauna (Shipp and Hopkins 1977, Darnell 1991b, Gittings et al. 1991, McEachran 1991, Snyder 2001). Faunal composition and habitat affinities were comparatively evaluated with previous studies on Gulf of Mexico and western Atlantic reef and offshore continental shelf fish species (e.g., Springer and Bullis 1956, Bullis and Thompson 1965, Bright and Cashman 1974, Smith et al. 1975, Walls 1975, Hastings et al. 1976, Smith 1976, Sonnier et al. 1976, Gilmore 1977, Shipp and Hopkins 1978, Williams and Shipp 1980, Boland et al. 1983, Clarke 1986, Dennis and Bright 1988a, b, Hoese and Moore 1998, Thompson et al. 1999, Snyder 2001). At least 250 reef-associated fishes have been documented from offshore banks, reefs, and other hard-bottom habitats in the northern Gulf of Mexico based on previous literature (Appendix B). The suite of primary reef fishes inhabiting the Pinnacles Reef Tract (**Table 1.4**) represents a depauperate, winnowed fraction of the total reef-fish fauna (Appendix B). The selectively winnowed reef-fish fauna of the Pinnacles Reef Tract appears to represent a characteristic assemblage of deep-reef fishes broadly distributed in the Pan-Caribbean area (Colin, 1974, Colin, 1976). It is important to establish the reasons for this winnowing, particularly if the potential effects of anthropogenic activities on the OCS are to be rationally assessed and monitored. It can be hypothesized that the known Pinnacles reef fish diversity is diminished relative to the Caribbean due to: 1) distance from the source fauna, 2) depth limitation, 3) temperature limitation, 4) habitat limitation due to turbidity, 5) trophic limitations, 6) fishing pressure, or 7) incomplete sampling. However, the first alternative can largely be eliminated as mid-shelf and shelf edge banks off Texas and Louisiana are as far or farther from the Caribbean source region, but support a large number of reef species (Appendix B). Over 150 reef fish species reported to occur in the northwestern Gulf and the Florida Middle Ground have not been documented in the Pinnacles Reef Tract (Appendix B). Thus, a large number of Caribbean reef-fish species do arrive on reefs in the northern Gulf either by larval transport on ocean currents (e.g., Loop Current intrusions), or by active migration. Therefore, habitat or other limitations, and not geographic location alone, appear to be responsible for the absence (or rarity) of many reef fishes on the Pinnacles.

Many Caribbean reef-fish species do not occur at increasing depths within a given geographic area, even in regions of high water clarity and warm temperatures that extend beyond 100 m (Colin 1974, 1976, Dennis and Bright 1988a). Depth per se does not have a direct effect on fish assemblages but covaries with light, temperature, and other physical parameters. The effects of temperature versus depth are difficult to distinguish, and highly variable according to geographic location. The northern Gulf of Mexico is exposed to winter cold fronts that can drastically lower the temperature of inshore waters (Kelly and Bender 2001). The position of the Pinnacles Reef Tract on the OCS provides temperature buffering, with deep Gulf waters moderating temperature fluctuations. Winter bottom temperature averaged 18.1°C with a low of 15.4°C during the study period (Kelly and Bender, 2001). These temperatures are just below levels required for reef development and are similar to conditions at mid-shelf banks in the northwestern Gulf of Mexico that lack active reef growth (Bright et al. 1984, Rezak et al. 1985). While reef fish recruits can colonize outside their normal geographic range they often do not persist due to limiting environmental conditions. However, water temperatures are not low enough at the Pinnacles Reef Tract to be a limiting factor to colonization for reef fishes. *Chaetodon ocellatus* (spotfin butterflyfish), a tropical reef species, does not survive winter temperatures below 10°C though numerous recruits colonize New Jersey estuaries annually (McBride and Able 1998). Similarly, reef fishes in the northern Adriatic can tolerate temperatures from 7-10°C during winter months (Kotrschal and Reynolds 1982). These temperatures are well below winter minima recorded at the Pinnacles Reef Tract and the temperature range becomes less variable with depth contributing to stable environmental conditions (Rezak et al. 1985, Kelly and Bender 2001).

A persistent nepheloid layer characterized by high turbidity was identified as a controlling factor for hard bottom communities in the northwestern Gulf (Rezak et al. 1985). The nepheloid layer increases light attenuation resulting in decreased epibiota and reef fish species richness and abundance below 80 m (Dennis and Bright, 1988a, Rezak et al. 1990). Previous studies have suggested that the Mississippi River plume influences the distribution and abundance of sessile invertebrates within 70 km of the river delta, and may produce a gradient of sedimentation and water column turbidity throughout the Pinnacles Reef Tract (Gittings et al. 1992a, Hardin et al. 2001, Kelly and Bender 2001). In addition, turbidity may affect the feeding efficiency of planktivores (Cuker, 1993). In the northeastern Gulf, nepheloid layers are infrequent, though in conjunction with episodic Mississippi freshwater plumes and upwelling result in increased light attenuation (Kelly and Bender, 2001).

The combination of low winter temperatures and low light levels resulting from increased water depth and turbidity on the Pinnacles Reef Tract results in a reduction of algal and hard coral growth, and subsequent habitat availability for reef fishes. While planktivorous reef fishes dominate Pinnacles reefs, the absence of *Chromis multilineata* (brown chromis), *Chromis cyanea* (blue chromis), and *Clepticus parrae* (creole wrasse), planktivores that form dense schools on reefs in the northwestern Gulf, suggests that it is a result of factors associated with depth and not food limitation that accounts for the absence of such species on the Pinnacles Reef Tract. Of the 150 species listed in Appendix B, only 25 are known from below 60 m depths, equivalent to the shallowest Pinnacles reefs. Conversely, a number of Pinnacles species, notably the dominant anthiine serranids, are absent from the shallow coral cap regions of the Flower Garden Banks (18-45 m) and also are not present at the Florida Middle Ground, where depths range from 26-48 m (Smith et al. 1975, Clarke 1986, Brooks and Doyle 1991). Increased water depth and associated light attenuation may induce food limitations that account for the absence or rarity of other taxa. For example, herbivorous scarids and acanthurids, which form large, free-roaming schools that graze algae from the reef substratum on shallow coral reefs throughout the Caribbean, and occur at both the Flower Gardens and Florida Middle Ground, are absent from the Pinnacles Reef Tract. Similarly, many species of pomacentrids (*Stegastes* spp.) that propagate algal gardens on dead coral surfaces are absent from the Pinnacles Reef Tract fauna, but are present on shallower banks in the northwestern Gulf where light levels are sufficient for growth of filamentous and leafy algae (Dennis and Bright, 1988a). Reduced light levels also results in the absence of a well-developed algal-sponge zone, a dominant biotope occurring at the Flower Gardens at similar depth range (50-80 m) to the shallow Pinnacles reefs (Rezak et al. 1985). Reef fishes that are abundant on the algal-sponge zone at the Flower Gardens, including *Centropyge argi* (cherubfish), *Sparisoma atomarium* (greenblotch parrotfish), and *Serranus annularis* (orangeback bass) are absent on the Pinnacles Reef Tract.

Substrate complexity or rugosity contributes substantially to patterns of reef fish distribution and abundance (Syms and Jones 2000). Friedlander and Parrish (1998) found that epifauna played little role in determining fish assemblages; substrate complexity was a much more important factor. In low relief soft bottom habitats, pits and burrows are particularly important in determining fish distribution (Felley et al. 1989). On deep reefs, the dominant planktivores are visual predators active only during daylight hours. They retreat into crevices and shelter holes at night, and also during the day upon approach of potential predators. The relative abundance of small planktivores and benthivores may depend not only on food availability, but also on relative abundance of shelter holes (= substrate rugosity). While many studies have found correlations between hole size/number and structural complexity with reef fish abundance or habitat selection (Friedlander and Parrish 1998, Syms and Jones 2000, Snyder 2001), when empirically tested no limitation on shelter holes was found for a shallow water reef fish (Robertson and Sheldon 1979).

Most Pinnacle Reef Tract features are high relief drowned reefs giving rise to a range of biotopes (Gardner et al. 2001). Geological features associated with diaparism, including gas and brine seeps that greatly influence the biotic communities in the northwestern Gulf are rare in the Pinnacles Reef Tract (Gittings et al. 1992a, Gardner et al. 2001). Gittings et al. (1992a) and Hardin et al. (2001) have observed different assemblages of sessile macro-invertebrates in the Pinnacles Reef Tract related to structural form (e.g., horizontal summits versus vertical or rugged features). Study sites that have extensive flat-top areas including Roughtongue Reef, Yellowtail Reef, and Alabama Alps, develop a high diversity invertebrate assemblage that is dominated by octocorals, antipatharians, sponges, bryozoans, coralline algae (on shallower reef sites) and crinoids, and is typically characterized by relatively high percent cover of invertebrates (Hardin et al. 2001) (**Fig. 1.18**). Vertical reef faces, overhangs, and rock outcrops and boulders occurring at the reef base are dominated by the solitary coral *R. manuelensis* (**Fig. 1.17**). Results of our ROV analyses indicate strong fish faunal differentiation based on physically defined biotope type (**Table 1.5**; **Figs. 1.21-1.23**, Appendix A). Fine-scale factors such as habitat complexity (Friedlander and Parrish 1998) may control absolute fish abundance within a particular biotope type, but relative abundance appears more a function of basic biotope type.

Fishes observed on the reef top included the highest number of taxa across all biotopes, and this species richness is likely due to the diversity of microhabitats available, including rock outcrops, sand pockets, and dense assemblages of invertebrates such as sponges, octocorals (including large sea fans), and antipatharians that form spatially complex structures. Also the reef top represents the greatest reef area; thus the species-area relationship may be a factor (MacArthur and Wilson, 1963). The diversity of habitat present on the reef top also presents a wide variety of prey resources that are associated with unconsolidated sediments and a diverse invertebrate assemblage. This biotope not only supports planktivores (including *C. enchrysura*), but also benthic carnivores (*H. bathyphilus* and *D. puellaris*), epibenthic browsers (*C. rostrata*, *C. sedentarius* and *H. bermudensis*), and generalized carnivores (*S. phoebe* and *L. eukrines*) (see Chapter 2 for more details on trophic categories).

The reef crest and face are important foraging habitat not only for planktivores, but also for epibenthic carnivores, and mobile piscivores that feed on both planktivores and benthivores. The rugose, highly sculptured substrate provides shelter for small fishes. Stony corals largely replace soft corals, crinoids, antipatharians, and sponges on vertical reef faces, limiting the structural complexity of the reef surface. The reef base, composed of caves and undercuts, is often occupied by species such as *G. hispanus*, *P. umbrosus*, *C. spinosus*, *O. trachypoma*, and *L. eukrines*. Extending out from the reef base is the circum-reef talus apron. This biotope is characterized by small to medium-size benthic carnivores (e.g., labrids, serranids, *P. umbrosus*) that forage for benthic and epibenthic prey, and not plankton. Once on the open sand flat habitat of the shelf proper, fish density is low and fish are primarily active at night and aggregated around any structure (Felley et al. 1989). The distinct fish assemblages within each biotope and the different areal extent of biotopes among reefs needs further study to provide a more detailed picture of factors controlling deep reef community structure. We are extending our future research in this area.

Reef profile and topographic complexity remain somewhat enigmatic in their respective roles in controlling community structure of reef fishes. Beyond a critical threshold, the overall height of a pinnacle structure may be fairly unimportant. What is critical is that the structure be of sufficient height to reduce exposure to turbidity and sedimentation, and perturb flow on the reef face and crest, and over the reef top (Gittings et al. 1992a, MacDonald and Peccini 2001). Messing et al. (1990) found that lithoherm banks in the northeastern Straits of Florida hydrodynamically accelerated ambient 2-7 cm/s bottom currents to greater than 100 cm/s over the upcurrent reef crest. These authors schematically illustrate both the compression of current streamlines over a lithoherm resulting in current acceleration (Messing et al. 1990, Fig. 3), and the resultant upcurrent to downcurrent biozonation of suspension-feeding sessile macroinvertebrates (Messing et al. 1990, Fig. 4). Fairly continuous currents from the southwest sweep the steep-sided Pinnacle reefs as reflected in the orientation of soft corals (MacDonald and Peccini 2001). Flow models indicate that acceleration of currents over shelf-edge pinnacles may increase availability of pelagic prey in the vicinity of high profile features (Kelly and Bender 2001). The "wall of mouths" concept developed on the Great Barrier Reef (Hamner et al. 1988) suggests an upcurrent to downcurrent pattern of faunal differentiation due to plankton removal from the impinging current and the importance of plankton availability in controlling fish faunal assemblages among biotopes. The characterization of biotopes and their associated fish communities on a finer scale that couples water currents and biological/geological characteristics of the benthic habitat may ultimately be necessary to explain the occurrence and composition of the reef fish assemblage. We are presently following this line of inquiry.

Although hermatypic corals with zooxanthellae and leafy algae are a major carbon source for fishes on shallow reefs (Ogden 1982), recent research has revealed that plankton also may be of great importance in certain regions (Hamner et al. 1988). A characteristic set of deep-water planktivores, together with a suite of geographically ubiquitous, deep-water browsers and benthic carnivores, dominate the Pan-Caribbean deep-water fish fauna (Colin, 1974, Colin, 1976; Dennis and Bright, 1988a, this study). Indeed, a model of trophic partitioning of the reef-fish fauna in deep water, based on the Pinnacles Reef Tract example, may have broad application throughout deep reef communities of the world's oceans (see Chapter 2 for details). Trophic partitioning of the Pinnacles fauna closely parallels the earlier findings of Thresher and Colin (1986) for the deep (>75-90 m) reef community of Enewetak Atoll in the southwestern Pacific. Below 90 m, the Enewetak fish fauna was similarly dominated by planktivorous anthiine serranids (>90% of all individuals), together with planktivorous labrids and pomacentrids (*Chromis* spp.). All other trophic guilds were very poorly represented in deep water, except for piscivores (1-10% by number) that feed on the abundant planktivores. Patterns are similar in the Pinnacles Reef Tract except for the low abundance of piscivores.

Both the dominant sessile macro-invertebrates (e.g., gorgonians and antipatharians) and reef fishes on Pinnacles Reef Tract reefs are planktivores, and spatial and temporal access to plankton appear to be major factors in the control of community structure and organism distribution (Hardin et al. 2001, MacDonald and Peccini 2001). Consistency of supply and volume of the planktonic food source may be a strong controlling factor for these fish assemblages. Intercepting the incoming current, the upcurrent reef face and crest should be the most favorable biotopes for swarms of diurnal planktivores (predominantly anthiine serranids). We hypothesize that this is true based on ROV observations, but a quantitative assessment is needed.

Direct anthropogenic effects, such as fishing, also may have altered the reef fish community in the Pinnacles Reef Tract. Commercial fisheries for *Lutjanus campechanus* began in the 1870's, first based in Pensacola, Florida, and expanding to numerous fleets based throughout the Gulf by the early 1930's (Jarvis 1935), targeting snappers and groupers on offshore banks. Darnell (1991b) reports declines in biomass of bottom fishes on the shelf and decreased harvest rates of *L. campechanus*, and attributes these patterns to overfishing and habitat loss. Snyder (2001) points out declining catch rates of large groupers (*Epinephelus* spp. and *Mycteroperca* spp.), *L. campechanus*, and *S. dumerili* throughout the northeastern Gulf since the early 1970's, and a rise in catch rates of *R. aurorubens* during this same time period. These patterns have been linked to the widespread use of bottom longlines in outer shelf waters of the Gulf (Richards and McGowan 1989) that target large demersal fishes, and may explain the low abundance of these species in our collections and ROV surveys. The apparent decrease in the abundance of large piscivores in the Pinnacles Reef Tract due to fishing activities may have had the further consequence of increasing the absolute and relative abundance of their primary prey, the anthiine serranid planktivores or other species of lower trophic levels, such as *R. aurorubens*, and lead to alteration of ecosystem structure and function (Parsons 1992, 1996, Pauly et al. 1998). Thus, caution should be exercised in generalizing patterns in community structure for ecosystems that have been subject to anthropogenic alteration.

Fishes and invertebrates have been characterized at the Pinnacles Reef Tract by three major studies and all major reef features have been precisely mapped. This area may be the most well-known deep hard bottom area in the world. Thus we postulate that the majority of the reef fish species that occur at depths between 60 and 110 m are now documented. Yet due to the large area and diversity of habitat further scientific inquiry will continue to add to our knowledge of the fish fauna. Our present knowledge of the Pinnacles ichthyofauna can be used to characterize the fundamental taxonomic composition and trophic structure of deep reef-fish communities throughout southeastern United States and Gulf of Mexico OCS areas and therefore be useful in assessing future anthropogenic impacts on faunal structure.

CHAPTER 2

TROPHIC ECOLOGY OF PINNACLES TRACT REEF FISHES

INTRODUCTION

Defining trophic pathways is the key to developing an understanding of the ecological framework in the reef fish community. Analysis of food web structure also identifies relative importance of resident reef fishes (autochthonous) versus off-reef trophic resources (allochthonous) such as adjacent soft-substrate and pelagic prey in the diet of large predatory fishes, predator-prey relationships among fishes and invertebrates, and may also identify potential pathways of energy transfer from fishes to the benthic invertebrate assemblage through the release of fecal material. Trophic guild categories are general terms to describe the location of their main source of prey and identify pelagic versus benthic trophic pathways. Within each feeding guild most members will utilize a wide spectrum of prey based on availability/encounter rates, prey size, and prey mobility. Detailed studies of the food habits of deep reef fishes have not been reported in the literature, and few reports of shallow reef fish diets in the Gulf of Mexico are available (e.g., Bullock and Smith 1991, Nelson and Bortone 1996, Weaver 1996). Investigations on food habits of reef fishes in the South Atlantic Bight primarily have focused on commercially important species (Manooch 1977, Grimes 1979, Ross 1982, Matheson et al. 1986, Dodrill et al. 1993, Lindquist and Clavijo 1993, Lindquist et al. 1994, Sedberry and Cuellar 1993). The reef fish, invertebrate, and plant assemblages that characterize live bottom communities in the Gulf of Mexico vary dramatically with depth (Rezak et al. 1985, 1990), limiting comparisons among shallow and deep reef communities from published literature. Therefore, identifying food habits of deep reef fishes and developing food web models from the literature would yield an inaccurate, simplistic view. A full understanding requires sampling of fishes from deepwater reef communities to document dietary patterns. Diets of marine fishes are known to vary dramatically with body size, local microhabitat, and season (Crabtree et al. 1991, Mullaney and Gale 1995, Sheridan and Trimm 1983, Starck 1971), and therefore collection of fishes provides the only method to develop a detailed description of trophic pathways in the deep reef environment. Trophodynamic investigations undertaken in the present study include feeding habits and food web structure of Pinnacles Reef Tract fishes.

OBJECTIVES

- Delineate food habits of numerically dominant fish species.

- Construct a trophic model based on quantitatively-defined food webs that model the Pinnacles fish community structure and function, and convey predictions about primary sources of forage base and energy for reef and reef-associated biotopes.

METHODS

There is an extensive body of literature regarding methods for analysis of fish stomach contents and food habits, and conventional quantitative parameters of broad application have been reviewed (Hyslop 1980). Specimens sampled for food habits from USGS 97-01 through 2000-01 cruises were kept on ice, frozen, or preserved in formalin until processed in the laboratory at the Florida Caribbean Science Center, Gainesville, FL (FCSC). Only specimens from hook and line sampling were analyzed and specimens with empty or everted stomachs were excluded. Trap specimens were not included in the analysis. Fishes were dissected in the laboratory and the whole digestive tracts (stomachs plus intestines) were removed. Prey items were identified to lowest possible taxonomic level. For simplicity, dietary analyses in this report are given as percent number, calculated by dividing the number of prey within each taxon by the total number of prey items for each of the characteristic reef fishes collected excluding empty stomachs. Stomach contents were used to identify the ecological role of each taxon in the reef fish community and used to identify feeding guilds following previous authors (Hobson 1982, Bohnsack et al. 1999).

Food Web Model

A food web model was developed for the Pinnacles fish community. A quantitative model was based on numerical contribution of prey to the diet of each predator. Primary goals of food web models are: 1) to compare relative contribution of allochthonous materials (i.e., plankton and adjacent soft-bottom off-reef organisms) to the energy budget of the dominant members of the reef fish community; and 2) to determine the relative importance of reef fishes in the diet of large reef-associated carnivores. Diets of the characteristic reef fishes were incorporated into a working food web model following the methods of Winemiller (1990) to identify the dominant trophic pathways among the reef fish community. Trophic position of each predator was calculated using the formula:

$$T_i = 1.0 + \sum_{j=1}^{n} T_j \, (p_{ij})$$

where T_i is the trophic level of an individual predator species i, summing relative importance of prey taxon j where p_{ij} is the proportion of the total diet (based on numerical abundance) for species i consisting of prey taxon j. Primary producers are assigned a value of T=0.0, herbivores T=1.0, and a consumer eating half plant and half herbivore tissue would be T=1.5, and so forth, as T_i's are computed sequentially from bottom to top. Calculated T_i values were used as the y axis for placement of consumer nodes of the food web. The x coordinate of each consumer was weighted according to the proportion of prey from different habitat compartments. Proportions of pelagic prey (plankton) were multiplied by 0.0 (far left), reef-based prey by 0.5 (middle), and soft bottom prey by 1.0 (far right), to determine relative dependence on each habitat for prey (Winemiller 1990). This method gives estimates of relative dependence on allochthonous versus autochthonous materials (i.e., a position close to the left portion of the web is dependent on pelagic prey, the middle portion resident reef prey, and the right side off-reef soft bottom prey). Links connecting each compartment were then calculated with respect to movement of energy from prey to predator (uplinks) (Winemiller 1990). Links among the different nodes (predator-prey relation) can be expressed with uniform width and relative strength (qualitative models) or line width varied to reflect proportional contribution of prey in the diet (quantitative models). Terminology of plankton size classes and constituent members follow Christensen (1995).

RESULTS AND DISCUSSION

Over 1000 individuals were examined for food habits with approximately 50% containing prey items. Many specimens everted their stomachs due to the change in pressure when brought to the surface and the majority of the large predators (jacks, snappers, and groupers) had empty stomachs. In addition, many resident reef fishes were poorly sampled by hook and line angling, reflected by low sample sizes. Feeding guilds were defined by characteristic prey (**Table 2.1**). Dietary patterns of the characteristic reef fish taxa are presented in this report (**Table 2.2**, Appendix C). Fish were assigned to feeding guilds based on stomach contents to identify similarity in prey resources among species, sources of prey, and overall patterns in trophic structure (**Table 2.3**). Use of the conventional terms, such as macroinvertivores and microinvertivores, by other authors to describe feeding guilds is avoided due to the wide size range of prey selected by most species (e.g., *Serranus phoebe* feeds on adult crabs and fishes as well as decapod and fish larvae).

The numerically dominant species (greater than 80% of the individuals observed by ROV) on high profile reefs, *Pronotogrammus martinicensis* and *Hemanthias vivanus*, have diets dominated by calanoid copepods, gastropod larvae, and a variety of other pelagic mesoplankton organisms (**Table 2.2**, Appendix C). Macroplanktivores that prey on larger size classes of plankton include *Rhomboplites aurorubens*, *Pristigenys alta*, *Apogon pseudomaculatus*, and *Chaetodon aya*. Benthic feeders included *Pagrus pagrus*, *Pareques umbrosus*, *Decodon puellaris*, and *Halichoeres bathyphilus*.

Table 2.1. Feeding guilds defined by characteristic prey type.

Feeding Guild
Mesoplanktivore- Mixed zooplankton in the microzooplankton to mesoplankton (20-2000μ) size classes. Includes copepods, ostracods, larvaceans, gastropod veligers, pteropods, crustacean larvae, invertebrate eggs, and fish eggs.
Macroplanktivore- Mixed zooplankton in the macroplankton (>2000μ) size class. Includes hyperiid amphipods, shrimp zoea, stomatopod zoea, crab megalopa, fish larvae, salps, and squids.
Benthic Carnivores (~microinvertivores)-primarily infauna/epifaunal invertebrates including crabs, bivalves, gastropods, brittle stars, sea urchins, and polychaetes.
Epibenthic Browsers- encrusting, sessile invertebrates including hydrozoans, bryozoans, soft corals, crinoids, and sponges.
Generalized Carnivores (~macroinvertivores)- a variety of mobile, epibenthic prey that may include fishes, crabs, shrimps, and gastropods.
Piscivores- includes fishes and squids.

Table 2.2. Dietary analysis of characteristic reef fishes of the Pinnacles Reef Tract by trophic guild. Values given are based on numerical contribution to the diet (%N).

		Mesoplanktivores					Macroplanktivores					Benthic Carnivores						
		Bregmaceros cantori	*Chromis enchrysura*	*Hemanthias vivanus*	*Paranthias furcifer*	*Pronotogrammus martinicensis*	*Apogon pseudomaculatus*	*Chaetodon aya*	*Priacanthus arenatus*	*Pristigenys alta*	*Rhomboplites aurorubens*	*Bodianus pulchellus*	*Caulolatilus chrysops*	*Decodon puellaris*	*Halichoeres bathyphilus*	*Pagrus pagrus*	*Pareques iwamotoi*	*Pareques umbrosus*
	Sample Size	2	20	47	1	120	5	13	15	9	72	4	2	2	10	28	1	4
Phylum	**Prey Item**	**Percent Number**																
	Invertebrate eggs	-	19.1	3.0	-	11.0	-	-	-	-		-	-	-	-	-	-	-
Protoctista	Foraminiferans	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	-	-	-
	Radiolarians	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-
Porifera	Sponges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-
Cnidaria	Hydrozoans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soft Corals	-	-	-	-	-	-	4.8	-	-	-	-	-	-	-	-	-	-
Mollusca	Heteropods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gastropods	-	-	-	-	-	-	-	-	-	-	14.3	-	31.3	-	16.0	33.3	-
	Pelecypods	-	-	-	-	-	-	-	-	-	-	38.1	20.0	37.5	48.3	3.2	-	-
	Pteropods	-	-	-	-	-	-	-	1.3	-	6.9	-	-	-	-	-	-	-
	Chitons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Squids	-	-	-	-	-	-	-	32.9	16.0	0.2	-	-	-	3.4	-	-	-
Annelida	Polychaetes	-	13.3	17.7	35.7	10.3	-	-	-	-	14.3	-	45.0	6.3	3.4	4.3	-	9.1
Arthropoda	Copepods	60.0	32.4	78.8	28.6	69.7	-	-	-	-	15.2	-	-	-	-	-	-	-
	Amphipods	20.0	-	-	-	0.2	-	5.1	-	-	15.2	-	-	-	-	-	-	-
	Barnacle larvae	-	-	-	-	0.1	-	-	-	-	1.4	-	-	-	-	-	-	-
	Crab larvae	-	1.1	-	14.3	0.4	12.5	90.1	14.5	16.0	3.7	-	-	12.5	13.8	2.1	-	-
	Crabs	-	-	-		-	25.0	-	1.3	2.0	-	19.0	5.0	6.3	6.9	34.0	33.3	36.4
	Isopods	-	-	-	-	-	37.5	-	-	-	-	-	-	-	-	-	-	-
	Ostracods	-	-	0.1	-	1.7	-	-	-	-	2.1	-	-	-	-	-	-	-
	Shrimp larvae	20.0	2.1	-	21.4	-	25.0	-	1.3	16.0	10.1	-	-	-	6.9	-	-	9.1
	Shrimps	-	-	-	-	-	-	-	3.9	40.0	-	-	-	-	-	2.1	-	36.4
	Stomatopod larvae	-	-	-	-	-	-	-	27.6	6.0	8.0	-	-	6.3	-	6.4	-	-
	Stomatopods	-	-	-	-	-	-	-	-	-	-	-	25	-	-	4.3	-	-
Bryozoa	Bryozoans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echindermata	Echinoids	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.2	-	-
	Ophiuroids	-	-	-	-	-	-	-	-	-	-	9.5	5.0	-	6.9	-	33.3	9.1
	Holothuroids	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-
	Crinoids	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chordata	Larvaceans	-	32.0	0.1	-	1.9	-	-	-	-	1.1	-	-	-	-	-	-	-
	Salps	-	-	-	-	0.5	-	-	-	-	9.9	-	-	-	-	-	-	-
	Fish eggs	-	-	-	-	2.4	-	-	-	-	1.4	-	-	-	-	-	-	-
	Fish larvae	-	-	-	-	-	-	-	14.5	-	10.6	-	-	-	-	-	-	-
	Fishes	-	-	-	-	-	-	-	2.6	2.0	-	19.0	-	-	3.4	5.3	-	-

Table 2.2. (continued).

		Epibenthic browsers			Generalized Carnivores										Piscivores		
		Holacanthus bermudensis	*Chaetodon sedentarius*	*Canthigaster rostratus*	*Centropristis ocyurus*	*Epinephelus flavolimbatus*	*Holocentrus adscensionis*	*Liopropoma eukrines*	*Lutjanus campechanus*	*Malacanthus plumieri*	*Opsanus pardus*	*Pontinus rathbuni*	*Sargocentron bullisi*	*Serranus phoebe*	*Aulostomus maculatus*	*Gymnothorax saxicola*	*Seriola dumerili*
	Sample Size	4	8	2	6	2	3	1	26	7	5	1	2	44	1	1	6
Phylum	**Prey Item**	**Percent Number**															
	Invertebrate eggs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protoctista	Foraminiferans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Radiolarians	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Porifera	Sponges	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria	Hydrozoans	-	71.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soft Corals	41.7	14.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollusca	Heteropods	-	-	-	-	-	-	-	5.1	-	-	-	-	-	-	-	-
	Gastropods	-	-	3.2	11.8	-	-	-	-	25.0	33.3	-	-	-	-	-	-
	Pelecypods	-	-	7.8	-	-	-	-	-	18.8	-	-	-	-	-	-	-
	Pteropods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Chitons	-	-	2.1	-	-	-	-	-	-	-	-	16.7	-	-	-	-
	Squids	-	-	-	-	-	-	-	2.6	-	-	-	-	1.4	-	-	-
Annelida	Polychaetes	-	-	-	-	-	-	-	-	-		-	16.7	1.4	-	-	-
Arthropoda	Copepods		5.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amphipods	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-	-	-
	Barnacle larvae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Crab larvae	-	-	-	-	-	42.9	-	-	-	-	-	33.3	5.6	-	-	-
	Crabs	-	-	-	76.5	-	-	-	5.1	18.8	25.0		-	41.7	-	-	-
	Isopods	-	-	-	-	-	-	-	10.3	-	-	-	-	-	-	-	-
	Ostracods	-	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Shrimp larvae	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Shrimps	-	-	-	5.9	33.3	14.3	-	7.7	-	-	60.0	-	5.6	-	-	-
	Stomatopod larvae	-	-	-	-	-	-	-	-	-	-	-	33.3	-	-	-	-
	Stomatopods	-	-	-	-	-	-	-	2.6	-	-	-	-	1.4	-	-	-
Bryozoa	Bryozoans	41.7	-	-	-	-	-	-	-	6.3	-	-	-	-	-	-	-
	Echinoids	-	1.5	-	-	-	-	-	-		8.3	-	-	-	-	-	-
	Ophiuroids	-	-	-	5.9	-	-	-	-	12.5	-	-	-	1.4	-	-	-
	Holothuroids	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Crinoids	8.3	-	78.6	-	-	-	-	-	-	8.3	-	-	-	-	-	-
Chordata	Larvaceans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Salps	-	-	-	-	-	-	-	10.3	-	-	-	-	-	-	-	-
	Fish eggs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish larvae	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-
	Fishes	-	-	-	-	66.7	42.9	100	56.4	18.8	25.0	40.0	-	37.5	100	100	100

Table 2.3. Feeding guilds of fishes along the Pinnacles Reef Tract. Determination of feeding guild is modified from Hobson (1982) and Bohnsack et al. (1997, 1999) and based on stomach contents identified in this study, or from food habits by Randall (1967) for closely related taxa.

Feeding Guild
Mesoplanktivores- *Anthias tenuis* (threadnose bass), *Chromis enchrysura* (yellowtail reeffish), *Hemanthias vivanus* (red barbier), *Paranthias furcifer* (creole-fish), *Pronotogrammus martinicensis* (roughtongue bass), *Trachurus lathami* (rough scad).
Macroplanktivores- *Apogon pseudomaculatus* (twospot cardinalfish), *Chaetodon aya* (bank butterflyfish), *Priacanthus arenatus* (bigeye), *Pristigenys alta* (short bigeye), *Rhomboplites aurorubens* (vermilion snapper).
Benthic Carnivores- *Balistes capriscus* (gray triggerfish), *Calamus leucosteus* (whitebone porgy), *Calamus nodosus* (knobbed porgy), *Caulolatilus chrysops* (goldface tilefish), *Decodon puellaris* (red hogfish), *Halichoeres bathyphilus* (greenband wrasse), *Pagrus pagrus* (red porgy), *Pareques iwamotoi* (blackbar drum), and *P. umbrosus* (cubbyu).
Epibenthic Browsers –*Canthigaster rostrata* (sharpnose puffer), *Chaetodon sedentarius* (reef butterflyfish), *Chaetodon ocellatus* (spotfin butterflyfish), *Holacanthus bermudensis* blue angelfish), *Parablennius marmoreus* (seaweed blenny).
Generalized Carnivores- *Bodianus pulchellus* (spotfin hogfish), *Centropristis ocyurus* (bank sea bass), *Corniger spinosus* (spinycheek soldierfish), *Epinephelus flavolimbatus* (yellowedge grouper), *Epinephelus nigritus* (Warsaw grouper), *Epinephelus niveatus* (snowy grouper), *Holocentrus adscensionis* (squirrelfish), *Liopropoma eukrines* (wrasse bass), *Lutjanus campechanus* (red snapper),Muraenidae, *Opsanus pardus* (leopard toadfish), *Malacanthus plumieri* (sand tilefish), *Sargocentron bullisi* (deepwater squirrelfish), *Pontinus rathbuni* (highfin scorpionfish), *Rypticus maculatus* (whitespotted soapfish), *Scorpaena dispar* (hunchback scorpionfish), *Serranus phoebe* (tattler).
Piscivores- *Aulostomus maculatus* (trumpetfish), *Fistularia petimba* (red cornetfish), Muraenidae, *Mycteroperca microlepis* (gag), *M. phenax* (scamp), *Seriola dumerili* (greater amberjack), *Seriola fasciata* (lesser amberjack), *Seriola rivoliana* (almaco jack).

Epibenthic browsers included *Chaetodon sedentarius* and *Holacanthus bermudensis* whose diets were composed of sessile invertebrates. Piscivores were represented by *Mycteroperca* spp., *Seriola* spp., *Lutjanus campechanus*, muraenids, *Aulostomus maculatus,* and *Fistularia petimba*. The generalized carnivore guild was represented by numerous taxa including *S. phoebe,* and a variety of serranids, scorpaenids, muraenids, and holocentrids. As discussed by Snyder (2001), this guild contains the most taxa of deep reef fishes, although individual species are not as numerically abundant as planktivores and benthic carnivores in reef communities.

Planktivorous anthiine fishes may serve as a keystone predator by foraging in the water column and transferring energy to the deep reef ecosystem. Anthiines in turn become prey for a variety of reef predators. Stomach contents indicate that newly settled juveniles and young-of-the-year anthiines are an important seasonal component of the diet for a variety of reef fishes, including *L. campechanus*, carangids, and serranids. Trophic pathways among the deep reef community indicate primary links to the pelagic community through direct consumption of planktonic organisms and may be supplemented by surrounding benthic communities through consumption of eggs and larvae of soft-bottom fishes, a variety of invertebrates, and potentially by spawning populations of migratory species from nearshore reef communities (e.g., *Mycteroperca microlepis*). In contrast, Darnell (1991a) concluded that zooplankton contributed only 2% of the overall foods for the soft-bottom fish community of the Mississippi-Alabama shelf, and that small epibenthic organisms, infauna, and larger demersal organisms constituted the majority of the food resources for the soft bottom assemblage.

Initial analysis of food web structure (**Figs. 2.1, 2.2**) for the deep reef community further identifies potential pathways of energy flow and trophic links between hard- and soft-bottom habitats that may be useful in identifying changes in trophic structure associated with anthropogenic activities (e.g., the oil/gas exploration and fishing) in areas that are of special concern to resource managers. The current reef fish community exhibits trophic pathways that are primarily supported by planktonic prey, as planktivorous reef fishes dominated all reef biotopes observed during ROV surveys and *R. aurorubens,* a macroplanktivore, was the numerically dominant predator taken by angling and traps.

While generalized carnivores are the most speciose feeding guild on the Pinnacles Reef Tract, they were relatively rare in ROV surveys and collections made during this study. Planktivores (primarily anthiines and the pomacentrid *C. enchrysura*) numerically dominated all reef biotopes during ROV surveys with benthic carnivores (Gobiidae, *H. bathyphilus, D. puellaris,* and *P. umbrosus)* second in importance. Generalized carnivores were represented by *S. phoebe* and *L. eukrines*, but individual taxa made up 2% or less by number on reef biotopes. Food web models based on relative abundance of fishes indicate that the primary pathway of energy to the deep reef community is by direct consumption of copepods, amphipods, fish larvae, decapod larvae, and gelatinous zooplankton that prey on smaller planktonic prey groups in the water column (**Figs. 2.1, 2.2**). Secondary pathways that support benthic carnivores are presumably based on detrital pathways that support infaunal and epifaunal invertebrates. The numerically dominant predators, *R. aurorubens* and *P. pagrus,* feed directly on planktonic and soft-

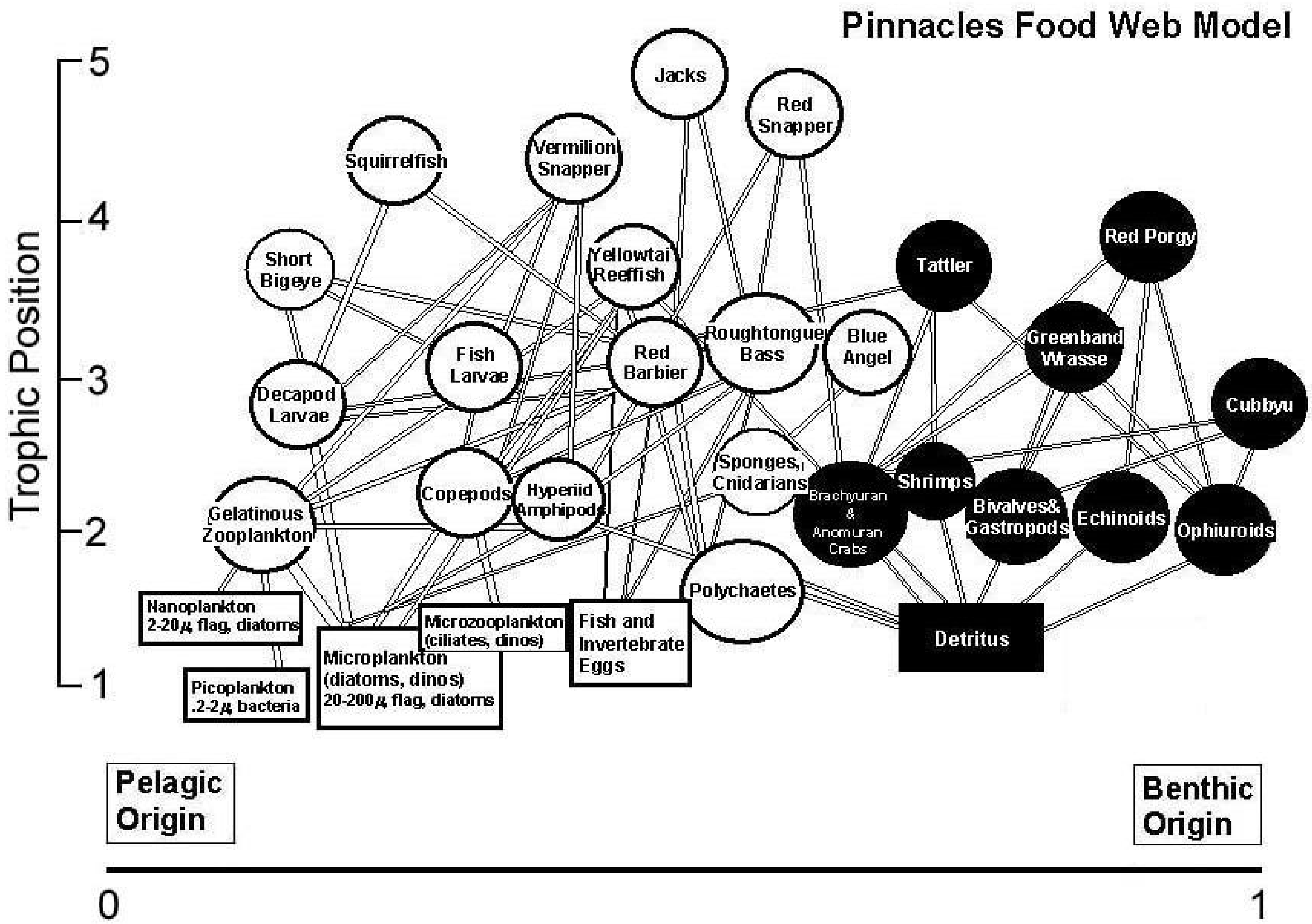


Figure 2.1. Qualitative food web model for reef fishes of the Pinnacles Reef Tract constructed from stomach content analysis. Position on the food web model is based on relative proportion of pelagic prey (x axis) and trophic position (y axis).

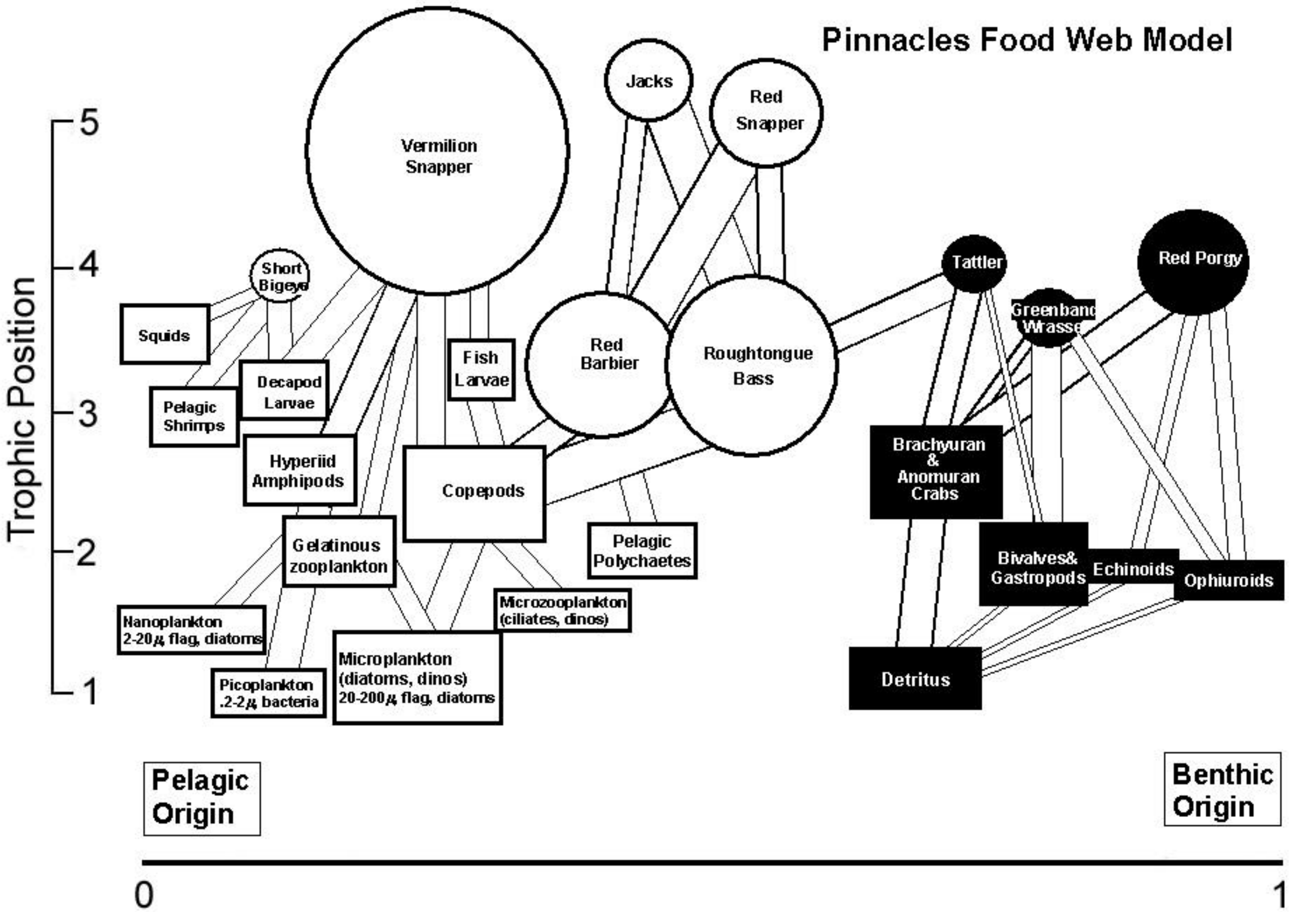


Figure 2.2. Quantitative food web model for reef fishes of the Pinnacles Reef Tract constructed from stomach content analysis. Position on the food web model is based on relative proportion of pelagic prey (x axis) and trophic position (y axis). Relative sizes of nodes (circles) depict abundance of reef fishes based on ROV data analysis and hook and line collections and relative widths of links depicted are based on numerical contribution of prey in the diet of each predator.

bottom organisms, respectively, and do not have diets characterized by reef-associated fishes or invertebrates. *Seriola* spp., *L. campechanus*, and *S. phoebe* prey upon anthiine serranids, and therefore also appear to be supported primarily by pelagic trophic pathways.

While few groupers examined during this study retained identifiable stomach contents, anthiine serranids presumably form a significant part of their diet, as *A. tenuis*, *H. vivanus*, and *P. martinicensis* have been reported from the stomach contents of deepwater groupers (Bullock and Smith 1991). Predation on anthiines would provide a direct link to pelagic food webs.

Trophic pathways within reef systems have been the subject of study since the 1950's (Odum and Odum 1955, Hiatt and Strasburg 1960), yet trophic interactions and mechanisms of energy transfer within the reef fish community are still poorly known (Bohnsack and Sutherland 1985, Nelson and Bortone 1996). In their original work on the trophic structure of coral reefs, Odum and Odum (1955) concluded that the coral reef community at Enewetak Atoll was primarily supported by benthic and zooxanthellate algae, and suggested that incoming plankton was not a significant component of organic matter to the community. Tropical oceans that bathe most coral reefs are oligotrophic, therefore most shallow reef systems might be self-supporting, although more recent studies have identified the important trophic links to zooplankton in tropical coral reef communities (Hamner et al. 1988). Benthic algae typically supports a large population of grazing reef fishes. These herbivores are dominant members of many shallow coral reef systems (Hiatt and Strasburg 1960, Ogden 1982, Ebeling and Hixon 1991), yet are absent from the Pinnacles Reef Tract. Porter and Porter (1977) suggested that coral reef communities support a self-generated food web, and tightly recycle nutrients. Pinnacles deep reef communities are characterized by an abundance of planktivorous fishes and suspension-feeding invertebrates (Hardin et al. 2001), utilizing allochthonous prey resources in the water column to sustain populations, and are therefore very different in trophic structure when compared to many shallow coral reef communities.

The relative importance of plankton in food web structure of reef communities has received limited attention, particularly for more eutrophic warm-temperate reef ecosystems in the Atlantic and Gulf of Mexico. Advection of plankton from open ocean water masses to the continental shelf has been noted (Hopkins et al. 1981). Bottom currents also bring plankton from adjacent shelf waters to the shelf break (Kelly and Bender 2001). Copepods and gelatinous zooplankton are the common grazers of phytoplankton and nanoplankton (<5 μ) in the open water column and may be important in transfer of open water primary production to other components of marine ecosystems such as the benthic fish assemblage (Fourtier et al. 1994, Kleppel et al. 1996). Along a shallow windward reef face in Australia, transport of plankton from the open ocean was considered the major input of organic material to the fish and invertebrate community (Hamner et al. 1988). On temperate reefs in California, over 67% of fishes are obligate or facultative planktivores (Ebeling and Hixon 1991). Planktivorous fishes also dominate fish communities on New Zealand rocky reefs (Kingsford and MacDiarmid 1988, Kingsford 1989). Feeding on plankton is an important trophic pathway in many reef fish communities, particularly those exposed to strong ocean currents. Planktivory is considered an important route of energy flow to the reef community by two pathways: 1) direct consumption of zooplankton by planktivorous fishes and sessile macroinvertebrates, and 2) consumption of planktivores by larger piscivores or deposition of fecal material to the reef (Hobson 1991). On Indo-Pacific coral reefs, fecal material provides an alternative source of nutrients to reef inhabitants as many fishes ingest fecal material of *Chromis atropectoralis*, a planktivore that releases feces of high energy content (Bailey and Robertson 1982**.** Hamner et al. (1988) also noted that fecal pellets of planktivores were observed on the reef surface more frequently than zooplankton. *Chromis punctipinnis*, a common member of the reef fish community in California, has been shown to deposit substantial quantities of fecal material to rocky reefs each night (Bray et al. 1981). Many invertebrates (e.g., crabs, shrimps, and brittle stars) rapidly ingest deposited fecal material deposited by planktivorous fishes (Rothans and Miller 1991) and in turn these mobile invertebrates are preyed upon by fishes. Sedberry and Cuellar (1993) discussed the potential role in energy transfer by *R. aurorubens* through release of feces over the reef surface. This pathway may be important in trophic connections between planktivorous reef fishes and benthic invertebrate assemblages in deep reef communities throughout the western Atlantic. Reef-dwelling planktivores that dominate the Pinnacles reef community may supplement the diet of many motile reef invertebrates that are the dominant prey of other resident fishes.

Hard-bottom communities are generally characterized by much higher fish biomass than surrounding, unconsolidated sediments (Sedberry and Van Dolah 1984, Parker and Ross 1986). However, studies of productivity on shallow (<38 m) hard-bottom reef systems along the southeastern U. S. reveal that these reef communities are heterotrophic and not nearly as productive as their tropical coral reef counterparts. Typical productivity/ respiration ratios for the southeastern U.S. live bottom reefs average 0.68 versus 1.45 on Indo-Pacific coral reefs (Longhurst and Pauly 1987, Hopkinson et al. 1991). Shallow hard bottom communities require secondary production via pelagic zooplankton or benthic primary production in adjacent sandy habitats as a food source to support reef organisms (Hopkinson et al. 1991). Deep reefs in the Gulf of Mexico should exhibit even lower primary productivity/respiration ratios than shallow water communities. Therefore, dense populations of Pinnacles fishes appear to exceed levels that could be supported solely by locally produced prey resources. Fishes on deep reefs must therefore be “subsidized” by passive transport of prey from surrounding benthic or pelagic habitats on water currents, or via active feeding migrations of predators to adjacent areas of the water column or the underwater landscape (Polis et al. 1997). On shallow coral reef ecosystems, grunts of the genus *Haemulon* migrate away from the reef to forage on benthic invertebrates in adjacent sea grass beds and sand flat areas at night, and form inactive schools over coral reefs by day (Meyer et al. 1983, Parrish 1989). Temperate reef fishes also forage in off-reef habitats and consume invertebrates in neighboring soft-bottom habitats (Posey and Ambrose 1994, Weaver 1996). In both tropical and temperate reef systems, planktivorous reef fishes aggregate at discrete areas and rely on water currents to transport prey resources from the surrounding water column (Bray 1981, Hamner et al. 1988). Passive transport of planktonic prey to resident fishes, or active migration away from reefs to forage on benthic or pelagic prey resources represents allochthonous trophic subsidies. Spatial subsidies, where primary and secondary productivity of adjacent habitats provides prey resources that are transported to the reef community enhance populations of resident predators, result in increased predator density at levels well above those sustainable from local resources (Polis et al. 1997). Local enhancement of fish populations at the Pinnacles occurs through two major pathways: 1) consumption of plankton by numerically dominant anthiines and *R. aurorubens* as they actively forage into the water column or 2) foraging in adjacent soft-bottom sediments by benthic carnivores such as *P. pagrus, S. phoebe*, and labrids.

While small diurnal planktivores, such as *P. martinicensis* and *H. vivanus,* are considered to be an important trophic link between open water plankton and the reef community, resident nocturnal planktivores may play a relatively minor role in the overall energetics of the reef community. Although nocturnal planktivores are widely distributed on reefs, most resident species occur in low abundance (i.e., *P. alta*), and are not considered to be important prey for piscivorous fishes due to their deep bodies and well-developed fin spines (Hobson 1991). Hobson (1991) also noted that reef-dwelling nocturnal planktivores were likely to be less important in transferring energy between open-water communities and the reef ecosystem, since they forage close to the reef on emergent prey at night. Many of the emergent plankters such as amphipods and crab zoea collected at night were common prey in the diet of nocturnal planktivores (Alldredge and King 1977, Porter and Porter 1977). Amphipods, isopods, and a variety of other small crustaceans make up substantial populations of cryptofauna that live within the reef substrata during the day (Klumpp et al. 1988).

However, on the deep reef tract of the Pinnacles, other nocturnal planktivores appear to play an important role in reef trophodynamics. Small midwater species such as *B. cantori*, *T. lathami,* and myctophids are periodically abundant on high profile reefs, and would provide an additional prey resource for nocturnal carnivores. While rarely observed in ROV surveys, *R. aurorubens* appears to be the numerically dominant predator and forages by day and night on plankton (Grimes 1979). Other species that feed on the reef surface at night include *Leiostomus xanthurus,* a species normally associated with soft bottom habitats. Foraging activities of these species may transport considerable energy between hard bottom, soft bottom and pelagic habitats during feeding migrations.

Large predators, including *S. dumerili* and *L. campechanus*, also utilize prey from pelagic, reef, and soft-bottom habitats and provide pathways of energy transfer. The presence of *B. cantori*, *T. lathami* and urochordates in the diet of *L. campechanus* indicates direct links to the pelagic food web, while the presence of soft bottom fishes, including lizardfishes and sea robins in the diet of *S. dumerili* indicates foraging activities in soft bottom habitats. Large predators, including groupers, will often migrate between reef structures and opportunistically consume soft-bottom and pelagic prey (Weaver 1996) and provide conduits of energy flow between reef and off-reef communities.

Potential impacts of the petroleum industry in outer shelf regions may differentially affect pelagic versus benthic feeders if drilling wastes and other discharges influence near-bottom turbidity, sedimentation, and prey availability. Identification of trophic structure may also assist in evaluation of overfishing of large predators and the associated shift in the reef fish community. Shelf-edge reef sites are the primary spawning locations for many commercially important groupers and snappers, and have been heavily fished in recent years (Richards and McGowan 1989, Gilmore and Jones 1992, Coleman et al. 1996, Koenig et al. 2000). Koenig et al. (2000) reported a decrease in large predator abundance (primarily *Mycteroperca phenax* and *S. dumerili*), and attributed this change to increased fishing activity in this region. Based on ROV surveys, *P. martinicensis* and *H. vivanus* comprised 6% (total planktivores made up 6.4%) of the reef fish community in 1980, and 71% (total planktivores ~84%) of the reef fish community in 1997 surveys on the east coast of Florida (Koenig et al. 2000), a pattern that parallels the current reef fish community at the Pinnacles. This increase in lower trophic levels in the deep reef fish community also parallels a reported decline in the mean trophic level of commercial fisheries worldwide (Pauly et al. 1998). The numerical dominance by small planktivorous reef fish taxa in shelf-edge reef communities and *R. aurorubens* in our hook and line samples in the Pinnacles Reef Tract have likely been magnified by removal of piscivores through recent increases in commercial fishing activity in this region and historical fishing practices throughout the northwestern Gulf of Mexico since the mid 1800's. Snyder (2001) discusses the decline in catch rates of the large predatory species that characterize offshore reef ecosystems since the 1970's, and an increase in catch rates of *R. aurorubens* during this same time period. While our observations of trophic structure in the deep reef community closely resemble those observed in the Indo-Pacific (Thresher and Colin 1986), the influence on fishing activity will be difficult to assess in determining a natural community, and the current patterns of reef fish community structure may have been greatly altered by human activity through fishing during the past century.

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APPENDIX A

Summary of ROV surveys from 1997-2001

Legend:

A=Alabama Alps
C=Cat's Paw Reef
D=Double Top Reef
CS=Corkscrew Reef
C5=CMEP Monitoring Site 5
F=Far Tortuga Reef
L=Ludwick&Walton Pinnacle
P=Porgy Reef
PF=Patch Reef Field
R=Roughtongue Reef
S=Shark Reef
SC=Scamp Reef
SM=Solitary Mound
T=Triple Top Reef
Y=Yellowtail Reef

Appendix A1. Summary of reef-associated fishes observed during 1997 (97-01) ROV surveys by habitat. Data are expressed as number of fish observed per minute of video for each site. ND-No Data and (n)-night survey.

Station No.	**04**	**08**	**09**	**11**	**12**	**20**	**22**	**27**	**33**	**35**	**36**	**44**	**45**	**50**
Base Depth (m)	**68**	**68**	**78**	**78**	**78**	**78**	**106**	**104**	**110**	**110**	**110**	**77**	**71**	**72**
Study Site	**Y**	**Y**	**R**	**R**	**R**	**C**	**L-A**	**L-B**	**L-C**	**L-1**	**L-1**	**PF**	**SM-1**	**SM-2**
Taxa														
Antigonia capros	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-
Apogonidae	-	0.09	-	-	-	-	-	-	-	-	-	-	-	-
Apogon pseudomaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bregmaceros cantori	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canthigaster rostrata	0.14	-	0.08	0.10	-	-	-	-	-	-	-	-	0.04	-
Carangidae	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-
Centropristis ocyurus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetodon aya	-	0.09	-	0.36	0.09	-	0.03	-	0.06	0.05	0.18	0.03	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
Chaetodon sedentarius	-	0.18	-	0.05	0.09	0.04	-	-	-	-	-	-	-	0.06
Chilomycterus schoepfii	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromis enchrysura	4.58	-	0.08	0.57	0.19	-	-	-	-	-	-	-	0.09	0.51
Corniger spinosus	-	0.18	-	-	-	0.04	0.03	-	0.01	0.19	-	0.03	0.02	-
Cyclopsetta fimbriata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon puellaris	0.14	-	0.31	-	0.09	-	0.11	-	0.01	0.09	-	0.03	0.35	-
Diodon holocanthus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epinephelus flavolimbatus	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-
Epinephelus niveatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fistularia petimba	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiidae	0.56	0.18	2.33	1.20	-	0.04	-	-	0.01	-	-	0.09	1.56	-
Gonioplectrus hispanus	-	0.09	-	-	-	-	-	-	0.02	-	0.18	-	-	-
Gymnothorax kolpos	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-
Halichoeres bathyphilus	0.28	0.35	0.93	1.30	0.09	-	-	-	-	-	0.04	0.02	-	-
Hemanthias leptus	-	-	-	-	-	-	0.03	-	0.04	-	0.04	-	-	-
Hemanthias vivanus	28.75	-	10.11	25.08	31.50	-		-	-	1.30	0.97	0.41	7.78	-
Holacanthus bermudensis	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-
Holacanthus tricolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holocentrus adsensionus	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-
Leiostomus xanthurus	-	-	-	-	-	-	-	-	-	-	-			
Liopropoma eukrines	-	0.09	-	0.26	0.19	-	0.06	-	-	-	0.04	0.02	0.06	-
Lutjanus campechanus	-	-	-	-	0.19	-		-	0.04	-	-	-	0.09	0.03
Monacanthus spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muraenidae	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-
Mycteroperca microlepis	-	-	-	-	-	-	-	-	0.12	-	-	-	0.02	-
Mycteroperca phenax	-	-	-	-	0.37	-	-	-	-	0.05	0.04	-	0.06	-
Myctophidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ogcocephalus spp.	-	-	0.08	-	-	-	0.03	-	-	-	-	-	-	0.03
Opsanus pardus	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
Ostichthys trachypoma	-	-	-	-	-	-	0.31	-	-	-	0.04	-	-	-
Pagrus pagrus	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-
Parablennius marmoreus	-	-	0.08	0.05	-	-	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	1.12	-	-	-	-	-	-	-	-	-
Pareques iwamotoi	-	-	-	-	-	-	0.06	-	0.07	-	0.04	-	-	-
Pareques umbrosus	-	0.62	-	-	-	-	-	-	0.02	-	-	0.02	-	0.03
Peprilus burti	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontinus spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Priacanthus arenatus	-	-	-	-	-	0.07	0.08	-	-	-	-	-	-	-
Pristigenys alta	0.28	0.27	0.08	0.10	0.09	0.04	-	-	0.05	0.51	0.09	0.02	0.11	0.45
Pronotogrammus martinicensis	0.42	16.93	0.86	3.02	2.52	2.66	7.18	-	3.33	1.72	6.52	0.73	0.84	0.03
Rhomboplites aurorubens	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.12
Rypticus maculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sargocentron bullisi	-	-	-	0.10	0.09	-	-	-	-	-	-	-	-	-
Scorpaena dispar	-	-	-	0.05	-	0.07	0.14	-	0.05	-	-	0.02	-	0.06
Seriola dumerili	0.14	0.09	-	-	-	-	-	-	0.04	-	-	-	0.04	-
Seriola fasciata	-	-	-	-	0.09	-	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Serranus notospilus	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-
Serranus phoebe	0.14	0.09	-	-	0.19	-	0.03	-	-	-	-	0.03	0.04	0.03
Sphoeroides spengleri	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synodus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachurus lathami	-	-	-	-	-	-	-	-	-	-	-	-	-	0.57
Trichiuridae	-	-	-	-	-	-	-	-	-			-	-	-
Unidentified flatfish	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-
Upeneus parvus	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
Total Fish per Minute	**35.42**	**19.24**	**14.93**	**32.36**	**36.90**	**2.95**	**8.21**	**-**	**3.92**	**4.10**	**8.24**	**1.45**	**11.17**	**2.01**
No. Minutes	**7.2**	**11.3**	**12.9**	**19.2**	**10.7**	**27.3**	**35.9**	**ND**	**84.4**	**21.5**	**22.7**	**58.6**	**46.3**	**33.3**

Appendix A1. (continued).

53	54	56	63	64	65	69	72	76	81	83	86	87	90	**Station No.**
76	**78**	**78**	**77**	**77**	**78**	**78**	**78**	**78**	**70**	**68**	**68**	**68**	**68**	**Base Depth (m)**
T	**D**	**D**	**S**	**S**	**R**	**R(n)**	**CS**	**P(n)**	**F**	**Y(n)**	**Y**	**Y**	**Y**	**Study Site**
														Taxa
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Antigonia capros*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	Apogonidae
-	-	-	-	-	-	0.04	0.02	0.07	-	0.08	-	-	-	*Apogon pseudomaculatus*
-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	*Aulostomus maculatus*
-	-	-	-	-	0.02	-	-	-	-	-	0.03	0.02	-	*Bodianus pulchellus*
-	-	-	-	-	-	0.09	-	0.32	-	-	-	-	-	*Bregmaceros cantori*
-	-	-	-	-	0.19	0.06	0.02	0.03	-	0.05	-	0.21	0.07	*Canthigaster rostrata*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	Carangidae
-	0.09	-	-	-	-	-	-	-	0.09	-	-	-	-	*Centropristis ocyurus*
-	0.06	0.02	0.02	-	0.15	0.06	0.29	0.03	0.17	0.11	0.17	0.19	0.28	*Chaetodon aya*
-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	*Chaetodon ocellatus*
-	-	-	0.02	0.10	0.02	0.06	0.02	0.03	-	0.05	0.14	0.02	-	*Chaetodon sedentarius*
-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	*Chilomycterus schoepfii*
-	0.03	-	0.03	-	0.35	0.08	0.05	-	-	0.21	0.28	0.11	0.21	*Chromis enchrysura*
-	-	-	0.02	-	0.06	0.14	0.15	-	-	0.05	0.10	0.13	0.07	*Corniger spinosus*
-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	*Cyclopsetta fimbriata*
-	0.14	0.02	0.17	0.10	0.10	-	0.10	0.02	0.04	0.03	0.17	0.06	0.28	*Decodon puellaris*
-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	*Diodon holocanthus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Epinephelus flavolimbatus*
-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	*Epinephelus niveatus*
-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	*Fistularia petimba*
-	0.43	0.02	0.17	0.97	-	-	0.10	0.05	0.89	0.05	0.38	0.49	0.07	Gobiidae
-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	*Gonioplectrus hispanus*
-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	*Gymnothorax kolpos*
-	0.02	-	-	-	0.37	-	0.27	-	0.26	0.03	0.10	0.19	0.28	*Halichoeres bathyphilus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hemanthias leptus*
-	1.89	1.43	0.19	-	8.24	0.09	1.34	-	-	0.08	1.59	4.79	8.78	*Hemanthias vivanus*
-	-	-	-	-	0.08	-	0.07	-	-	-	-	-	-	*Holacanthus bermudensis*
-	-	-	-	-	0.02	0.01	-	-	-	-	-	-	-	*Holacanthus tricolor*
-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	*Holocentrus adsensionus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lactophrys quadricornis*
						0.10	-	-	-	-	-	-	-	*Leiostomus xanthurus*
-	-	0.10	-	-	0.02	-	0.15	-	0.13	-	0.03	0.15	0.50	*Liopropoma eukrines*
-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	*Lutjanus campechanus*
-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	*Monacanthus spp.*
-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	Muraenidae
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mycteroperca microlepis*
-	-	-	-	-	-	-	0.12	-	-	-	-	0.15	0.07	*Mycteroperca phenax*
-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	Myctophidae
-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	*Ogcocephalus* spp.
-	-	-	-	-	-	0.01	-	0.02	0.09	0.05	-	0.02	0.07	*Opsanus pardus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ostichthys trachypoma*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pagrus pagrus*
-	-	-	-	-	0.04	-	-	-	-	-	-	0.04	-	*Parablennius marmoreus*
-	-	-	-	-	-	0.01	-	-	-	-	-	0.08	0.14	*Paranthias furcifer*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pareques iwamotoi*
-	0.14	-	0.03	-	0.02	0.02	0.90	-	-	0.03	-	-	-	*Pareques umbrosus*
-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	*Peprilus burti*
-	-	0.02	-	0.05	-	0.01	-	0.03	-	-	0.03	-	-	*Pontinus spp.*
-	-	-	-	-	0.06	0.01	0.02	-	-	-	-	-	-	*Priacanthus arenatus*
-	0.08	0.02	0.03	-	0.08	0.28	0.20	-	0.17	0.21	0.24	0.04	-	*Pristigenys alta*
-	0.68	0.82	0.32	0.20	2.56	1.29	4.74	1.20	0.72	0.05	3.42	3.84	6.79	*Pronotogrammus martinicensis*
-	0.03	0.17	0.02	0.15	-	0.05	-	0.17	-	-	-	-	-	*Rhomboplites aurorubens*
-	-	-	0.03	-	-		-	-	-	-	-	-	-	*Rypticus maculatus*
-	-	-	-	-	0.06	-	-	-	-	0.13	-	0.02	-	*Sargocentron bullisi*
-	-	0.10	0.05	-	0.02	0.14	0.02	-	-	0.21	-	-	-	*Scorpaena dispar*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Seriola dumerili*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Seriola fasciata*
-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	*Seriola rivoliana*
-	-	-	0.05	-	-	-	0.07	-	-	-	-	-	-	*Serranus notospilus*
-	0.03	0.10	-	0.15	0.10	0.04	0.10	-	0.47	0.08	-	0.04	0.14	*Serranus phoebe*
-	-	-	0.02	-	-	-	-	-	-	-	-	-	0.07	*Sphoeroides spengleri*
-	0.03	-	-	-	0.02	0.02	-	-	0.04	-	-	-	-	*Synodus* sp.
-	-	-	-	-	-	0.10	-	0.12	-	0.08	-	-	-	*Trachurus lathami*
-	-	-	-	-	-	-	-	0.07	-	0.29	-	-	-	Trichiuridae
-	-	-	-	-	-	-	-	-	-	-	-	-	-	Unidentified flatfish
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Upeneus parvus*
-	**3.68**	**2.86**	**1.17**	**1.79**	**12.61**	**2.82**	**8.89**	**2.22**	**3.06**	**2.12**	**6.71**	**10.61**	**17.91**	**Total Fish per Minute**
ND	**65.0**	**41.3**	**59.1**	**19.6**	**48.1**	**123.2**	**41.0**	**58.5**	**23.5**	**37.2**	**28.9**	**97.2**	**14.1**	**No. Minutes**

Appendix A2. Summary of fishes associated with the talus zone observed during 1997 (97-01) ROV surveys. Data are as number of fish observed per minute of video. ND-No Data and (n)-night survey.

Station No.	**04**	**08**	**09**	**11**	**12**	**20**	**22**	**27**	**33**	**35**	**36**	**44**	**45**	**50**
Base Depth (m)	**68**	**68**	**78**	**78**	**78**	**78**	**106**	**104**	**110**	**110**	**110**	**77**	**71**	**72**
Study Site	**Y**	**Y**	**R**	**R**	**R**	**C**	**L-A**	**L-B**	**L-C**	**L-1**	**L-1**	**PF**	**SM-1**	**SM-2**
Taxa														
Ancylopsetta dilecta	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromis enchrysura	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon puellaris	-	2.20	-	-	-	-	-	-	-	-	-	-	-	-
Gobiidae	-	8.81	-	-	-	-	-	-	0.68	-	-	-	-	-
Halichoeres bathyphilus	-	0.31	-	-	-	-	-	-	-	-	-	-	-	-
Liopropoma eukrines	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-
Opistognathidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontinus sp.	-	-	-	-	-	-	-	-	0.14	-	-	-	-	-
Priacanthus arenatus	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-
Pristigenys alta	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-
Pronotogrammus martinicensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaena dispar	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Serranus notospilus	-	0.16	-	-	-	-	-	-	0.27	-	-	-	-	-
Serranus phoebe	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-
Synodus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Fish per Minute	-	**12.74**	-	-	-	-	-	-	**1.35**	-	-	-	-	-
No. Minutes	**ND**	**6.4**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**7.4**	**ND**	**ND**	**ND**	**ND**	**ND**

Appendix A3. Summary of fishes associated with the sand flats observed during 1997 (97-01) ROV surveys. Data are as number of fish observed per minute of video. ND-No Data and (n)-night survey.

Station No.	**04**	**08**	**09**	**11**	**12**	**20**	**22**	**27**	**33**	**35**	**36**	**44**	**45**	**50**
Base Depth (m)	**68**	**68**	**78**	**78**	**78**	**78**	**106**	**104**	**110**	**110**	**110**	**77**	**71**	**72**
Study Site	**Y**	**Y**	**R**	**R**	**R**	**C**	**L-A**	**L-B**	**L-C**	**L-1**	**L-1**	**PF**	**SM-1**	**SM-2**
Taxa														
Bregmaceros cantori	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centropristis ocyurus	-	0.21	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys cornutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon puellaris	-	-	-	-	-	-	-	-	0.03	-	-	0.29	1.00	-
Gobiidae	-	0.63	-	-	-	-	0.08	0.04	0.31	0.56	-	0.18	0.25	-
Halichoeres bathyphilus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Halieutichthys aculeatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemanthias vivanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoplunnis sp.	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-
Lagodon rhomboides	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leiostomus xanthurus	-	-	-	-	-	-	-	-	-	-		-	-	-
Lepophidium brevibarbe	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Ogcocephalus spp.	-	-	-	-	-	-	-	0.01	0.03	-	-	-	-	-
Ophichthidae	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Opistognathidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pagrus pagrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys squamilentus	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-
Parequetus umbrosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prionotus stearnsi	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Pristipomoides aquilonaris	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Raja sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchoconger sp.	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Saurida sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaena dispar	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Serranus atrobranchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Serranus notospilus	-	1.26	-	-	-	-	0.17	0.33	0.23	0.07	-	0.11	1.24	-
Serranus phoebe	-	-	-	-	-	-	0.17	0.02	-	-	-	0.04	-	-
Sphoeroides sp.	-	0.21	-	-	-	-	-	-	-	-	-	-	-	-
Syacium papillosum	-	-	-	-	-	-	-	0.01	0.05	-	-	-	-	-
Symphurus sp.	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Synodus sp.	-	-	-	-	-	-	-	0.02	0.03	0.07	-	-	-	-
Trachurus lathami	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-
Trichiuridae	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Unidentified flatfish	-	-	-	-	-	-	-	0.01	0.03	-	-	-	-	-
Upeneus parvus	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-
Total Fish per Minute	-	**2.09**	-	-	-	-	**0.42**	**0.73**	**0.75**	**0.70**	-	**0.73**	**2.49**	-
No. Minutes	**ND**	**4.8**	**ND**	**ND**	**ND**	**ND**	**12.0**	**84.7**	**38.5**	**14.3**	**ND**	**27.5**	**4.0**	**ND**

Appendix A2. (continued).

53	54	56	63	64	65	69	72	76	81	83	86	87	90	**Station No.**
76	**78**	**78**	**77**	**77**	**78**	**78**	**78**	**78**	**70**	**68**	**68**	**68**	**68**	**Base Depth (m)**
T	**D**	**D**	**S**	**S**	**R**	**R(n)**	**CS**	**P(n)**	**F**	**Y(n)**	**Y**	**Y**	**Y**	**Study Site**
														Taxa
-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	*Ancylopsetta dilecta*
-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	*Chromis enchrysura*
-	-	-	-	-	-	-	0.10	-	0.05	-	0.25	0.21	0.86	*Decodon puellaris*
-	-	-	-	-	-	-	3.12	-	1.03	-	4.43	0.21	-	Gobiidae
-	-	-	-	-	-	-	-	-	-	-	-	0.64	-	*Halichoeres bathyphilus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Liopropoma eukrines*
-	-	-	-	-	-	-	0.10	-	0.05	-	-	-	-	Opistognathidae
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pontinus* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Priacanthus arenatus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pristigenys alta*
-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	*Pronotogrammus martinicensis*
-	-	-	-	-	-	-	-	-	0.05	-	0.12	-	-	*Scorpaena dispar*
-	-	-	-	-	-	-	0.31	-	-	-	-	-	-	*Serranus notospilus*
-	-	-	-	-	-	-	-	-	0.05	-	0.74	-	-	*Serranus phoebe*
-	-	-	-	-	-	-	0.21	-	0.09	-	0.37	-	-	*Synodus* sp.
-	**-**	**-**	**-**	**-**	**-**	**-**	**3.84**	**-**	**1.30**	**-**	**6.28**	**1.06**	**0.86**	**Total Fish per Minute**
ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**9.6**	**ND**	**21.6**	**ND**	**8.1**	**4.7**	**1.2**	**No. Minutes**

Appendix A3. (continued).

53	54	56	63	64	65	69	72	76	81	83	86	87	90	**Station No.**
76	**78**	**78**	**77**	**77**	**78**	**78**	**78**	**78**	**70**	**68**	**68**	**68**	**68**	**Base Depth (m)**
T	**D**	**D**	**S**	**S**	**R**	**R(n)**	**CS**	**P(n)**	**F**	**Y(n)**	**Y**	**Y**	**Y**	**Study Site**
														Taxa
0.07	-	-		-	-	-	-	0.33	-	-	-	-	-	*Bregmaceros cantori*
-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	*Centropristis ocyurus*
-	-	-	-	-	-	-	-	-	-	-	0.18	-	-	*Citharichthys cornutus*
-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	*Decodon puellaris*
0.16	-	0.18	1.48	-	-	-	0.55	0.83	-	-	1.06	-	-	Gobiidae
-	-	-	-	-	-	-	0.08	-	-	-	0.18	-	-	*Halichoeres bathyphilus*
0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	*Halieutichthys aculeatus*
-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	*Hemanthias vivanus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hoplunnis* sp.
-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	*Lagodon rhomboides*
-	-	-	0.08	-	-	-	-	0.08	-	-	-	-	-	*Leiostomus xanthurus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lepophidium brevibarbe*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ogcocephalus* spp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ophichthidae
-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	Opistognathidae
-	-							0.08	-	-	-	-	-	*Pagrus pagrus*
-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	*Paralichthys squamilentus*
-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	*Parequetus umbrosus*
-	-	-	-	-	-	-	-	0.17	-	-	-	-	-	*Pontinus* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Prionotus stearnsi*
0.07	-	-	-	-	-	-	0.16	-	-	-	-	-	-	*Pristipomoides aquilonaris*
-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	*Raja* sp.
-	-	-	-	-	-	-	-	0.08	-	-	1.94	-	-	*Rhynchoconger* sp.
2.03	-	-	-	-	-	-	-	-	-	-	0.35	-	-	*Saurida* sp.
-	-	-	0.08	-	-	-	0.08	-	-	-	0.18	-	-	*Scorpaena dispar*
0.03	-	-	-	-	-	-	-	-	-	-	0.18	-	-	*Serranus atrobranchus*
0.03	1.43	0.18	-	-	-	-	0.51	0.42	-	-	1.06	-	-	*Serranus notospilus*
-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	*Serranus phoebe*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Sphoeroides* sp.
0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	*Syacium papillosum*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Symphurus* sp.
0.07	1.43	0.73	-	-	-	-	0.04	0.50	-	-	5.11	-	-	*Synodus* sp.
-	-	0.18	-	-	-	-	-	-	-	-	-	-	-	*Trachurus lathami*
-	-	-	-	-	-	-	-	0.08	-	-	0.18	-	-	Trichiuridae
-	-	0.18	-	-	-	-	-	-	-	-	0.35	-	-	Unidentified flatfish
-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Upeneus parvus*
2.63	**2.86**	**1.45**	**1.88**	**-**	**-**	**-**	**1.75**	**2.67**	**-**	**-**	**10.74**	**-**	**-**	**Total Fish per Minute**
30.5	**0.7**	**5.5**	**12.8**	**ND**	**ND**	**ND**	**25.7**	**11.8**	**ND**	**ND**	**5.7**	**ND**	**ND**	**No. Minutes**

Appendix A4. Summary of Cruise USGS 99-03 and 2000-01(0001) ROV surveys. Values given are number of individuals observed per minute of tape time. Night surveys are indicated by (n).

Station No.	0001-028	0001-029	0001-036	0001-055	0001-057	0001-060	9903-2132	0001-016	0001-018	0001-019	0001-033	0001-052	0001-059
Base Depth (m)	**69**	**69**	**88**	**110**	**105**	**79**	**109**	**80**	**110**	**110**	**88**	**110**	**105**
Study Site	**Y**	**Y**	**A**	**L-H**	**SC**	**C5**	**L-1(n)**	**R (n)**	**L-2 (n)**	**L-2 (n)**	**A (n)**	**L-A (n)**	**SC (n)**
Taxa													
Anthias tenuis	-	0.02	-	-	-	-	-	-	-	-	0.11	-	-
Apogon pseudomaculatus	-	0.22	0.05	-	-	-	-	0.04	-	-	0.05	-	0.01
Aulostomus maculatus	-	0.04	0.05	-	-	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	0.11	-	-	-	-	-	-	-	-	-	-	-
Bregmaceros cantori	-	-	-	-	-	-	-	-	-	2.22	0.03	-	-
Brotula barbata	-	-	-	-	0.04	0.09	-	-	-	-	0.01	-	-
Canthigaster jamestyleri	0.11	-	-	-	-	-	-	0.01	-	-	-	-	-
Canthigaster rostrata	0.32	0.22	0.15	-	-	-	-	0.32	-	-	0.01	-	-
Carapidae	-	-	-	-	-	-	-	-	-	0.02	-	-	-
Centropristis ocyurus	-	-	-	-	-	0.44	-	-	-	-	-	-	-
Chaetodon aya	0.43	0.20	0.70	0.04	0.13	0.44	-	0.26	-	0.03	0.05	0.18	0.03
Chaetodon sedentarius	0.11	0.04	0.10	-	-	-	-	0.10	-	-	-	-	-
Chilomycterus antillarum	-	-	-	-	-	-	-	-	-	0.02	-	-	-
Chromis enchrysura	1.51	1.40	0.05	-	-	0.27	-	0.23	-	-	0.02	-	-
Chromis insolata	-	0.04	-	-	-	-	-	-	-	-	-	-	-
Chromis scotti	-	0.47	-	-	-	0.27	-	0.01	-	-	-	-	-
Corniger spinosus	-	0.11	0.15	-	0.04	0.27	-	0.03	-	-	0.07	-	-
Coryphopterus punctipectophorus	0.22	0.15	-	-	-	-	-	0.03	-	-	-	-	-
Decodon puellaris	-	0.02	-	0.05	-	-	-	0.04	-	-	-	-	0.01
Epinephelus niveatus	-	-	-	-	-	0.09	-	-	-	-	-	-	-
Fistularia petimba	-	-	-	-	-	-	-	-	-	-	-	-	0.01
Gonioplectrus hispanus	-	-	-	-	0.04	0.09	-	-	-	-	-	-	-
Gymnothorax hubbsi	0.11	-	-	-	-	-	-	-	-	-	-	-	-
Gymnothorax kolpos	-	-	-	-	-	-	-	-	-	-	-	0.18	-
Halichoeres bathyphilus	0.11	0.20	0.05	0.10	-	-	-	0.04	-	-	0.01	-	-
Hemanthias leptus	-	-	-	-	0.26	-	-	-	-	-	-	-	-
Hemanthias vivanus	36.97	6.74	0.10	-	2.57	25.71	-	2.25	-	-	0.04	0.18	-
Holacanthus bermudensis	0.11	0.04	-	0.01	0.09	0.09	-	-	-	-	0.01	-	-
Holocentrus adscensionus	0.11	-	-	-	-	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	0.09	-	-	-	-	-	-	-
Liopropoma eukrines	-	0.13	0.05	0.09	0.09	0.18	-	0.05	-	-	0.02	0.18	-
Lutjanus campechanus	-	-	0.05	-	-	-	-	-	-	-	0.01	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	0.01	-	-	-	-	-
Muraenidae	-	0.02	-	-	-	-	-	-	-	-	0.01	-	-

Appendix A4. (continued).

Station No.	0001-028	0001-029	0001-036	0001-055	0001-057	0001-060	9903-2132	0001-016	0001-018	0001-019	0001-033	0001-052	0001-059
Base Depth (m)	**69**	**69**	**88**	**110**	**105**	**79**	**109**	**80**	**110**	**110**	**88**	**110**	**105**
Study Site	**Y**	**Y**	**A**	**L-H**	**SC**	**C5**	**L-1(n)**	**R (n)**	**L-2 (n)**	**L-2 (n)**	**A (n)**	**L-A (n)**	**SC (n)**
Taxa													
Mustelus sp.	-	-	-	-	-	-	0.04	-	-	0.02	0.01	-	0.01
Mycteroperca microlepis	-	-	-	-	0.04	-	-	-	-	-	-	-	-
Mycteroperca phenax	-	0.02	-	0.01	0.13	-	-	-	-	0.02	0.01	0.18	0.03
Myctophidae	-	-	-	-	-	-	0.24	-	0.65	0.10	-	27.37	2.15
Neoepinnula americana	-	-	-	-	-	-	-	-		0.03	-	-	-
Oagocephalus sp.	-	-	-	-	-	0.09	-	0.01	-	-	0.01	-	0.01
Opistognathus lonchurus	-	0.02	-	-	-	-	-	-		-	-	-	-
Opsanus pardus	-	-	-	-	-	-	-	0.01	-	-	-	-	-
Ostichthys trachypoma	-	-	-	-	0.09	-	-	-	0.13	0.03	-	1.46	-
Pagrus pagrus	-	-	-	0.11	0.09	-	0.04	0.01	-	-	-	-	0.01
Paranthias furcifer	-	0.37	-	-	-	-	-	-	-	-	-	-	-
Pareques iwamotoi	-	-	-	-	-	0.09	-	-	-	-	0.02	0.36	0.10
Pareques umbrosus	-	0.02	0.15	0.04	0.21	0.44	-	-	-	-	0.20	0.55	0.04
Pomatomus saltatrix	-	-	-	-	-	-	-	-	-	-	-	-	0.01
Priacanthus arenatus	-	-	-	-	-	0.27	-	0.01	-	-	-	-	-
Pristigenys alta	0.32	0.02	0.20	0.32	0.09	0.53	0.05	0.14	0.13	0.32	0.10	0.91	0.07
Pronotogrammus martinicensis	0.97	2.79	14.01	1.48	11.41	20.83	0.02	4.13	-	0.22	3.74	3.10	0.03
Rhomboplites aurorubens	-	-	-	-	-	-	-	-	0.04	0.02	-	-	-
Rypticus maculatus	-	-	-	-	-	-	-	-	-	-	-	-	-
Sargocentron bullisi	0.11	0.07	-	0.01	-	-	-	0.08	-	-	-	-	-
Scomberomorus cavalla	-	-	-	-	-	-	-	-	0.04	-	-	-	-
Scorpaena dispar	-	0.02	-	0.01	-	-	-	0.06	-	-	0.04	-	-
Scorpaenidae	-	-	-	0.06	0.13	0.18	0.02	0.03	0.04	0.11	0.01	-	0.07
Seriola dumerili	-	-	0.25	-	-	0.35	-	0.14	-	0.10	0.22	0.55	0.01
Seriola rivoliana	0.22	0.02	-	-	-	-	-	-	-	-	0.02	-	-
Serranus phoebe	0.22	0.04	0.05	0.04	-	0.62	-	0.04	-	-	-	-	-
Sphoeroides spengleri	-	-	-	-	-	-	-	0.01	-	-	-	-	-
Stenotomus caprinus	-	-	-	-	-	-	-	-	-	-	-	-	0.01
Synodus sp.	-	-	-	-	-	-	-	-	-	0.11	0.02	-	0.13
Trachurus lathami	-	-	-	-	-	-	-	0.03	0.52	0.87	0.09	0.73	-
Trichiurus lepturus	-	-	-	-	-	-	4.31	-	-	-	-	0.18	0.01
Upeneus parvus	-	-	-	-	-	-	-	-	-	0.05	-	0.91	0.07
Total Fish per Minute	1.84	3.39	14.66	2.09	12.18	23.40	4.71	4.71	1.57	1.98	4.49	36.31	2.79
No. Minutes	9.3	53.7	20.1	80.3	23.3	11.3	55.0	77.0	22.6	63.1	97.0	5.5	69.9

APPENDIX B

A list of reef-fish species from natural reefs in the northern Gulf of Mexico

Appendix B. A list of reef-fish species from natural reefs in the northern Gulf of Mexico with a comparison among the northwestern Gulf, Pinnacles, and West Florida shelf. Data sources: NW Gulf: Ca-Cashman 1973, Br-Bright et al. 1974, So-Sonnier et al. 1976, Bo-Boland et al. 1983, Pu-Putt et al. 1986, DB-Dennis and Bright 1988a, b, Pa-Pattengill et al. 1997, and HB-Hoese and Moore 1998. West Florida: SW-Springer and Woodburn, 1960, Po-Powell et al. 1972, Sm-Smith et al. 1975, Sm-Smith 1976, SH-Shipp and Hopkins 1978, Ha-Hastings 1979, WS-Williams and Shipp 1980, BG-Bullock and Godcharles 1982, DG-Darcy and Gutherz 1984, Cl-Clarke 1981, DK-Darnell and Kleypas 1987, and BS-Bullock and Smith 1991.

		NW Gulf		**Pinnacles**	**West Florida Shelf**	
Scientific Name	**Common Name**	**<60 m**	**>60 m**	**60-110 m**	**<30 m**	**>30 m**
Orectolobidae – carpet sharks						
Ginglymostoma cirratum	nurse shark	So			Sm76	
Muraenidae – morays						
Enchelycore carychroa	chestnut moray	Ca				
Enchelycore nigricans	viper moray	Ca				
Gymnothorax funebris	green moray				Cl	
Gymnothorax hubbsi	lichen moray			X		
Gymnothorax kolpos	blacktail moray			X		
Gymnothorax miliaris	goldentail moray	Pa				
Gymnothorax moringa	spotted moray	Ca	DB	X	Sm75	
Gymnothorax vicinus	purplemouth moray	Ca				
Muraena retifera	reticulated moray			X	Sm75	SH
Synodontidae – lizardfishes						
Synodus intermedius	sand diver	DB	DB	X	Sm75	
Synodus saurus	bluestripe lizardfish	Pa			Sm75	
Synodus synodus	red lizardfish	Ca	DB			
Bythiditidae – viviparous brotulas						
Ogilbia cayorum	key brotula				SW	DK
Ophidiidae - cusk-eels						
Brotula barbata	bearded brotula		HM	X		
Batrachoididae						
Opsanus pardus	leopard toadfish	HM		X	SW/Sm75	SH

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Holocentridae - squirrelfishes						
Corniger spinosus	spinycheek soldierfish			X		
Holocentrus adscensionis	squirrelfish	Ca	DB	X	Sm75	
Holocentrus rufus	longspine squirrelfish	Ca	DB			
Myripristis jacobus	blackbar soldierfish	Ca			Sm75	DG
Neoniphon marianus	longjaw squirrelfish	DB	DB			DK
Ostichthys trachypoma	bigeye soldierfish			X		SH/DG
Plectrypops retrospinis	cardinal soldierfish	Ca				
Sargocentron bullisi	deepwater squirrelfish			X	Sm75	SH/DK
Sargocentron coruscum	reef squirrelfish				Po	
Sargocentron poco	saddle squirrelfish	Ca				
Sargocentron vexillarium	dusky squirrelfish	Pa			Ha	DG
Caproidae - boarfishes						
Antigonia capros	deepbody boarfish			X		
Aulostomidae – trumpetfishes						
Aulostomus maculatus	trumpetfish	Ca		X	Sm75	
Fistulariidae – cornetfishes						
Fistularia petimba	red cornetfish			X		
Fistularia tabacaria	bluespotted cornetfish	Bo				
Scorpaenidae – scorpionfishes						
Neomerinthe hemingwayi	spinycheek scorpionfish			DK		DK
Pontinus rathbuni	highfin scorpionfish			X		
Scorpaena bergi	goosehead scorpionfish				DG	
Scorpaena dispar	hunchback scorpionfish		DB	DK	Po	DK
Scorpaena inermis	mushroom scorpionfish					DK
Scorpaena plumieri	spotted scorpionfish	So			Sm75	
Scorpaenodes caribbaeus	reef scorpionfish	Ca				

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Serranidae - sea basses						
Anthias nicholsi	yellowfin bass					SH/WS[1]
Anthias tenuis	threadnose bass		?	X		
Bathyanthias mexicana	yellowtail bass		HM			DG/BS
Cephalopholis cruentata	graysby	Ca			Sm75	Cl
Cephalopholis fulva	coney	DB			Sm75	
Dermatolepis inermis	marbled grouper	Ca	DB			BG
Epinephelus adscensionis	rock hind	Ca	DB		Sm75	BS
Epinephelus drummondhayi	speckled hind			X	Sm75	
Epinephelus guttatus	red hind	Ca	DB		Sm75	BS
Epinephelus itajara	jewfish				SW/Sm75	
Epinephelus morio	red grouper	Bo/Pa			Sm75/DK	BS
Epinephelus mystacinus	misty grouper					BS
Epinephelus niveatus	snowy grouper		DB	X		
Epinephelus nigritus	warsaw grouper		DB	X		
Epinephelus striatus	Nassau grouper	DB				
Gonioplectrus hispanus	Spanish flag		Br	X		
Hemanthias aureorubens	streamer bass		HM	?[2]		BS
Hemanthias leptus	longtail bass		DB	X		
Hemanthias vivanus	red barbier		DB	X		DG
Hypoplectrus puella	barred hamlet	?			Sm75	Cl/DK
Liopropoma eukrines	wrasse bass	Ca	DB	X	Po	SH/Cl
Liopropoma rubre	peppermint bass	Ca				
Mycteroperca acutirostris	comb grouper	Ca/So				
Mycteroperca bonaci	black grouper	DB			Sm75	DG
Mycteroperca interstitialis	yellowmouth grouper	Ca	DB		Sm75	

[?] presence uncertain.
[1] photo from DeSoto Canyon indicates *P. martinicensis* whereas specimen from west Florida Shelf is *A. nicholsi*.
[2] reported by Gittings et al. 1991 but no specimens known to confirm its occurrence.

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Serranidae (continued)						
Mycteroperca microlepis	gag		HM	X	Sm75	DG
Mycteroperca phenax	scamp		DB	X	Sm75	
Mycteroperca tigris	tiger grouper	DB			BG	
Mycteroperca microlepis	gag		HM	X	Sm75	DG
Mycteroperca phenax	scamp		DB	X	Sm75	
Mycteroperca tigris	tiger grouper	DB			BG	
Mycteroperca venenosa	yellowfin grouper	So			SW/Sm75	
Paranthias furcifer	creole-fish	Ca		X	Sm75	SH
Plectranthias garrupellus	apricot bass					BS
Pronotogrammus martinicensis	roughtongue bass		DB	X	Po	SH[1]
Rypticus bistrispinus	freckled soapfish			DK	WS	SH/WS
Rypticus maculatus	whitespotted soapfish	DB		X	Sm75	SH
Rypticus subbifrenatus	spotted soapfish	Ca				
Serraniculus pumilio	pygmy sea bass				SW	
Schultzea beta	school bass	HM		DK		DG
Serranus annularis	orangeback bass	DB	DB			BS
Serranus notospilus	saddle bass			X		DK/DG
Serranus phoebe	tattler	DB	DB	X		Cl/SH
Serranus subligarius	belted sandfish	Pu			Sm75/DK	Cl
Serranus tabacarius	tobaccofish	Pa			Sm75	BS
Serranus tigrinus	harlequin bass				Sm75	
Serranus tortugarum	chalk bass					DG
Grammatidae – basslets						
Lipogramma regia	royal basslet			X		
Opistognathidae – jawfishes						
Opistognathus aurifrons	yellowhead jawfish	DB			Sm75	Cl
Opistognathus lonchurus	moustache jawfish		DB	X	Po	

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Priacanthidae – bigeyes						
Heteropriacanthus cruentatus	glasseye snapper	Ca				
Priacanthus arenatus	bigeye	Ca	DB	X	Sm76	SH
Pristigenys alta	short bigeye		DB	X	Sm75	SH
Apogonidae – cardinalfishes						
Apogon affinis	bigtooth cardinalfish	Pa			Po	WS
Apogon aurolineatus	bridle cardinalfish	HM	DB		SW/Sm76	WS/DK
Apogon binotatus	barred cardinalfish				Sm75	
Apogon maculatus	flamefish	Ca	DB		Sm75	Cl/DK
Apogon pseudomaculatus	twospot cardinalfish	So	DB	X	Sm75	SH
Apogon quadrisquamatus	sawcheek cardinalfish	Pa			Po/DK	WS/DK
Apogon townsendi	belted cardinalfish	Ca				
Astrapogon alutus	bronze cardinalfish				SW/Sm76	
Astrapogon stellatus	conchfish					DK
Phaeoptyx conklini	freckled cardinalfish	Ca				
Phaeoptyx pigmentaria	dusky cardinalfish	Ca				
Phaeoptyx xenus	sponge cardinalfish				SW/Sm75	
Malacanthidae - tilefishes						
Caulolatilus chrysops	goldface tilefish		HM	X		
Caulolatilus cyanops	blackline tilefish		DB			Po/DG
Malacanthus plumieri	sand tilefish	Ca	Br	X	Sm75	Po
Carangidae – jacks						
Caranx bartholomaei	yellow jack	So				
Caranx latus	horse-eye jack	Ca				
Caranx lugubris	black jack	So				
Caranx ruber	bar jack	Ca			Sm75	
Seriola dumerili	greater amberjack	Ca	Br	X	Sm75	
Seriola rivoliana	almaco jack	Ca		X	Sm75	

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Lutjanidae – snappers						
Apsilus dentatus	black snapper		HM			
Etelis oculatus	queen snapper					DG
Lutjanus apodus	schoolmaster				SW	
Lutjanus campechanus	red snapper	Ca	Br	X	Sm75	SH
Lutjanus cyanopterus	cubera snapper	Pa			Sm75	
Lutjanus griseus	gray snapper	Ca			SW/Sm75	Cl
Lutjanus jocu	dog snapper	So				
Lutjanus synagris	lane snapper	HM	DB		Sm75	
Ocyurus chrysurus	yellowtail snapper	Ca			SW/Sm75	
Rhomboplites aurorubens	vermilion snapper	Pu	HM	X	Sm75	SW/DG
Haemulidae – grunts						
Anisotremus virginicus	porkfish	HM			SW/DK	
Anisotremus surinamensis	black margate	Pa				
Haemulon aurolineatum	tomtate	Ca			SW/Sm75	
Haemulon melanurum	cottonwick	Ca	Br			
Haemulon macrostomum	Spanish grunt	Pa			SW/DK	
Haemulon plumieri	white grunt	HM			SW/Sm75	
Haemulon sciurus	bluestriped grunt				Po	
Haemulon striatum	striped grunt		DB			Po/DG
Inermiidae – bonnetmouths						
Emmelichthyops atlanticus	bonnetmouth	Pa				
Inermia vittata	boga	Pa			DG	
Sparidae – porgies						
Archosargus probatocephalus	sheepshead	Pu			Sm76	
Calamus bajonado	jolthead porgy				Sm75	DK
Calamus calamus	saucereye porgy	Pa			DG	
Calamus nodosus	knobbed porgy	Ca		X	Sm75	DK

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Sparidae (continued)						
Calamus penna	sheepshead porgy				DG	
Pagrus pagrus	red porgy		DB	X	Sm75	DK
Sciaenidae – drums						
Equetus lanceolatus	jackknife fish	Ca	Br		Sm75	Cl
Equetus punctatus	spotted drum	So	DB			
Odontoscion dentex	reef croaker	HM			Sm76	
Pareques iwamotoi	blackbar drum		HM	X		SH
Pareques umbrosus	cubbyu	Pu	DB	X	Sm75	SH/DK
Mullidae – goatfishes						
Mulloidichthys martinicus	yellow goatfish	Ca				
Pseudupeneus maculatus	spotted goatfish	Ca	Br		Sm76	
Chaetodontidae –butterflyfishes						
Chaetodon aculeatus	longsnout butterflyfish	Ca	DB			
Chaetodon aya	bank butterflyfish	Pa	Ca	X	Po	SH/DK
Chaetodon capistratus	foureye butterflyfish	So			Sm75	DK
Chaetodon ocellatus	spotfin butterflyfish	Ca		X	SW/Sm75	SH/DK
Chaetodon sedentarius	reef butterflyfish	Ca	Br	X	Sm75	SH/DK
Chaetodon striatus	banded butterflyfish	So			Sm76/DK	
Pomacanthidae – angelfishes						
Centropyge argi	cherubfish	Ca	DB		Sm75	
Holacanthus bermudensis	blue angelfish	Ca	Br	X	SW/Sm5	SH/DK
Holacanthus ciliaris	queen angelfish	Ca		X	SW/Sm75	SH
Holacanthus tricolor	rock beauty	Ca	Br	X	WS	
Pomacanthus arcuatus	gray angelfish	DB			Sm75/DK	
Pomacanthus paru	French angelfish	Ca	DB		SW/Sm75	

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Kyphosidae - sea chubs						
Kyphosus incisor	Yellow chub	So				
Kyphosus sectatrix	Bermuda chub	Ca			Po/Cl	
Pomacentridae – damselfishes						
Abudefduf saxatilis	sergeant major	Pu			SW/Sm76	
Chromis cyanea	blue chromis	Ca			Sm75	
Chromis enchrysura	yellowtail reeffish	Ca	Br	X	Sm75	SH/DK
Chromis insolata	sunshinefish	DB		X	Po	
Chromis multilineata	brown chromis	Ca				
Chromis scotti	purple reeffish	Ca		X	Sm75	SH/DK
Microspathodon chrysurus	yellowtail damselfish	Ca				DK?
Stegastes adustus	dusky damselfish	Bo				
Stegastes diencaeus	longfin damselfish	Pa				
Stegastes leucostictus	beaugregory	Pu			DK	
Stegastes partitus	bicolor damselfish	Ca			Sm75	DK
Stegastes planifrons	threespot damselfish	Ca				WS
Stegastes variabilis	cocoa damselfish	Ca			SW/Sm75	Cl
Cirrhitidae – hawkfishes						
Amblycirrhitus pinos	redspotted hawkfish	Ca	DB			
Labridae – wrasses						
Bodianus pulchellus	spotfin hogfish	Ca	Br	X	Cl	SH/DG
Bodianus rufus	Spanish hogfish	Ca			Sm75	
Clepticus parrae	creole wrasse	Ca				
Decodon puellaris	red hogfish		HM	X		DK
Doratonotus megalepis	dwarf wrasse				Ha	
Halichoeres bathyphilus	greenband wrasse			X	Po	
Halichoeres bivittatus	slippery dick	Ca	DB		SW/Sm75	Cl
Halichoeres caudalis	painted wrasse	So			SW/Sm75	Cl/DK

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Labridae (continued)						
Halichoeres garnoti	yellowhead wrasse	Ca				
Halichoeres maculipinna	clown wrasse	Ca				
Halichoeres pictus	rainbow wrasse				Po	Cl/DK
Halichoeres radiatus	puddingwife	Ca	DB			
Lachnolaimus maximus	hogfish	So			SW/Sm75	Cl
Thalassoma bifasciatum	bluehead	Ca			Sm75	
Xyrichtys martinicensis	rosy razorfish				Po	
Xyrichtys splendens	green razorfish	Pa				Po
Scaridae – parrotfishes						
Scarus coelestinus	midnight parrotfish	Pa			Ha	
Scarus iserti	striped parrotfish	So/Pa			Sm75	
Scarus taeniopterus	princess parrotfish	Ca				
Scarus vetula	queen parrotfish	Ca				
Sparisoma atomarium	greenband parrotfish	DB	DB		WS	
Sparisoma aurofrenatum	redband parrotfish	Ca			Sm75	
Sparisoma chrysopterum	redtail parrotfish				Ha	DG
Sparisoma rubripinne	redfin parrotfish				Ha	
Sparisoma radians	bucktooth parrotfish	HM			Sm75	DK
Sparisoma viride	stoplight parrotfish	Ca			Ha	
Labrisomidae - labrisomids						
Labrisomus haitiensis	longfin blenny				Sm75	
Labrisomus nuchipinnis	hairy blenny	HM				
Starksia ocellata	checkered blenny	Ca			SW/Cl	DK
Nemaclinus atelestos	threadfin blenny	Ca				
Paraclinus fasciatus	banded blenny				Po	

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Chaenopsidae – pikeblennies						
Chaenopsis limbaughi	yellowface pikeblenny				Po	Po
Chaenopsis ocellata	bluethroat pikeblenny				SW	SW/Po
Emblemaria atlantica	banner blenny		DB		Cl	Cl
Emblemaria pandonis	sailfin blenny	Ca			Sm76	
Emblemaria piratula	pirate blenny				WS	WS
Blenniidae- combtooth blennies						
Hypleurochilus bermudensis	barred blenny	Ca			Po	
Hypleurochilus multifilis	plumed blenny	HM				
Hypleurochilus caudovittatus	zebratail blenny				SW/DK	
Hypsoblennius invemar	tessellated blenny	HM				
Ophioblennius atlanticus	redlip blenny	Ca				
Parablennius marmoreus	seaweed blenny	HM/DB		X	Sm75	DK
Scartella cristata	molly miller	HM				
Gobiidae – gobies						
Coryphopterus eidolon	pallid goby	Pa				
Coryphopterus glaucofraenum	bridled goby				Sm75	
Coryphopterus punctipectophorus	spotted goby	HM/Pa		X	SW/Cl	
Coryphopterus thrix	sand goby	Ca				
Evermannichthys spongicola	sponge goby					Po
Gnatholepis thompsoni	goldspot goby	Ca				
Gobiosoma grosvenori	rockcut goby					DK
Gobiosoma horsti	yellowline goby				Sm75	DK
Gobiosoma macrodon	tiger goby				SW/DK	
Gobiosoma oceanops	neon goby	Ca			Sm75	Cl
Gobiosoma xanthiprora	yellowprow goby	X[3]	X[3]		Cl	Cl
Gobulus myersi	paleback goby				Cl	

[3]new record in NW Gulf

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Gobiidae (continued)						
Lythrypnus elasson	dwarf goby				Cl/WS	WS
Lythrypnus nesiotes	island goby	Ca			Po	WS/DK
Lythrypnus phorellus	convict goby	Ca				
Lythrypnus spilus	bluegold goby	Ca				
Priolepis hipoliti	rusty goby	Ca				
Psilotris celsus	highspine goby				Cl	
Risor ruber	tusked goby	Ca		X	Po	WS/DK
Microdesmidae - dartfishes						
Ptereleotris calliurus	blue dartfish	DB	DB		SW/Sm75	Cl
Ephippidae – spadefish						
Chaetodipterus faber	Atlantic spadefish	Pu		DK	Sm75	
Bothidae – lefteye flounder						
Bothus lunatus	peacock flounder	Pa				
Bothus ocellatus	eyed flounder	Pa			DK	DK
Acanthuridae – surgeonfishes						
Acanthurus bahianus	ocean surgeonfish	Ca				
Acanthurus chirurgus	doctorfish	So			Sm75	
Acanthurus coeruleus	blue tang	Ca			SW/Sm76	
Sphyraenidae – barracudas						
Sphyraena barracuda	great barracuda	Ca	DB		Sm76	
Balistidae – leatherjackets						
Balistes capriscus	gray triggerfish	Ca		X	Sw/Sm75	DG
Balistes vetula	queen triggerfish	Ca	DB		Sm76	
Canthidermis maculata	rough triggerfish	Ca				
Canthidermis sufflamen	ocean triggerfish	Ca	DB		Po	
Melichthys niger	black durgon	Ca				
Xanthichthys ringens	sargassum triggerfish	Ca	DB		DK	DG

Appendix B. (continued).

Scientific Name	Common Name	NW Gulf <60 m	NW Gulf >60 m	Pinnacles 60-110 m	West Florida Shelf <30 m	West Florida Shelf >30 m
Monacanthidae – filefishes						
Aluterus heudelotii	dotteral filefish				DK	DK
Aluterus monoceros	unicorn filefish	Bo/Pa				
Aluterus scriptus	scrawled filefish	Ca		DK	Cl	DK
Cantherhines macrocerus	whitespotted filefish	So				DK
Cantherhines pullus	orangespotted filefish	Ca				
Monacanthus tuckeri	slender filefish	Ca		X		
Stephanolepis setifer	pygmy filefish	Ca			Sm75	DK
Ostraciidae – boxfishes						
Acanthostracion polygonia	honeycomb cowfish	Pa			DG	
Lactophrys bicaudalis	spotted trunkfish	Pa				
Lactophrys trigonus	trunkfish				SW	
Lactophrys triqueter	smooth trunkfish	Ca			Po	
Tetraodontidae - puffers						
Canthigaster rostrata	sharpnose puffer	Ca	DB	X	Sm75	DK
Canthigaster jamestyleri	goldfaced puffer			X		
Sphoeroides spengleri	bandtail puffer	Pa	?	X	SW/Sm75	SH
Diodontidae – porcupinefishes						
Chilomycterus antennatus	bridled burrfish	Pa				
Chilomycterus antillarum	web burrfish			X		
Diodon holocanthus	balloonfish	So	DB	X	Po	
Diodon hystrix	porcupinefish	Pa				
Triacanthodidae						
Parahollardia lineata	jambeau			DK		DK/DG

APPENDIX C

Food habits of reef fishes of the Pinnacles Reef Tract

Appendix C. Food habits of reef fishes of the Pinnacles Reef Tract by trophic guild. Number of specimens examined that contained prey are given, along with range of standard length (SL). Values given are based on relative abundance (% number) of prey items in the diet as determined by stomach content analysis.

Trophic Guild: Mesoplanktivores

Bregmaceros cantori — **codlet**
2 specimens: 51 mm SL

FOOD	
Copepods	60.0
Amphipods	20.0
Shrimp Larvae	20.0

Chromis enchrysura — **yellowtail reeffish**
20 specimens: 66-90 mm SL

FOOD	
Copepods	32.4
Larvaceans	32.0
Invertebrate eggs	19.1
Polychaetes	13.3
Shrimp and shrimp larvae	2.1
sergestids	
Crab larvae	1.1

Hemanthias vivanus — **red barbier**
47 specimens: 67-110 mm SL

FOOD	
Copepods	78.8
Polychaetes	17.7
Invertebrate eggs	3.0
Larvaceans	0.14
Ostracods	0.14
Urochordates	0.07
salps	
Amphipods	0.04
hyperiids	
Radiolarians	0.03
Pteropods	0.03
Chaetognaths	0.02
Crab larvae	0.01
Fishes	0.01
Hemanthias vivanus	
Fish larvae	0.01
Fish eggs	0.01

Paranthias furcifer — **creole-fish**
1 specimen: 245 mm SL

FOOD	
Polychaetes	35.7
Copepods	28.6
Shrimp larvae	21.4
Crab larvae	14.3

Pronotogrammus martinicensis — **roughtongue bass**
120 specimens: 70-152 mm SL

FOOD	
Copepods	69.7
Invertebrate eggs	11.0
Polychaetes	10.3
Fish eggs	2.4
Larvaceans	1.9
Ostracods	1.7
Radiolarians	1.5
Urochordates	0.5
salps	
Crab larvae	0.4
Amphipods	0.2
hyperiids	
Barnacle larvae	0.1
Fish larvae	0.05
squid	0.05

Appendix C. (continued).

Trophic Guild: Macroplanktivores

Apogon pseudomaculatus	**twospot cardinalfish**
5 specimens: 62-71 mm SL	
FOOD	
Isopods	37.5
Crabs	25.0
Shrimps and shrimp larvae	25.0
Crab larvae	12.5

Chaetodon aya	**bank butterflyfish**
13 specimen: 67-94 mm SL	
FOOD	
Crab and shrimp larvae	90.1
Amphipods	5.1
Gorgonians	4.8

Pristigenys alta	**short bigeye**
9 specimens: 134-257mm SL	
FOOD	
Shrimp	40.0
Lucifer faxoni	
Squids	16.0
Shrimp larvae	16.0
Crab larvae	16.0
Stomatopod larvae	6.0
Fishes	2.0
Crabs	2.0

Priacanthus arenatus	**bigeye**
15 specimens: 196-295 mm SL	
FOOD	
Squids	32.9
Stomatopod larvae	27.6
Fish larvae	14.5
Scomberomorus sp.	
Bothus sp.	
Synodus sp.	
Crab larvae	14.5
Shrimp	3.9
Fishes	2.6
nettostomatid	
Shrimp larvae	1.3
Pteropods	1.3
Crabs	1.3

Rhomboplites aurorubens	**vermilion snapper**
72 specimens: 120-372 mm SL	
FOOD	
Amphipods	15.2
hyperiids	
Copepods	15.2
Polychaetes	14.3
Fish and fish larvae	10.6
Bregmaceros cantori	
myctophid	
Prionotus sp.(larvae)	
Synodus sp. (larvae)	
Shrimps and shrimp larvae	10.1
Lucifer faxoni	
Urochordates	9.9
salps	
Stomatopod larvae	8.0
Pteropods	6.9
Crab larvae	3.7
Ostracods	2.1
Fish eggs	1.4
Barnacle larvae	1.4
Larvaceans	1.1
Squids	0.2

Appendix C. (continued).

Trophic Guild: Benthic Carnivores

Bodianus pulchellus **spotfin hogfish**
4 specimens: 155-161 mm SL

FOOD	
Pelecypods	38.1
Crabs	19.0
Fishes	19.0
H. vivanus	
P. martinicensis	
Gastropods	14.3
Ophiuroids	9.5

Caulolatilus chrysops **goldface tilefish**
2 specimens: 331-443 mm SL

FOOD	
Polychaetes	45.0
Stomatopods	25.0
Pelecypods	20.0
Ophiuroids	5.0
Crabs	5.0

Pareques iwamotoi **blackbar drum**
1 specimen: 234 mm SL

FOOD	
Ophiuroids	33.3
Gastropods	33.3
Crabs	33.3

Pareques umbrosus **cubbyu**
4 specimens: 110-177 mm SL

FOOD	
Crabs	36.4
Munida sp.	
Calappa sp.	
xanthid	
Shrimps	36.4
Shrimp larvae	9.1
Ophiuroids	9.1
Polychaetes	9.1

Decodon puellaris **red hogfish**
2 specimens: 125-132 mm SL

FOOD	
Pelecypods	37.5
Gastropods	31.3
Crab larvae	12.5
Polychaetes	6.3
Crabs	6.3
pagurid	
Stomatopod larvae	6.3

Halichoeres bathyphilus **greenband wrasse**
10 specimens: 97-107 mm SL

FOOD	
Pelecypods	48.3
Crab larvae	13.8
Ophiuroids	6.9
Crabs	6.9
Shrimps and shrimp larvae	6.9
Foraminifera	6.9
Fishes	3.4
Polychaetes	3.4
Squids	3.4

Pagrus pagrus **red porgy**
28 specimens: 147-455 mm SL

FOOD	
Crabs	34.0
pagurids	
Munida sp.	
Calappa sp.	
Petrolisthes sp.	
Echinoids	20.2
spatangoids	
Gastropods	16.0
Stomatopod larvae	6.4
Fishes	5.3
Pristopomoides aquilonaris	
Kathetostoma albigutta	
Hemanthias vivanus	
Stomatopods	4.3
Polychaetes	4.3
Pelecypods	3.2
Crab Larvae	2.1
Shrimps	2.1
alpheid	
Holothiuroids	1.1
Sponges	1.1

Trophic Guild: Generalized Carnivores

Centropristis ocyurus **bank sea bass**
6 specimens: 142-212 mm SL

FOOD	
Crabs	72.2
pagurids	
portunids	
calappid	
Munida sp.	
Gastropods	11.1
Ophiuroids	5.6
Shrimps and shrimp larvae	5.6
Coral fragment	5.6

Epinephelus flavolimbatus **yellowedge grouper**
2 specimens: 156-694 mm SL

FOOD	
Fishes	66.7
myctophid	
Shrimps	33.3

Holocentrus adscensionis **squirrelfish**
3 specimens: 168-228 mm SL

FOOD	
Fishes	42.9
Hemanthias vivanus	
Crab larvae	42.9
Shrimps	14.3
alpheid	

Liopropoma eukrines **wrasse bass**
1 specimen: 70 mm SL

FOOD	
Fishes	100.0
Coryphopterus sp.	

Lutjanus campechanus **red snapper**
26 specimens: 192-465 mm SL

FOOD	
Fishes	56.4
Hemanthias vivanus	
Serranus sp.	
Bregmaceros cantori	
Hoplunnus sp.	
Trachurus lathami	
Isopods	10.3
Urochordates	10.3
Shrimps	7.7
Sicyona sp.	
Heteropods	5.1
Crabs	5.1
Stomatopods	2.6
Squids	2.6

Malacanthus plumieri **sand tilefish**
7 specimens: 345-376 mm SL

FOOD	
Gastropods	25.0
Fishes	18.8
Hemanthias vivanus	
Pronotogrammus martinicensis	
Crabs	18.8
Pelecypods	18.8
Ophiuroids	12.5
Bryozoans	6.3

Opsanus pardus **leopard toadfish**
5 specimens: 194-215 mm SL

FOOD	
Gastropods	33.3
Crabs	25.0
Fishes	25.0
Pronogrammus martinicensis	
Crinoids	8.3
Echinoids	8.3

Sargocentron bullisi **deepwater squirrelfish**
2 specimens: 129-134 mm SL

FOOD	
Crabs and crab larvae	33.3
Stomatopod larvae	33.3
Polychaetes	16.7
Chitons	16.7

Serranus phoebe **tattler**
44 specimens: 107-168 mm SL

FOOD	
Crabs	41.7
Munida sp.	
Xanthids	
Fishes	37.5
Hemanthias vivanus	
Coryphopterus sp.	
Crab larvae	5.6
Shrimps	5.6
alpheids	
Fish larvae	2.8
Ophiuroids	1.4
Squids	1.4
Stomatopods	1.4
Amphipods	1.4
Polychaetes	1.4

Appendix C. (continued).

Trophic Guild: Piscivores

Aulostomus maculatus **trumpetfish**
1 Specimen: 160 mm SL

FOOD	
Fishes	100.0
Coryphopterus sp.	

Gymnothorax saxicola **honeycomb moray**
1 specimen: 453 mm SL

FOOD	
Fishes	100.0
Hippocampus sp.	

Seriola dumerili **greater amberjack**
6 specimens: 561-744 mm SL

FOOD	
Fishes	100.0
Synodus sp.	
Prionotus sp.	
Hemanthias vivanus	
Pronotogrammus martinicensis	
Trachurus lathami	

Trophic Guild: Epibenthic Browsers

Chaetodon sedentarius **reef butterflyfish**
8 specimens: 92-107mm SL

FOOD	
Hydrozoans	71.4
Gorgonians	14.4
Copepods	5.2
Urochordates	3.2
tunicates	
Ostracods	2.2
Shrimp larvae	2.1
Echinoid spines	1.5

Canthigaster rostrata **sharpnose puffer**
2 specimens: 37-40 mm SL

FOOD	
Crinoids	78.6
Bivalves	7.8
Gastropods	3.2
Chitons	2.1

Holacanthus bermudensis **blue angelfish**
4 specimens: 210-291mm SL

FOOD	
Bryozoans	41.7
Gorgonians	41.7
Crinoids	8.3
Sponges	8.3

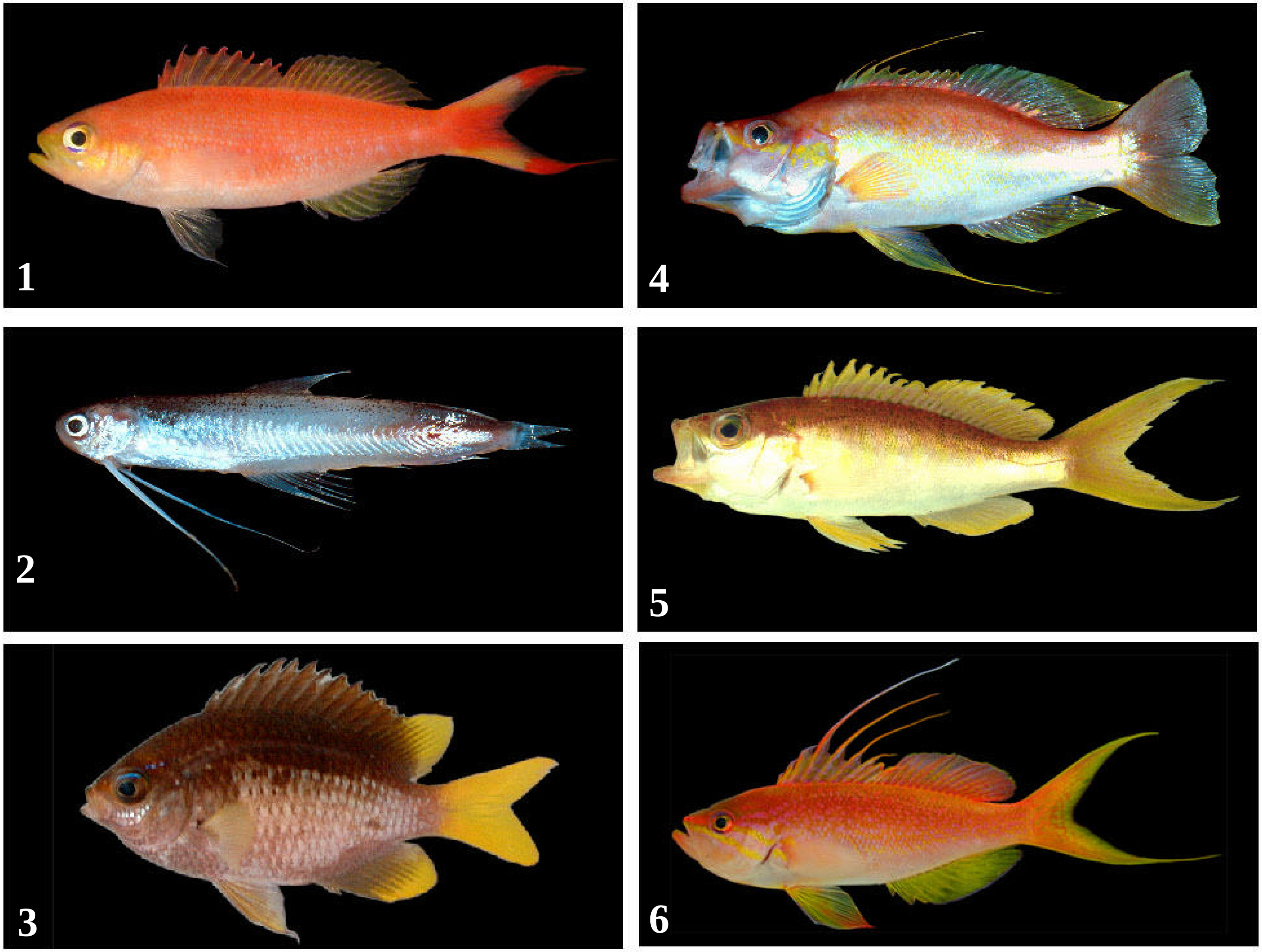
APPENDIX D

Characteristic ichthyofauna of Pinnacles Reef Tract, displaying the biodiversity of fishes by trophic guild.

Appendix D. Characteristic ichthyofauna of Pinnacles Reef Tract, displaying the biodiversity of fishes by trophic guild. Maximum body size given follows Smith-Vaniz et al. (1999) or Robins and Ray (1986). Depth range is based on videotape analysis or site of collection recorded for each species.

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Mesoplanktivores					
1. *Anthias tenuis*	threadnose bass	90 SL	D	A, R, Y	61- 88
2. *Bregmaceros cantori*	antenna codlet	60 SL	N	R, S	65-110
3. *Chromis enchrysura*	yellowtail reeffish	105 SL	D	D, R, T, Y	61- 80
4. *Hemanthias leptus*	longtail bass (adult)	450 SL	D	L, S	100-110
5. *Hemanthias leptus*	longtail bass (juvenile)				
6. *Hemanthias vivanus*	red barbier	120 SL	D	All Sites	61-110

FL=fork length, SL=standard length, and TL=total length.
D=Diurnal, N=Nocturnal, C=Crepuscular.
A=Alabama Alps, D=Double Top Reef, L=Ludwick and Walton Pinnacles, R=Roughtongue Reef, S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.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Appendix D. (continued).

Species	**Common Name**	**Maximum Body Size (mm)**	**Activity Pattern**	**Study Sites**	**Depth Range(m)**
Mesoplanktivores (continued)					
7. *Paranthias furcifer*	creole-fish	350 SL	D	R, Y	61- 80
8. *Pronotogrammus martinicensis*	roughtongue bass	160 SL	D	All Sites	61-110
Macroplanktivores					
9 *Apogon pseudomaculatus*	twospot cardinalfish	105 TL	N	All Sites	61-110
10. *Chaetodon aya*	bank butterflyfish	150 TL	D	All Sites	61-110
11. *Opistognathus lonchurus*	moustache jawfish	100 TL	D	Y, R	61- 80
12. *Priacanthus arenatus*	bigeye	360 SL	N	A, L, R, Y	61-110

FL=fork length, SL=standard length, and TL=total length.
D=Diurnal, N=Nocturnal, C=Crepuscular.
A=Alabama Alps, D=Double Top Reef, L=Ludwick and Walton Pinnacles, R=Roughtongue Reef,
S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.


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Appendix D. (continued).

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Macroplanktivores (continued)					
13. *Pristigenys alta*	short bigeye	330 FL	N	All Sites	61-110
14. *Rhomboplites aurorubens*	vermilion snapper	600 TL	D/N	All Sites	61-110
Generalized Carnivores					
15. *Bodianus pulchellus*	spotfin hogfish	330 FL	N	R, Y	61- 80
16. *Brotula barbata*	bearded brotula	330 FL	N	L, S	100-110
17. *Centropristis ocyurus*	bank sea bass	300 TL	D/N	D, Y	61- 80
18. *Corniger spinosus*	spinycheek soldierfish	200 TL	N	All Sites	61-110

FL=fork length, SL=standard length, and TL=total length.
D=Diurnal, N=Nocturnal, C=Crepuscular.
A=Alabama Alps, D=Double Top Reef, L=Ludwick and Walton Pinnacles, R=Roughtongue Reef,
S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.


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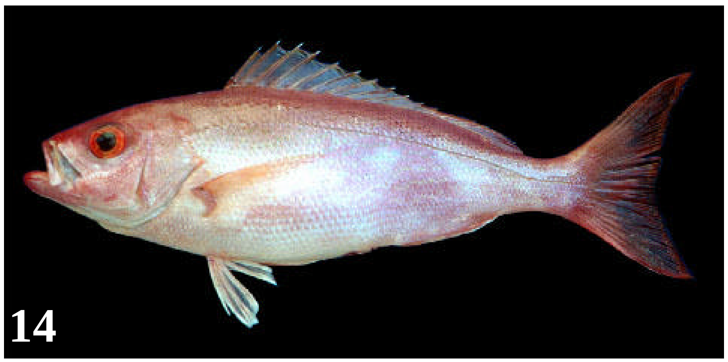
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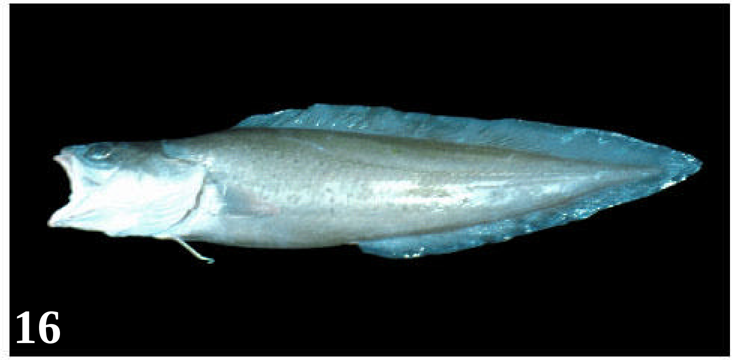
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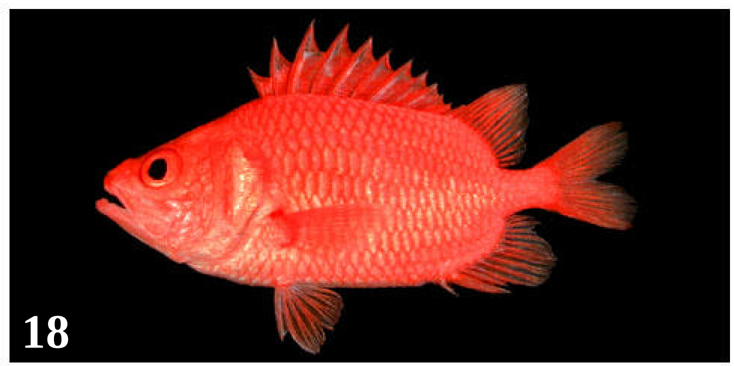
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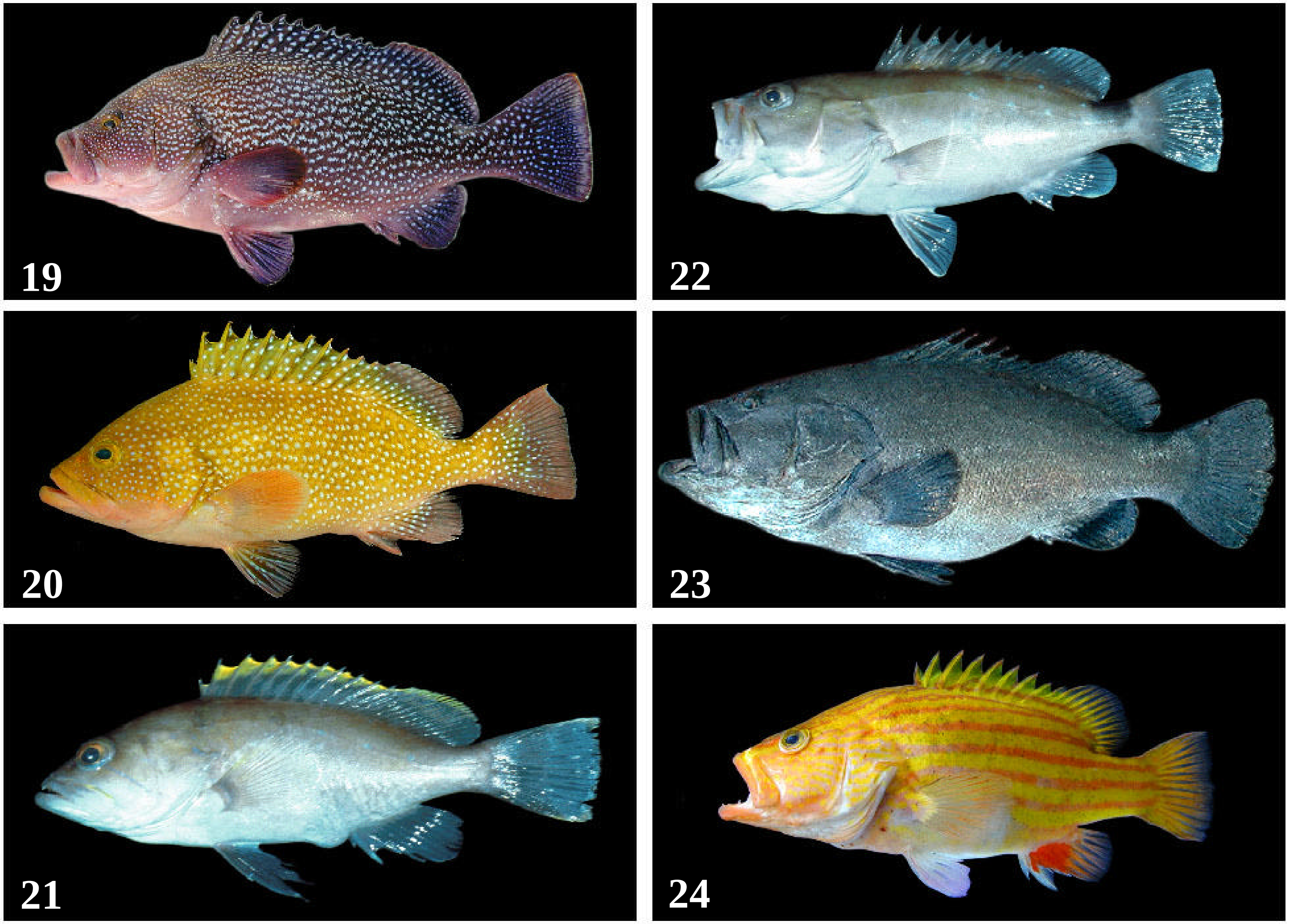
Appendix D. (continued).

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Generalized Carnivores (continued)					
19. *Epinephelus drummondhayi*	speckled hind (adult)	1100 TL	D/N	Y	61- 80
20. *Epinephelus drummondhayi*	speckled hind (juvenile)				
21. *Epinephelus flavolimbatus*	yellowedge grouper	1150 TL	D/N	L	100-110
22. *Epinephelus niveatus*	snowy grouper	1200 TL	D/N	D, L	70-110
23. *Epinephelus nigritus*	warsaw grouper	2300 TL	D/N	A	70- 88
24. *Gonioplectrus hispanus*	Spanish flag (adult)	230 TL	D/N	All Sites	61-110

FL=fork length, SL=standard length, and TL=total length.
D=Diurnal, N=Nocturnal, C=Crepuscular.
A=Alabama Alps, D=Double Top Reef, L=Ludwick and Walton Pinnacles, R=Roughtongue Reef, S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.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Appendix D. (continued).

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Generalized Carnivores (continued)					
25. *Gonioplectrus hispanus*	Spanish flag (juvenile)	230 TL	D/N	All Sites	61-110
26. *Gymnothorax hubbsi*	lichen moray	300 TL	N	A, Y	61- 88
27. *Holocentrus adscensionis*	squirrelfish	345 SL	N	R, Y	61- 80
28. *Liopropoma eukrines*	wrasse bass	130 TL	D/N	All Sites	61-110
29. *Lutjanus campechanus*	red snapper	1000 TL	D/N	All Sites	61-110
30. *Malacanthus plumieri*	sand tilefish	600 TL	D	R, Y	61- 80

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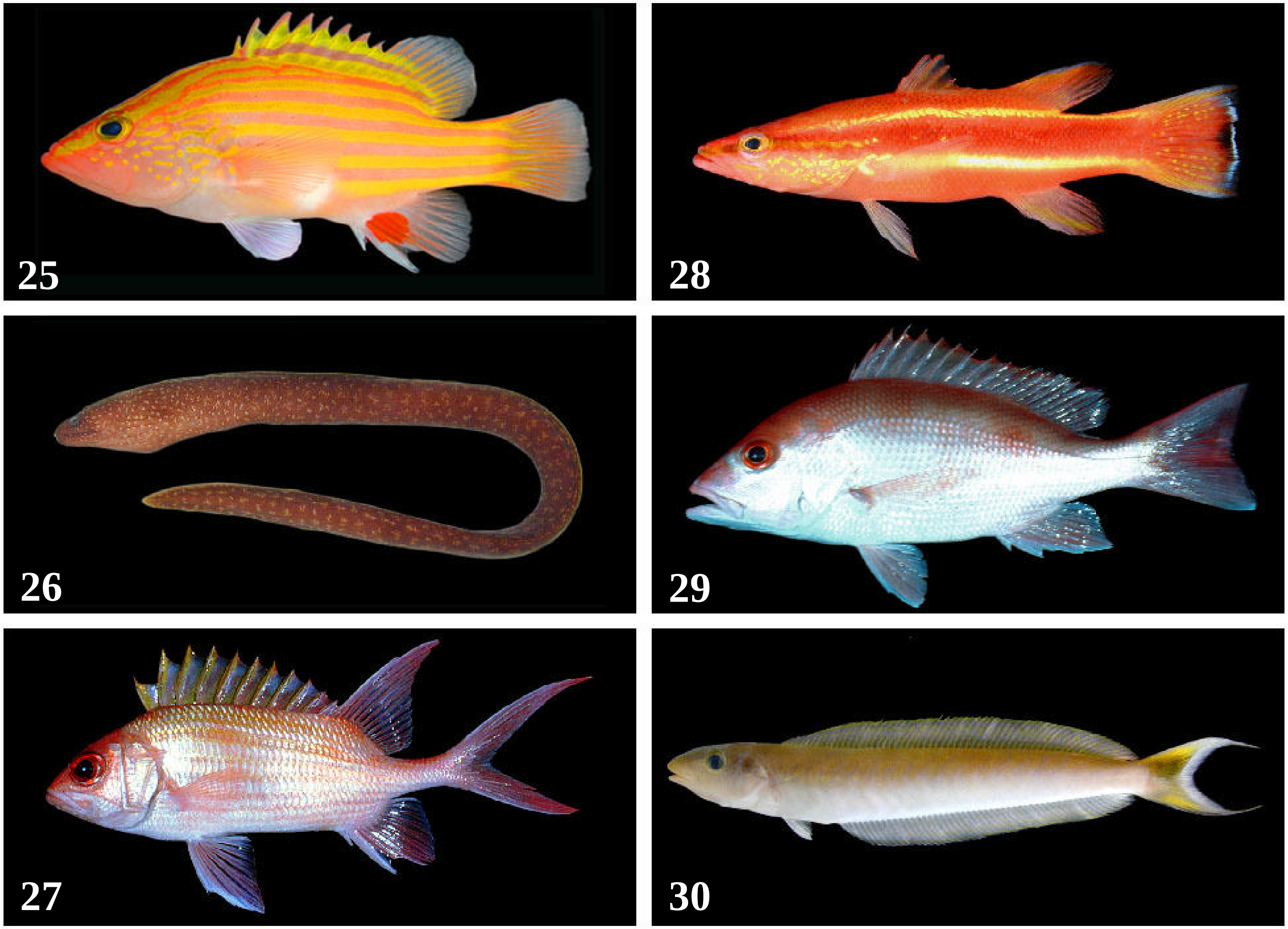
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Appendix D. (continued).

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Generalized Carnivores (continued)					
31. *Opsanus pardus*	leopard toadfish	380 TL	D/N	R, Y	61- 80
32. *Pontinus rathbuni*	highfin scorpionfish	250 TL	D/N	R, Y	61- 80
33. *Rypticus maculatus*	whitespotted soapfish	200 TL	D/N	R, Y	61- 80
34. *Sargocentron bullisi*	deepwater squirrelfish	130 SL	N	L, R, Y	61-110
35. *Scorpaena dispar*	hunchback scorpionfish	300 TL	N	All Sites	61-110
36. *Serranus phoebe*	tattler	215 SL	D	All Sites	61-110

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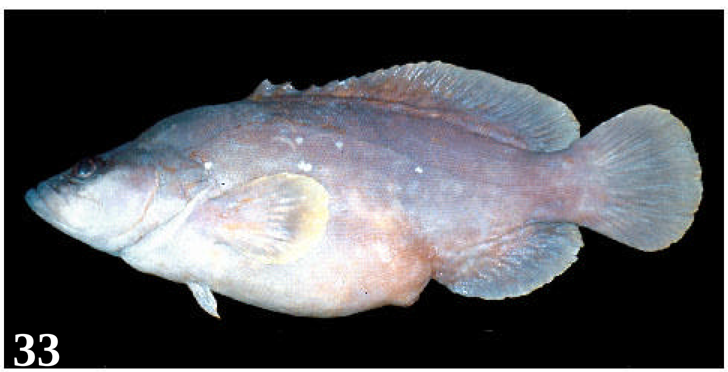
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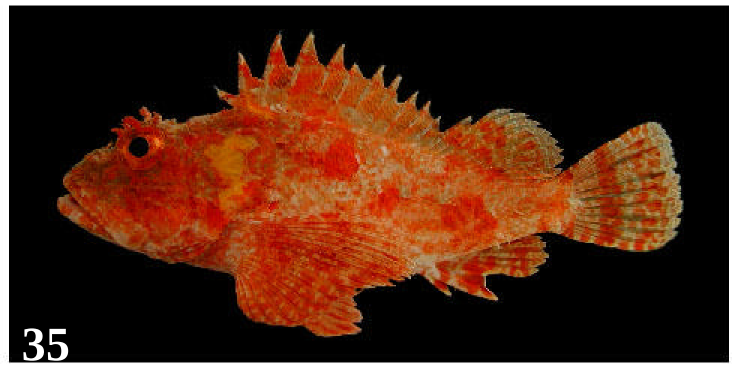
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Appendix D. (continued)

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Piscivores					
37. *Aulostomus maculatus*	trumpetfish	750 TL	D	A, R, Y	61- 88
38. *Fistularia petimba*	red cornetfish	1800 TL	D/N	R, S	65-110
39. *Gymnothorax kolpos*	blacktail moray	900 TL	D/N	All Sites	61-110
40. *Muraena retifera*	reticulated moray	900 TL	D/N	All Sites	61-110
41. *Mycteroperca microlepis*	gag	1200 TL	D/C	All Sites	61-110
42. *Mycteroperca phenax*	scamp	900 TL	D/C	All Sites	61-110

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S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.


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Appendix D. (continued).

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Piscivores (continued)					
43. *Seriola fasciata*	lesser amberjack	680 FL	D/N	All Sites	61-110
44. *Synodus intermedius*	sand diver	380 SL	D/N	Y, L	61-110
Benthic Carnivores					
45. *Caulolatilus chrysops*	goldface tilefish	600 TL	D/N	L	100-110
46. *Caulolatilus intermedius*	anchor tilefish	600 TL	D/N	L	100-110
47. *Calamus leucosteus*	whitebone porgy	460 TL	D/N	Y, R	61- 80
48. *Calamus nodosus*	knobbed porgy	460 TL	D/N	Y, R	61- 80

FL=fork length, SL=standard length, and TL=total length.
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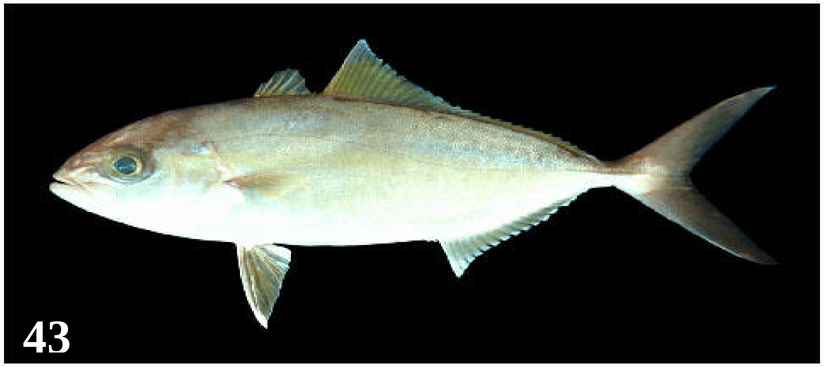
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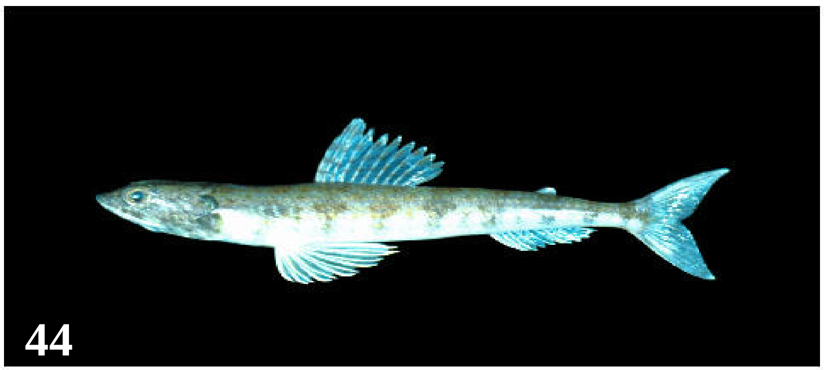
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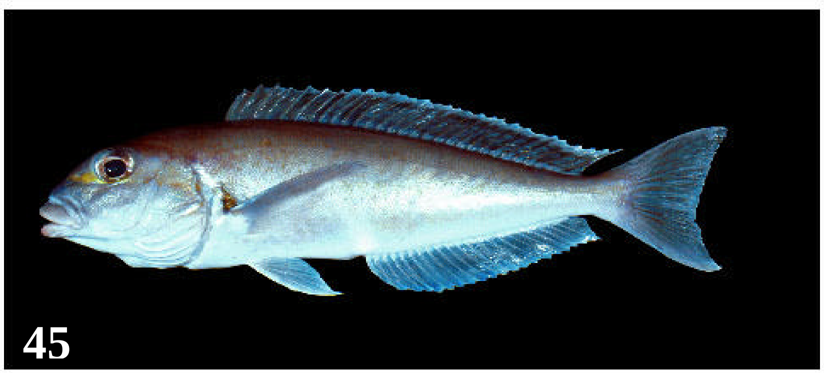
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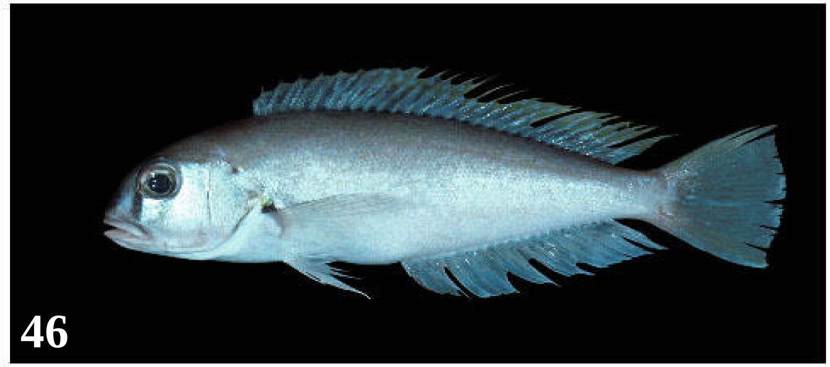
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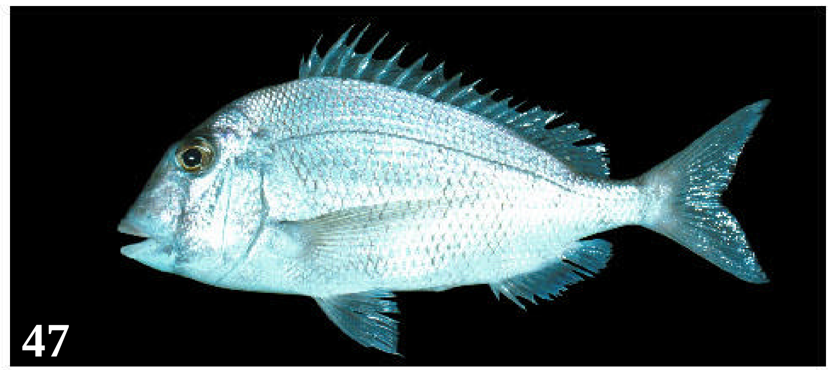
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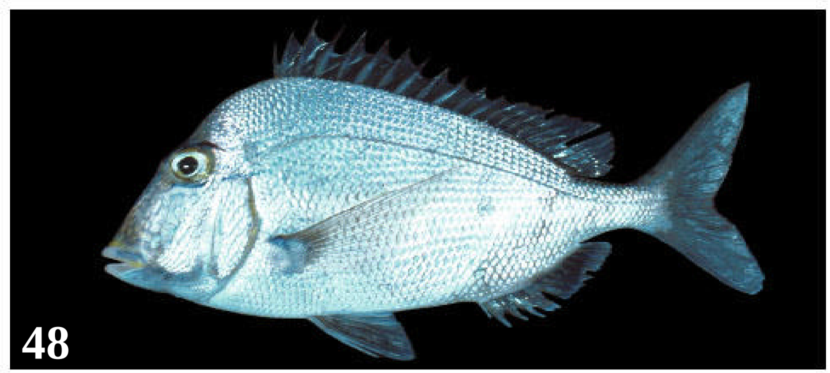
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Appendix D. (continued)

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Benthic Carnivores (continued)					
49. *Decodon puellaris*	red hogfish	300 TL	D	All Sites	61-110
50. *Halichoeres bathyphilus*	greenband wrasse (f)	230 TL	D	All Sites	61-110
51. *Halichoeres bathyphilus*	greenband wrasse (m)				
52. *Ogcocephalus declivirostris*	slantbrow batfish	165 TL	D/N	All Sites	61-110
53. *Pagrus pagrus*	red porgy	910 TL	D/N	All Sites	61-110
54. *Pareques iwamotoi*	blackbar drum	300 TL	D/N	A, L, S	70-110

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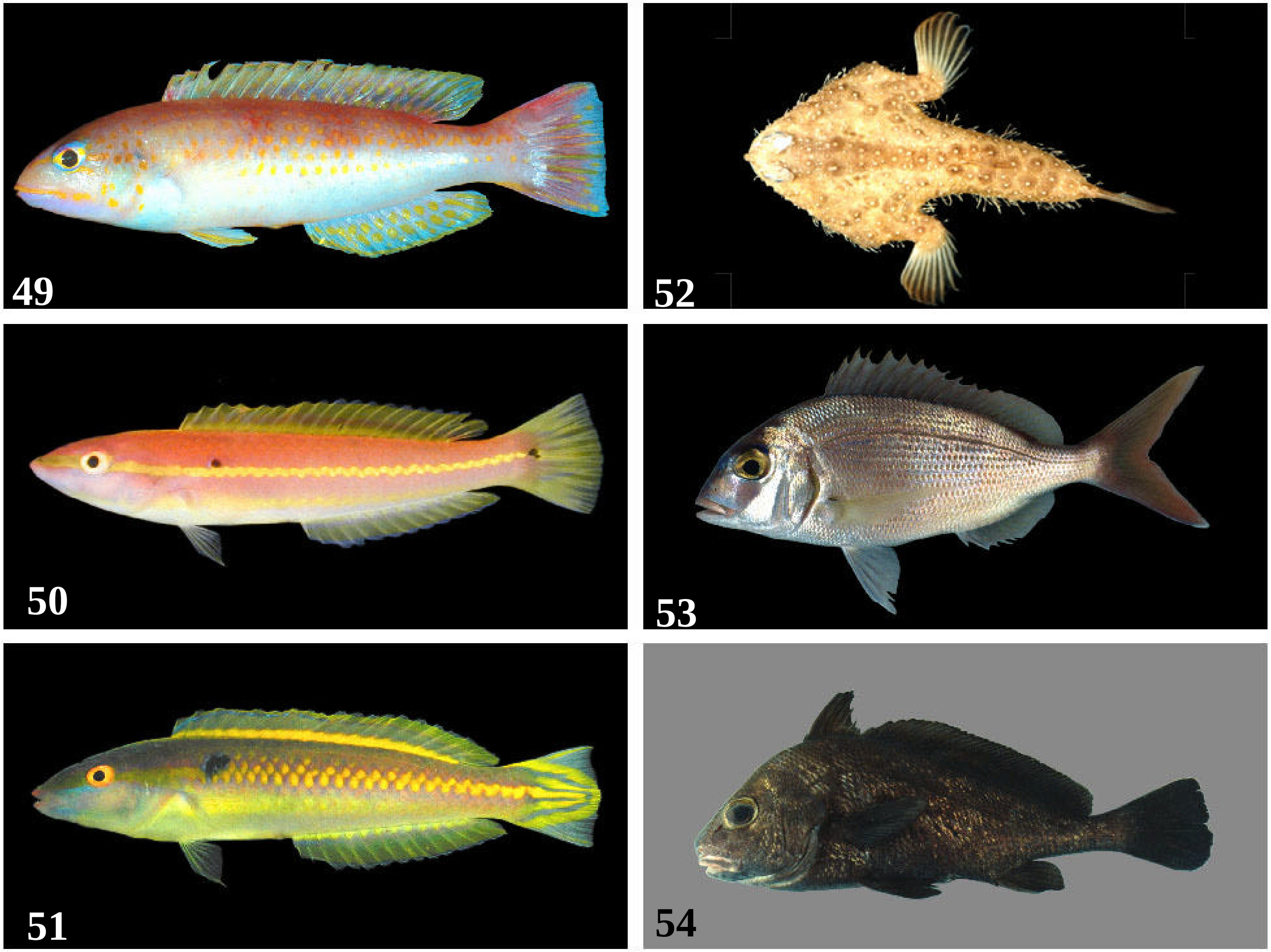
S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.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Appendix D. (continued)

Species	Common Name	Maximum Body Size (mm)	Activity Pattern	Study Sites	Depth Range(m)
Benthic Carnivores (continued)					
55. *Pareques umbrosus*	cubbyu	250 TL	D/N	All Sites	61-110
Epibenthic Browsers					
56. *Chaetodon sedentarius*	reef butterflyfish	150 TL	D	A, D, R, Y	61- 88
57. *Chaetodon ocellatus*	spotfin butterflyfish	200 TL	D	R, Y	61- 80
58. *Canthigaster jamestyleri*	goldface sharpnose puffer	110 TL	D	R, Y	61- 80
59. *Canthigaster rostrata*	sharpnose puffer	110 TL	D	A, R, Y	61- 88
60. *Holacanthus bermudensis*	blue angelfish	440 TL	D	All Sites	61-110

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S=Scamp Reef, T=Triple Top Reef, Y=Yellowtail Reef.


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12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***

Topographic prominences form reef-like features along the outer continental shelf (OCS) edge and continental slope of the southeastern United States and Gulf of Mexico. An extensive set of reef features, known as the Pinnacles Reef Tract, occurs off Mississippi and Alabama at depths between 60 and 110 m. Eighteen sites within the combined Mississippi-Alabama Marine Ecosystems Study and Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study area were surveyed. All sampling combined returned over 6,000 specimens for food habits analyses, taxonomic verification and documentation, and subsequent life history analyses. The results of this study have expanded the number of fishes documented from the Pinnacles Reef Tract, and is the first extensive collection of deep (greater than 60 m) reef fishes made in this region, and possibly worldwide. Our present knowledge of the Pinnacles ichthyofauna can be used to characterize the fundamental taxonomic composition and trophic structure of deep reef-fish communities throughout southeastern United States and Gulf of Mexico OCS areas and therefore be useful in assessing future anthropogenic impacts on faunal structure.

14. SUBJECT TERMS

Pinnacles, geology, deep reef, hard bottom communities, fish, trophic ecology, food web, community ecology

15. NUMBER OF PAGES
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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The **MMS Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

The U.S. Geological Survey Mission

The U.S. Geological Survey (USGS) is a world leader in the natural sciences through our scientific excellence and responsiveness to society's needs. The USGS serves the Nation by providing reliable scientific information to 1) describe and understand the Earth; 2) minimize loss of life and property from natural disasters; 3) manage water, biological, energy, and mineral resources; and 4) enhance and protect our quality of life.