DEEP-WATER CORAL REEFS OF FLORIDA, GEORGIA AND SOUTH CAROLINA: A SUMMARY OF THE DISTRIBUTION, HABITAT, AND ASSOCIATED FAUNA

by
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Contract No: SA-04-05-NC/UNCW
Submitted to: South Atlantic Fishery Management Council
One Southpark Circle, Suite 306
Charleston, SC 29407

October 20, 2004

ABSTRACT

This report was compiled at the request of the South Atlantic Fishery Management Council (SAFMC) to provide a preliminary, general summary on the status of current knowledge concerning deep-water (> 200 m) reefs off the southeastern U.S. from Florida to North Carolina. The outcome will provide target areas of deep-water, live-bottom habitats for: 1) potential designation as Habitat Areas of Particular Concern (HAPC) or Marine Protected Areas (MPA) by the SAFMC, and 2) high-resolution habitat maps and habitat characterization studies. The resource potential of the deep-water habitats in this region is unknown in terms of fisheries and novel compounds yet to be discovered from associated fauna that may be developed as pharmaceutical drugs. Although these habitats have not been designated as MPAs or HAPCs, they are incredibly diverse and irreplaceable resources. Activities involving bottom trawling, pipelines, or oil/gas production could negatively impact these reefs. This report primarily summarizes recent submersible data regarding deep-water reefs off Florida but also includes sites off Georgia and South Carolina. A report on the North Carolina reefs has been submitted separately by Dr. Steve Ross, UNCW. This report does not include the deep-water *Oculina* reefs off central eastern Florida or deep shelf-edge reefs with hermatypic coral (<100 m). The sites included in this report are the following: 1) Stetson Reefs- hundreds of pinnacles along the eastern Blake Plateau off South Carolina include a 152-m tall pinnacle (822 m depth) where recent submerisible dives discovered live bushes of *Lophelia* coral, sponges, gorgonians, and black coral bushes. 2) Savannah Lithoherms- numerous lithoherms at depths of 550 m with relief up to 60 m provide live-bottom habitat. 3) East Florida *Lophelia* Reefs- echosounder transects along a 222-km stretch off eastern Florida (depth 700-800 m) mapped hundreds of 15-152 m tall coral pinnacles and lithoherms. 4,5) Miami Terrace and Pourtales Terrace- Miocene age terraces off southeastern Florida and the Florida reef tract provide high-relief, hard-bottom habitats and rich benthic communites. 6) SW Florida Lithoherms- in the Gulf of Mexico off the southwestern Florida shelf slope, 15-m tall *Lophelia* coral lithoherms (500 m depth) are described the first time from SEABEAM and ROV dives.

JUSTIFICATION

The South Atlantic Fishery Management Council (R. Pugliese) requested that this preliminary summary report on the state of knowledge of Deep Sea Coral Ecosystems (DSCE) in the region be available in time for the Habitat Advisory Panel meeting of the SAFMC, October 26, 2004. The Council needs immediate scientific data and maps as it considers designation of new Habitat Areas of Particular Concern (HAPC) to protect DSCE areas. Such protection may be needed to prevent long-term (perhaps permanent) damage, such as has occurred on shallower *Oculina* reefs off Florida and *Lophelia* banks in the northeastern Atlantic, both destroyed in part by trawling. After trawlers were banned from the *Oculina* HAPC, there is justified concern that trawlers may move to deeper habitats in search of valuable commercial fisheries, such as royal red shrimp or benthic finfish. NOAA is currently developing priority mapping sites, including Marine Protected Areas and DSCE. NOAA OE funding for 2005 will likely support habitat mapping of shelf-edge and deep-water reef habitats in the South Atlantic Bight and Gulf of Mexico. Data compiled in this report provides potential targets for future mapping, MPAs and HAPCs. The resource potential of the deep-water habitats in this region is unknown in terms of fisheries and novel compounds yet to be discovered from associated fauna that may be developed as pharmaceutical drugs. Although these habitats are not currently designated as MPAs or HAPCs, they are incredibly diverse and irreplaceable resources. Activities involving bottom trawling, pipelines, or oil/gas production could negatively impact these reefs.

OBJECTIVES

Objectives of this report and accompanying DVD are the following:

1) Compile list of references regarding geology and biology of deep-water reef habitats in the South Atlantic Bight, Straits of Florida and southwest Florida slope.
2) Describe general habitat for each reef type and region (northeastern Florida, Straits of Florida, southwest Florida slope, and areas of DSCE off Georgia and South Carolina).
3) Provide representative digital still images and video clips for examples of reef types and regions (on DVD).
4) Provide species list of dominant benthic invertebrates that are directly associated with these reefs based on recent collections and observations by the PI (based on current status of taxonomic identifications).
5) Provide species list of fish that are directly associated with these reefs based on recent collections and observations by the PI (based on current status of taxonomic identifications).
6) Provide general maps of known DSCE reefs in the region.

BACKGROUND

Deep-water reefs are sometimes defined as bioherms, coral banks, or lithoherms (Teichert, 1958; Stetson et al., 1962; Neumann et al., 1977; Wilson, 1979; Reed, 1980; Freiwald et al. 1997; Fosså et al. 2000; Paull et al., 2000). Some deep-water reefs consist of caps of living coral on mounds of unconsolidated mud and coral debris, such as some *Oculina* and *Lophelia* coral reefs (Reed 2002a,b), whereas deep-water lithoherms are defined as high-relief, lithified carbonate limestone mounds rather than unconsolidated mud mounds (Neumann et al., 1977). Rogers (1999) has suggested that deep-water coral bioherms fall within the definition of a coral reef based on their physical and biological characteristics. Various types of deep-water, high-relief bioherms are common off the southeastern United States, along the base of the Florida-Hatteras Slope, on the Blake Plateau, in the Straits of Florida, and eastern Gulf of Mexico. Only a small percentage of deep-water reefs have had their benthic and fish resources characterized.

Recent research expeditions by Principal Investigator (PI), J. Reed, Harbor Branch Oceanographic Institution (HBOI), using HOVs (human occupied vehicle) and ROVs (remotely operated vehicle) along with previous research by the PI in the 1990s and 1980s, have compiled new information on the status, distribution, habitat, and biodiversity of some of these relatively unknown and newly discovered deep reef ecosystems. In 2004, during a State of Florida funded mission with the *Johnson-Sea-Link* (*JSL*) Submersible, the PI discovered nearly 300 potential targets during echosounder transects that may be newly discovered deep-water reefs off the east coast of Florida, some of which are up to 168 m (550 feet) in height at depths of 732 m (2400 feet) (Reed and Wright, 2004; Reed et al., 2004b). Expeditions in 2002 and 2003 for biomedical research by the PI and funded by the National Oceanic and Atmospheric Administration's Office of Ocean Exploration (NOAA OE) enabled preliminary exploration of additional deep-water reef sites in the western Atlantic (Blake Plateau) and eastern Gulf of Mexico on southwest Florida shelf slope (Reed, 2003, 2004; Reed and Pomponi, 2002b; Reed et al., 2002, 2003, 2004d). These were the first HOV and ROV dives ever to document the habitat and benthic biodiversity of some of these relatively unknown deep-water reefs. A small scale, high-definition topographic SEABEAM map was also conducted by the PI at the southwest Florida site. Considerable work remains to analyze these data and prepare for scientific publications (three papers in preparation or submitted by PI: Florida's Deep-Water *Lophelia* Reefs; Miami Terrace Deep-Water Reefs; Deep-Water Sinkholes and Bioherms of Pourtales Terrace- Habitat and Biology). These are very preliminary analyses based on only a few submersible or ROV dives at the various sites.

<u>Florida DSCE</u>

Deep sea coral ecosystems (DSCE) in U.S. EEZ waters exist along the eastern and southwest Florida shelf slope (in addition to the *Oculina* Marine Protected Area and deep shelf-edge reefs with hermatypic coral). These include a variety of high-relief, hard-bottom, live-bottom habitats at numerous sites along the base of the Florida-Hatteras Slope off northeastern and central eastern Florida, the Straits of Florida, the Miami Terrace and Pourtales Terrace off southeastern Florida, and the southwestern Florida shelf slope. The predominate coral on these reefs are the azooxanthellate, colonial scleractinian corals, *Lophelia pertusa*, *Madrepora oculata*, and *Enallopsammia profunda*; various species of hydrocorals of the family Stylasteridae, and species of the bamboo octocoral of the family Isididae. Various types of high-relief, live-bottom habitat have been discovered in the area: *Lophelia* mud mounds, lithoherms, sinkholes, ancient Miocene escarpments and karst topographic features (Reed 2002b; Reed et al., 2004a,b). These all provide hard-bottom substrate and habitat for sessile macrofauna including deep-water corals, octocorals (gorgonians), black coral, and sponges, which in turn provide habitat and living space for a relatively unknown but biologically rich and diverse community of associated fish, crustaceans, mollusks, echinoderms, polychaete and sipunculan worms, and other macrofauna, many of which are undoubtedly undescribed species. Our preliminary studies have found new species of octocorals and sponges from some these sites (Reed et al., 2004 a,b).

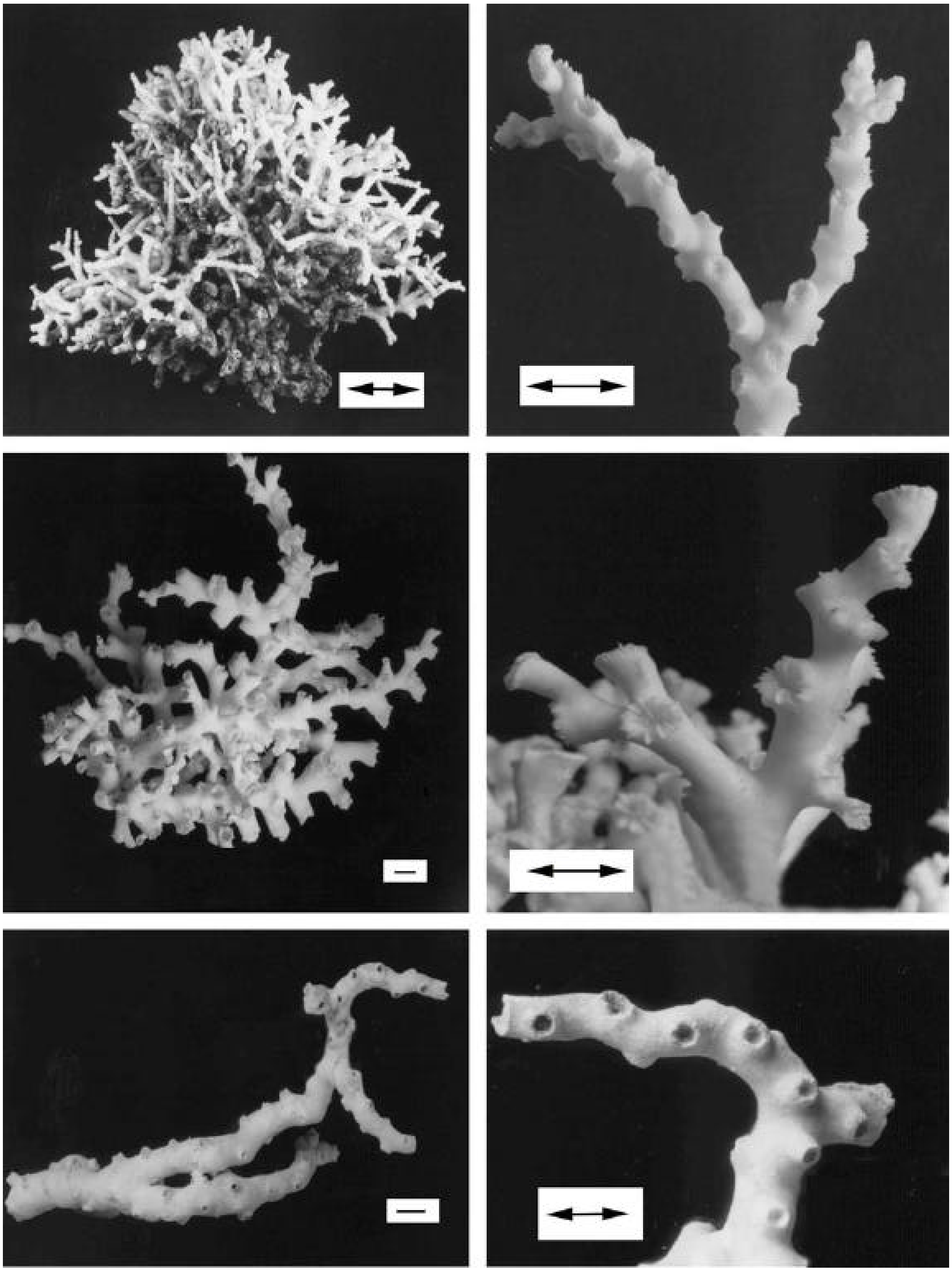
RESULTS

<u>Coral Description and Distribution (from Reed, 2002a)</u>

The dominant colonial scleractinian coral species forming deep-water reefs in the western North Atlantic region are *Oculina varicosa*, *Lophelia pertusa*, and *Enallopsammia profunda*, although other branching colonial scleractinia may also occur, including *Solenosmilia variabilis* and *Madrepora oculata* (Figs. 1 and 2). Numerous solitary coral species are also common (Cairns, 1979).

Lophelia pertusa (*Linnaeus*, 1758) (= *L. prolifera*): This coral forms massive, dendroid, bushy colonies, 10-150 cm in diameter, with anastomosing branches (Figure 1). Its distribution ranges in the western Atlantic from Nova Scotia to Brazil and the Gulf of Mexico, and also in the eastern Atlantic, Mediterranean, Indian, and eastern Pacific Oceans at depths of 60-2170 m (Cairns, 1979). Along with *Enallopsammia profunda*, it is the primary constituent of deep-water reefs at the base of

Figure 1. Coral colony and branch tip: top- *Oculina varicosa* (80m); middle- *Lophelia pertusa* (490m); bottom- *Enallopsammia profunda* (585m). (scale lines = 1 cm; top left fig. Scale = 5 cm) (from Reed, 2002a; Hydrobiologia 471: 57-69)



the Florida-Hatteras slope and at depths of 500-800 m from Miami to South Carolina (Figure 3, Region B and C). In addition, over 200 banks have been mapped at depths of 640-869 m (Region D) on the outer eastern edge of the Blake Plateau (Stetson et al., 1962; Popenoe and Manheim, 2001). Elsewhere deep-water *Lophelia* reefs are known from the Gulf of Mexico (Ludwick & Walton, 1957; Moore & Bullis, 1960; Newton et al., 1987) and the eastern Atlantic off Norway and Scotland (Teichert, 1958; Wilson, 1979a; Mortensen et al., 1995; Freiwald et al., 1997, 1999). In the eastern Atlantic, *Madrepora oculata* commonly occurs with *Lophelia* rather than *E. profunda*.

Enallopsammia profunda (Pourtalès, 1867) (=*Dendrophyllia profunda*): This species also forms dendroid, massive colonies up to 1 m in diameter (Figure 1). It is endemic to the western Atlantic and ranges from the Antilles in the Caribbean to Massachusetts at depths of 146-1748 m (Cairns, 1979). *E. profunda* occurs with *L. pertusa* at Regions B, C, and D (Figure 3). It appears to be the primary constituent of the deep-water reefs at Site D except at the tops of the mounds where *L. pertusa* is more prevalent (Stetson et al., 1962).

Six regions (B-D, G-I) of deep-water reef habitats off southeastern U.S. from Florida to South Carolina may be considered targets for potential HAPCs (Figs. 3-8). Figure 3 shows the general boundaries of Regions A-H off eastern Florida, Georgia, and South Carolina. It also includes the *Oculina* Reefs (A) that are already designated as an HAPC and two regions (E,F) that are within Bahamian waters, but are not discussed in this report (see Reed 2002a,b). Recent submersible dive sites and echosounder locations of high-relief reef habitat off the east coast are shown in Figure 4 (see Table 1 for corresponding dive sites). Details of the *Lophelia* mounds of Region D (Stetson's Reefs) are shown in Figure 5 (Popenoe and Mannheim, 2001). Figure 6 shows the bathymetry and submersible dive sites at Region G, Miami Terrace Escarpment. Figure 7 shows the bathymetry and submersible dive sites at Region H, Pourtales Terrace. Figure 8 shows the bathymetry and ROV dive sites in the Gulf of Mexico at Region I, Southwest Florida Lithoherms.

Figure 2. Depth range and maximum relief of deep-water coral reefs off southeastern U.S.A. Dominant colonial coral listed for each site (see Figure 3 for site locations). (from Reed, 2002a; Hydrobiologia 471: 57-69)

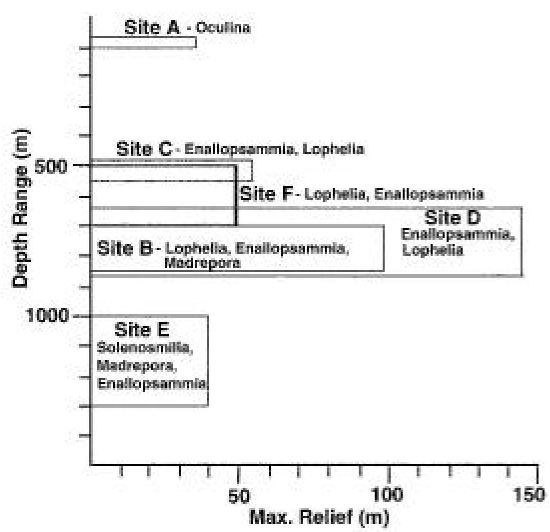


Figure 3. Deep-water coral reef regions off southeastern U.S.A. (see Table 1 for locations).

?= *Johnson-Sea-Link* I and II submersible dive sites and echosounder sites of high-relief reefs; Regions: A=*Oculina* Coral Reefs, B= East Florida *Lophelia* Reefs, C= Savannah *Lophelia* Lithoherms, D= Stetson's Reefs (D1= region of dense pinnacles), E= *Enallopsammia* Reefs (Mullins et al., 1981), F= Bahama Lithoherms (Neumann et al., 1977), G= Miami Terrace Escarpment. (from Reed et al., 2004b; chart from NOAA, NOS, 1986)

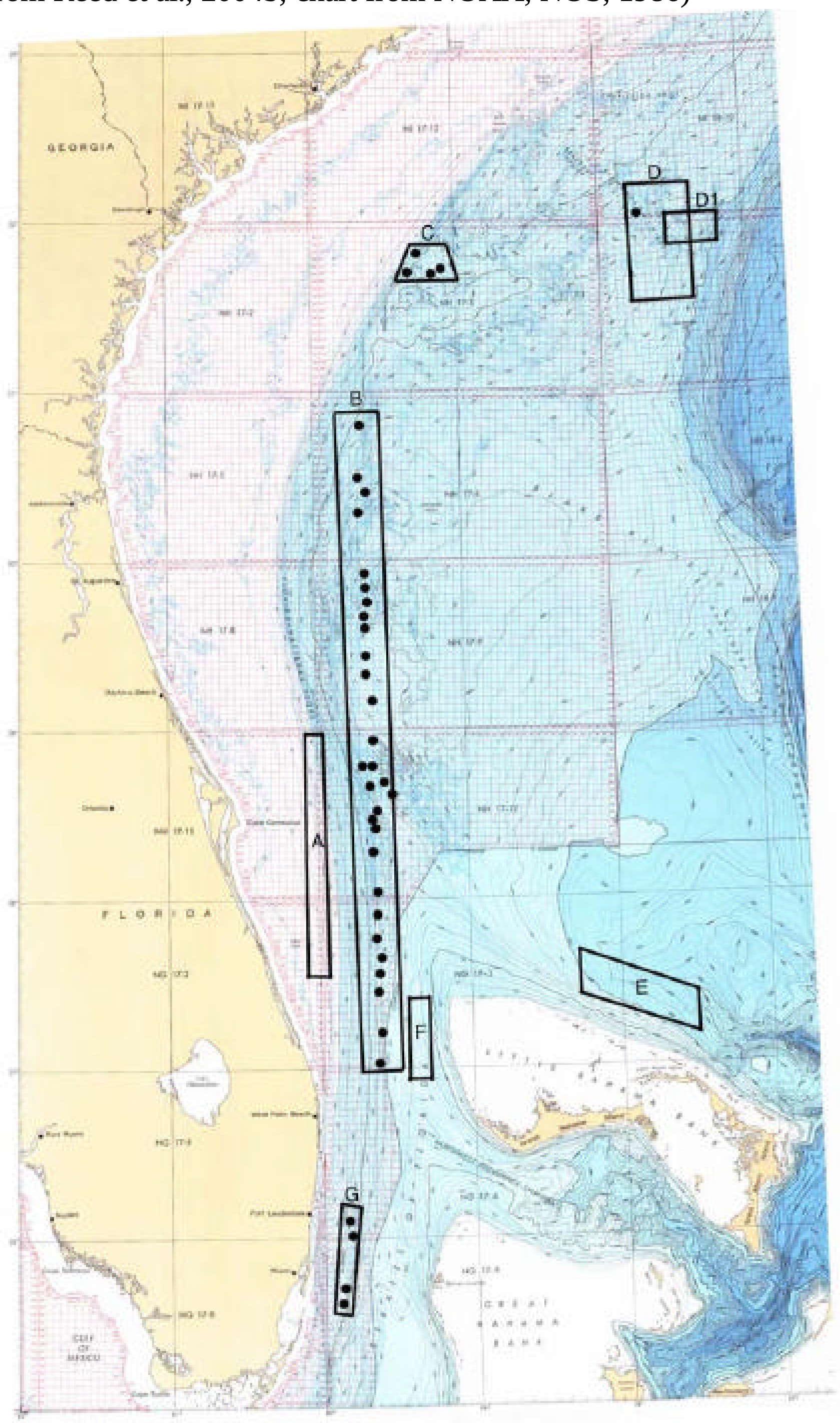


Figure 4. Submersible dive sites and echosounder sites on deep-water reefs off southeastern U.S.A. (see Table 1 for locations). ?# = *Johnson-Sea-Link* I and II submersible dive sites, F# = high-relief pinnacles from echosounder transects. (from Reed et al., 2004b; chart from NOAA, NOS, 1986)

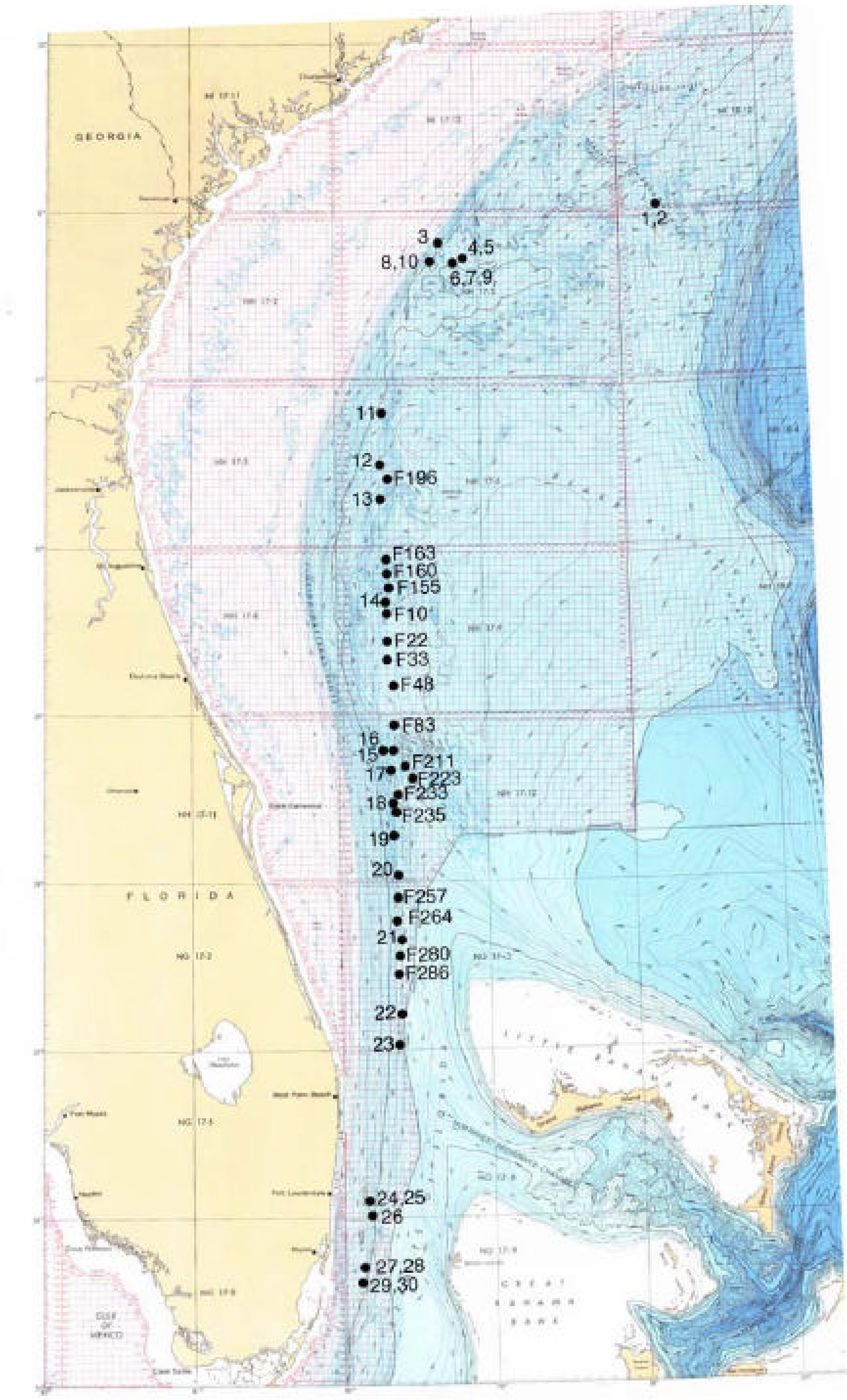


Figure 5. Detailed chart of high-relief region with *Lophelia* coral mounds on Charleston Bump, Blake Plateau. (from Popenoe and Manheim, 2001; American Fisheries Society Symposium 25: 43-94)

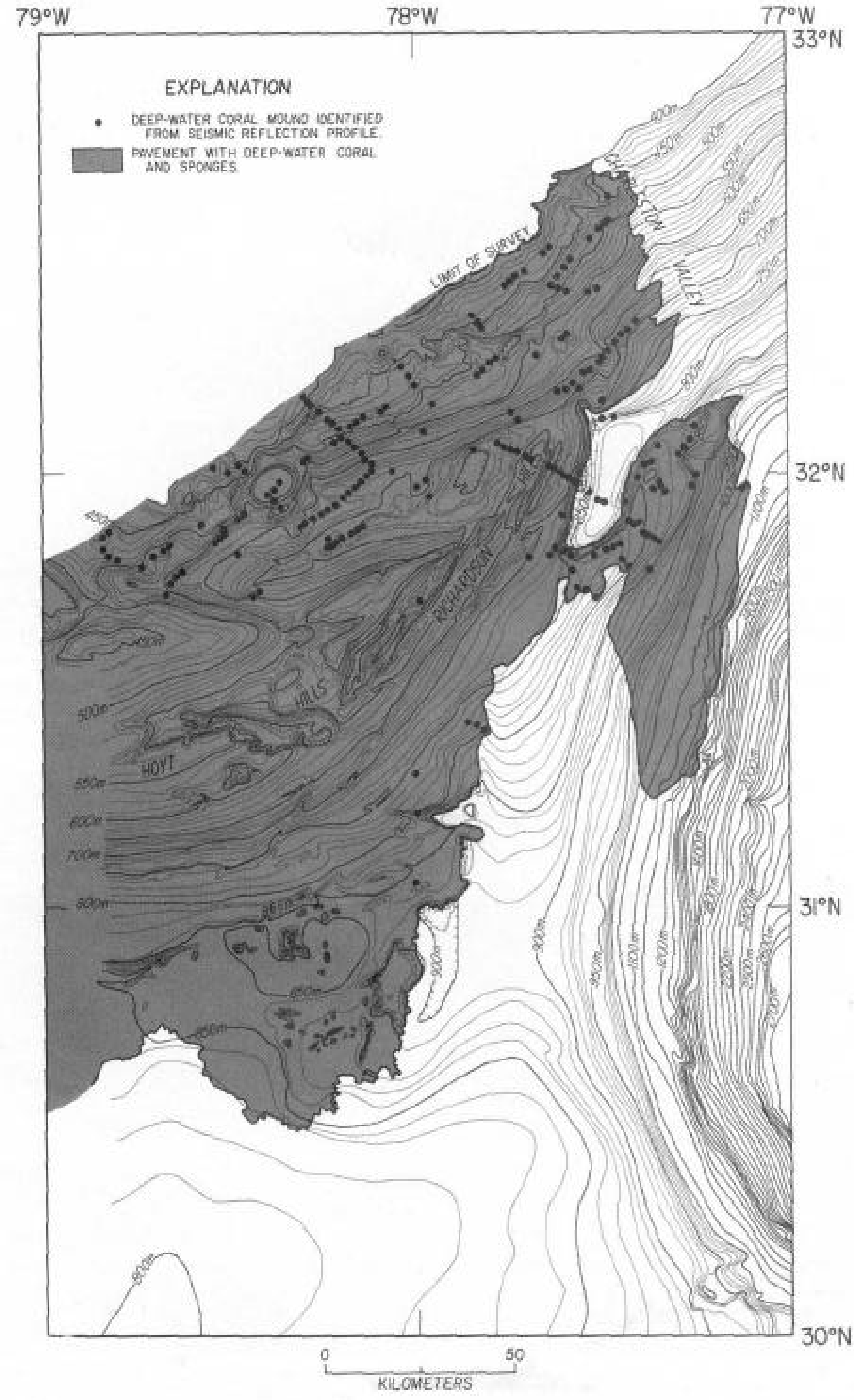


Figure 6. Bathymetry and submersible dive sites on Miami Terrace Escarpment at Region G (see Table 1 for locations). ?= *Johnson-Sea-Link* I submersible dive sites. (from Reed et al., 2004b; chart from Ballard and Uchupi, 1971; MTS Journal 5: 43-48)

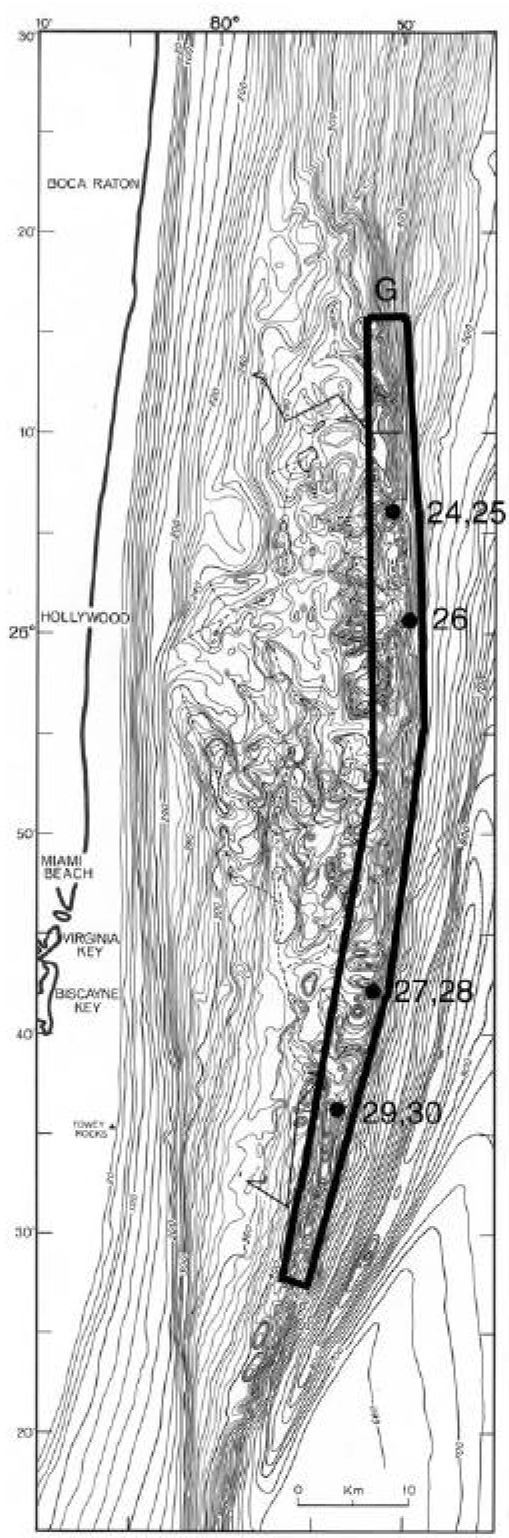


Figure 7. Bathymetry and submersible dive sites on Pourtalès Terrace at Region H (see Table 2 for locations). ?= *Johnson-Sea-Link* and *Clelia* submersible dive sites; JS= Jordan Sinkhole, MS= Marathon Sinkhole, TB1= Tennessee Humps Bioherm #1, TB2= Tennessee Humps Bioherm #2, AB3= Alligator Humps Bioherm #3, AB4= Alligator Humps Bioherm #4. (from Reed et al., 2004b; chart from Malloy and Hurley, 1970; Geol. Soc. Amer. Bull. 81: 1947-1972)

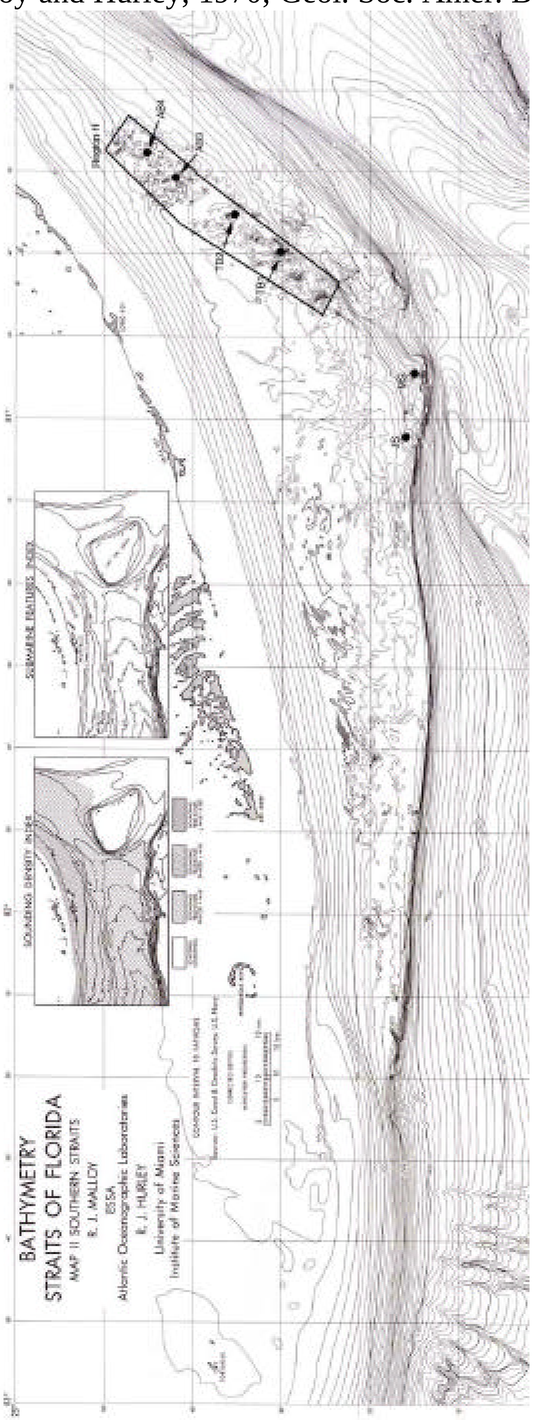
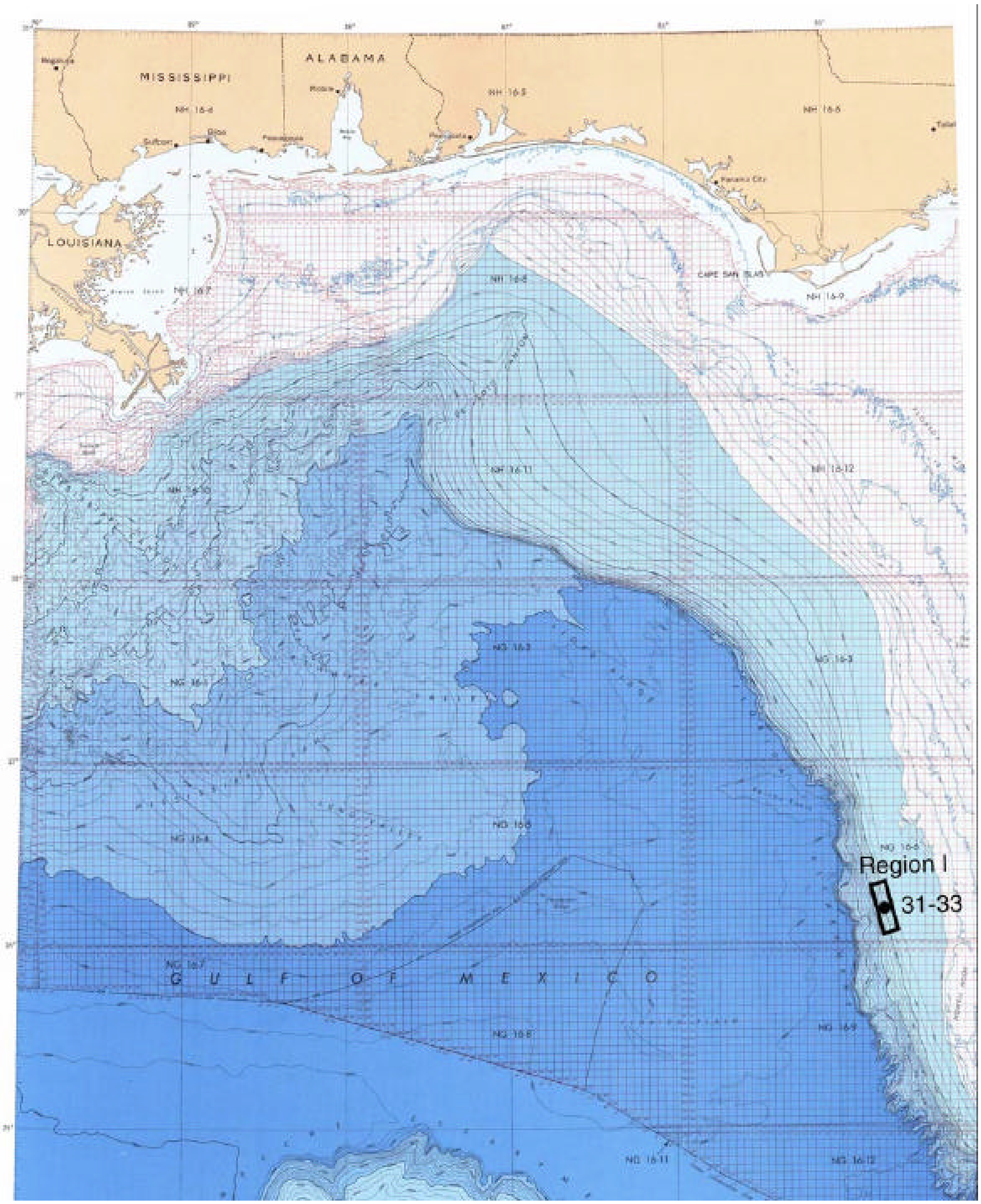


Figure 8. Deep-water coral lithoherms and ROV dive sites at Region I off southwest Florida slope (see Table 1 for locations). ?= *Innovator* ROV dive sites. (from Reed et al., 2004b; chart from NOAA, NOS, 1986)



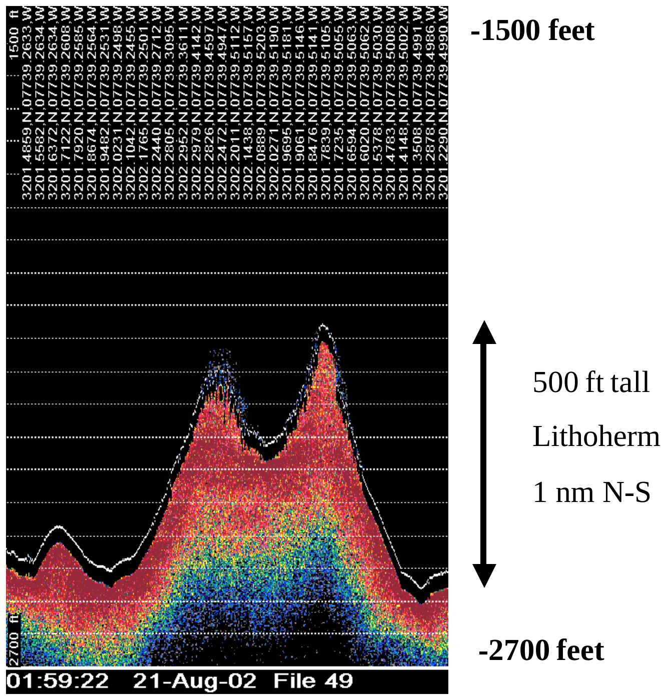
Deep-water Coral Reef Communities (from Reed, 2002a,b)
The deep-water coral reefs support very rich communities of associated invertebrates. Faunal diversity on the *Oculina* reefs is equivalent to many shallow-water tropical reefs. Over 20,000 individual invertebrates were found living among the live and dead branches of 42 small *Oculina* colonies from deep and shallow water, yielding 230 species of mollusks, 50 species of decapods, 47 species of amphipods, 21 species of echinoderms, 15 species of pycnogonids, and numerous other taxa (Reed et al., 1982; Reed & Hoskin, 1987; Reed & Mikkelsen, 1987; Child, 1998). A striking difference between the *Oculina* and *Lophelia* reefs is that larger sessile invertebrates such as massive sponges and gorgonians are common on the *Lophelia* reefs but are not common on the deep-water *Oculina* reefs. The coral itself is a dominant component providing habitat on both the *Oculina* and *Lophelia* reefs. The percentage of live coral coverage is generally low on the majority of *Lophelia* and *Oculina* reefs in this region (1-10%); however, some areas may have nearly 100% live cover and some areas may have extensive areas of 100% dead coral rubble.

In comparison, Rogers' (1999) review of literature on deep-water *Lophelia* coral reefs in the northeastern Atlantic recorded 886 species of associated invertebrates. Quantified analyses of live and dead colonies of *Lophelia pertusa* from the Faeroe shelf off of Scotland resulted in 298 species, dominated by Polychaeta (67 sp.), Bryozoa (45 sp.), Mollusca (31 sp.), Porifera (29 types), and Crustacea (15 sp.) (Jensen & Frederiksen, 1992). Studies of infauna associated with the *Lophelia* reefs of the western Atlantic reefs off North Carolina have just begun (Ross, in prep).

Region D: Stetson Reefs, Eastern Blake Plateau (from Reed, 2002a; Reed et al., 2004b)
This site is on the outer eastern edge of the Blake Plateau, ~120 nm SE of Charleston, South Carolina, at depths of 640-869 m (Table 1, Figs. 3-5). Over 200 coral mounds up to 146 m in height occur over this 6174 km^2 area that was first described by Thomas Stetson from echo soundings and bottom dredges (Stetson et al., 1962; Uchupi, 1968). These were described as steep-sloped structures with active growth on top of the banks. Live coral colonies up to 50 cm in diameter were observed with a camera sled. *E. profunda* (=*D. profunda*) was the dominant species in all areas although *L. pertusa* was concentrated on top of the mounds. Densest coral growth occurred along an escarpment at Region D1. Stetson *et al*. (1962) reported an abundance of hydroids, alcyonaceans, echinoderms, actiniaria, and ophiuroids, but a rarity of large mollusks. The flabelliform gorgonians were also current-oriented. Popenoe and Manheim (2001) have made detailed geological maps of this Charleston Bump region which also indicate numerous coral mounds (Fig. 5).

Recent fathometer transects by the PI indicated dozens and possibly hundreds of individual pinnacles and mounds within the small region that we surveyed which is only a fraction of the Stetson Bank area (Reed and Pomponi, 2002b; Reed et al., 2002; Reed et al., 2004b). From our fathometer transects, two pinnacle regions were selected. Three submersible dives were made on "Pinnacle 3" and four dives on "Stetson's Peak" which is described below (Table 1). A small subset of the Stetson Bank area was first mapped by six fathometer transects covering ~28 nm^2 (6 nm x 4.7 nm; 31°59.03'N to 32°05.03'N and 77°42.75'W to 77°37.98'W), in which six major peaks or pinnacles and four major scarps were plotted. The base depth of these pinnacles ranged from 689 m to 643 m, with relief of 46 to 102 m. A subset of this was further mapped with 70 fathometer transects spaced 250 m apart (recording depth, latitude and longitude ~ every 3 seconds), covering an area of 1 x 1.5 nm (32°00.5'N to 32°01.5'N and 77°40.0'W to 77°42.5'W), resulting in a 3-D bathymetric GIS Arcview map of a major feature, which we named Stetson's Pinnacle (Fig. 9).

Figure 9. Echosounder profile of Stetson's Pinnacle (depth 780 m, relief 153 m). (from Reed et al., 2004b)



Stetson's Pinnacle was 780 m at the south base and the peak was 627 m (differential GPS coordinates of submersible at the peak: 32°01.6882'N, 77°39.6648'W). This represents one of the tallest *Lophelia* coral lithoherms known, nearly 153 m in relief. The linear distance from the south base to the peak was ~0.5 nm. The lower flank of the pinnacle from ~762 m to 701 m on the south face was a gentle slope of 10-30° with a series of 3-4 m high ridges and terraces that were generally aligned 60-240° across the slope face. These ridges were covered with nearly 100% *Lophelia* coral rubble, 15-30 cm colonies of live *Lophelia*, and standing dead colonies of *Lophelia*, 30-60 cm tall. Very little rock was exposed, except on the steeper exposed, eroded faces of the ridges. Some rock slabs, ~30 cm thick, have slumped from these faces. From 701 m to 677 m the slope increased from ~45° to 60°. From 671 m to the peak, the geomorphology was very complex and rugged, consisting of 60-90° rock walls and 3-9 m tall rock outcrops. Colonies of *Lophelia*, 30-60 cm tall, were more common, and some rock ledges had nearly 100% cover of live *Lophelia* thickets. The top edge of the pinnacle was a 30 cm thick rock crust which was undercut from erosion; below this was a 90° escarpment of 3-6 m. The peak was a flat rock plateau at 625- 628 m and was approximately 0.1 nm across on a S-N submersible transect. The north face was not explored in detail but is a vertical rock wall from the peak to ~654 m then grades to a 45° slope with boulders and rock outcrops.

Dominant sessile macrofauna consisted of scleractinia, stylasterine hydrocorals, gorgonacea and sponges (Table 3). The colonial scleractinia were dominated by colonies of *Lophelia pertusa* (30-60 cm tall) and *Enallopsammia profunda*, and *Solenosmilia variabilis* were present. Small stylasterine corals (15 cm tall) were common and numerous species of solitary cup corals were abundant. Dominant octocorallia consisted of colonies of Primnoidae (15-30 cm tall), paramuriceids (60-90 cm), Isididae bamboo coral (15-60 cm), stolonifera, and stalked Nephtheidae (5-10 cm). Dominant sponges consisted of Pachastrellidae (25 cm fingers and 25-50 cm plates), Corallistidae (10 cm cups), Hexactinellida glass sponges (30 cm vase), *Geodia* sp. (15-50 cm spherical), and *Leiodermatium* sp. (50 cm frilly plates). Although motile fauna were not targeted, some dominant groups were noted. No large decapods crustaceans were common although some red portunids were observed. Two species of echinoids were common, one white urchin and one stylocidaroid. No holothurians or asteroids were noted. Dense populations of Ophiuroidea were visible in close-up video of coral clusters and sponges. No large Mollusca were noted except for some squid. Fish consisted mostly of benthic gadids and rattails. On the steeper upper flank, from 671 to 625 m the density, diversity, and size of sponges increased; 15-50 cm macro sponges were more abundant. Massive *Spongosorites* sp. were common, Pachastrellidae tube sponges were abundant, and Hexactinellida glass sponges were also common. On the peak plateau the dominant macrofauna were colonies of *Lophelia pertusa* (30-60 cm tall), coral rubble, *Phakellia* sp. fan sponges (30-50 cm), and numerous other demosponges were abundant. No large fish were seen on top.

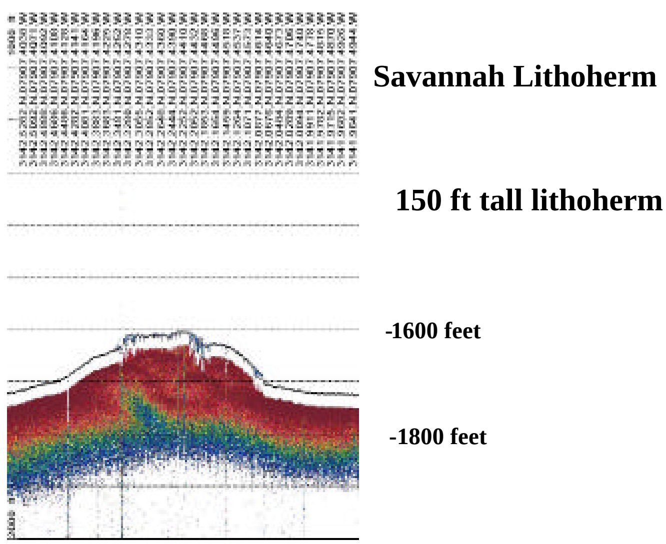
Region C: Savannah Lithoherms, Blake Plateau (from Reed, 2002a; Reed et al., 2004b)

A number of high-relief lithoherms occur within this region of the Blake Plateau, ~90nm east of Savannah, Georgia (Table 1; Figs. 3,4). Region C is at the base of the Florida-Hatteras Slope, near the western edge of the Blake Plateau, and occurs in a region of phosphoritic sand, gravel and rock pavement on the Charleston Bump (Sedberry, 2001). Wenner and Barans (2001) described 15-23 m tall coral mounds in this region that were thinly veneered with fine sediment, dead coral fragments and thickets of *Lophelia* and *Enallopsammia*. They found that blackbellied rosefish and wreckfish were frequent associates of this habitat. In general, the high-relief *Lophelia* mounds occur in this region at depths of 490-550 m and have maximum relief of 61 m (Table 1). *JSL*-II dives 1690, 1697 and 1698 reported a coral rubble slope with <5% cover of 30 cm, live coral colonies (Reed, 2002a). On the reef crest were 30-50 cm diameter coral colonies covering ~10% of the bottom. Some areas consisted of a rock pavement with a thin veneer of sand, coral rubble, and 5-25 cm phosphoritic rocks. At *Alvin* dive sites 200 and 203, Milliman *et al*. (1967) reported elongate coral mounds, approximately 10 m wide and 1 km long, that were oriented NNE-SSW. The mounds had 25-37^o slopes and 54 m relief. Live colonies (10-20 cm diameter) of *E. profunda* (=*D. profunda*) dominated and *L. pertusa* (=*L. prolifera*) was common. No rock outcrops were observed. These submersible dives found that these lithoherms provided habitat for large populations of massive sponges and gorgonians in addition to the smaller macroinvertebrates which have not been studied in detail. Dominant macrofauna included large plate-shaped sponges (*Pachastrella monilifera*) and stalked, fan-shaped sponges (*Phakellia ventilabrum*), up to 90 cm in diameter and height. At certain sites (*JSL*-II dive 1697), these species were estimated at 1 colony/10 m^2. Densities of small stalked spherical sponges (*Stylocordyla* sp., Hadromerida) were estimated in some areas at 167 colonies/10 m^2. Hexactinellid (glass) sponges such as *Farrea*? sp. were also common. Dominant gorgonacea included *Eunicella* sp. (Plexauridae) and *Plumarella pourtalessi* (Primnoidae).

Recent fathometer transects by the PI at Savannah Lithoherm Site #1 (JSL II-3327) extended 2.36 nm S-N (31^{o}40.3898'N to 31^{o}42.7558'N along the longitude of 79^{o}08.5'W) revealed a massive lithoherm feature that consisted of five major pinnacles with a base depth of 549 m, minimum depth of 465 m, and maximum relief of 83 m (Reed and Pomponi, 2002b; Reed et al., 2002; Reed et al., 2004b). The individual pinnacles ranged from 9 to 61 m in height. A single submersible transect, south to north, on Pinnacle #4 showed a minimum depth of 499 m. The south flank of the pinnacle was a gentle 10-20^{o} slope, with ~90% cover of coarse sand, coral rubble and some 15 cm rock ledges. The peak was a sharp ridge oriented, NW-SE, perpendicular to the prevailing 1 kn current. The north side face of the ridge was a 45^{o} rock escarpment of about 3 m which dropped onto a flatter terrace. From a depth of 499 to 527 m, the north slope formed a series of terraces or shallow depressions, ~9-15 m wide, that were separated by 3 m high escarpments of 30-45$^{\backslash o}$. Exposed rock surfaces showed a black phosphoritic rock pavement. The dominant sessile macrofauna occurred on the exposed pavement of the terraces and in particular at the edges of the rock outcrops and the crest of the pinnacle. The estimated cover of sponges and gorgonians was 10% on the exposed rock areas. Colonies of *Lophelia pertusa* (15-30 cm diameter) were common but not abundant with ~1% coverage. Dominant Cnidaria included several species of gorgonacea (15-20 cm tall), Primnoidae, Plexauridae (several spp.), *Antipathes* sp. (1 m tall), and *Lophelia pertusa* (Table 3). Dominant sponges included large *Phakellia ventilabrum* (fan sponges, 30-90 cm diameter), Pachastrellidae plate sponges (30 cm), Choristida plate sponges (30 cm), and Hexactinellid glass sponges. Motile fauna consisted of decapod crustaceans (*Chaceon fenneri*, 25 cm; and Galatheidae, 15 cm) and mollusks. Few large fish were observed but a 1.5 m swordfish, several 1 m sharks, and numerous blackbelly rosefish were noted.

A fathometer transect by the PI at Savannah Lithoherm Site 2 extended 4.6 nm, SW to NE (31^{o}42.0812'N, 79^{o}07,6333'W to 31^{o}45.5025'N, 79^{o}04.0797'W), mapped 8 pinnacles with maximum depth of 549 m and relief of 15-50 m (Fig. 10).

Figure 10. Echosounder profile of Savannah Lithoherm, Site 2, Pinnacle #1 (depth 537 m, relief 50 m). (from Reed et al., 2004b)



Submersible dives were made on Pinnacles 1, 5 and 6 of this group (Table 1). Pinnacle 1 was the largest feature of this group; the base was 537 m and the top was 487 m. The south face, from a depth of 518 to 510 m, was a gentle 10^{o} slope, covered with coarse brown sand and

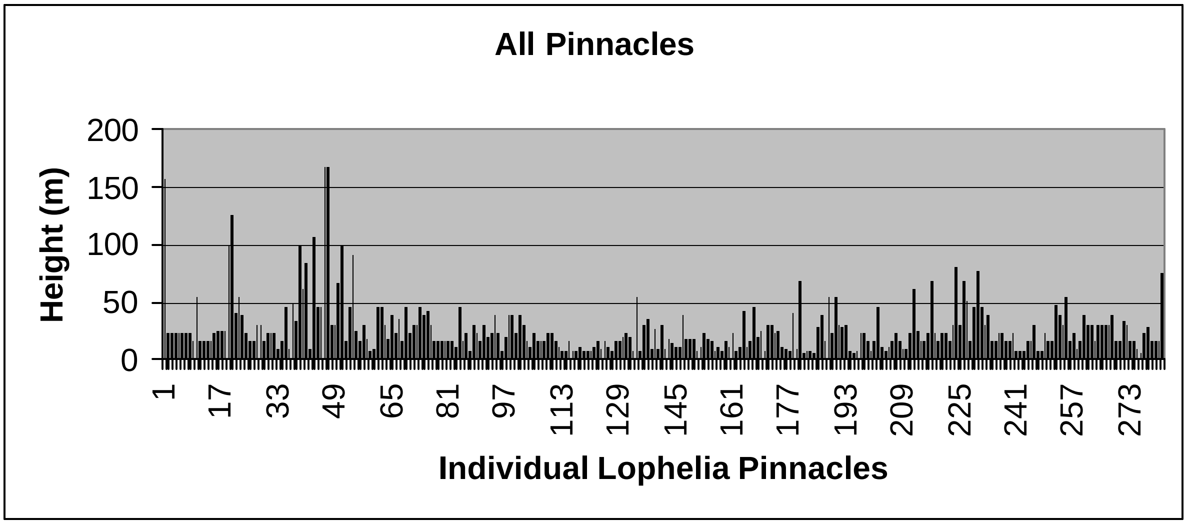
Lophelia coral rubble. A 3-m high ridge of phosphoritic rock, extended NE-SW, cropped out at a depth of 510 m. This was covered with nearly 100% cover of 15 cm thick standing dead *Lophelia* coral and dense live colonies of *Lophelia pertusa* (15-40 cm). From depths of 500 m to 495 m were a series of exposed rock ridges and terraces, that were 3-9 m tall with 45^o slopes. Some of the terraces were ~30 m wide. Each ridge and terrace had thick layers of standing dead *Lophelia*, and dense live coral. These had nearly 100% cover of sponges (*Phakellia* sp., *Geodia* sp., Pachastrellidae, and Hexactinellida), scleractinia (*Lophelia pertusa*, *Madrepora oculata*), stylasterine hydrocorals, numerous species of gorgonacea (Ifalukellidae, Isididae, Primnoidae), and 1 m bushes of black coral (*Antipathes* sp.). Deep deposits of sand and coral rubble occurred in the depressions between the ridges. The north face, from 500 m to 524 m was a gentle slope of 10^o, that had deep deposits of coarse brown foraminiferal sand and coral rubble. Exposed rock pavement was sparse on the north slope, but a few low rises with live bottom habitat occurred at 524 m. Dominant mobile fauna included decapod crustaceans (*Chaceon fenneri*, 15 cm Galatheidae), rattail fish, and 60 cm sharks were common.

Region B: Florida *Lophelia* Pinnacles (from Reed, 2002a; Reed et al., 2004b)

Numerous high-relief *Lophelia* reefs and lithoherms occur in this region at the base of the Florida-Hatteras Slope and at depths of 670-866 m (Table 1, Figs. 3, 4). The reefs in the southern portion of this region form along the western edge of the Straits of Florida and are 15-25 nmi east of the *Oculina* coral banks Marine Protected Area (MPA). Along a 222-km stretch off northeastern and central Florida (from Jacksonville to Jupiter), nearly 300 mounds from 8 to 168 m in height (25-550 ft) were recently mapped by the PI using a single beam echosounder (Fig. 11; Reed et al., 2004b). Between 1982 and 2004, dives with the *Johnson-Sea-Link* (*JSL*) submersibles and ROVs by the PI confirmed the presence of *Lophelia* mounds and lithoherms in this region (Reed, 2002a; Reed et al., 2002; Reed and Wright, 2004; Reed et al., 2004b). The northern sites off Jacksonville and southern Georgia appeared to be primarily lithoherms which are pinnacles capped with exposed rock (described in part by Paull et al., 2000), whereas the features from south of St. Augustine to Jupiter were predominately *Lophelia* coral pinnacles or mud mounds capped with dense 1-m-tall thickets of *Lophelia pertusa* and *Enallopsammia profunda* with varying amounts of coral debris and live coral. Dominant habitat-forming coral species were *Lophelia pertusa*, *Madrepora oculata*, *Enallopsammia profunda*, bamboo coral (Isididae), black coral (Antipatharia), and diverse populations of octocorals and sponges (Reed et al., 2004b).

Paull et al. (2000) estimated that over 40,000 coral lithoherms may be present in this region of the Straits of Florida and the Blake Plateau. Their dives with the *Johnson-Sea-Link* submersible and the U.S. Navy's submarine NR-1 described a region off northern Florida and southern Georgia of dense lithoherms forming pinnacles 5 to 150 m in height with 30-60^o slopes that had thickets of live ahermatypic coral (unidentified species, but photos suggest *Lophelia* and/or *Enallopsammia*). The depths range from 440 to >900 m but most mounds were within 500-750 m. Each lithoherm was ~100-1000 m long and the ridge crest was generally oriented perpendicular to the northerly flowing Gulf Stream current (25-50 cm s^{-1} on flat bottom, 50-100 cm s^{-1} on southern slopes and crests). Thickets of live coral up to 1 m were mostly found on the southern facing slopes and crests whereas the northern slopes were mostly dead coral rubble. These were termed lithoherms since the mounds were partially consolidated by a carbonate crust, 20-30 cm thick, consisting of micritic wackestone with embedded planktonic foraminifera, pteropods, and coral debris (Paull et al., 2000).

Figure 11. Height of *Lophelia* pinnacles and lithoherms on echosounder transects from Jacksonville to Jupiter, Florida at depths of 600 to 800 m. (from Reed et al., 2004b)



A recent echosounder transect by the PI revealed a massive lithoherm, 3.08 nm long (N-S) that consisted of at least 7 individual peaks with heights of 30-60 m (Fig. 12; Reed and Wright, 2004; Reed et al., 2004b). The maximum depth was 701 m with total relief of 157 m. Three submersible dives (JSL II-3333, 3334; I-4658) were made on Peak 6 of pinnacle #204B (30°30.1194'N, 79°39.4743'W) which was the tallest individual feature of the lithoherm with maximum relief of 107 m and a minimum depth at the peak of 544 m (Reed et al., 2004b). The east face was a 20-30° slope and steeper (50°) near the top. The west face was a 25-30° slope which steepened to 80° from 561 m to the top ridge. The slopes consisted of sand and mud, rock pavement and rubble. A transect up the south slope reported a 30-40° slope with a series of terraces and dense thickets of 30-60 cm tall dead and live *Lophelia* coral that were mostly found on top of mounds, ridges and terrace edges. One peak at 565 m had dense thickets of live and dead standing *Lophelia* coral (~20% live) and outcrops of thick coral rubble. Dominant sessile fauna consisted of *Lophelia pertusa*, abundant Isididae bamboo coral (30-60 cm) on the lower flanks of the mound, Antipatharia black coral, and abundant small octocorals including the gorgonacea (*Placogorgia* sp., *Chrysogorgia* sp, and Plexauridae) and Nephtheidae soft corals (*Anthomastus* sp., *Nephthya* sp.). Dominant sponges consisted of *Geodia* sp., *Phakellia* sp., *Spongosorites* sp. Petrosiidae, Pachastrellidae, and Hexactinellida (Table 3).

Further south off Cape Canaveral, echosounder transects by the PI on *Lophelia* Pinnacle #113 (28°47.6258'N, 79°37.5859'W) revealed a 61 m tall pinnacle with maximum depth of 777 m (Table 1; Fig. 13). The width (NW-SE) was 0.9 nm and consisted of at least 3 individual peaks or ridges on top, each with 15-19 m relief. One submersible dive (JSL II-3335) reported 30-60° slopes, with sand, coral rubble, and up to 10% cover of live coral. No exposed rock was observed. This appeared to be a classic *Lophelia* mud mound.

Figure 12. Echosounder profile of Jacksonville Lithoherm, Pinnacle #204B (depth 701 m, relief 157 m). (from Reed et al., 2004b)

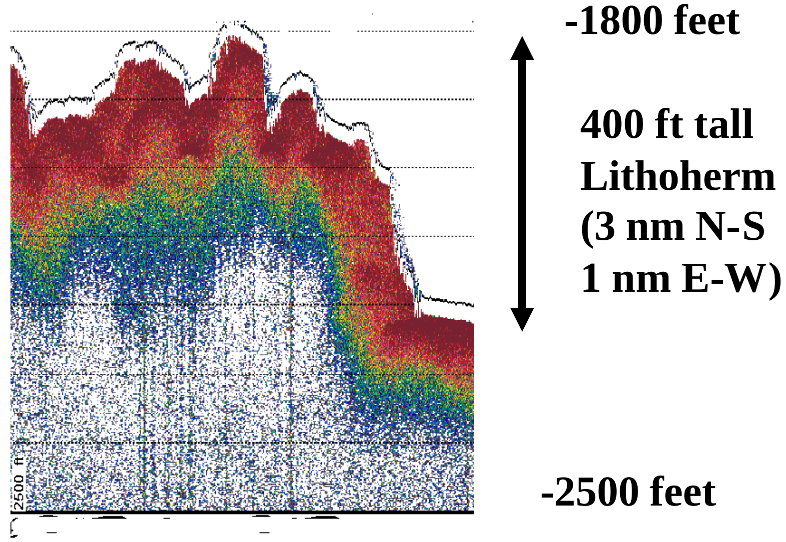
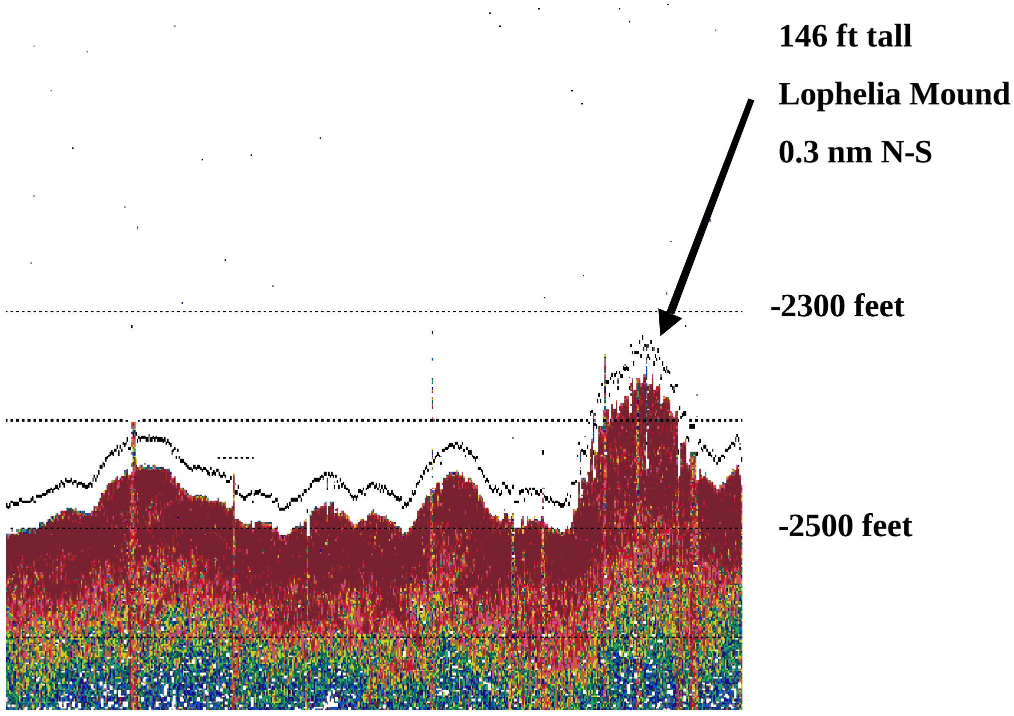


Figure 13. Echosounder profile of Cape Canaveral *Lophelia* Reef, Pinnacle #113 (depth 777 m, relief 61 m). (from Reed et al., 2004b)



The second dive site (JSL II-3336) at Pinnacle #151 (28°17.0616'N, 79°36.8306'W) was also a deep-water *Lophelia* coral reef comprised entirely of coral and sediment (Table 1). Maximum depth was 758 m, with 44 m relief, and ~0.3 nm wide (N-S). The top was a series of ridged peaks from 713 to 722 m in depth. The lower flanks of the south face was a 10-20° slope of fine light colored sand with a series of 1-3 m high sand dunes or ridges that were linear NW-SE. The ridges had ~50% cover of thickets of *Lophelia pertusa* coral. The thickets consisted of 1 m tall dead, standing and intact, *Lophelia pertusa* colonies. Approximately 1-10% were alive on the outer parts (15-30 cm) on top of the standing dead bases. There was very little broken dead coral rubble in the sand and there was no evidence of trawl or mechanical damage. Most of the coral was intact, and the dead coral was brown. The sand between the ridges was fine and light colored, with 7-15 cm sand waves. The upper slope steepened to 45° and 70-80° slope near the upper 10 m from the top. The top of the pinnacle had up to 100% cover of 1-1.5 m tall coral thickets, on a narrow ridge that was 5-10 m wide. The coral consisted of both *Lophelia pertusa* and *Enallopsammia profunda*. Approximately 10-20% cover was live coral of 30-90 cm. The north slope was nearly vertical (70-80°) for the upper 10 m then consisted of a series of coral thickets on terraces or ridges. No exposed rock was visible and the entire pinnacle appeared to be a classic *Lophelia* mud mound.

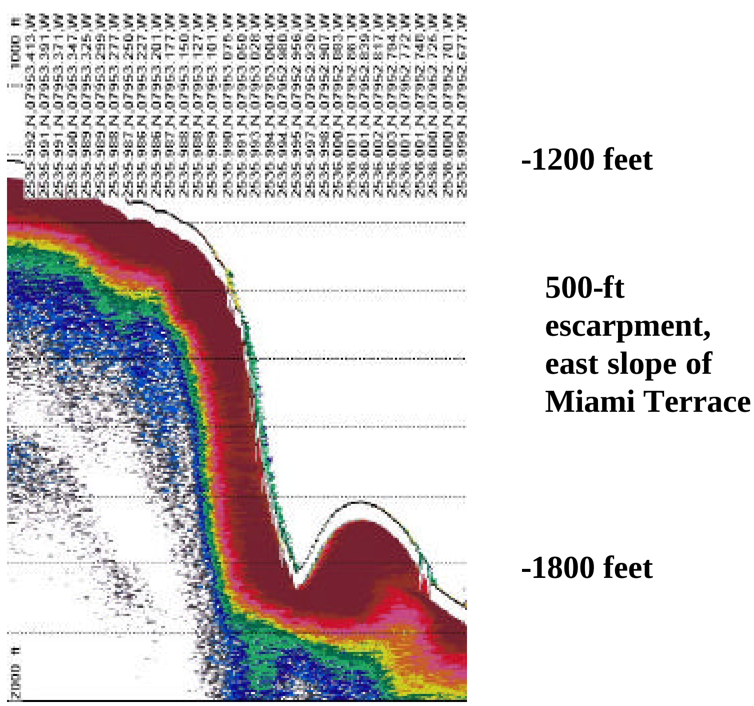
No discernable zonation of macrobenthic fauna was apparent from the base to the top. Corals consisted of *Lophelia pertusa*, *Enallopsammia profunda*, *Madrepora oculata*, and some stylasterine hydrocorals. Dominant octocoral gorgonacea included Primnoidae (2 spp.), Isididae bamboo coral (*Isidella* sp. and *Keratoisis flexibilis*), and the alcyonaceans *Anthomastus* sp. and *Nephthya* sp (Table 3). Dominant sponges consisted of several species of Hexactinellida glass sponges, large yellow demosponges (60-90 cm diameter), Pachastrellidae, and *Phakellia* sp. fan sponges. Echinoderms included urchins (cidaroid and *Hydrosoma*? sp.) and comatulid crinoids, but no stalked crinoids. Some large decapod crustaceans included *Chaceon fenneri* and large galatheids. No mollusks were observed but were likely within the coral habitat that was not collected. Common fish were 2 m sharks, 25 cm eels, 25 cm skates, chimaera, and blackbelly rosefish (Table 4).

Region G: Miami Terrace Escarpment (from Reed et al., 2004b)

The Miami Terrace is a 65-km long carbonate platform that lies between Boca Raton and South Miami at depths of 200-400 m in the northern Straits of Florida. It consists of high-relief Tertiary limestone ridges, scarps and slabs that provide extensive hard bottom habitat (Uchupi, 1966, 1969; Kofoed and Malloy, 1965; Uchupi and Emery, 1967; Malloy and Hurley, 1970; Ballard and Uchupi, 1971; Neumann and Ball, 1970). At the eastern edge of the Terrace, a high-relief, phosphoritic limestone escarpment of Miocene age with relief of up to 90 m at depths of 365 m is capped with *Lophelia pertusa* coral, stylasterine hydrocoral (Stylasteridae), bamboo coral (Isididae), and various sponges and octocorals (Reed et al., 2004b; Reed and Wright, 2004). Dense aggregations of 50-100 wreckfish were observed here by the PI during *JSL* submersible dives in May 2004 (Reed et al., 2004b). Previous studies in this region include geological studies on the Miami Terrace (Neumann and Ball, 1970; Ballard and Uchupi, 1971) and dredge- and trawl-based faunal surveys in the 1970s primarily by the University of Miami (e.g., Halpern, 1970; Holthuis, 1971, 1974; Cairns, 1979). *Lophelia* mounds are also present at the base of the escarpment (~670 m) within the axis of the Straits of Florida, but little is known of their distribution, abundance or associated fauna. Using the *Aluminaut* submersible, Neumann and Ball (1970) found thickets of *Lophelia*, *Enallopsammia* (=*Dendrophyllia*), and *Madepora* growing on elongate depressions, sand ridges and mounds. Large quantities of *L. pertusa* and *E. profunda* have also been dredged from 738-761 m at 26°22' to 24'N and 79°35' to 37'W (Cairns, 1979).

Recent JSL submersible dives and fathometer transects by the PI at four sites (Reed Site #BU4, 6, 2, and 1b) indicated the outer rim of the Miami Terrace to consist of a double ridge with steep rocky escarpments (Table 1; Fig. 6; Reed and Wright, 2004; Reed et al., 2004b). At Miami Terrace Site #BU4, the narrow N-S trending east ridge was 279 m at the top and had a steep 95 m escarpment on the west face. The east and west faces of the ridges were 30-40° slopes with some near vertical sections consisting of dark brown phosphoritic rock pavement, boulders and outcrops. The crest of the east ridge was a narrow plateau ~10 m wide. At Site #BU6, the crest of the west ridge was 310 m and the base of the valley between the west and east ridges was 420 m. At Site #BU2, the echosounder transect showed a 13 m tall rounded mound at a depth of 636 m near the base of the terrace within the axis of the Straits of Florida. The profile indicated that it is likely a *Lophelia* mound. West of this feature the east face of the east ridge was a steep escarpment from 567 m to 412 m at the crest. The west ridge crested at 321 m. Total distance from the deep mound to the west ridge was 2.9 nm. Site #BU1b was the most southerly transect on the Miami Terrace. An E-W echosounder profile at this site indicated a double peaked east ridge cresting at 521 m, then a valley at 549 m, and the west ridge at 322 m. The east face of the west ridge consisted of a 155 m tall escarpment (Fig. 14).

Figure 14. Echosounder profile of Miami Terrace Escarpment, Site #BU1b, west ridge (depth 549 m at base, relief 155 m). (from Reed et al., 2004b)



There were considerable differences among the sites in habitat and fauna; however, in general, the lower slopes of the ridges and the flat pavement on top of the terrace were relatively barren. However, the steep escarpments especially near the top of the ridges were rich in corals, octocorals, and sponges. Dominant sessile fauna consisted of the following Cnidaria: small (15-30 cm) and large (60-90 cm) tall octocoral gorgonacea (*Paramuricea* spp., *Placogorgia* spp., Isididae bamboo coral); colonial scleractinia included scattered thickets of 30-60 cm tall *Lophelia pertusa* (varying from nearly 100% live to 100% dead), *Madrepora oculata* (40 cm), and *Enallopsammia profunda*; stylasterine hydrocorals (15-25 cm); and Antipatharia (30-60 cm tall) (Table 3). Diverse sponge populations of Hexactinellida and Demospongiae included: *Heterotella* sp., *Spongosorites* sp., *Geodia* sp., *Vetulina* sp., *Leiodermatium* sp., *Petrosia* sp., Raspailiidae, Choristida, Pachastrellidae, and Corallistidae. Other motile invertebrates included *Asteroporpa* sp. ophiuroids, *Stylocidaris* sp. urchins, Mollusca, Actiniaria, and Decapoda crustaceans (*Chaceon fenneri* and Galatheidae). Schools of ~50-100 wreckfish (*Polyprion americanus*), ~60-90 cm in length, were observed on several submersible dives along with blackbelly rosefish, skates, sharks, and dense schools of jacks (Table 4).

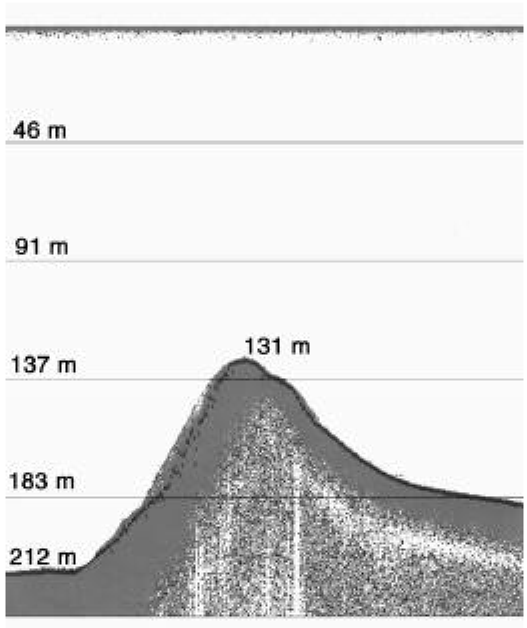
Region H: Pourtalès Terrace Lithoherms (from Reed et al., 2004a)

The Pourtalès Terrace provides extensive, high-relief, hard-bottom habitat, covering 3,429 km^2 (1,000 nm^2) at depths of 200-450 m. The Terrace parallels the Florida Keys for 213 km and has a maximum width of 32 km (Jordan, 1954; Jordan and Stewart, 1961; Jordan et al., 1964; Gomberg, 1976; Land and Paull, 2000). Reed et al. (2004a) surveyed several deep-water, high-relief, hard-bottom sites including the Jordan and Marathon deep-water sinkholes on the outer edge of the Terrace, and five high-relief bioherms on its central eastern portion (Table 2, Fig. 7). The *JSL* and *Clelia* submersibles were used to characterize coral habitat and describe the fish and associated macrobenthic communities. These submersible dives were the first to enter and explore any of these features. The upper sinkhole rims range from 175 to 461 m in depth and have a maximum relief of 180 m. The Jordan Sinkhole may be one of the deepest and largest sinkholes known. The high-relief area of the middle and eastern portion of the Pourtalès Terrace is a 55 km-long, northeasterly trending band of what appears to be karst topography that consists of depressions flanked by well defined knolls and ridges with maximum elevation of 91 m above the terrace (Jordan et al., 1964; Land and Paull, 2000). Further to the northeast of this knoll-depression zone is another zone of 40-m high topographic relief that lacks any regular pattern (Gomberg, 1976). The high-relief bioherms (the proposed HAPC sites within this region) lie in 198 to 319 m, with a maximum height of 120 m. A total of 26 fish taxa were identified from the sinkhole and bioherm sites (Table 4). Species of potential commercial importance included tilefish, sharks, speckled hind, yellow-edge grouper, warsaw grouper, snowy grouper, blackbelly rosefish, red porgy, drum, scorpion fish, amberjack, and phycid hakes. Many different species of Cnidaria were recorded, including Antipatharia black corals, stylasterine hydrocorals, octocorals, and one colonial scleractinian (*Solenosmilia variabilis*) (Table 3).

Tennessee and Alligator Humps, Bioherms #1-4- Pourtalès Terrace (from Reed et al., 2004a)

The Tennessee and Alligator Humps are among dozens of lithoherms that lie in a region called "The Humps" by local fishers, ~14 nm south of the Florida Keys and south of Tennessee and Alligator Reefs (Table 2, Fig. 7). Three dives were made by the PI on Bioherm #3 (*Clelia* 597, 598, 600; Aug. 2001), approximately 8.5 nm NE of Bioherm #2 (Fig. 15). Bioherm #3 consisted of two peaks 1.05 nm apart with a maximum relief of 62 m. The North Peak's minimum depth

Figure 15. Echosounder profile of Pourtalès Terrace, Tennessee Bioherm #2 (depth 212 m at base, relief 85 m). (from Reed et al., 2004a)



was 155 m (submersible DGPS: 24°42.4573'N, 80°31.0513'W) and was 653 m wide at the base, which was 217 m deep at the east base and 183 m at the west side. The minimum depth of South Peak was 160 m and was about 678 m in width E to W at the base. The surrounding habitat adjacent to the mounds was flat sand with about 10% cover of rock pavement. From 213 m to the top, generally on the east flank of the mound, were a series of flat rock pavement terraces at depths of 210, 203, 198, 194, 183, and 171 m and the top plateau was at 165 m. Between each terrace a 30-45° slope consisted of either rock pavement or coarse sand and rubble. Below each terrace was a vertical scarp of 1-2 m where the sediment was eroded away leaving the edge of the terrace exposed as a horizontal, thin rock crust overhang of <1 m and 15-30 cm thick. The top of the bioherm was a broad plateau of rock pavement with 50-100% exposed rock, few ledges or outcrops, and coarse brown sand. Less time was spent on the western side, which was more exposed to the strong bottom currents. The west side of South Peak sloped more gradually than the eastern side, had more sediment, and no ledges were observed.

Fish Communities (from Reed et al., 2004a)

A total of 31 fish taxa, of which 24 were identified to species level, were identified from our submersible videotapes and were associated with the deep-water sinkholes and high-relief bioherms (Table 4). Few studies have directly documented deep-water fish associations with deep-water reef habitats in the western Atlantic. Most of the work has concentrated on the Charleston Bump region of the Blake Plateau off Georgia and South Carolina (Sedberry, 2001). Ross (pers. comm.) reported the following species are common to both the deep-water *Lophelia* reefs on the Blake Plateau off the Carolinas and those of this study: *Chloropthalmus agassizi*, *Helicolenus dactylopterus*, *Hoplostethus* sp., *Laemonema melanurum*, *Nezumia* sp., and *Xiphias gladius*.

Species most common to the high-relief bioherms included deepbody boarfish, blueline tilefish, snowy grouper, and roughtongue bass. Some species were common at both the sinkhole and bioherm sites and included snowy grouper, blackbelly rosefish, and mora. In addition to the moribund swordfish observed in the Jordan Sinkhole, a swordfish was observed from the NR-1 submersible on top of Pourtales Terrace (C. Paull, pers. observation).

Species of potential commercial importance included tilefish, sharks, speckled hind, yellowedge grouper, warsaw grouper, snowy grouper, blackbelly rosefish, red porgy, drum, scorpionfish, amberjack, and phycid hakes. However, the fish densities that we saw at any of the sites were in insufficient numbers to suggest commercial or recreation harvest. In fact, any of the features, both sinkholes and bioherms, could be overfished very easily since only a few individuals of the larger grouper species were present at any one site.

Benthic Communities (from Reed et al., 2004a)

The benthos at the bioherm sites was dominated by sponges, octocorals and stylasterids (Table 3). A total of 21 taxa of Cnidaria were sampled or observed and 16 were identified to species level. These included 3 species of antipatharian black coral, 5 stylasterid hydrocorals, 11 octocorals with one possible new species, and 1 scleractinian (*Solenosmilia variabilis*). Eight species were associated only with the Pourtalès sinkholes and not the bioherms; these included two species of antipatharians; the octocorals *Paramuricea placomus*, *Plumarella pourtalesii*, *Trachimuricea hirta*; and the scleractinian *Solenosmilia variabilis*. Although Gomberg (1976) found evidence of skeletal remains of the colonial scleractinians *Lophelia* and *Madrepora* in sediment samples from the terrace, we did not see any colonies at our dive sites. Sponges identified from collections included 28 taxa. Five species of stylasterine hydrocorals were *Distichopora foliacea*, *Pliobothrus echinatus*, *Stylaster erubescens*, *S. filogranus*, and *S. miniatus*. On the flat pavement adjacent to the base of the mounds, stylasterids and antipatharian black coral bushes were common along with sea urchins and sea stars.

The densities of sponges, stylasterid hydrocorals and octocorals were very high, especially on the plateaus and terraces of the bioherms on the Pourtalès Terrace. Maximum densities of sponges (>5 cm) on the plateaus ranged from 1-80 colonies m^{-2}. Stylasterid coral densities ranged from 9-96 colonies m^{-2} and octocorals 16-48. Densities of sponges (1-2 colonies m^{-2}) and stylasterids (1-20) also dominated the terraces and slopes of the bioherm sites but generally in lower densities than the peak plateaus whereas the octocorals generally had higher densities on the flanks (1-80 colonies m^{-2}).

Region I: Southwest Florida Shelf *Lophelia* Lithoherms (from Reed et al., 2003; Reed et al., 2004 a, b, d)

This region consists of dozens and possibly hundreds of 5-15 m tall lithoherms at depths of 500 m, some of which are capped with thickets of live and dead *Lophelia* coral (Fig. 8). In 1987, Newton et al. described the area from limited dredge and seismic survey. In 2003, Seabeam topographic mapping was conducted by the PI over a small portion of the region (Table 1, Figs. 16,17); ROV dives ground-truthed three of the features: a 36-m tall escarpment and two of the lithoherms (Reed, 2004; Reed et al., 2003; Reed et al., 2004b,d). The lithoherms appeared to consist of rugged black phosphorite-coated limestone boulders and outcrops capped with 0.5-1.0 m tall thickets of *Lophelia pertusa*, which were up to ~10-20% live. Dominant sessile macrofauna included stony corals, octocorals, stylasterid hydrocorals, black corals and sponges (Table 3). The high number of hard bottom lithoherms revealed by the (limited) Seabeam mapping effort indicated tremendous potential for unexplored coral and fish habitat in this region.

Figure 16. Seabeam image of escarpment and lithoherms at Region I off southwest Florida slope. ?= *Innovator* ROV dive sites #6- 8. (from Reed et al., 2004b)

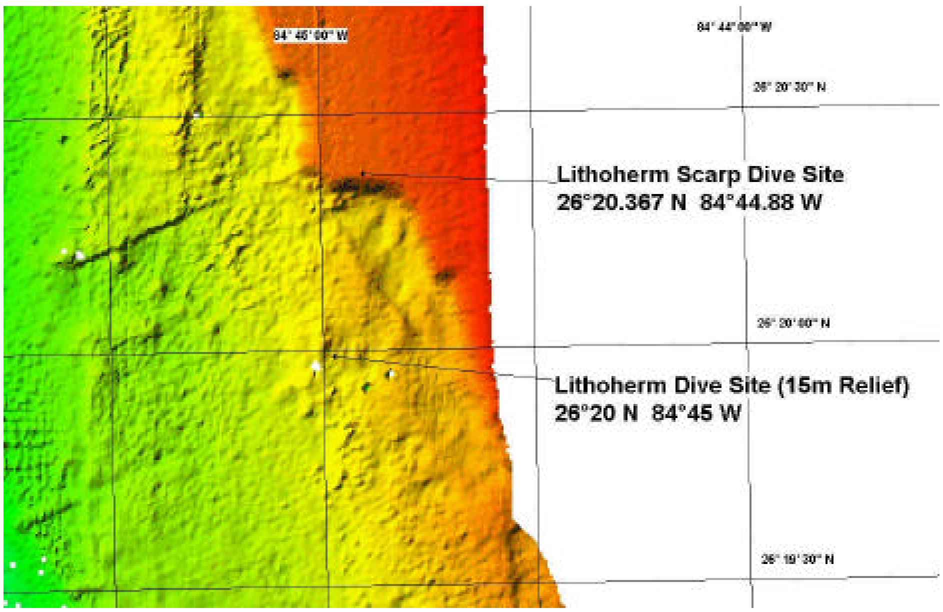
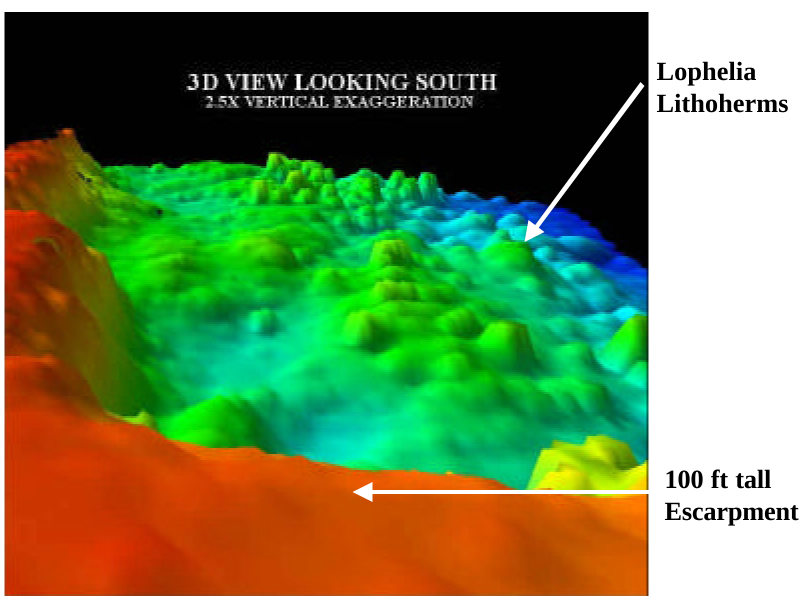


Figure 17. Seabeam image of escarpment and lithoherms at Region I off southwest Florida slope; simulated view from top of escarpment, looking south.. (from Reed et al., 2004b)



An ROV dive by the PI on the 36-m tall escarpment (Fig. 17; top- 412 m, base- 448 m), showed a near vertical wall with a series of narrow ledges, and very rugged topography with crevices and outcrops. Dominant sessile fauna consisted of Antipatharia black coral (30 cm tall), numerous octocoral gorgonacea including Isididae bamboo coral (30-40 cm), and sponges (*Heterotella* sp., *Phakellia* sp., Corallistidae). Pinnacle #4 was a 12 m tall and 60 m wide lithoherm at a depth of 466 m. Eight other lithoherms were apparent on the ROV's sonar within a 100 m radius. A transect up the face of the pinnacle revealed a series of terraces on a rugged 45^o up to 70^o rock slope which consisted of black rock boulders (1-2 m) and outcrops with 1 m crevices. The top ridge was oriented ~NNE. Thickets of live and dead *Lophelia pertusa* were found on some of the slope terraces but primarily on the top ridge. The NE slope face appeared to have more live coral than the NW face. Some of the thickets were ~30-60 cm tall and 60-90 cm diameter. Coral cover was estimated from <5% to over 50% in some areas, and estimated to be 1-20% live. The dominant fauna were similar to the escarpment except for *Lophelia* which was not observed on the escarpment. Common sessile benthic species included Cnidaria: Antipatharia black coral (*Antipathes* sp. and *Cirrhipathes* sp.), *Lophelia pertusa*, gorgonacea octocorals; and sponges: *Heterotella* sp. and other Hexactinellida vase sponges, various plate and vase Demospongiae (Pachastrellidae, Petrosiidae, Choristida). Common motile invertebrates included Mollusca, Holothuroidea, Crinoidea, Decapoda crustaceans (*Chaceon fenneri* and Galatheidae), blackbelly rosefish, and various other benthic fish (fish tapes have not been analyzed yet).

SUMMARY AND RECOMMENDATIONS

The biological and geological characteristics of six regions of deep-water reefs off the southeastern U.S.A. from southwest Florida to South Carolina were summarized in this report based on current data and knowledge compiled primarily from recent submersible and ROV dives. Region A, the *Oculina* Reefs, have been designated an Habitat Area of Particular Concern since 1984 (NOAA, 1982; Reed, 1981d; Reed, 2002b) and portions are a Marine Protected Area for the protection of the coral habitat and snapper/ grouper complex. Even so, extensive areas of the *Oculina* reefs have been severely impacted by legal and illegal bottom trawling since 1984. The six regions outlined in this report (Regions B-D, G-I) are each unique in their own respect. The resource potential of the deep-water habitats in this region is unknown in terms of fisheries and novel compounds yet to be discovered from associated fauna that may be developed as pharmaceutical drugs. Although these habitats are not currently designated as MPAs or HAPCs, they are incredibly diverse and irreplaceable resources. Activities involving bottom trawling, pipelines, or oil/gas production could negatively impact these reefs. This PI strongly recommends that HAPC designation be given to these deep-water reef habitats to provide some protection to these resources. Evidence of potential spawning aggregations of wreckfish (*Polyprion americanus*) and considerable populations of blackbelly rosefish (*Helicolenus dactylopterus*) and other commercially important species could actually threaten the future longevity of these fragile habitats unless bottom trawling in these regions is prohibited or strictly regulated and monitored. These studies summarized in this report are only preliminary and point to the need for additional geological, biological and ecological research. Initially, most of these regions need detailed mapping and habitat characterization studies which will provide data for final determinations of potential HAPC boundaries and future research needs.

ACKNOWLEDGMENTS

Numerous individuals have contributed to this research over many years. I especially thank Dr. Robert Avent who initiated these studies in the 1970s and Dr. Charles 'Skip' Hoskin who provided years of enthusiastic collaboration and leadership. I gratefully acknowledge the Division of Biomedical Marine Research at Harbor Branch Oceanographic Institution (HBOI) which funded and provided data from recent *JSL* submersible dives on the *Oculina* and *Lophelia* reefs and lithoherms. We thank NOAA's Office of Ocean Exploration for funding our biomedical research studies on these reefs in 2002 and 2003 and the State of Florida for funding the Center of Excellence in Biomedical and Marine Biotechnology (HBOI and Florida Atlantic University) which provided ship and submersible funding in 2004 and 2005. The following individuals provided taxonomic identifications: Dr. Shirley Pomponi and Dr. Michelle Kelly, sponges; Dr. Charles G. Messing and John Miller, echinoderms; Dr. Stephen Cairns, scleractinia; and Dr. Charles G. Messing, gorgonacea. The various crew of HBOI vessels, and *Johnson-Sea-Link* and *Clelia* submersibles are also thanked for their support. This is contribution no. 1570 from Harbor Branch Oceanographic Institution.

Table 1. Site summary for deep-water coral reefs and lithoherms off SE USA.
In order north to south. Site #1-33 refer to Fig. 4. (from Reed, 2002a; Reed et al., 2004a,b)

*Site Reference	Depth at Base (m)	Depth at Peak (m)	Max. Relief (m); (Width at base)	GPS Coordinates (Peak)
Region D				
1) Stetson's Reefs, Stetson's Pinnacle	780	627	153 (0.8 nm N-S)	32^o01.6882'N, 77^o39.6648'W
2) Stetson's Reefs, Pinnacle #3, Peak 1-4	694	579 (Peak 1)	114 (2.2 nm N-S)	32^o00.6302'N, 77^o41.9285'W (Peak 1)
Region C				
3) Savannah Lithoherms, ALVIN site	550	500	54	31^o48'N, 79^o15'W
4) Savannah Lithoherms, Site 2, Pinnacle #6	549	511	38 (0.4 nm NE-SW)	31^o44.3814'N, 79^o05.2516'W
5) Savannah Lithoherms, Site 2, Pinnacle #5	549	533	15 (0.3 nm NE-SW)	31^o44.0975'N, 79^o05.5544'W
6) Savannah Lithoherms, Site 2, Pinnacle #1	537	487	50 (0.53 nm N-S)	31^o42.2555'N, 79^o07.4831'W
7) Savannah Lithherms	541			31^o41.82'N, 79^o08.60'W
8) Savannah Lithoherms	532	499	33	31^o41.5'N, 79^o18.06'W
9) Savannah Lithoherms, Site 1, Pinnacle #4	549	488	61 (0.47 nm N-S)	31^o41.4259'N, 79^o08.5964'W
10) Savannah Lithoherms	503	490	13	31^o41.23'N, 79^o17.46'W
Region B				
11) Paull (2000) Lithoherm Site	671 (440-914)	579	91 (150 max)	30^o48.2'N 79^o38.4'W
12) Jacksonville Lophelia Reef, Pinnacle #204B, Peak 6	701	544	157 max; Peak 6= 107 (3nm N-S; 0.8nm E-W)	30^o30.1194'N, 79^o39.4743'W
13) Jacksonville Lophelia Reef, Pinnacle #186	866	744	122 (0.9 nm N-S; 0.9 nm E-W)	30^o16.8114'N, 79^o38.9784'W

14) St. Augustine Lophelia Reef, Pinnacle #3	822	734	88 (0.99 nm N-S)	29°40.2628’N, 79°38.0678’W
15) Cape Canaveral Lophelia Reefs, Pinnacle #113	777	716	61 (0.3 nm N-S; 0.9 nm NW-SE)	28°47.6258’N, 79°37.5859’W
16) Cape Canaveral Lophelia Reefs	793	762	30	28°46.72’N, 79°41.17’W
17) Cape Canaveral Lophelia Reef, Pinnacle #129	791	716	75 (0.53 nm N-S)	28°39.8464’N, 79°37.6735’W
18) Cape Canaveral Lophelia Reef, Pinnacle #TS7 (Near P 135)	762	718	44 (0.78 nm N-S)	28°28.3513’N, 79°37.0064’W
19) Cape Canaveral Lophelia Reefs, Pinnacle #151	758	713	44 (0.3 nm N-S)	28°17.0616’N, 79°36.8306’W
20) Cape Canaveral Lophelia Reefs	838	741	97	28°02.04’N, 79°36.51’W (Loran C)
21) Ft. Pierce Lophelia Reef, Pinnacle #TS4 (near P212)	750	721	29 (0.84 nm N-S)	27°39.4305’N, 79°34.9679’W
22) Stuart Lophelia Reef, Pinnacle #292	723	676	46 (0.95 nm N-S; 0.82 nm E-W)	27°12.5695’N, 79°35.5994’W
23) Jupiter Lophelia Reef, Pinnacle #293	723	685	42 (1.66 nm N-S; 1.0 nm E-W)	27°01.3474’N, 79°35.3889’W
Region A *Oculina* Reefs (Reed, 1980, 2002a,b)	70-100		24	27°32.8’N, 79°56.2’W to 28°59.2’N, 80°06.6’W
Region E (Mullins et al., 1981; Reed, 2002a)	1000-1300		40	27°40’N, 78°15’W to 27°10’N, 77°30’W
Region F (Neumann et al., 1977; Messing et al., 1990; Reed, 2002a)	610- 675		50	26°56.72’N, 79°16.02’W to 27°25’N, 79°20’W
Region G 24) Miami Terrace, East Ridge, W. Face, Site #BU4	375	279	95	26°05.7066’N, 79°50.3634’W (ridge top)

25) Miami Terrace, East Ridge, E. Face, Site #BU4	335	284	51	26°05.6902'N, 79°50.2540'W (base of escarptment)
26) Miami Terrace, West Ridge, East Face, Site #BU6	437	310	126	26°01.2885'N, 79°49.3258'W (base of escarpment)
27) Miami Terrace, East Ridge, E. Face, Site #BU2	573	399	174	25°41.9970'N, 79°51.0510'W (base of escarpment)
28) Miami Terrace, West Ridge, E. Face, Site #BU2	391	321	70	25°41.9959'N, 79°51.8924'W (base of escarpment)
29) Miami Terrace, West Ridge, Base E. Face, Site BU1b	549	393	155	25°35.9963'N, 79°52.9368'W (base of escarpment)
30) Miami Terrace, West Ridge, W. Face, Site #BU1b	430	322	112	25°35.9864'N, 79°54.2491'W
Region H				
*Pourtales Terrace Sites (Reed et al., 2004)	198- 461		12-180	24°15.33'N, 80°54.27'W to 24°44.71'N, 80°27.59'W
Region I				
31) SW Fla. Lithoherms, Pinnacle #1	558	554	4	26°19.9094'N, 84°45.8639'W
32) SW Fla. Lithoherms, Site 2 Escarpment	448	412	36 escarp-ment	26°20.3915'N, 84°44.8733'W
33) SW Fla. Lithoherms, Pinnacle #4	466	454	12	26°20.0133'N, 84°45.0030'W (base)

Regions A-H: Southeast USA; Region I: Eastern Gulf of Mexico; *= Region I, Pourtales Terrace Sites- see separate table; dive number: JSL I, II= HBOI's *Johnson-Sea-Link I* and *II* manned submersibles, CORD= HBOI's *Cord* Remotely Operated Vehicle (ROV), ROV= Sonsub *Innovator* ROV, ALVIN= WHOI's *Alvin* submersible; depth= at base, peak, maximum relief, and maximum width at base of bioherm; coordinates are submersible/ROV GPS location at peak of bioherm (or as indictated).

Table 2. Site summary for deep-water sinkholes and bioherms off south Florida, Pourtalès Terrace. (from Reed et al., 2004a)

*Site Reference	Depth (m)	Max. Relief (m)	Width (m)	GPS Coordinates
Naples Sinkhole	175	-55	152	26°05.1791'N 84°13.4678'W
Jordan Sinkhole	366	-180	229	24°16.4241'N, 81°02.1846'W
Marathon Sinkhole	461	-61	610	24°15.3289'N, 80°54.2705'W
Key West Bioherm	198	12	422	24°21.8038'N, 81°50.7397'W
Tennessee Bioherm #1	319	120	574	24°30.1670'N, 80°40.1880'W
Tennessee Bioherm #2	213	85	1613	24°35.2676'N, 80°35.3345'W
Alligator Bioherm #3	217	62	678	24°42.4573'N, 80°31.0513'W
Alligator Bioherm #4	213	48	1778	24°44.71'N, 80°27.59'W

Depth and width at base of bioherm or top of sinkhole; coordinates are submersible GPS location at peak of bioherm or base of sinkhole.

Table 3. Species list of macroinvertebrates associated with deep-water reefs off southeastern U.S.A. (Phyla: ART= Arthropoda, BRY= Bryozoa, CNI= Cnidaria, ECH= Echinodermata, MOL= Mollusca, POR= Porifera, VES= Vestimetifera; Sites: SC= Stetson's Reefs, South Carolina; GA= Savannah Lithoherms, Georgia; FL-E= East Coast Florida *Lophelia* Reefs; MT= Miami Terrace Escarpment; PT= Pourtalès Terrace Sinkholes and Bioherms; FL-W= SW Florida Lithoherms; VK= Viosca Knoll). (from Reed et al., 2004a,b)

Phylum	Taxonomy	Min Depth (m)	Max Depth (m)	SC	GA	FL-E	MT	PT	FL-W	VK
ART	Chaceon fenneri (golden crab)	509	509		X					
BRY	Membranipora? sp. Blainville, 1830	631	631	X						
CNI	Muriceides sp. (not hirta, not kukenthali) Studer, 1887	191	191					X		
CNI	Stylaster erubescens Pourtales, 1868	175	186					X		
CNI	Swiftia casta (Verrill, 1883)	525	525					X		
CNI	Swiftia new sp.? Duchassaing & Michelotti, 1864	497	497					X		
CNI	Solenosmilia variabilis Duncan, 1873	470	470					X		
CNI	Trachymuricea hirta (Pourtales, 1867)	462	468					X		
CNI	Paramuricea placomus (Linnaeus, 1924)	462	470					X		
CNI	Antipathes rigida? Pourtales, 1868	319	319					X		
CNI	Placogorgia mirabilis Deichmann, 1936	172	212					X		
CNI	Thesea parviflora Deichmann, 1936	183	183					X		
CNI	Hydroida	202	656	X				X		
CNI	Stylaster miniatus (Pourtales, 1868)	175	200					X		
CNI	Stylaster filogranus Pourtales, 1871	175	200					X		
CNI	Distichopora foliacea Pourtales, 1868	175	175					X		
CNI	Pliobrothus echinatus Cairns, 1986	175	175					X		
CNI	Bathypsammia? sp. Marenzeller, 1907	418	640	X					X	
CNI	Clavularia new sp.? Quoy & Gaimard, 1834	648	648	X						
CNI	Eunephthya nigra (Pourtales, 1868)	648	768	X						
CNI	Octocorallia, unid. spp.	501	671	X	X					
CNI	Lophelia pertusa (Linnaeus, 1758)	284	815	X	X	X	X		X	X
CNI	Scleractinia, unid. spp.	582	632	X		X				
CNI	Enallopsammia profunda (Pourtales, 1867)	305	742	X	X	X	X			
CNI	Ifalukellidae, new sp.? Bayer, 1955 (ye morph)	502	649	X	X					
CNI	Eunicella modesta (Verrill, 1883)	518	732		X	X				
CNI	Keratoisis flexibilis (Pourtales, 1868) (wh morph)	378	816	X	X	X		X		
CNI	Ifalukellidae, new sp.? Bayer, 1955 (or morph)	519	656	X	X					
CNI	Actiniaria	565	751			X				
CNI	Placogorgia? sp.1 Wright & Studer, 1889	565	579			X				
CNI	Chrysogorgia squamata (Verrill, 1883)	581	581			X				
CNI	Bathypathes alternata Brook, 1889	466	716			X			X	
CNI	Pterostenella? new sp.? Versluys, 1906	754	754			X				
CNI	Zoanthidea, unid. sp.2	734	734			X				
CNI	Stylaster unid. sp.1	557	557						X	
CNI	Placogorgia tenuis? (Verrill, 1883)	457	557						X	
CNI	Callogorgia verticillata (Pallas)	511	511							X
CNI	Isidella sp.1 Gray, 1857	744	762			X				
CNI	Paramuricea sp.2 Kölliker, 1865	573	573			X				

CNI	Madrepora oculata Linnaeus, 1758	322	763		X	X	X			
CNI	Paramuricea sp.4 Kölliker, 1865	762	762			X				
CNI	Plumarella pourtalessi (Verrill, 1883)	171	753	X	X	X	X	X		
CNI	Keratoisis flexibilis (Pourtales, 1868) (pi morph)	374	734			X	X			
CNI	Actiniaria, unid. sp.1 (Venus fly trap)	284	734			X	X			
CNI	Candidella imbricata (Johnson, 1862) + Thouarella? sp. Gray, 1870	732	732			X				
CNI	Paramuricea sp.3 Kölliker, 1865	558	732			X				
CNI	Anthomastus nr. agassizzi Verrill, 1922	420	753			X			X	
CNI	Telestula? sp.2 Madsen, 1944	734	784			X				
CNI	Paramuricea sp.5 Kölliker, 1865	743	744			X				
CNI	Paramuricea sp.1 Kölliker, 1865	590	744			X				
CNI	Paramuricea sp.6 Kölliker, 1865	328	727			X	X			
CNI	Paramuricea sp.7 Kölliker, 1865	711	711			X				
CNI	Paramuricea sp.8 Kölliker, 1865	701	716			X				
CNI	Capnella nigra (Pourtales, 1868)	325	762			X	X			
CNI	Paramuricea multispina Deichmann, 1936	189	715			X		X		
CNI	Plexauridae, unid. sp.1 Gray, 1859	579	716	X		X				
CNI	Muriceides hirta? (=Trachymuricea) (Pourtales, 1867)	681	716			X				
CNI	Paramuriceidae sp.2 (nr. Paramuricea echinata Deichmann, 1936)	716	716			X				
CNI	Paramuriceidae sp.4 (nr. Paramuricea placomus (Linnaeus))	296	296				X			
CNI	Antipatharia, unid. sp.1 (re-or morph)	283	767	X		X	X	X		X
CNI	Paramuriceidae sp.3 (nr. Paramuricea placomus (Linnaeus))	283	304				X			
CNI	Antipatharia, unid. sp.2 (wh-pi morph)	328	515		X		X	X	X	
CNI	Paramuriceidae sp.5 (nr. Echinomuricea atlantica (Johnson, 1862))	284	284				X			
CNI	Zoanthidea, unid. sp.1	419	699			X	X			
CNI	Paramuricea sp.9 Kölliker, 1865	326	336				X			
CNI	Paramuriceidae sp.6 (nr. Paramuricea placomus (Linnaeus))	326	326				X			
CNI	Paramuriceidae sp.7 (nr. Paramuricea multispina Deichmann, 1936)	323	323				X			
CNI	Zoanthidea, unid. sp.3	328	328				X			
CNI	Villogorgia nr. nigrescens Duchassaing & Michelotti, 1860	215	215					X		
CNI	Paramuricea sp.10 Kölliker, 1865	403	403				X			
CNI	Paramuricea sp.11 Kölliker, 1865	322	358				X			
CNI	Paramuricea sp.12 Kölliker, 1865	366	366				X			
CNI	Stylasteridae, unid. sp.	173	742		X	X	X	X		
CNI	Paramuriceidae sp.8 (nr. Echinomuricea atlantica (Johnson, 1862))	323	323				X			
CNI	Paramuricea sp.13 Kölliker, 1865	323	323				X			
CNI	Hydroida, unid. sp.1	284	322				X			
ECH	Holothuroidea	181	181					X		
ECH	Tamaria? sp.	653	653	X						
ECH	Solaster sp.	653	653	X						
ECH	Asteroidea + Cidaroidea	516	516		X					
ECH	Asteroidea, 2 unid. spp.	518	518		X					
ECH	Asteroidea, unid. sp.1	454	454						X	
ECH	Asteroporpa? sp.	304	304				X			

MOL	Calliostoma pulchrum (C.B. Adams, 1850)	187	187					X		
MOL	Hyalina albolineata (Orbigny, 1842)	187	187					X		
MOL	Scaphella gouldiana (Dall, 1887)	187	188					X		
MOL	Bivalvia, unid. sp.1	445	445							X
MOL	Bursa tenuisculpta (Dautzenberg & Fischer, 1906)	187	283				X	X		
MOL	Perotrochus amabilis (F.M. Bayer, 1963)	181	265					X		
MOL	Conus villepini Fisher and Bernardi, 1857	171	188					X		
MOL	Murex beauii Fischer & Bernardi, 1857	188	188					X		
MOL	Entemnotrochus adansonianus (Crosse & Fischer, 1861)	180	265					X		
MOL	Perotrochus midas F.M. Bayer, 1965	262	393					X		
POR	Haplosclerida?	171	184					X		
POR	Aka sp. de Laubenfels, 1934 or Spongosorites sp. Topsent, 1896 + Haplosclerida	543	543					X		
POR	Haplosclerida + Siphonodictyon sp. Bergquist, 1965 or Spongosorites sp. Topsent, 1896	187	543					X		
POR	Theonellidae	470	472					X		
POR	Pachastrella sp. Schmidt, 1868 or Poecillastra sp. Sollas, 1888	467	467					X		
POR	Stellettidae?	312	312					X		
POR	Erylus transiens (Weltner, 1882)	262	262					X		
POR	Halichondrida	260	260					X		
POR	Theonellidae, new genus, new sp.	199	208					X		
POR	Mycalidae	284	312					X		
POR	Chondrosia? sp. Nardo, 1847	297	300					X		
POR	Halichondriidae	237	648	X				X		
POR	Plakortis sp. Schulze, 1880	220	312					X		
POR	Petrosiidae	178	750	X		X	X	X	X	
POR	Porifera, unid. sp.	192	297					X		
POR	Corallistes sp. Schmidt, 1870 or Callipelta sp. Sollas, 1888	206	206					X		
POR	Spirophorida	183	183					X		
POR	Lithistida	185	310					X		
POR	Geodiidae	180	816			X		X		
POR	Poecilosclerida	132	717			X		X		
POR	Epipolasis sp. de Laubenfels, 1936	211	211					X		
POR	Axinellida + Plakortis? sp. Schulze, 1880	210	210					X		
POR	Axinellidae	168	183					X		
POR	Characella? sp. Sollas, 1886	198	198					X		
POR	Stellettinopsis? sp. Carter, 1879	198	198					X		
POR	Echinodictyum sp. Ridley, 1881	171	172					X		
POR	Phakellia new sp.1 Bowerbank, 1862	171	171					X		
POR	Auletta sp. Schmidt, 1870	171	207					X		
POR	Phakellia new sp.2 Bowerbank, 1862	174	174					X		
POR	Phakellia new sp.3 Bowerbank, 1862	174	174					X		
POR	Dictyoceratida?	172	172					X		
POR	Pachastrellidae	166	811	X	X	X	X	X		X
POR	Lychniscosida	649	662	X						
POR	Lyssacinosida	628	757	X		X				
POR	Phakellia sp. Bowerbank, 1862	171	756	X	X	X	X	X	X	
POR	Corallistes sp. Schmidt, 1870	226	689	X				X		
POR	Oceanapia sp. Norman, 1869	172	652	X				X		

POR	Plakinidae	638	660	X						
POR	Aka (Siphonodictyon) sp.de Laubenfels, 1934	183	648	X				X		
POR	Ancorina? sp. Schmidt, 1862	641	641	X						
POR	Phakellia sp.2 Bowerbank, 1862	509	509		X					
POR	Hexasterophora	517	761	X	X	X				
POR	Axinellida	201	499		X			X		
POR	Biemnidae	512	628	X	X					
POR	Pachastrellidae (different)	527	527		X					
POR	Ircinia new sp.? Nardo, 1833	500	500		X					
POR	Choristida, new sp.?	520	520		X					
POR	Raspailiidae	321	763		X	X	X	X		
POR	Hexactinellida	186	800	X	X	X	X	X		
POR	Heterotella sp. Gray, 1867	418	762		X	X			X	
POR	Stylocordyla sp. Thomson, 1873	515	515		X					
POR	Phakellia sp.3 Bowerbank, 1862	515	515		X					
POR	Aka sp. de Laubenfels, 1934 + Hadromerida	456	456						X	
POR	Myxillina? sp. Hajdu, Van Soest & Hooper, 1994	442	442							X
POR	Dendroceratida	448	448							X
POR	Hyalonematidae? + Zoanthidea	737	737			X				
POR	Oceanapiidae	758	758			X				
POR	Calthropellidae	757	757			X				
POR	Ancorinidae?	586	586			X				
POR	Dercitus cf. bucklandi (Bowerbank, 1858)	809	809			X				
POR	Aphrocallistes sp. Gray, 1858	587	800			X				
POR	Polymastia sp. Bowerbank, 1864	726	726			X				
POR	Phakellia sp. (different) Bowerbank, 1862	735	735			X				
POR	Corallistidae	186	767	X			X	X		
POR	Asterophorida	431	431				X			
POR	Leiodermatium sp. Schmidt, 1870	172	754	X			X	X		
POR	Spongosorites sp. Topsent, 1896	171	671	X		X	X	X		
POR	Geodia sp. Lamarck, 1815	174	767	X			X	X		
POR	Hexactinellida + Zoanthidea	328	411				X			
POR	Poecillastra? sp. Sollas, 1888	323	427				X		X	
POR	Choristida	173	509		X		X	X		
POR	Choristidae?	323	323				X			
POR	Oceanapiidae or Topsentia sp. Berg, 1899	173	173					X		
POR	Hymedesmia sp.1 Bowerbank, 1864 (blue morph)	172	179					X		
POR	Hymedesmia sp.2 Bowerbank, 1864 (ye morph)	172	179					X		
POR	Demospongiae	170	541				X	X		
POR	Discodermia sp. du Bacage, 1869	180	269					X		
POR	Choristida or Petrosida	258	258					X		
POR	Zyzzya sp. de Laubenfels, 1936	222	222					X		
POR	Smenospongia sp. Wiedenmayer, 1977 or Ircinia sp. Nardo 1833	222	222					X		
POR	Petrosida or Halichondrida	183	183					X		
POR	Vetulina sp. Schmidt, 1879 or Leiodermatium sp. Schmidt, 1870	415	415				X			
POR	Erylus sp. Gray, 1867	216	356				X	X		
VES	Vestimentifera, unid. sp.	443	443							X

Table 4. Species list of fish associated with deep-water reefs off Florida (Sites: FL= Florida East Coast *Lophelia* Reefs; MT= Miami Terrace Escarpment; PT= Pourtalès Terrace). (from Reed et al., 2004a,b)

Taxonomy	**Common Name**	**Max Depth (m)**	**Min Depth (m)**	**FL**	**MT**	**PT**
Anthias nicholsi Firth, 1933	yellowfin bass	283	179		X	X
Antigonia capros Lowe, 1843	deepbody boarfish	219	174			X
Beryx dacadactylus?	alphonsino?	287			X	
Brotulidae	cusk-eel	469	322		X	X
Carcharhinus falciformis (Müller & Henle, 1839)	silky shark	522	335			X
Caulolatilus microps Goode and Bean, 1878	blueline tilefish	223	172			X
Chaetodon aya	bank butterflyfish	179				X
Chlorophthalmidae	greeneye	296			X	
Chlorophthalmus agassizi Bonaparte, 1840	shortnose greeneye	522	396		X	X
Conger conger?	conger eel	296	0		X	
Congridae	conger eel	381	0			X
Cookeolus japonicus (Cuvier, 1829)	longfinned bulleye	198	171			X
Epinephelus drummondhayi Goode and Bean, 1878	speckled hind	183				
Epinephelus flavolimbatus Poey, 1865	yellowedge grouper	174				
Epinephelus nigritus (Holbrook, 1855)	Warsaw grouper	198	180			X
Epinephelus niveatus (Valenciennes, 1828)	snowy grouper	308	174			X
Epinephelus sp. (misty grouper?)	misty grouper?	287				X
Galeus arae (Nichols, 1927)	roughtail catshark	518				X
Gephyroberyx darwinii (Johnson, 1866)	big roughy	518	392			X
Gymnothorax sp. (cf. funebris Ranzani, 1840)	green moray	187	174			
Gymnothorax sp. (new moray?)	new moray	179				X
Helicolenus dactylopterus (Delaroche, 1809)	blackbelly rosefish	497	179		X	X
Hemanthias sp.	seabass	194	174			X
Hemanthias vivanus (Jordan & Swain, 1885)	red barbier	191	168			X
Hoplostethus mediterraneus Cuvier, 1829	silver roughy	461				X
Hoplostethus sp.	roughies	496	189			X
Hydrolagus sp.	spotted ratfish	762	714	X		
Hyperoglyphe sp.	barrelfish	287	284		X	
Laemonema melanurum Goode and Bean, 1896	mora	546	186	X	X	X
Mola mola	ocean sunfish	180				X
Mustelidae?	dogfish	586		X		
Mustelus sp.	dogfish	369			X	
Myctophidae	laternfish	500	296	X	X	
*Nezumia sp. (*3 spp.- *N. bairdii, N. aequalis, or N. atlantica)*	grenadier, rattail	726	322	X	X	X
Ostichthys trachypoma (Günther, 1859)	bigeye soldierfish	180				
Pagrus pagrus (Linnaeus, 1758)	red porgy	175				
Pareques iwamotoi Miller and Woods, 1988	blackbar drum	183				
Peristidion sp.	armored sea robin	438			X	
Plectranthias garrupellus Robins and Starck, 1961	apricot bass	172				X
Polyprion americanus	wreckfish	693	283	X	X	
Pronotogrammus martinicensis (Guichenot, 1868)	roughtongue bass	212	168			X

Raja sp.	skate	738	339	X	X	
Scorpaenidae	scorpionfish	296	186		X	X
Scyliorhinidae?	catshark?	326			X	
Seriola dumerili (Risso, 1810)	greater amberjack	187	175			X
Seriola rivoliana	Almaco jack	179				X
Squalidae	dogfish	399	322		X	
Synaphobranchidae?	cutthroat eel	762	714	X		
Unid.- silver body, barbels		336			X	
Urophycis sp.	phycid hake	297				X
Xeiidae?	red dory?	376			X	
Xiphias gladius Linnaeus, 1758	swordfish	518				X

FIGURE CAPTIONS

Figure 1. Coral colony and branch tip: top- *Oculina varicosa* (80m); middle- *Lophelia pertusa* (490m); bottom- *Enallopsammia profunda* (585m). (scale lines = 1 cm; top left fig. Scale = 5 cm) (from Reed, 2002a; Hydrobiologia 471: 57-69)

Figure 2. Depth range and maximum relief of deep-water coral reefs off southeastern U.S.A. Dominant colonial coral listed for each site (see Figure 3 for site locations). (from Reed, 2002a; Hydrobiologia 471: 57-69)

Figure 3. Deep-water coral reef regions off southeastern U.S.A. (see Table 1 for locations). ?= *Johnson-Sea-Link* I and II submersible dive sites; Regions: A=*Oculina* Coral Reefs, B= East Florida *Lophelia* Reefs, C= Savannah *Lophelia* Lithoherms, D= Stetson's Reefs (D1= region of dense pinnacles), E= *Enallopsammia* Reefs (Mullins et al., 1981), F= Bahama Lithoherms (Neumann et al., 1977), G= Miami Terrace Escarpment. (from Reed et al., 2004a; chart from NOAA, NOS, 1986)

Figure 4. Submersible dive sites and echosounder sites on deep-water reefs off southeastern U.S.A. (see Table 1 for locations). ?# = *Johnson-Sea-Link* I and II submersible dive sites, F# = high-relief pinnacles from echosounder transect. (from Reed et al., 2004a; chart from NOAA, NOS, 1986)

Figure 5. Detailed chart of high-relief region with *Lophelia* coral mounds on Charleston Bump, Blake Plateau (from Popenoe and Manheim, 2001; American Fisheries Society Symposium 25: 43-94)

Figure 6. Bathymetry and submersible dive sites on Miami Terrace Escarpment at Region G. (see Table 1 for locations). ?= *Johnson-Sea-Link* I submersible dive sites. (from Reed et al., 2004a; chart from Ballard and Uchupi, 1971; MTS Journal 5: 43-48)

Figure 7. Bathymetry and submersible dive sites on Pourtalès Terrace at Region H. (see Table 2 for locations). ?= *Johnson-Sea-Link* and *Clelia* submersible dive sites; JS= Jordan Sinkhole, MS= Marathon Sinkhole, T1= Tennessee Humps Bioherm #1, T2= Tennessee Humps Bioherm #2, A3= Alligator Humps Bioherm #3, A4= Alligator Humps Bioherm #4. (from Reed et al., 2004b; chart from Malloy and Hurley, 1970; Geol. Soc. Amer. Bull. 81: 1947-1972)

Figure 8. Deep-water coral lithoherms and ROV dive sites at Region I off southwest Florida slope (see Table 1 for locations). ?= *Innovator* ROV dive sites. (from Reed et al., 2004a; chart from NOAA, NOS, 1986)

Figure 9. Echosounder profile of Stetson's Pinnacle (depth 780 m, relief 153 m). (from Reed et al., 2004b)

Figure 10. Echosounder profile of Savannah Lithoherm, Pinnacle #1 (depth 537 m, relief 50 m). (from Reed et al., 2004b)

Figure 11. Height of *Lophelia* pinnacles and lithoherms on echosounder transects from Jacksonville to Jupiter, Florida at depths of 600 to 800 m. (from Reed et al., 2004b)

Figure 12. Echosounder profile of Jacksonville Lithoherm, Pinnacle #204B (depth 701 m, relief 157 m). (from Reed et al., 2004a)

Figure 13. Echosounder profile of Cape Canaveral Lophelia Reef, Pinnacle #113 (depth 777 m, relief 61 m). (from Reed et al., 2004a)

Figure 14. Echosounder profile of Miami Terrace Escarpment, Site #BU1b, west ridge (depth 549 m at base, relief 155 m). (from Reed et al., 2004a)

Figure 15. Echosounder profile of Pourtalès Terrace, Tennessee Bioherm #2 (depth 213 m at base, relief 85 m). (from Reed et al., 2004b)

Figure 16. Seabeam image of escarpment and lithoherms at Region I off southwest Florida slope. ?= *Innovator* ROV dive sites #6 and 7. (from Reed et al., 2004b)

Figure 17. Seabeam image of escarpment and lithoherms at Region I off southwest Florida slope, simulated view from top of escarpment. ?= *Innovator* ROV dive sites #6 and 7. (from Reed et al., 2004b)

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Part 3: Eastern Atlantic and General Deep Sea Reefs (p.68)

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