

## FINAL REPORT

Survey of Fish Assemblages and Benthic Habitat and at Pulley Ridge, S.W. Florida

Part 1. Characterization of Benthic Habitat and Biota with Documentation of Hard/Live Bottom

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M/V *Freedom Star* (NASA)  
*Super Phantom* ROV (NOAA NURP, UCONN)

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## INTRODUCTION

### Geology and Benthic Habitat of Deep-water Reefs in the Eastern Gulf of Mexico

The west Florida shelf in the eastern Gulf of Mexico is a broad carbonate platform that extends 750 km from DeSoto Canyon in the north to the western Straits of Florida and covers ~78,000 km<sup>2</sup> (Holmes, 1981). At the shelf break on the southwest Florida Platform, a series of ancient reef complexes and limestone outcrops of Pleistocene and possibly Miocene ages provide deep-water, hard-bottom habitat: Pulley Ridge forms a 100 km long, moderate relief reef at depths of 60-70 m with zooxanthellate scleractinian plate corals (*Agaricia* sp. and *Leptoseris* sp.) and macroalgae; Howell Hook crests at 130-150 m and a third lies between 210 and 235 m (Jordan and Stewart, 1961; Reed et al., 2005). Seaward of the shelf, on the southwest Florida carbonate-ramp slope, a 20-km long zone of high-relief (10-15 m) Pleistocene coral mounds also provide habitat for coral and hard-bottom communities (Newton et al., 1987; Reed, et al., 2005). The slope then grades into the Florida Escarpment, which extends from depths of 2500 m to 3280 m into the eastern Gulf of Mexico. The face of the escarpment has steep vertical limestone cliffs of Cretaceous age, with intervening sediment covered planes that also provide habitat for dense chemosynthetic communities (Paull et al., 1984, 1990).

Pulley Ridge lies ~ 40 nm west of the Tortugas Reserve and stretches 60 nm north along the west Florida shelf. Pulley Ridge has been called the deepest known 'photosynthetic' coral reef in the continental U.S. waters. Deep-water, zooxanthellate reefs, termed mesophotic reefs, are more restricted than azooxanthellate (without zooxanthellae) reefs in depth and distribution in the western Atlantic, Caribbean, and Gulf of Mexico (Reed and Ginsburg, 2007). Deep-water, azooxanthellate reefs occur below photosynthetic zone and in this region include *Oculina* coral reefs at 70-100 m depths off central eastern Florida (Reed, 1980; Reed, 2002a) and *Lophelia* and *Enallopsammia* reefs which occur at greater depths, 490-870 m, on the Blake Plateau from Florida to North Carolina, in the Straits of Florida, and the eastern Gulf of Mexico (Stetson et al., 1962; Newton et al., 1987; Reed, 2002b; Reed et al., 2005, 2006).

In general, mesophotic reefs occur at depths greater than typical shallow-water reefs (30-100 m) but still require sufficient light for algae and zooxanthellae to survive. Mesophotic reefs off the southeastern U.S. occur exclusively in the Gulf of Mexico and include Sherwood Forest (Tortugas Reserve), Pulley Ridge, Florida Middle Grounds, and Flower Gardens. A series of deep-water reefs that occur at depths of 60-90 m along the paleo-shoreline of western Florida include Pulley Ridge, Twin Ridges, and Madison-Swanson. Light levels on Pulley Ridge are quite low for a photosynthetic reef and are about 1-2% (5-30 microEinsteins m<sup>-2</sup> s<sup>-1</sup>) of surface light compared to 5% for typical shallow-water reefs (USGS, 2004). Pulley Ridge was first discovered in 1950 and was surveyed relatively extensively in the 1970s and 80s for the Bureau of Land Management (BLM, 1977; CSA, 1985, 1987). These surveys consisted of video sled transects and bottom grabs. In the 1980s and 1990s, scientists from Harbor Branch Oceanographic Institution (J. Reed, Principal Investigator) made the first manned submersible dives on Pulley Ridge and also in a newly discovered deep-water sinkhole off Naples (Reed et al., 2005). In 2003, Reed et al. conducted ROV dives to survey a deep-water *Lophelia* coral reef at depths of 500 m, west of Pulley Ridge, and also some of the mesophotic reefs off western Florida including Twin Ridges and Madison Swanson (Reed, 2004; Reed et al., 2004, 2005). Between 1999 and 2004, USGS (Bob Halley, David

Twichell) and USF (David Naar, Brian Donahue, Al Hine) geologists completed several moderate resolution (5 m) multibeam sonar bathymetry sets of the region. Multibeam sonar bathymetry of Pulley Ridge shows it to be a relatively low-relief feature at depths of 60-70 m, with <10 m relief and ~5 km wide (USGS, 2004). USGS scientists have published a report of bottom photographs of some of the dominant benthic flora and fauna from Pulley Ridge (Cross et al., 2004). Seven species of hard coral occur on Pulley Ridge including *Agaricia* spp., *Leptoceris* [sic] *cucullata*, *Montastraea cavernosa*, *Madracis formosa*, *M. decactis*, *Porites divericata*, and *Oculina tenella* (USGS, 2004). The platy-corals, *Agaricia* and *Leptoseria*, are the most abundant. They also found coralline algae such as coralline nodules and *Halimeda* sp. to be major sediment producers in addition to the coral. It appears that Pulley Ridge is a biostrome which has accumulated several meters of carbonate sediment from biological processes (USGS, 2004). In 2005, the "Islands in the Stream" mission headed by Sylvia Earle and nearly 40 scientists used submersibles, ROV and scuba to document the benthos of Pulley Ridge.

Although Pulley Ridge was the primary target of our survey, we also conducted a survey of a deep-water sinkhole just west of Pulley Ridge. Reed et al. (2005) first discovered and described the benthic habitat, fish and invertebrates of this Naples Sinkhole in detail. Jordan (1954) first discovered large sinkholes on the Pourtales Terrace, in the Straits of Florida, south of the Florida Keys. Land and Paull (2000) mapped and described nine of these sinkholes using side-scan sonar aboard the US Navy's submersible NR-1. The largest is the 1.2 km diameter Jordan Sinkhole at a depth of 350 m. Its maximum vertical relief of 260 m is an order of magnitude greater than terrestrial sinkholes on the Florida Platform. The Marathon Sinkhole also consists of a pair of holes with 64 m maximum relief at a depth of 460 m (Reed et al., 2005).

## **METHODS AND MATERIALS**

Seven sites were surveyed with the NOAA *Superphantom* II ROV on Pulley Ridge. A single ROV dive (~1 hr) was completed at each of the seven sites. Video/photographic transects were used to document and characterize the benthic habitat and biota and allowed for quantitative estimates of densities and sizes of biota. The primary protocol was to document the presence or absence of hard-bottom habitat. Qualitative estimates of size of habitat features and size of benthic invertebrates were made from videotapes and digital images using the cameras' parallel 10 cm lasers. During the transects the ROV was kept close to the bottom (< 0.5 m) whenever possible. The video and digital still cameras were ~0.5 m off the bottom and angled down ~45° during the transects. Periodically (~1/ minute) the ROV was stopped and the digital still camera was turned down 90° for quantitative photos. Depending on the cameras' degree of zoom, the field of view ranged from 25 cm to ~2 m but can be determined by the lasers in the image. The observer's field of view which was limited by visibility of the water column and available light from the ROV was approximately 30-40 ft. Throughout each dive the Investigator (JR) made verbal notes on the videotapes and detailed written notes describing all aspects of the habitat and benthic biota. The log form included time, depth, photo number and description of each photograph, habitat description (substrate, shape and height of feature), and description of density and size of benthic invertebrates. These data were transcribed into an Excel spreadsheet.

## **Data Analysis**

Each videotape and digital still image was reviewed after the cruise and further annotations were added to the original Excel log describing habitat and benthic biota (Appendix 1). All macro-benthic (>3-5 cm) species were identified to the lowest taxa possible for the master species list which included sessile invertebrates (Cnidaria- Scleractinia, Hydroida, Gorgonacea, Antipatharia, Actiniaria; Porifera; Bryozoa; Ascidiacea), macro-algae (Rhodophyta, Phaeophyta, Chlorophyta), and motile invertebrates (Echinodermata, Mollusca, Arthropoda). A total of 30 (when possible) random photographic images were selected from each dive site for quantitative analysis of benthic habitat cover (sand, rock ledge, rock pavement, rubble/cobble) and benthic biota. Each dive had an average of 55 still images but for the quantitative analyses some images were deleted including duplicate or overlapping images, blurred or turbid, too dark or light, or incorrect angle. Each photographic image was overlaid with 25 randomly distributed points to determine percent cover for each habitat type and biota using CPCe software (Kohler and Gill, 2006). The higher taxa (i.e., Gorgonacea, Porifera) were used for the point count analysis. These results were listed in an Excel spreadsheet for each dive which calculated mean percent cover for habitat and biota type. These were then plotted into area graphs.

## **Deep-water Habitat Survey Protocol and Terminology**

The Southeast Area Monitoring and Assessment Program (SEAMAP) deep-water mapping project has documented deep-water, hard-bottom habitat from existing data throughout the South Atlantic Bight and Straits of Florida (Arendt et al., 2003). The SEAMAP bottom mapping workgroup has defined deep-water hard-bottom as including the following subcategories of habitat types: coral, rock rubble, coral rubble, exposed hard pavement, thinly covered hard substrate, and artificial structures. In addition, a category of 'Special Habitats' includes the subcategories of canyons, tilefish burrows, consolidated mud, methane seeps, sinkholes, and coral banks. They define deep-water corals as including Scleractinia (hard corals), Octocorallia (soft corals), Hydrocoral (hydro corals and stylasterine corals), and Antipatharia (black corals). In our Pulley Ridge survey we define vertical relief of bottom features (such as a mound or ridge) as low relief (<1 m), moderate relief (1-3 m), or high relief (>3 m). Rubble is defined as <5 cm size rock, coral debris, bivalve shell, or *Halimeda* plates. Cobble is defined as 5-10 cm size coralline algal nodules or rock.

The productivity of hard-bottom communities varies depending upon environmental and physical factors including but not limited to depth, current, light penetration, reef topography, habitat availability and location. Areas of hard bottom provide cover and foraging areas for many fish and invertebrates, including several commercially important species. The importance of hard bottom to fisheries stocks has been recognized and the SAFMC has designated all natural and artificial hard bottom as Essential Fish Habitat (EFH) and/or Habitat Area of Particular Concern (HAPC).

## RESULTS AND DISCUSSION

### Site Descriptions

Of the seven sites that were surveyed with the ROV, three sites were within the Pulley Ridge Habitat Area of Particular Concern (HAPC) and four were outside the boundaries just to the north or west of the HAPC. Four of the sites were selected from recent multibeam sonar surveys which indicated moderate relief ridges where hard or live bottom could be expected. Three sites were selected from previous submersible and trawl surveys conducted previously by Harbor Branch Oceanographic Institution (J. Reed, Chief Scientist). The following describes the general habitat, geomorphology and benthic biota (sessile and motile invertebrates and algae) of these sites based on the ROV video and photo transects. Complete annotations of each dive including coordinates, depth, time, habitat description, fish and benthic biota, and human artifacts are listed in Appendix 1. Each dive was approximately one hour but some were shortened where there was no hard bottom.

#### Site 1- North of HAPC (HBOI- J. Reed Site: 17-VII-92-2, 13-VIII-95-3, and 13-VIII-95-4)

This site was selected from 19 previous dive sites conducted by HBOI's Division of Biomedical Marine Research from 1992 to 2005. Three scientific trawls were made in 1992 and 1995 which indicated a rubble bottom with a high diversity of sponges. No multibeam was available for this site. The ROV dive consisted of three transects: Transect 1- Heading East ~60 m in order to find any reefs which tend to be oriented N-S along the paleo-shoreline; Transect 2- Northerly ~200 m along an apparent reef line; Transect 3- West ~80 m. The total distance and heading from start coordinate to finish coordinate was 143 m at 353°; this however does not indicate true transect length. The depth ranged from 68-75 m. In general, this site is primarily sand with rubble and cobble (82% of the transect, based on percent of total dive transect time), and three patch reefs were found (18% of the transect) (Table 1). The non-reef areas are flat sand with 10-30% cover of rock rubble and 5-10-cm size rock cobble with a few 10-30 cm boulders (App. 2- Figs. 1,2). In the sediment-cobble zone, small <5-10 cm demosponges are most common dominated by *Ircinia campana* vase sponges, Axinellidae, *Cinachyra*, and *Geodia* (Table 2). Dominant Cnidaria are gorgonians and black coral which may indicate underlying rock pavement but was not visible. The gorgonians *Swiftia exerta* (App. 2- Fig.4) and *Muricea* are present, along with black corals Antipathidae and the corkscrew whip *Cirrhopathes*, and Pennatulacea sea pens. Fish burrows are evident where 1-m diameter depressions have rock cobble piled up. Our previous submersible dives elsewhere on Pulley Ridge have observed red grouper associated with similar burrows, some up to 3 m diameter.

The three reefs consist of exposed rock pavement with low relief (<0.5 m to maximum 1 m) ledges and rock outcrops (App. 2- Figs. 3.4). This zone has dense cover of gorgonians, sponges and fish. Macro-algae are not common. Dominant gorgonians consist of ~5 species, include 80-cm tall *Swiftia exerta* and Ellisellidae whip coral. Common demosponges include Axinellidae, *Placospongia*, *Bubaris*, *Niphates vaginalis*, and Haplosclerida. Several bushy Antipathidae black coral occur with the whip coral *Cirrhopathes*. Various encrusting ascidians are common, especially Didemnidae. Common motile invertebrate fauna include the starfish *Narcissia trigonaria*, octopus, and Gorgonocephalidae basketstarfish which attach to the gorgonians.

Seventy taxa were identified at this site including 27 Porifera, 11 Cnidaria (5 Gorgonacea, 4 Antipathidae), and 6 algae (3 Rhodophyta, 2 Phaeophyta, and 1 Chlorophyta) (Table 2).

#### Site 2- North of HAPC (USF Multibeam Site)

The multibeam sonar survey showed a 4-m relief ridge. Our ROV dive consisted of two transects: Transect 1- heading West across two reefs; Transect 2- north along the west edge of Reef #2. Total distance and heading from start to end coordinates was 587 m at 321° and depth ranged from 75-80 m. This site has an extensive reef system oriented N-S and 61% of the transect was on reef habitat. Sand-cobble habitat consisted of 39% of the dive. The non-reef areas are primarily flat sand with low density (<10%) cover of 5-10 cm rock cobble or high density cover ranging from 30- >50% cobble (App. 2- Fig. 5). No rock pavement or ledges are apparent in this zone. The sand-cobble habitat has low density and diversity of macrobiota such as a few demosponges and Pennatulacea. No gorgonians or algae were observed. Several 1-m fish burrows with piled cobble are present.

Three reef areas were crossed. The first two appeared to be isolated patch reefs with 1-2-m diameter boulders and low relief (<1 m) ledges (App. 2- Fig. 6). The one reef was no more than 10 m in diameter. Dense reef fish are present but benthic macro-biota are sparse. The main reef system consists of a N-S oriented ledge facing west that is an apparent paleo-shoreline. The ROV transected along the top west edge, west-facing slope, and base of this ridge for a total of 35 minutes and did not come to the end of the reef. A hard fix was taken on top of the reef (26° 21.061'N, 83° 46.759'W, 75 m). The fixed camera drop was on this reef. This habitat is 100% hard bottom. Overall relief is 6 m from 75 m on top to 81 m at the west base. The west-facing ledge occurs over a width of 10-20 m forming a 20-30° slope that consists of 1-2 m diameter boulders and rock slabs with a series of steps or ledges of <1 m relief (App. 2- Figs. 7,8). The top edge of the reef tends to be rock pavement with rubble, cobble and low relief ledges (<50 cm). Dense aggregations of small reef fish and grouper especially scamp are common. The benthic community of the reef zone has a relatively dense cover dominated by demosponges, gorgonians and black coral. Few macro-algae are common except for encrusting red corallines. No scleractinians were observed. Gorgonians consist of at least six species including 40-80 cm *Swiftia exerta* and *Carijoa*, *Muricea*, Plexauridae, and Ellisellidae. Bushy black corals consist of at least four species including *Antipathes caribbeana*, *A. expansa*, and *Parantipathes tetrasticha*. Dominant sponges include Axinellida, numerous unidentified small demosponges, *Ircinia campana*, *Lissodendoryx*, and *Mycale*. A few *Panularis argus* lobster were observed under ledges. Manmade debris included two piles of apparent long-line fishing gear.

In total 24 taxa were identified, including 12 Porifera, 18 Cnidaria, and 11 macro-algae.

#### Site 3- North of HAPC (USF Multibeam Site)

This site was selected from the multibeam sonar survey which indicated three E-W oriented finger like ridges, ~1 km in length and ~3 m relief. The parallel ridges ~78 m at the top and 81 m in the valleys between the ridges. Tracking was not working correctly during the dive which lasted 28 minutes on a north heading across the ridges. The great majority of the dive was on sand bottom (82% of dive) and 18% was on sand-rubble habitat. The valleys are 100% soft bottom habitat whereas the tops of the ridges are either soft sediment or sand with shell hash and sparse <5 cm cobble. It appears that the three ridges are likely sand waves or dunes. The sand

areas have evidence of bioturbation with 5-10 cm mounds and depressions from sipunculans or polychaetes. Dominant benthic fauna include 30 cm Pennatulacea sea pens, *Eucidaris tribuloides* pencil urchins, and Comatulida crinoids. On top of the ridges is sand sediment with up to 10% cover of sparse rubble and cobble. These areas have few small demosponges, hydroids, and algae including the green rhizoid alga *Caulerpa floridana* (App. 2- Fig. 9). This site had 13 benthic taxa identified including 8 algae and 2 cnidarians.

#### Site 4- West of HAPC (HBOI- J. Reed Site: Naples Sinkhole)

Although this site did not have a multibeam survey, it has been well documented with echosounder (fathometer) surveys and *Johnson-Sea-Link* submersible dives as the first dives to the bottom of this sinkhole. Reed et al. (2005) described the Naples Sinkhole in detail (as summarized below) including the geomorphology, habitat, benthic fish and invertebrates:

Three submersible dives (*JSL II-3164*, 3165, 3173; August 1999) were made in the Naples Sinkhole, which lies on the outer southwest Florida shelf, ~204 km (110 nm) north of the Dry Tortugas and 241 km (130 nm) west of Naples, Florida. Its geomorphology resembles that of shallow-water and terrestrial sinkholes on the Florida peninsula. The sinkhole, which lies on a relatively flat rock and sand bottom at a depth of ~175 m, has steep rocky walls and a maximum depth of 230 m with a maximum vertical relief of ~55 m. Multiple fixes taken during the submersible's transect around the upper rim revealed a maximum diameter of 152 m from the NW to SW edge and a minimum of 91 m from the E to SW edge. The interior diameter at the maximum depth (230 m) is approximately 152 m as measured by the submersible's sonar.

The bottom of the sinkhole is sand, shell-hash and rubble with no evidence of rock outcrops or crevices. At the SW base, the depth is shallower (210 m) and the wall has a 3-m rocky overhang at the interface with the flat sand bottom. The south rock wall is steepest with a 70-90° slope. One rock (sample: 12-VIII-99-2-301), collected at 229 m from a rock outcrop on the vertical wall near the sand bottom, is a conglomerate that was heavily encrusted with serpulid polychaete worm tubes, bryozoans, and thin encrusting sponges. From 224 to 183 m, the rugged, irregular and near vertical wall is pitted with 10-20 cm oval holes. The upper lip of the hole is vertical rugged rock, with 1-3 m outcrops. Overhangs on the wall occur at 192-195 m and 207 m. From 183- ~175 m, is a 30-60° slope with numerous <1 m rock outcrops or boulders on a muddy-sand bottom. Surrounding the top edge at depths of 172-175 m, is 90% hard bottom, with <1 m rock outcrops or boulders and 5-10 cm cobble. Further away from the top edge, the bottom is relatively flat silty-sand, with 30-60 cm scattered rock talus.

Dominant sessile macrofauna are predominately sponges with 14 taxa identified. Around the upper edge, the dominant sponges (5-25 cm diameter) include Lithistida (cup-shaped *Corallistes* sp. and frilly-plate *Leiodermatium* sp.), Pachastrellidae, Axinellida, and Hexactinellida. Counts from video transects along the top edge of the sinkhole at 172 m, indicate maximum densities of 5-10 *Corallistes* m<sup>-2</sup>. In addition, clusters of black comatulid crinoids (15 cm diam.) are common on the surrounding rock boulders along with slit shell gastropods (*Perotrochus amabilis*) and large spider crabs (*Mithrax?* sp., 12 cm carapace). No octocorals or scleractinians were observed along the top, but some stylasterid hydrocorals (5-10 cm tall) are present. Sponge diversity is greatest inside the sinkhole, on the vertical wall, where *Corallistes* spp. dominate along with Hexactinellida glass sponges (cup and trumpet, 25 cm) and various Demospongiae (*Strongylophora* sp., *Spongosorites* sp., Axinellida, and several species of Pachastrellidae). Small stylasterid hydrocorals are also common on the wall.

Fourteen species of fish were identified from the *Johnson-Sea-Link* videotapes. The largest concentration occurred around the top edge of the sinkhole. Species include schools of greater amberjack (*Seriola dumeril*) and anthiines (*Pronotogrammus martinicensis*, *Hemanthias vivanus*, *Anthias nicholsi*), red porgy (*Pagrus pagrus*), blueline tilefish (*Caulolatilus microps*), snowy

grouper (*Epinephelus niveatus*, 50 cm total length), speckled hind (*Epinephelus drummondhayi*, 60 cm), Warsaw grouper (*Epinephelus nigritus*, 120 cm), green moray (*Gymnothorax* sp., 40 cm), yellowedge grouper (*Epinephelus flavolimbatus*, 80 cm), blackbar drum (*Pareques iwamotoi*), and bigeye soldierfish (*Ostichthys trachypoma*). Congregations of amberjacks and large groupers were estimated at 10-100 and 10-20 individuals, respectively.

There was no evidence of salinity or temperature anomalies (such as an active seep or aquifer) within the hole; however, the submersible's CTD sensor was about 3 m off the bottom. In fact, temperature, salinity, and oxygen measurements were stable and consistent from the top to bottom of the hole.

The above account from *Johnson-Sea-Link* submersible dives were primarily along the south and west walls and bottom of the sinkhole. During the present Pulley Ridge survey, the ROV dive was made along the top edge of the sinkhole and down the upper walls, transecting along the south wall, east wall, and north wall from depths of 175 m (near top) to 205 m on the vertical rock wall. The ROV did not go to the bottom of the hole. Coordinates were taken at the rim of the south wall (26° 05.194'N, 84° 13.452'W; 175 m) starting the dive and at the north wall (26° 05.259'N, 84° 13.4846'W; 178 m). The previous dives located the bottom of the hole at (26° 05.179'N, 84° 13.467'W). There is some discrepancy in the two GPS locations but the previous JSL dive sites had been recorded repeatedly on various dives. The south wall is described above. On the ROV dive we found that the east wall is vertical rock below 183 m, and has a ledge or overhang at 192 m with very rugged topography and vertical fissures. Above 183 m the wall becomes less steep, ~40-80° slope, and then flattens out to about 30° with 1 m boulders along the top rim. At 175 m the top rim is primarily flat rock pavement with low relief ledges or outcrops. From 183-206 m the north wall varies from 60-90° rugged rock slope with ledges apparent at 187 m. Further west along the NW wall is a zone of smooth rock wall which is very different from the karst-like rugged rock wall elsewhere. This may be smoothed from sediment spills over the lip of the sinkhole in this region. This area has relatively sparse benthic biota compared to the more rugged portions of the wall.

In general, the benthic and fish species observed on this dive were comparable to those described previously (Reed et al., 2005). A total of 28 macro-invertebrate fauna were identified including 18 Porifera which are dominated by at least 4 species of Hexactinellida plate and vase shaped glass sponges (App. 2- Fig. 10), *Corallistes* cup sponges, and Lithistida. The site is too deep for algae. Cnidaria include various Antipathidae black corals and Hydroida. One species of scleractinian *Madracis mirabilis* (App. 2- Fig. 12) was observed but no deep sea *Lophelia pertusa* coral were seen. Both *Madracis* and *Stylasterina* corals were noted in this survey but not in Reed et al. 2005. Reed documented 14 species of fish (App. 2- Fig. 11) but this survey found xx species and including two additional species that were not listed before (queen snapper, misty grouper). One fishing line was found hung up on boulders along the rim but otherwise little evidence of fishing gear impacts were noted.

#### Site 5- Central HAPC (USF Multibeam Site)

The multibeam sonar survey indicated a N-S oriented ridge with 1 m relief, ~100 m in width, and ~ 1 km in length. We ran three ROV transects during the dive to maximize the various possible features of the ridge: Transect 1- North along the top of the ridge; Transect 2- West to the west base of the ridge; Transect 3- NE up the west slope and top of the ridge (we ran out of time prior to getting to the east slope of the ridge). Total length from the start and end coordinates was 116



m at 270° and at depths from 75-76 m. The dive was aborted early due to poor or no tracking and no compass. The feature turned out to be a sand dune or wave. No ledges or rock pavement were apparent. Two habitats occur at this site: sand with rubble and cobble (86% of the dive) and soft sand sediment (14%). The sand-rubble-cobble zone is primarily on top of the ridge and consists of 10-50% cover of rubble and 5-10 cm rock cobble (App. 2- Figs. 13,14). This rubble may overlay rock pavement in some areas as there are emergent gorgonians and black coral that would indicate hard bottom. Also occasional 2-m diameter piles of cobble may indicate fish burrowing activities. At the west base of the ridge the bottom is nearly 100% soft sand bottom with evidence of bioturbation.

Although this site did not have reef hard bottom, it was relatively diverse with a total of 50 benthic macro-biota including 25 Porifera, 7 Cnidaria (2 Gorgonacea, 1 Scleractinia, 2 Antipathidae), and 14 algae (6 Rhodophyta, 3 Phaeophyta, 5 Chlorophyta). The site is dominated by sponges and algae. The dominant algae are large sheets (10-30 cm) of the green alga *Anadyomene menziesii*, along with various brown algae *Lobophora variegata* and *Spatoglossum schroederi*, and leafy red algae *Peysonnellia*, *Liagora*, *Maripelta*, and *Rhodymenia*. All the sponges are demosponges and dominated by Spirastrellidae, *Bubaris*, *Lissodendoryx*, Axinellida, Raspailiidae, *Holopsamma*, *Geodia* and *Ircinia campana*. One scleractinian coral was tentatively identified (from poor quality video) as Agariciidae. Various species of agariciids are common on Pulley Ridge (USGS, 2004) especially at sites further south that we did not have the opportunity to survey due to mechanical failure of the ROV which shortened the cruise.

#### Site 6- Central HAPC (USF Multibeam Site)

The multibeam sonar survey of this site indicated two finger like ridges oriented NW-SE. The ROV dive consisted of one transect starting at the valley at the SW base of the first ridge, then headed north, over the ridge 1, into the valley and onto the ridge 2. Total distance from start to end coordinates was 760 m at 360° and depth range of 72-76 m. Both ridges and valleys between proved to be 100% soft sediment bottom with no evidence of rock rubble, ledges, or pavement (App. 2- Fig. 15). This site has the lowest diversity of benthic biota with only 8 taxa consisting of 1 Hydroida, 3 Echinodermata (Asteroidea starfish, Clypeastroidea sea biscuit, *Eucidaris tribuloides* pencil urchin; App. 2- Fig. 16), and 4 algae. The dominant fauna are the pencil urchin and vast mats an unattached red alga *Haloplegma duperreyi* (App. 2- Fig. 17). Although this alga is known to prefer low light habitat such as caves and caverns, this may be a new depth and geographic distributional record for the species (Littler and Littler, 2000).

#### Site 7- South Central HAPC (HBOI- J. Reed Site: 16-VIII-98-2)

This site was selected from a previous survey conducted by the Biomedical Marine Research Division of Harbor Branch Oceanographic Institution in 1998 (J. Reed, Chief Scientist). One short scientific trawl (5 minutes) was made at this site which indicated a sand-cobble bottom with a high diversity of sponges. Many of these were small and encrusted with sediment and rubble. A total of 49 taxa of sponges and macro-algae were collected. No multibeam is available for this site. The total distance from start to end coordinates of the ROV transect was 653 m at 90° from 74-76 m. One transect was made heading east. Tracking was out for the first 10 minutes of the dive. Two habitat types occur at this site: sand-rubble-cobble (30% of the dive) and soft sand sediment (70%). The rubble-cobble habitat consists of sand with 80-100%

cover of rubble, *Halimeda* hash, and <5 cm rock cobble. No pavement or ledges were observed. Although diversity of dominant benthic biota is relatively low, the density is high, primarily from red, green, and brown algae and small demosponges. Dominant demosponges include Choristida, *Cinachyra*, and various encrusting sponges. Dominant algae are the green algae *Anadyomene menziesii*, *Caulerpa verticillata*, *Codium*, *Verdigellas peltata*; brown algae *Lobophora variegata*, *Padina profunda*, *Spatoglossum schroederi*; and red algae *Haloplegma duperreyi*, *Rhodymenia* (App. 2- Fig. 18), and *Peysonnellia*. Two Cnidaria taxa include several colonies of the scleractinian *Madracis mirabilis* and one Ellisellidae gorgonian. No agariciid plate corals or black coral were observed.

The second half of the dive was on 100% sand bottom with areas of bioturbation indicated by 10 cm mounds. Patches of rubble appear to consist of plates of the calcareous green alga *Halimeda*. A surficial microbial layer is apparent over much of the sand habitat which binds the sediment. In particular, 1-2 m circular brown patches are common and are likely Cyanophyta blue green algal mats (App. 2- Fig. 19). These are not associated with any obvious fish burrows but could indicate seeps of high nutrient water. However, the CTD records did not indicate any evidence of this. The dominant biota in this habitat are a few demosponges and pencil urchins are common.

This site had a total of 27 benthic macro-biota, including 5 Porifera, 2 Cnidaria, and 15 algae.

### **Habitat Comparisons**

The sites are divided into two habitat types: soft bottom and hard/live bottom (Table 1). The soft bottom habitat is primarily sand sediment with relatively little rubble such as small size rock, bivalve shells or *Halimeda* plates. Where there is little or no rubble this habitat is often bioturbated which is evident by 5-10 cm conical mounds from infaunal activity by sipunculid, hemichordate, and/or polychaete worms. This habitat has the lowest diversity and density of epifauna. The hard/live bottom habitat is divided into two sub-categories: sand-rubble-cobble and low to high relief rock reef. The former is found primarily on top of the ridges and is relatively flat sandy bottom with varying amounts of cover of rubble (< 5 cm size rock or *Halimeda* plates) and cobble (5-10 cm size rock or algal nodules). This habitat ranges from low density cover (10-30%) to high density (30-100%). In some regions this sand-cobble habitat appears to cover underlying rock pavement as evident from the presence of sessile organisms such as gorgonians and black corals which require a hard, stable substrate. The 'reef' areas are of three types: isolated low relief (<1 m) 'patch' reefs, linear ledges of moderate relief (1-3 m), and a high relief sinkhole. The few patch reefs that occur in this region appear to be outcrops of hard bottom with rock pavement, low ledges or boulders (<1 m diameter). The most extensive reef was found on Dive 2. This is likely an ancient paleo-shoreline. This reef is oriented N-S with a west facing escarpment which consists of a series of rock ledges with a total relief of 6 m. The sinkhole on Dive 4 is a massive rock structure of karst topography. This site is west of the Pulley Ridge proper. Its surface depth of 175 m (bottom of hole= 230 m) is much deeper than the Pulley Ridge itself which lies along the 60-70 m contour of the shelf. All three hard bottom types provide habitat for the highest densities of benthic biota in this region.

Table 1. Percent cover of each major habitat type for each ROV site. Calculated from percent of time during each dive that was within that habitat type. Soft Bottom: 100% sand habitat with no or relatively little rubble; Hard Bottom: Sand-Cobble (high and low density cover of rubble and rock cobble on sand and may be overlying rock pavement), Reef (low to high relief ledges, boulders or rock pavement).

| ROV Dive | Hard Bottom |               | Soft Bottom |
|----------|-------------|---------------|-------------|
|          | Reef        | Rubble-Cobble | Sand        |
| Site 1   | 18          | 82            |             |
| Site 2   | 61          | 39            |             |
| Site 3   |             | 18            | 82          |
| Site 4   | 100         |               |             |
| Site 5   |             | 86            | 14          |
| Site 6   |             |               | 100         |
| Site 7   |             | 30            | 70          |

### **Benthic Biota**

A total of 147 taxa of benthic macro-invertebrates and algae were identified from the photographic and video ROV surveys (Table 2). In general, these taxonomic determinations can only be tentative at best. Exact identification of many deep-water sessile fauna such as sponges, gorgonians, and black coral is difficult or impossible without a specimen in hand. Most sponges and gorgonians require microscopic analysis of their spicules for proper identification. Many species look similar based on external morphological characters and many of the sponges in this area are small, encrusting species or are encrusted with sediment and debris making identification from video even more difficult. Therefore, many of the identifications are at order or class level, e.g., orange encrusting Demospongiae. Also the videotapes are low resolution and in many cases have serious noise problems obscuring part of the image. Furthermore, the photographic still images that were taken from a down-looking camera and used for quantification of benthos are not high resolution that would allow more detailed zoom for identifications.

Table 2. List of benthic macro-biota taxa from Pulley Ridge ROV dive sites (alphabetical order). Phylum: Ann= Annelida, Art= Arthropoda, Bry= Bryozoa, Chl= Chlorophyta, Cho= Chordata (Asciacea), Cni= Cnidaria, Cya= Cyanophyta, Ech= Echinodermata, Mol= Mollusca, Pha= Phaeophyta, Por= Porifera, Rho= Rhodophyta. Common Name terminology: bu= bushy, ze= thick encrusting, te= thin encrusting, fi= finger, eb= erect branching, fa= fan, fuz= fuzzy, bl= blade, ma= massive, tu= tubular, lo= lobate, cl= cluster, sp= spherical, pl= plate, st= stalked, ht= hollow tube, cb= creeping branching, va= vase, fl= flat; or= orange, re= red, br= brown, gn= green, ye= yellow, pu= purple, gy= grey, ta= tan, wh= white, pi= pink, la= lavender.

| Phylum | Taxonomy           | Common Name         | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 |
|--------|--------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|
| Ann    | Sabellidae         | feather duster worm |        |        |        |        |        |        | x      |
| Art    | Crustacea          | striped shrimp      |        |        |        | x      |        |        |        |
| Art    | Galatheididae      | squat lobster       |        | x      |        |        | x      |        |        |
| Art    | <i>Mithrax</i> sp. | spider crab         |        |        |        | x      |        |        |        |

|     |                                  |                      |   |            |   |   |    |   |   |
|-----|----------------------------------|----------------------|---|------------|---|---|----|---|---|
| Art | <i>Panularis argus</i>           | lobster              |   | x          |   |   |    |   |   |
| Art | <i>Stenorhynchus seticornis</i>  | arrow crab           | x | x          |   |   | x  |   | x |
| Bry | Bryozoa                          | bu                   | x |            |   |   |    |   |   |
| Chl | <i>Anadyomene menziesii</i>      | sea lettuce          |   |            |   |   | x  |   | x |
| Chl | <i>Caulerpa floridana</i>        | feather              |   |            | x |   | x  |   |   |
| Chl | <i>Caulerpa verticillata</i>     | stolon gn            |   |            |   |   |    |   | x |
| Chl | Chlorophyta                      | bu gn                |   |            |   |   |    |   | x |
| Chl | Chlorophyta                      | gn mat               |   |            | x |   |    |   |   |
| Chl | Chlorophyta                      | gn te                | x | x          |   |   |    |   |   |
| Chl | <i>Codium</i> sp.                | fuzzy gn             |   |            |   |   | x  |   | x |
| Chl | <i>Halimeda</i> sp.              | chain                |   |            | x |   | x  |   |   |
| Chl | <i>Verdigellas peltata</i>       | slimy gn             |   |            |   |   | x  |   | x |
| Cho | Ascidiacea                       | tunicate             | x | x          |   |   |    |   |   |
| Cho | Ascidiacea                       | ye ze tunicate       | x |            |   |   |    |   |   |
| Cho | Didemnidae                       | te                   | x | x          |   |   |    |   |   |
| Cni | Actiniaria                       | anemone              |   |            |   |   | x  |   |   |
| Cni | <i>Agaricia</i> sp.              | plate coral          |   |            |   |   | x? |   |   |
| Cni | <i>Antipathes caribbeana</i>     | black coral          |   | x          |   |   |    |   |   |
| Cni | <i>Antipathes expansa</i>        | black coral          |   | x          |   |   |    |   |   |
| Cni | <i>Antipathes rigida</i>         | black coral          | x |            |   |   |    |   |   |
| Cni | Antipathidae                     | black coral          | x | x (3 spp.) |   | x | x  |   |   |
| Cni | <i>Astrangia</i> sp.             | cup coral            |   | x          |   | x |    |   |   |
| Cni | <i>Bebryce</i> sp.               | gorgonian            |   | x          |   |   |    |   |   |
| Cni | <i>Carijoa</i> sp.               | gorgonian            | x | x          |   |   |    |   |   |
| Cni | <i>Cirripathes</i> sp.           | corkscrew coral      | x | x          |   |   | x  |   |   |
| Cni | <i>Condylactis gigantea</i>      | pink tip anemone     |   | x          |   |   |    |   |   |
| Cni | <i>Diodogorgia</i> sp.           | gorgonian            |   |            |   |   | x  |   |   |
| Cni | <i>Ellisella barbadensis</i>     | sea whip             |   | x          |   |   |    |   |   |
| Cni | Ellisellidae                     | sea whip             | x | x          |   |   | x  |   | x |
| Cni | Gorgonacea                       | gorgonian            | x | x          |   |   |    |   |   |
| Cni | Gorgoniidae                      | gorgonian            |   | x          |   |   |    |   |   |
| Cni | Hydroida                         | hydroid              | x |            | x | x | x  | x |   |
| Cni | <i>Madracis mirabilis</i>        | finger coral         |   |            |   | x |    |   | x |
| Cni | <i>Muricea</i> sp.               | gorgonian            | x | x          |   |   |    |   |   |
| Cni | <i>Parantipathes tetrasticha</i> | black coral          | x | x          |   |   |    |   |   |
| Cni | Pennatulacea                     | sea pen              | x | x          | x |   |    |   |   |
| Cni | Stylasterida                     | hydro coral          |   |            |   | x |    |   |   |
| Cni | <i>Swiftia exerta</i>            | red gorgonian        | x | x          |   |   |    |   |   |
| Cya | Cyanophyta                       | blue green algae mat |   |            |   |   | x  |   | x |
| Ech | Asteroidea                       | re starfish          |   |            |   |   |    | x |   |
| Ech | Clypeastroidea                   | sea biscuit          |   |            |   |   |    | x |   |
| Ech | Comatulida                       | crinoid              |   |            | x |   |    |   |   |
| Ech | <i>Eucidaris tribuloides</i>     | pencil urchin        |   |            | x | x |    | x | x |
| Ech | Gorgonocephalidae                | basketstar           | x |            |   |   |    |   |   |
| Ech | Holothuroidea                    | sea cucumber         |   |            |   | x |    |   |   |
| Ech | <i>Narcissia trigonaria</i>      | starfish             | x |            |   |   | x  |   |   |
| Mol | Gastropoda                       | egg case             |   |            | x |   |    |   |   |
| Mol | Octopoda                         | octopus              | x | x          |   |   |    |   |   |
| Mol | <i>Perotrochus</i> sp.           | slit shell           |   |            |   | x |    |   |   |
| Mol | <i>Xenophora</i> sp.             | carrier shell        |   |            |   |   |    |   | x |
| Pha | <i>Dictyota</i> sp.              | br eb                | x |            |   |   | x  |   |   |
| Pha | <i>Lobophyta variegata</i>       | br fa                | x | x          | x |   | x  | x | x |

|     |                                |                     |   |   |   |   |   |   |   |
|-----|--------------------------------|---------------------|---|---|---|---|---|---|---|
| Pha | <i>Padina profunda</i>         | br fa               |   |   |   |   |   |   | x |
| Pha | Phaeophyta                     | br                  |   | x |   |   |   |   |   |
| Pha | Phaeophyta                     | br bu               |   |   |   |   |   |   | x |
| Pha | Phaeophyta                     | br fuz              |   |   | x |   |   |   |   |
| Pha | <i>Sargassum</i> sp.           | seaweed             |   |   |   |   |   |   | x |
| Pha | <i>Spatoglossum schroederi</i> | br blade            |   |   |   |   | x | x | x |
| Por | <i>Anthosigmella varians</i>   | demosponge          |   |   |   |   | x |   |   |
| Por | <i>Aplysina fistularis</i>     | ma fi               | x |   |   |   |   |   |   |
| Por | <i>Aplysina</i> sp.            | re tu               |   |   |   |   | x |   |   |
| Por | <i>Auleta</i> sp.              | demosponge          |   |   |   |   | x |   |   |
| Por | Axinellida                     | finger              |   |   |   | x |   |   |   |
| Por | Axinellida                     | or fa               | x | x |   |   |   |   |   |
| Por | Axinellida                     | ye tu               |   |   |   |   | x |   |   |
| Por | <i>Bubaris</i> sp.             | demosponge          | x | x |   |   | x |   |   |
| Por | Choristida                     | ball por            |   |   |   | x |   |   |   |
| Por | Choristida                     | lo                  |   |   |   |   | x |   |   |
| Por | Choristida                     | ma                  | x |   |   |   |   |   |   |
| Por | Choristida                     | ma gy               | x |   |   |   |   |   |   |
| Por | Choristida                     | ta pl               |   |   |   |   | x |   |   |
| Por | <i>Cinachyra</i> sp.           | demosponge          | x |   |   |   |   |   |   |
| Por | <i>Corallistes</i> sp.         | cup                 |   |   |   | x |   |   |   |
| Por | Corallistidae                  | plate               |   |   |   | x |   |   |   |
| Por | Demospongiae                   | br ze               | x |   |   |   |   |   |   |
| Por | Demospongiae                   | br ze               | x |   |   |   |   |   |   |
| Por | Demospongiae                   | finger              | x |   |   |   |   |   |   |
| Por | Demospongiae                   | or te               |   |   |   |   | x |   |   |
| Por | Demospongiae                   | or ze               | x | x |   |   | x |   | x |
| Por | Demospongiae                   | pi te               |   |   |   |   | x |   |   |
| Por | Demospongiae                   | re ze               | x | x |   |   |   |   |   |
| Por | Demospongiae                   | ta lo               | x |   |   |   |   |   |   |
| Por | Demospongiae                   | ta lu               |   |   |   |   |   |   | x |
| Por | Demospongiae                   | ta ze               | x | x |   |   |   |   |   |
| Por | Demospongiae                   | wh lo               | x |   |   |   |   |   |   |
| Por | Demospongiae                   | wh ze               |   |   |   | x |   |   |   |
| Por | Demospongiae                   | ye te               |   | x |   |   |   |   |   |
| Por | Demospongiae                   | ye ze               | x |   |   |   |   |   |   |
| Por | Demospongiae                   | ye ze               |   |   |   | x |   |   |   |
| Por | Dictyoceratida                 | shaggy              |   |   |   |   | x |   |   |
| Por | <i>Geodia</i> sp.              | demosponge          | x |   |   |   | x |   |   |
| Por | Hadromerida                    | cl tu               |   |   |   |   |   |   | x |
| Por | Hadromerida                    | demosponge          |   | x |   |   | x |   |   |
| Por | Hadromerida                    | or cake             |   |   |   | x |   |   |   |
| Por | Hadromerida                    | st                  |   |   |   | x |   |   |   |
| Por | Halichondrida                  | br shag             | x |   |   |   |   |   |   |
| Por | Halichondrida                  | ta sp               |   |   |   |   | x |   |   |
| Por | Halichondrida                  | ye cake             |   |   |   | x |   |   |   |
| Por | Halichondrida                  | ye tu               |   | x |   |   |   |   |   |
| Por | Haplosclerida                  | demosponge          | x |   |   |   |   |   |   |
| Por | Haplosclerida                  | or tu               |   |   |   |   | x |   |   |
| Por | Hexactinellida sp.1            | vase glass sponge   |   |   |   | x |   |   |   |
| Por | Hexactinellida sp.2            | vase glass sponge   |   |   |   | x |   |   |   |
| Por | Hexactinellida sp.3            | flower glass sponge |   |   |   | x |   |   |   |
| Por | Hexactinellida sp.4            | plate glass sponge  |   |   |   | x |   |   |   |
| Por | <i>Holopsamma</i> sp.          | or ze               | x |   |   |   | x |   |   |

|     |                                     |              |   |   |   |   |   |   |   |
|-----|-------------------------------------|--------------|---|---|---|---|---|---|---|
| Por | <i>Ircinia campana</i>              | vase sponge  | x | x |   |   | x |   |   |
| Por | <i>Ircinia strobilina</i>           | stink sponge |   |   |   |   | x |   |   |
| Por | <i>Leiodermatium</i> sp.            | florette     |   |   |   | x |   |   |   |
| Por | <i>Lissodendoryx</i> sp.            | or ze        | x | x |   |   | x |   |   |
| Por | Lithistida                          | demosponge   |   |   |   | x |   |   |   |
| Por | <i>Mycale</i> sp.                   | demosponge   |   | x |   |   |   |   |   |
| Por | <i>Mycale</i> sp.2                  | pu           |   |   |   |   | x |   |   |
| Por | <i>Niphates</i> sp.                 | fi           |   |   |   |   | x |   |   |
| Por | <i>Niphates vaginalis</i>           | ht           | x |   |   |   |   |   |   |
| Por | Pachastrellidae                     | plate        |   |   |   | x |   |   |   |
| Por | Petrosiidae                         | demosponge   |   |   |   |   |   |   | x |
| Por | <i>Phakellia</i> sp.                | fa           | x |   |   |   |   |   |   |
| Por | <i>Placospongia melobesiodes</i>    | br cb        | x |   |   |   |   |   |   |
| Por | Poecilosclerida                     | demosponge   |   | x |   |   |   |   | x |
| Por | Poecilosclerida sp.1                | tu           |   |   |   |   | x |   |   |
| Por | Poecilosclerida sp.2                | re cake      |   |   |   |   | x |   |   |
| Por | Raspaillidae                        | demosponge   |   |   |   |   | x |   |   |
| Por | Spirastrellidae                     | re te        | x |   |   |   | x |   |   |
| Por | <i>Spongosorites</i> sp.            | ye cake      |   |   |   | x |   |   |   |
| Por | <i>Strongylophora</i> sp.           | demosponge   |   |   |   | x |   |   |   |
| Por | Verongida                           | demosponge   | x |   |   |   |   |   |   |
| Por | <i>Xestospongia muta</i>            | ta va        | x |   |   |   |   |   |   |
| Rho | <i>Amphiroa</i> sp.                 | bu           | x |   |   |   |   |   |   |
| Rho | <i>Amphiroa</i> sp.                 | re coralline |   | x |   |   |   |   |   |
| Rho | <i>Asparagopsis</i> sp.             | bu           |   | x |   |   |   |   |   |
| Rho | Corallinales or<br>Peyssonneliaceae | re coralline | x | x |   |   | x |   | x |
| Rho | <i>Dasya</i> sp.                    | eb re        |   |   |   |   | x |   |   |
| Rho | <i>Galaxaura</i> sp.                | re coralline |   | x |   |   |   |   |   |
| Rho | <i>Gracilaria</i> sp.               | bu           |   | x |   |   |   |   |   |
| Rho | <i>Haloplegma duperreyi</i>         | la fl blade  |   |   |   |   |   | x | x |
| Rho | <i>Kallymenia</i> sp.               | st blade     |   | x | x |   |   |   | x |
| Rho | <i>Liagora</i> sp.                  | pi bu        |   |   | x |   | x |   |   |
| Rho | <i>Maripelta</i> sp.                | re bl        |   |   |   |   | x | x |   |
| Rho | <i>Peyssonnelia</i> sp.             | re frilly    | x | x |   |   | x |   | x |
| Rho | Rhodophyta                          | fleshy re    |   | x |   |   |   |   |   |
| Rho | <i>Rhodymenia</i> sp.               | re blade     |   |   | x |   | x |   | x |

The dominant benthic biota in terms of species richness and density are Porifera (70 taxa), Cnidaria (23 taxa), and algae (14 Rhodophyta, 8 Phaeophyta, 9 Chlorophyta) (Table 3). The majority of these are found in the hard bottom habitat, either rubble-cobble bottom or reef. Overall, the greatest species richness occurs in the high density sand-rubble-cobble areas which provide habitat for attachment of sessile biota, primarily sponges and algae. Sites 1 and 5 have the greatest species richness (52 and 50 taxa, respectively) and corresponding greatest percent cover of rubble-cobble habitat. Surprisingly, Sites 2 and 4 which have the greatest percent cover of reef habitat (61 and 100%, respectively), have intermediate species richness (24 and 28 taxa, respectively). Although the reef sites that have the largest sessile biota, such as sponges and gorgonians, the overall diversity appears less than the rubble-cobble habitat. Also Sites 2 and 4 have strikingly different sessile biota. Site 4, Naples Sinkhole, has a completely different species complement than any of the other Pulley Ridge sites since it is 175-230 m deep compared to 73-84 m at the other sites. It lacks the gorgonians and algae found at the shallower sites and is dominated by both demosponges (primarily Lithistida and Corallistidae) and Hexactinellida glass

sponges not found elsewhere. Sites 3 and 6 have relatively high percent cover of sand habitat and the lowest numbers of taxa (primarily sponges and algae). However, Site 7 which also has 70% cover of sand has much higher species number (27) compared to the other sandy sites. This was the result that the first part of that transect had the highest density of cover of rubble-cobble (70-100% cover) of all the sites.

Table 3. Number of benthic macro-biota taxa at each ROV site. Por= Porifera, Cni= Cnidaria, Rho= Rhodophyta, Pha= Phaeophyta, Chl= Chlorophyta. Total taxa also includes motile benthic species such as Echinodermata, Mollusca, and Arthropoda.

| ROV Dive   | # Taxa | Por | Cni | Rho | Pha | Chl |
|------------|--------|-----|-----|-----|-----|-----|
| Site 1     | 52     | 27  | 11  | 3   | 2   | 1   |
| Site 2     | 24     | 12  | 18  | 8   | 2   | 1   |
| Site 3     | 13     | 0   | 2   | 3   | 2   | 3   |
| Site 4     | 28     | 18  | 5   | 0   | 0   | 0   |
| Site 5     | 50     | 25  | 7   | 6   | 3   | 5   |
| Site 6     | 8      | 0   | 1   | 2   | 2   | 0   |
| Site 7     | 27     | 5   | 2   | 5   | 5   | 5   |
| Total Taxa | 147    | 70  | 23  | 14  | 8   | 9   |

### **Quantitative Analysis of Benthic Habitat and Biota**

Point count analysis of the downward looking photographic still images provides quantitative data on the relative percent cover of substrate types (rock ledge, rock pavement, rubble-cobble, sand), sessile macro-biota (scleractinian corals, gorgonians, black corals, sponges, algae, miscellaneous sessile biota, e.g., zoanthids, anemones, ascidians), benthic motile invertebrates (echinoderms, molluscs, decapod crustaceans), and fish. This analysis shows that Site 4 has 76% cover of rock ledge (Table 4, Fig. 1). This varies from Table 1 in that 100% of the dive was on rock ledge and wall, but individual points within point count analysis may fall on a small patches of sand. Sites 1 and 2 also have high percent cover of rock ledge (10 and 31%, respectively). Sites 5 and 7 show the greatest percent cover of rubble (20 and 55%, respectively) whereas Site 1 has 7% rubble. This also varies from the analysis of Table 1. Although 30% of the dive time at Site 7 was on rubble-cobble bottom, point counts show a relatively high percent cover (55%) since the rubble-cobble was much denser here than at Site 1. Also although the majority of the dive time at Site 1 was on sand-rubble bottom (82%), this was mostly low density rubble so the majority of the individual point counts landed on sand even though the overall habitat was rubble-cobble. So there is discrepancy depending on how the data is analyzed and perceived.

Point count provides data for comparative analysis of dominant sessile benthic species and their relative cover or density (Table 4, Fig. 1). The dominant species as described above (Table 2) were grouped into larger categories for calculating percent cover. Overall, the dominant sessile taxa are algae (15 and 8% cover at Sites 5 and 3, respectively), sponges (13 and 6% at Sites 4 and 5, respectively), and coral (8% at both Sites 1 and 2). Hard corals are relatively rare, so the dominant coral taxa are Gorgonacea (5 and 4% at Sites 1 and 2, respectively) and Antipatharia (4 and 3% at Sites 2 and 1). Scleractinian corals are very rare, only resulting in <1% cover at all sites and comprised primarily of *Madracis mirabilis*, *Astrangia*, and one possible sighting of an

agariciid plate coral. Algae are most dominant at Site 5 where all three classes (red, green, brown) are common. Red algae are common at Sites 2, 3, 5 and 7 (5, 5, 5, and 2% cover, respectively). Excluding the sinkhole Site 4 which is totally different in geomorphology and species from the other Pulley Ridge sites; overall, Site 2 with the extensive high relief ledge system provides the most diverse fauna with 8, 3, and 6% cover of coral, sponge and algae, respectively. The large 50-100 cm gorgonians (primarily, *Swifia exerta*) provide additional 3-dimensional structure for benthic fauna and fish. This site also has the greatest diversity of reef fish and densities of larger grouper species.

Table 4. Quantitative point count analysis (CPCe, Kohler and Gill, 2006) of still images (mean percent cover) for habitat types and benthic macro-biota at each ROV dive site.

| <b>MAJOR CATEGORIES<br/>(% of transect)</b> | <b>Site 1</b> | <b>Site 2</b> | <b>Site 3</b> | <b>Site 4</b> | <b>Site 5</b> | <b>Site 6</b> | <b>Site 7</b> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| CORAL                                       | 8             | 7.98          | 0             | 0.96          | 0.4           | 0             | 0.4           |
| SPONGE                                      | 3.14          | 3.49          | 0             | 12.79         | 6.27          | 0             | 0.27          |
| ALGAE                                       | 1.26          | 5.56          | 8.07          | 0             | 15.36         | 0.13          | 5.22          |
| OTHER SESSILE LIVE                          | 0.7           | 0.13          | 0             | 0             | 0.13          | 0.4           | 0.13          |
| FISH  | 0.55          | 2.43          | 0.24          | 0.71          | 0.27          | 0             | 0             |
| OTHER MOBILE LIVE                           | 0             | 0.27          | 0.72          | 0.24          | 0             | 0.4           | 0.81          |
| SAND, RUBBLE, PAVEMENT                      | 86.21         | 80.13         | 90.27         | 85.18         | 77.43         | 86.79         | 89.97         |
| UNKNOWNNS                                   | 0.14          | 0             | 0.71          | 0.13          | 0.13          | 12.28         | 3.2           |
| TAPE, WAND, SHADOW                          | 1.93          | 4.27          | 1.18          | 2.82          | 0.27          | 0             | 0.27          |
| <b>SUBCATEGORIES (% of transect)</b>        |               |               |               |               |               |               |               |
| CORAL                                       |               |               |               |               |               |               |               |
| Antipatharia                                | 2.81          | 4.3           | 0             | 0.37          | 0             | 0             | 0             |
| Gorgonacea                                  | 5.19          | 3.55          | 0             | 0.12          | 0.4           | 0             | 0             |
| Millepora                                   | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| Scleractinia                                | 0             | 0.13          | 0             | 0.47          | 0             | 0             | 0.4           |
| SPONGE                                      |               |               |               |               |               |               |               |
| Sponge                                      | 3.14          | 3.49          | 0             | 12.79         | 6.27          | 0             | 0.27          |
| ALGAE                                       |               |               |               |               |               |               |               |
| Chlorophyta                                 | 0.14          | 0.24          | 1.43          | 0             | 4             | 0             | 0.8           |
| Phaeophyta                                  | 0.14          | 0.27          | 1.9           | 0             | 6.15          | 0             | 2.4           |
| Rhodophyta                                  | 0.98          | 5.05          | 4.74          | 0             | 5.21          | 0.13          | 2.02          |
| OTHER SESSILE LIVE                          |               |               |               |               |               |               |               |
| Zoanthid                                    | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| anemone                                     | 0             | 0.13          | 0             | 0             | 0             | 0             | 0.13          |
| ascidian                                    | 0.14          | 0             | 0             | 0             | 0             | 0             | 0             |
| hydroid                                     | 0.56          | 0             | 0             | 0             | 0.13          | 0.4           | 0             |
| FISH  |               |               |               |               |               |               |               |
| Fish  | 0.55          | 2.43          | 0.24          | 0.71          | 0.27          | 0             | 0             |
| OTHER MOBILE LIVE                           |               |               |               |               |               |               |               |
| decapod                                     | 0             | 0.27          | 0             | 0.24          | 0             | 0             | 0             |
| echinoderm                                  | 0             | 0             | 0.72          | 0             | 0             | 0.27          | 0.81          |
| mollusk                                     | 0             | 0             | 0             | 0             | 0             | 0.13          | 0             |



|                        |       |       |       |       |       |       |       |
|------------------------|-------|-------|-------|-------|-------|-------|-------|
| SAND, RUBBLE, PAVEMENT |       |       |       |       |       |       |       |
| Pavement               | 15.59 | 6.8   | 0     | 0     | 0     | 0     | 0     |
| Rubble                 | 6.81  | 6.01  | 3.78  | 3.75  | 20.86 | 0.53  | 55.6  |
| Sand                   | 53.6  | 36.05 | 86.49 | 5.21  | 56.44 | 86.26 | 34.37 |
| rock ledge             | 10.21 | 31.27 | 0     | 76.22 | 0.13  | 0     | 0     |
| UNKNOWNNS              |       |       |       |       |       |       |       |
| unknown                | 0.14  | 0     | 0.71  | 0.13  | 0.13  | 12.28 | 3.2   |
| TAPE, WAND, SHADOW     |       |       |       |       |       |       |       |
| Human artifact         | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Shadow                 | 2.22  | 5.74  | 1.25  | 3.09  | 0.28  | 0     | 0.29  |
| Sub part               | 0     | 0     | 0     | 0     | 0     | 0     | 0     |

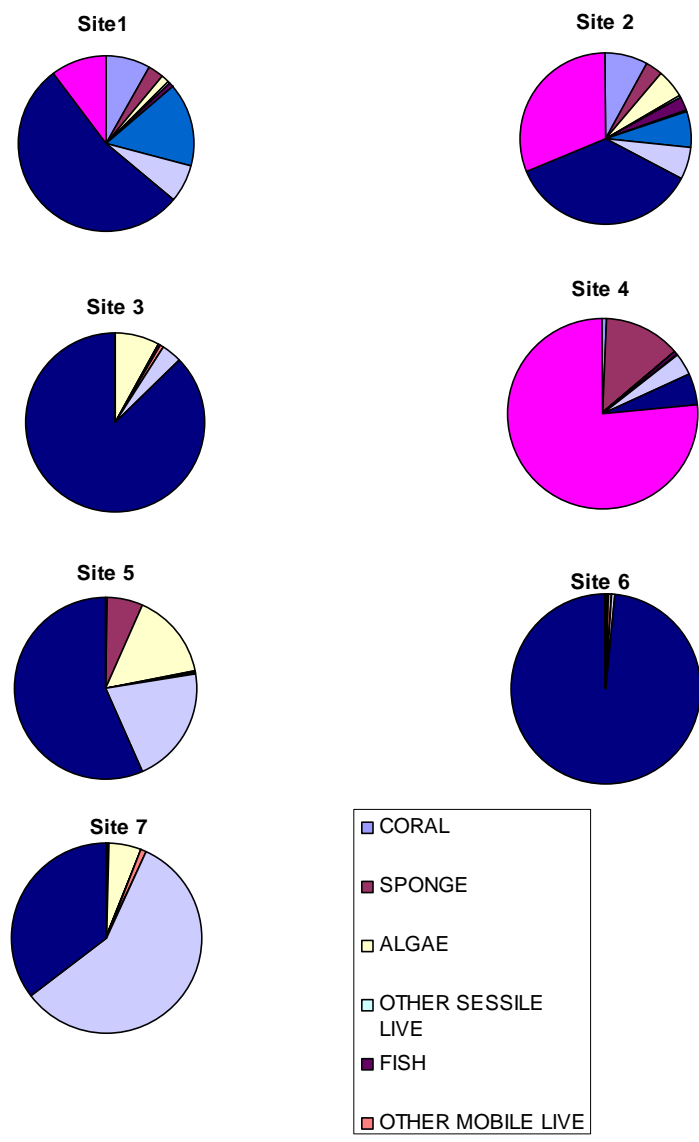


Figure 1. Quantitative point count analysis of still images (mean percent cover) for habitat types and benthic macro-biota at each ROV dive site.

## CONCLUSIONS

### **Multibeam Sonar as a Habitat Predictor**

Four of the seven sites that we surveyed were selected from multibeam sonar maps. Sites which showed some potential for hard bottom or at least high relief bottom were selected over featureless, flat bottom. The sonar images proved to be excellent in providing an accurate topological map of the bottom that allowed us to lay out dive transects prior to each dive that would allow us to ground truth each feature. We tried to survey each feature by conducting various transects during each dive that would cover the top of the feature and east and west (or north or south) slopes of the feature. The following gives a brief description of the sonar image and what we found at these four dive sites.

Site 2's sonar showed a 4-m relief ridge. The ROV dive found this to be a N-S oriented reef ridge with about 4-6 m relief on the west face. On top of the ridge we found sand and cobble with several patch reefs. The sharp drop off or escarpment of the feature was accurately indicated in the sonar image but we were not able to predict what type of habitat would be on top of the feature. The reefs also had the highest density of macro-biota which may be predicted based on the relatively high-relief escarpment of the sonar image. Basically, where there is dramatic high relief, it is likely hard bottom or rock which will provide substrate for benthic organisms. Site 3's sonar image showed three E-W oriented ridges, 1 km long, with 3 m relief. We could not predict the habitat on top of this feature prior to the dive. We found the feature to be basically a sand ridge, with 82% cover of soft bottom and no hard-bottom organisms were present. Site 5's sonar showed a 1-m tall N-S ridge, about 100 m wide and 1 km long. We found the feature to consist of a sand bottom with high density of rubble and cobble which provided habitat for a high diversity and density of sponges and algae. In fact, this site had 50 benthic taxa compared to the high-relief reef Site 2 which had 24 taxa. Site 6's sonar image showed two NW-SE oriented finger ridges. We found these to be nearly 100% sand bottom with some patches of rubble, and no hard bottom organisms were present.

We found that we could track (when working) the ROV over the displayed georeferenced sonar image with pinpoint accuracy (or at least to 1-3 m resolution). However, we could not predict *a priori* what the bottom habitat would be like. Also we could not predict what the benthic biota would be, the diversity or density of the biota. Side-scan sonar and more recently multibeam sonar has provided an indispensable tool for mapping large swaths of the bottom. Ideally we would like to be able to use the resulting images to predict the benthic habitat types. However, this has proved difficult and at times impossible. Without ground truthing of the maps by visual means such as video surveys with ROV or submersible, it is not possible to determine bottom types in many cases, especially for differentiating different types of hard bottom. The PI (J. Reed) has used side-scan sonar and multibeam sonar extensively to map regions of deep-water reefs (depths 600-800 m) in the Straits of Florida (Grasmueck et al., 2007), and also the deep-water *Oculina* reefs within the *Oculina* Habitat Area of Particular Concern off central eastern Florida (Reed et al., 2005b, 2007). We have had limited success in using the sonar to predict bottom habitat type. We can tell hard from soft (sand or mud) but not what habitat or biota exists in the various hard bottom sonar returns. However, the high-relief, hard bottom sonar return can

be used to predict a hard bottom habitat which usually indicates a high diversity of sessile, hard bottom organisms, which also in turn usually results in high diversity of fish.

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## APPENDIX 1

Annotations of each dive videotape describing habitat and benthic biota and including coordinates, depth, time, habitat description, fish and benthic biota, and human artifacts.

| <b>Pulley Ridge HAPC Cruise: Evaluation of Habitat and Fish - August 17-30, 2007</b> |   |                          |  |                        |  |                      |             |  |                      |
|--|---|--------------------------|--|------------------------|--|----------------------|-------------|--|----------------------|
| NOAA/UCONN NURC ROV Survey   |   |                          |  |                        |  |                      |             |  |                      |
| NASA Vessel M/V Freedom Star   |   |                          |  |                        |  |                      |             |  |                      |
| NOAA NURP Super Phantom ROV  |   |                          |  |                        |  |                      |             |  |                      |
| <b>Date</b>  | 8/26/2007                                       |                          |  |                        |  |                      |             |  |                      |
| <b>Location</b>  | Pulley Ridge- J Reed Site; N. of HAPC           |                          |  |                        |  |                      |             |  |                      |
| <b>ROV Dive #</b>  | 1   |                          |  |                        |  |                      |             |  |                      |
| <b>Video Tape #</b>  | 1   |                          |  |                        |  |                      |             |  |                      |
| <b>Station #</b>   | 2   |                          |  |                        |  |                      |             |  |                      |
| <b>Transect Description- Length, Heading</b>   | 149 m, 353 dg; 3 transects- heading E, N, and W | Annotations by John Reed | Dive site= HBOI J. Reed Site 13-VIII-95-3,4; 17-VII-92-2; no multibeam of site |                        |  |                      |             |  |                      |
| <b>Time</b>  | <b>Depth (ft)</b>                               | <b>Latitude</b>          | <b>Longitude</b>   | <b>Notes</b>           | <b>Habitat Description</b>               | <b>Habitat Type</b>  | <b>Fish</b> | <b>Invertebrates</b>                                     | <b>Human impacts</b> |
| 9:25:00- subtract 5 minutes for true time  | 242   | 26 15.7978               | 83 42.9635   | on bottom              | Sand, rubble, cobble, <10% cover, flat   | Sand, rubble, cobble |             |  |                      |
| 9:38   | 243   |                          |  | Transect 1- heading SE | Sand, rubble 5 cm diam, <10% cover, flat |                      |             | sparse demosponges 5-10 cm, hydroids, Pennatulacea 30 cm |                      |

|      |     |            |            |                      |   |                                     |                                  |  |  |
|------|-----|------------|------------|----------------------|---|-------------------------------------|----------------------------------|--|--|
| 9:40 | 236 | 26 15.7931 | 83 42.9444 | Patch Reef #1        | Patch reef #1- 26 15.7931, 83 42.9444; Low relief hard bottom - 4' relief, few ledges or outcrops, smooth rock; dense cover gorgonians, sponges, fish | Patch reef- low relief, hard bottom | jackknife fish, angelfish, scamp | Gorgonians- 80 cm Swiftia exerta, Ellisellidae; Gorgonocephalidae basketstar; Sponges- Demospongia 5-10 cm, Axinellidae, Placospongia, Bubaris; Antipathidae; Didemnidae |  |
| 9:41 |     |            |            |                      |   |                                     | red grouper                      |  |  |
| 9:42 |     |            |            |                      |   |                                     | bigeye                           |  |  |
| 9:43 | 242 |            |            |                      |   |                                     | reef butterfly                   | black coral  |  |
| 9:46 | 243 |            |            | end of reef          | Sand, rubble, cobble, 10-30% cover; few 20-30 cm boulders   | Sand, rubble, cobble                | bank seabass                     | orange sponges   |  |
| 9:48 | 234 |            |            |                      | Sand, cobble, over pavement?  |                                     |                                  | starfish - Narcissia trigonaria; Cirrhipathes, Antipathidae, Ircinia campana?  |  |
|      | 240 |            |            |                      | 1 m diameter fish burrow, pile of 5-10 cm cobble  |                                     |                                  |  |  |
| 0951 | 244 |            |            | Transect 2-Heading N |   |                                     | school of fish                   | octopus  |  |
| 0955 | 240 |            |            |                      |   |                                     | porgy, tattler                   |  |  |



|      |     |  |  |                                      |  |                                     |                             |  |  |
|------|-----|--|--|--------------------------------------|--|-------------------------------------|-----------------------------|--|--|
| 0958 | 236 |  |  | Patch Reef #2                        | Patch reef- low relief hard bottom, few ledges, smooth pavement; dense gorgonians, sponges | Patch reef- low relief, hard bottom | reef butterfly, porgy       | Gorgonians- 50-80 cm <i>Swiftia exerta</i> , Ellisellidae, spp. gorgonians; Cirrhipathes; demosponges- <i>Cinachyra</i> , Verongid; Antipathidae |  |
|      |     |  |  |                                      |  |                                     | reef butterfly              | Geodia sponge  |  |
| 959  | 237 |  |  | off reef                             | Pavement, rubble, cobble   | Sand, rubble, cobble                |                             |  |  |
| 1003 | 231 |  |  |                                      | rock rubble  |                                     |                             |  |  |
| 1004 | 234 |  |  |                                      | fish burrow- patch of dense cobble   |                                     | short bigeye, bank sea bass | 15 cm Gorgonian. <i>Muricea?</i> Sp.   |  |
| 1005 | 234 |  |  |                                      | Pavement, rubble, cobble; sparse gorgonians, sponges                                       | Pavement, rubble, cobble            |                             | 80 cm <i>Swiftia exerta</i> ; <i>Ircinia campana</i> ; Didemnidae; Hydroida  |  |
| 1008 | 238 |  |  |                                      |  |                                     | porgy                       |  |  |
| 1010 | 224 |  |  |                                      | Pavement, rubble, cobble; gorgonians, sponges  |                                     |                             | <i>Swiftia exerta</i> , <i>Ircinia campana</i> , Cirrhipathes,   |  |
| 1013 | 234 |  |  | Transect 3- change heading to 270 dg |  | Sand, cobble, rubble                |                             | <i>Swiftia</i> , Axinellidae sponge  |  |

|                     |                              |            |            |                 |   |                                     |  |  |  |
|---------------------|------------------------------|------------|------------|-----------------|---|-------------------------------------|--|--|--|
| 1014                | 227 top                      |            |            | Patch Reef #3   | Patch Reef #3- 26<br>15.8940, 83 42.9271;<br>Low relief hard bottom, pavement, 1-2' ledges, 1-2' solution holes, ~10' relief; dense gorgonians, sponges | Patch reef- low relief, hard bottom | cubbyu, squirrel fish, angelfish, rock hind, cotton wick | Gorgonians- 4-5 spp-<br>Swiftia exerta,<br>Ellisellidae;<br>Cirripathes,<br>Antipathidae- 3 spp,<br>Antipathes rigida?;<br>Demosponges-<br>Axinellidae, Niphates vaginalis,<br>Haplosclerida |  |
| 1020                | 238                          |            |            | off reef        | flat sand, sparse cobble  | Sand, cobble                        |  |  |  |
| 1021                | 238                          |            |            |                 | sand, <10% cobble   |                                     |  | Demosponges-<br>Axinellidae,<br>Cinachyra sp.  |  |
| 1031                | 242                          | 26 15.8781 | 83 42.9746 | end of transect |   |                                     |  |  |  |
| <b>Date</b>         | 8/26/2007                    |            |            |                 |   |                                     |  |  |  |
| <b>Location</b>     | Pulley Ridge - north of HAPC |            |            |                 |   |                                     |  |  |  |
| <b>ROV Dive #</b>   | 2                            |            |            |                 |   |                                     |  |  |  |
| <b>Video Tape #</b> | 2                            |            |            |                 |   |                                     |  |  |  |
| <b>Station #</b>    | 4                            |            |            |                 |   |                                     |  |  |  |

|  |   |                       |  |   |   |                           |                     |                               |                      |
|--|---|-----------------------|--|---|---|---------------------------|---------------------|-------------------------------|----------------------|
| <b>Transect Description- Length, Heading</b> | 587 m, 321 dg; 2 Transects- Transect 1 west across 2 reefs, Transect 2- north along west edge of Reef 2 | Annotation- John Reed | USF Multibeam Site- 4 m relief ledge; start on top of ridge, heading west to drop off of ledge, then head north along west face of ledge |   |   |                           |                     |                               |                      |
| <b>Time</b>                                  | <b>Depth (ft)</b>   | <b>Latitude</b>       | <b>Longitude</b>   | <b>Notes</b>  | <b>Habitat Description</b>  | <b>Habitat Type</b>       | <b>Fish Species</b> | <b>Invertebrates</b>          | <b>Human impacts</b> |
| 1155- subtract 5 minutes for true time       | 250   | 26 21.0627            | 83 46.5494   | on bottom - start transect; data overlay poor with noise, unable to see time or direction most of time, video poor quality; heading northerly | Sand, rubble, 5-10 cm cobble, <10% cover; sparse benthic macrobiota | Sand, rubble, cobble      | lizardfish          | few demosponges, Pennatulacea |                      |
| 1201   | 257   |                       |  |   | dense cobble 30- >50% cover; fish burrow with pile of cobble        | Sand, cobble, dense cover | tattler             |                               |                      |

|      |         |  |  |   |  |                                       |                 |   |  |
|------|---------|--|--|---|--|---------------------------------------|-----------------|---|--|
| 1203 | 253     |  |  | Heading westerly  | Sand cobble, <30% cover; sparse benthic biota  | Sand, rubble, cobble                  |                 | few demosponges                                       |  |
| 1212 | 253     |  |  |   |  |                                       | lizardfish      | more sea pens   |  |
| 1214 | 255     |  |  | Patch Reef #1   | Isolated patch reef-several boulders 1-2 m diam, low relief ledges <50 cm; dense fish reef fish, sparse benthic macro-biota  | Patch reef, boulders, cobble          | school of scad? |   |  |
| 1215 | 255     |  |  |   | <1m rock outcrops  |                                       | dense reef fish | arrow crabs   |  |
| 1218 | 255     |  |  | off reef  | sand, cobble; 50 cm fish burrows with cobble piles   | sand, cobble                          | sand diver      |   |  |
| 1220 | 255     |  |  | Patch Reef #2 or same as 1; audio and data overlay starting to work | Patch reef- < 10 m diam.; scattered 1-2 m boulders, < 1m relief; dense reef fish, numerous scamp, sparse macro-benthic biota | Patch Reef, boulders, cobble          | jackknife fish  | octopus   |  |
| 1222 | 251     |  |  | Heading westerly  | sand, dense cobble; sparse benthic macro-biota, no gorgonians  | Sand, cobble                          | tattler         | few Pennatulacea                                      |  |
| 1230 | 246     |  |  |   | Dense cobble >50% cover; no ledges, sparse biota   |                                       | porgy, tattler  |   |  |
| 1234 | 246 top |  |  | Reef #3   | Reef, N-S ridge, paelo-shoreline reef; 1-2 m boulders, <1 m relief; dense fish, sparse gorgonians, black coral, demosponges, | Linear reef, boulders, ledges, cobble | reef fish       | 40 cm gorgonians- Muricea, Cirrhipathes, Antipathidae |  |

|      |               |            |           |   |   |  |   |   |              |
|------|---------------|------------|-----------|---|---|--|---|---|--------------|
| 1236 | 265<br>bottom | 26 21.0607 | 83 46.759 | drop off of ledge; depth readout erratic-varied from 255 to 265 ft when stopped on bottom | West face of ledge, about <1 m relief, heading N-S, with boulders and rock slabs; total relief of reef from 245 to 265 ft; west edge drop off about 10-20 m wide, 20 dg slope with layers of boulders and rock ledges, 100% hard bottom, cobble; dense biota- gorgonians, black coral |  | scamp, rough tongue bass  | Axinellidae, Plexauridae, Ellisellidae, Cirrhipathes, |              |
| 1239 | 263           |            |           |   |   |  | rough tongue bass, wrasse bass, wrasse, short bigeye, several scamp | Swiftia, Cirrhipathes                                 | fishing line |
| 1241 | 265           |            |           | Heading north along west face of reef w/ camera facing E toward face of reef              |   |  |   |   |              |

|      |     |            |            |   |   |  |             |  |                    |
|------|-----|------------|------------|---|---|--|-------------|--|--------------------|
| 1243 | 270 | 26 21.0879 | 83 46.7604 | series of still photos along edge of reef   | same reef, 1 m relief ledges and boulders                                     |  | reef fish   | lobster; 2-3 spp Antipathidae, Parantipathes tetrasticha?; Ellisella barbadensis, Muricea sp., dominated by gorgonians and black coral, Swiftia exerta, Ellisellidae; few large sponges, no hard coral | cable or long line |
| 1249 | 242 |            |            | series of photos along upper 1/2 of west face of reef; still heading N along face                             | same reef   |  |             |  |                    |
| 1254 | 245 |            |            | series of photos along top of reef edge, heading north; depth readout ranging from 245 to 275 when not moving | same reef, top of reef, more flat pavement, 100% hard bottom, 10-20 cm relief |  |             | Ellisellidae, Axinellidae, Cirrhipathes, Swiftia, Antipathidae, Antipathes expansa?, A. caribbeana?  |                    |
| 1256 | 264 |            |            |   | small rock outcrops   |  |             |  |                    |
|      |     |            |            |   |   |  | red porgies |  |                    |

|                     |                              |            |            |   |  |  |   |   |  |
|---------------------|------------------------------|------------|------------|---|--|--|---|---|--|
| 1259                | 257                          |            |            | heading N along west top edge of reef; series of photos | same reef, top of reef, low relief, rock pavement      |  | bigeye  | Ircinia campana, 3 spp. Antipathidae, Ellisellidae, few Axinellidae, Bubaris? Sp., Swiftia exerta; few demosponges, mostly gorgonians, Antipathidae |  |
| 1303                | 257                          |            |            | heading N along west face                               | same reef  |  |   | no algae (except encrusting coralline red), no scleractinia coral   |  |
| 1305                | 257                          |            |            |   |  |  | several scamp, schools of anthiids, angelfish |   |  |
| 1311                | 260                          | 26 21.3084 | 83 46.7733 | depth overlay not correct - jumping all over the place  | same reef, 1 m relief along west face; end of transect |  |   |   |  |
| <b>Date</b>         | 8/26/2007                    |            |            |   |  |  |   |   |  |
| <b>Location</b>     | Pulley Ridge - north of HAPC |            |            |   |  |  |   |   |  |
| <b>ROV Dive #</b>   | 3                            |            |            |   |  |  |   |   |  |
| <b>Video Tape #</b> | 3                            |            |            |   |  |  |   |   |  |
| <b>Station #</b>    | 9                            |            |            |   |  |  |   |   |  |

| Transect Description- Length, Heading  | 0 m- start, end coordinates same?, tracking not correct; headed north entire transect for 30 minutes | Annotation- John Reed | Multibeam Site- 3 E-W oriented finger ridges; 3 m relief, 1 km long |   |   |                                   |                      |  |               |
|--|--|-----------------------|---|---|---|-----------------------------------|----------------------|--|---------------|
| Time                                   | Depth (ft)   | Latitude              | Longitude   | Notes   | Habitat Description   | Habitat Type                      | Fish Species         | Invertebrates  | Human impacts |
| 1554- subtract 5 minutes for true time | 266  | 26 12.5892            | 83 45.5378  | start transect; data overlay with noise, difficult to see most of time                              | sand, shell rubble, flat, no hard bottom; sparse benthic macro-fauna, some bioturbation, 5-10 cm mounds | Sand, sparse rubble; soft bottom  | flounder, lizardfish | Pennatulacea, 5 cm hydroids, few demosponges, no hard coral, no algae, Stylocidaris or Eucidaris pencil urchin |               |
| 1603                                   | 266  |                       |   |   | same, more bioturbation, 5-10 cm mounds and depressions   | Sand, sparse rubble, cobble; soft |                      |  |               |
| 1608                                   | 266  |                       |   | at base of first of three NW-SE oriented ridges (~3m relief on multibeam) - appear to be sand waves | same, occasional fish burrow 1 m depression   | sand, soft sediment               |                      | 30 cm Pennatulacea; pencil urchins Eucidaris? Sp., red-white Comatulid crinoids common                         |               |



|                     |  |                         |                         |                               |   |   |                                 |   |  |
|---------------------|--|-------------------------|-------------------------|-------------------------------|---|---|---------------------------------|---|--|
| 1611                | 261  |                         |                         | coming up slope of sand ridge | same; 100% soft sediment, no hard bottom; less bioturbation |   | eel poking its head out of hole | dominant fauna- crinoids, pennatulacea                                    |  |
| 1617                | 255  |                         |                         | slope of dune                 | same  |   |                                 | 10 cm hydroid, Caulerpa   |  |
| 1620                | 255  |                         |                         | on top of first ridge         | sand, soft bottom, 10% rubble, cobble                       | sand, soft sediment, 10% cobble,        |                                 | Caulerpa floridana?- Feathery caulerpa; 10 cm hydroid                     |  |
| 1625                | 257  | 26 12.5892- not correct | 83 45.5378- not correct | End transect                  | sand, soft bottom, sparse rubble, cobble                    | sand, soft sediment, 10% cobble, rubble | lizardfish                      | bryozoan, red coralline algae? Liagora?, small Demospongiae, Ellisellidae |  |
| <b>Date</b>         | 8/26/2007  |                         |                         |                               |   |   |                                 |   |  |
| <b>Location</b>     | Pulley Ridge-northwest of HAPC-J. Reed Sinkhole site |                         |                         |                               |   |   |                                 |   |  |
| <b>ROV Dive #</b>   | 4  |                         |                         |                               |   |   |                                 |   |  |
| <b>Video Tape #</b> | 4 a & b  |                         |                         |                               |   |   |                                 |   |  |
| <b>Station #</b>    | 10   |                         |                         |                               |   |   |                                 |   |  |

|  |  |                       |   |  |                            |                                  |                     |  |                      |
|--|--|-----------------------|---|--|----------------------------|----------------------------------|---------------------|--|----------------------|
| <b>Transect Description- Length, Heading</b> | 133 m, 336 dg; coordinates vary from previous surveys by Reed et al. 2005; transect along top edge of S wall, E wall, and N wall, from 575 to 675 ft | Annotation- John Reed | HBOI J. Reed Site- Naples Sinkhole (see Reed et al. 2005); no multibeam |  |                            |                                  |                     |  |                      |
| <b>Time</b>                                  | <b>Depth (ft)</b>  | <b>Latitude</b>       | <b>Longitude</b>  | <b>Notes</b>   | <b>Habitat Description</b> | <b>Habitat Type</b>              | <b>Fish Species</b> | <b>Invertebrates</b>   | <b>Human impacts</b> |
| 2047- subtract 5 minutes for true time       |  |                       |   | dense plankton (crustacea?) in water column                            | 100% rock, rugged outcrops | Rock ledges, outcrops, rock wall |                     | Several species demosponges- lithistids, corallistids, several species Hexactinellid glass sponges |                      |
| 2051   | 585  | 26 5.1941             | 84 13.4521  | looking at south top edge of sinkhole; audio not audible w/o headphone |                            |                                  | vermilion/queen?    |  |                      |

|      |     |  |  |   |  |  |  |   |  |
|------|-----|--|--|---|--|--|--|---|--|
| 2055 | 575 |  |  | top edge  | same   |  | AJ   | Hexactinellid cups,<br>lithistids,<br>Pachastrellidae, 10<br>cm Madracis<br>mirabilis?, |  |
| 2057 | 582 |  |  |   |  |  | rough<br>tongue<br>bass,<br>squirrel<br>fish         |   |  |
| 2058 | 585 |  |  |   |  |  | 40 cm<br>snowy<br>group<br>er                        |   |  |
| 2059 | 575 |  |  | facing south<br>at top south<br>edge of hole,<br>crabbing<br>ROV to the<br>east along<br>the top edge |  |  | greater<br>Ajs                                       | Strongylophora? Sp.   |  |
| 2102 | 581 |  |  |   |  |  | squirrel<br>fish,<br>blackb<br>ar<br>soldierf<br>ish |   |  |
| 2104 | 583 |  |  | top edge;<br>100% rock  |  |  | squirrel<br>fish                                     | hermit crab   |  |
| 2108 | 596 |  |  | east wall,<br>facing east   | 60 dg rock slope;<br>vertical rock wall at 600<br>ft |  |  |   |  |
| 2110 | 600 |  |  | vertical east<br>wall   | vertical fissure in<br>vertical rock, very<br>rugged |  | snowy<br>group<br>er                                 | spider crab Mithrax?<br>Sp.   |  |

|      |     |  |  |   |  |  |  |  |                      |
|------|-----|--|--|---|--|--|--|--|----------------------|
| 2116 | 625 |  |  | same                                    | same   |  | vermilion/queen?   | squid  |                      |
| 2122 | 631 |  |  | same                                    | vertical rock wall, rock overhang or ledge at 630 ft, very rugged karst topography |  |  | 10-20 cm hexactinellid plate sponges; lithistids, corallistids |                      |
| 2127 | 602 |  |  | NE face of wall, move upslope to 600 ft |  |  |  | pencil urchin  |                      |
| 2129 | 598 |  |  |   | less steep, 40-80 dg rugged rock slope   |  | queen snapper, misty grouper-- not in Reed et al 2005; snowy grouper | stylaster coral  |                      |
| 2132 | 599 |  |  |   |  |  | porgy  | squid  |                      |
| 2133 | 594 |  |  | moving up over rim of E wall            | 30 dg rock slope, 1 m relief with outcrops and/or boulders                         |  | queen snapper  |  |                      |
| 2134 | 583 |  |  |   | 30 dg rock, more sediment  |  | porgy  | squid  | longline w/ gangions |
| 2135 | 575 |  |  | top edge, E edge                        | flattening out, rugged rock  |  |  |  |                      |
| 2137 | 596 |  |  | right on north edge of sinkhole         |  |  | couple snowy grouper   |  |                      |

|      |     |  |  |  |  |  |   |  |          |
|------|-----|--|--|--|--|--|---|--|----------|
| 2142 | 600 |  |  | facing N, N wall;<br>continue transect to W along N wall | vertical rugged rock   |  |   | same biota;<br>Antipathidae 20 cm  | longline |
| 2145 | 615 |  |  | drop down to 650 ft on N wall                            | vertical, horizontal layers of ledges  |  |   | dense cup sponges<br>Corallistidae   |          |
| 2148 | 641 |  |  |  | rugged vertical  |  | AJ  |  |          |
| 2151 | 641 |  |  | dense plankton-copepods?                                 | wall varies from 60-90 dg  |  | queen snapper,<br>snowy grouper,<br>soldierfish |  |          |
| 2155 | 644 |  |  | off wall in open water                                   |  |  |   | dominant fauna- 8-10 spp sponges, few Antipathidae, few crinoid, no gorgonians, few Madracis, no Lophelia, |          |
| 2156 | 650 |  |  |  | plateau or ledge   |  |   |  |          |
| 2158 | 658 |  |  | NW wall  | very smooth rock wall, different from the rugged wall; barren, very sparse benthic fauna |  |   |  |          |
| 2200 | 672 |  |  |  |  |  |   |  |          |
| 2202 | 675 |  |  | move up slope, NW wall                                   | smooth 80 dg slope wall  |  |   | sparse benthic fauna compared to E and S wall  |          |

|  |  |                       |   |   |  |                     |                     |                       |                      |
|--|--|-----------------------|---|---|--|---------------------|---------------------|-----------------------|----------------------|
| 2205   | 645  |                       |   | looking at NW wall from inside sinkhole | same; maybe more sediment spills over this side?         |                     |                     |                       |                      |
| 2207   | 630  |                       |   | NW upper wall                           | back in zone of vertical rock, karst, rugged, ledges     |                     |                     | more of sessile fauna |                      |
| 2208   | 597  |                       |   | rim of sinkhole                         | 30-45 dg slope   |                     | blackbar drum       |                       |                      |
| 2208   | 593  |                       |   |   | 30 dg slope, boulders, outcrops; horizontal ledge 595 ft |                     |                     |                       |                      |
| 2213   | 584  |                       |   | tape 2                                  | flattening out, 10-20 dg slope, boulders, more sediment  |                     |                     | jellyfish, copepods   |                      |
| 2213   | 586  | 26 5.2599             | 84 13.4846  | end of dive                             |  |                     |                     |                       |                      |
| <b>Date</b>                                  | 8/27/2007  |                       |   |   |  |                     |                     |                       |                      |
| <b>Location</b>                              | Pulley Ridge - central HAPC  |                       |   |   |  |                     |                     |                       |                      |
| <b>ROV Dive #</b>                            | 5  |                       |   |   |  |                     |                     |                       |                      |
| <b>Video Tape #</b>                          | 5  |                       |   |   |  |                     |                     |                       |                      |
| <b>Station #</b>                             | 20   |                       |   |   |  |                     |                     |                       |                      |
| <b>Transect Description- Length, Heading</b> | 116 m, 270 dg.; 3 Transects- N along top of ridge, W to west base, NE up west slope of ridge | Annotation- John Reed | Multibeam site: N-S oriented ridge, 1 m relief, 100 m wide, 1 km length |   |  |                     |                     |                       |                      |
| <b>Time</b>                                  | <b>Depth (ft)</b>  | <b>Latitude</b>       | <b>Longitude</b>  | <b>Notes</b>                            | <b>Habitat Description</b>                               | <b>Habitat Type</b> | <b>Fish Species</b> | <b>Invertebrates</b>  | <b>Human impacts</b> |

|   |     |            |            |  |  |                                     |                            |  |  |
|---|-----|------------|------------|--|--|-------------------------------------|----------------------------|--|--|
| 0815-<br>subtract 5<br>minutes for<br>true time | 245 | 25 30.1110 | 83 38.9801 | Start<br>transect; on<br>bottom on<br>top of east<br>edge of the<br>ridge; 40 ft<br>visibility;<br>data overlay<br>not visible<br>most of dive<br>due to noise | sand, rubble, 5-10 cm<br>cobble, 10-30% cover;<br>may overlay rock<br>pavement, flat, no<br>ledges | Sand,<br>dense<br>rubble,<br>cobble | yellowt<br>ail<br>reeffish | Orange Axinellid<br>sponges common,<br>Raspailliidae,  |  |
| 0816  | 246 |            |            | Heading N<br>along top of<br>ridge   | dense pile of cobble,<br>fish burrow?  |                                     |                            |  |  |
| 0821  | 246 |            |            | green algae  | 1 m wide fish burrow,<br>cobble; 5 cm<br>demsponges and<br>Anadyomene common                       |                                     |                            | 10-20 cm<br>Anadyomene men.;<br>yellow<br>sponge, Spirastrellida<br>e, Bubaris? Sp.,<br>Lissodendoryx?<br>Sp., Hadromerida, no<br>gorgonians, no coral |  |
| 0823  | 246 |            |            |  | 30% cover rock cobble  |                                     | filefish                   | Red algae,<br>Gracilaria? Sp.,<br>Halimeda, Ircinia<br>campana,<br>Holopsamma,<br>Auletta, Axinellidae   |  |
| 0825  | 246 |            |            | transecting<br>N, speed to<br>fast for<br>survey   |  |                                     | reef<br>butterfl<br>yfish  | No scleractinia coral  |  |

|      |     |  |  |   |  |                      |                                       |  |
|------|-----|--|--|---|--|----------------------|---------------------------------------|--|
| 0827 | 244 |  |  | tracking problems   | occasional 2 m diam pile of cobble from fish burrow                |                      | school of scad, spotfin butterflyfish |  |
| 0832 | 247 |  |  |   | sand, 30% cover cobble   | Sand, rubble, cobble | scorpionfish                          | see some brown plates- Agaricia? Sp.; hydroid, hadromerids,  |
| 0834 | 249 |  |  |   | 50% cover cobble   |                      |                                       |  |
| 0835 | 247 |  |  |   | sand, patch w/ sparse cobble <10%, but most >30%; biota less dense |                      |                                       | Peysonnellia; Poecilosclerida; sea whip- Ellisellidae or Antipathidae  |
| 0836 | 246 |  |  |   |  |                      | filefish                              |  |
| 0837 | 244 |  |  |   | dense cobble, >30%   |                      | reef butterflyfish                    | Lobophora, Dictyota, encrusting coralline, Cirrhipathes, some cobble rhodoliths, Diodogorgia? Red gorgonian, hadromerid?,      |
| 0841 | 244 |  |  |   |  |                      | jackknife fish                        | 20 cm Antipathes   |
| 0844 | 245 |  |  | Start Transect 2- changing course - heading west towards bottom of feature on multibeam |  |                      |                                       | no large gorgonians, no scleractinians (possibly 1-2 plate corals earlier); fominant biota- 5-10 spp sponges, red, brown algae |



|             |           |            |            |  |  |               |                                     |   |  |
|-------------|-----------|------------|------------|--|--|---------------|-------------------------------------|---|--|
| 0849        | 246       |            |            | ROV tracking not working, compass not working  |  |               |                                     |   |  |
| 0852        | 249       |            |            | west slope of ridge  | sand, sparse rubble, cobble <10%                             |               | pufferfish                          | 30 cm Geodia sp.  |  |
| 0853        | 249       |            |            | west base of ridge   | sand, bioturbation, 5-10 cm mounds, no sand waves; 100% sand | soft sediment |                                     | starfish Narcissia trigonaria?; Lissodendoryx?, Rhodomenia? |  |
| 0855        | 249       |            |            | Start Transect 3-changing course - heading northeast to go over feature again and down the east side of it |  |               |                                     |   |  |
| 0857        | 247       |            |            |  |  |               |                                     |   |  |
| 0900        | 248       |            |            | back on ridge  | sand, rubble, cobble, 10-30% cover                           |               | sand perch, school of scad; batfish | Aulletta?   |  |
| 0902        | 246       |            |            | tracking problems, no sure of location   |  |               | scorpiofish                         |   |  |
| 0905        | 246       | 25 30.1110 | 83 39.0495 | end transect   |  |               |                                     |   |  |
| <b>Date</b> | 8/27/2007 |            |            |  |  |               |                                     |   |  |

|  |                                      |                       |   |  |   |                        |                             |  |                      |
|--|--------------------------------------|-----------------------|---|--|---|------------------------|-----------------------------|--|----------------------|
| <b>Location</b>                              | Pulley Ridge - central HAPC          |                       |   |  |   |                        |                             |  |                      |
| <b>ROV Dive #</b>                            | 6                                    |                       |   |  |   |                        |                             |  |                      |
| <b>Video Tape #</b>                          | 6                                    |                       |   |  |   |                        |                             |  |                      |
| <b>Station #</b>                             | 22                                   |                       |   |  |   |                        |                             |  |                      |
| <b>Transect Description- Length, Heading</b> | 760 m, 360 dg.; 1 transect heading N | Annotation- John Reed | Multibeam Site- 2 finger ridges oriented NW-SE, start at deeper valley at SW base of first ridge, then head N over first finger, into valley, then to second finger |  |   |                        |                             |  |                      |
| <b>Time</b>                                  | <b>Depth (ft)</b>                    | <b>Latitude</b>       | <b>Longitude</b>  | <b>Notes</b>   | <b>Habitat Description</b>                                | <b>Habitat Type</b>    | <b>Fish Species</b>         | <b>Invertebrates</b>                                     | <b>Human impacts</b> |
| 1103- subtract 5 minutes for true time       | 250                                  | 25 18.7209            | 83 37.4536  | start transect; heading unknown, compass not working, but tracking ok; 40 ft visibility, no bottom current | sand, sparse shell rubble, bioturbation; 100% soft bottom | 100% soft bottom, sand | eel poking head out of hole | pencil urchin Eudicdaris tribuloides or Stylocidaris sp. |                      |

|      |     |  |  |   |   |                        |            |   |  |
|------|-----|--|--|---|---|------------------------|------------|---|--|
| 1106 | 247 |  |  | at SW base of first ridge; start<br>Transect 1, heading N | 100% sand, bioturbation                                 | 100% soft bottom, sand |            |   |  |
| 1110 | 247 |  |  |   | sand, <5% cover rubble, 5 cm cobble                     |                        |            | pencil urchins  |  |
| 1112 | 247 |  |  |   | 100% sand, dense cover of loose algae clumps, 30% cover |                        |            | Haloplegma duperreyi, red algae- 10-20 cm piles, loose on bottom, flat bifurcate blades, appears light lavender, no other benthic epifauna or flora |  |
| 1114 | 247 |  |  |   |   |                        |            |   |  |
| 1116 | 245 |  |  |   | same  |                        |            | 20 cm hydroid or Antipathes; dense piles of Haloplegma  |  |
| 1119 | 241 |  |  |   |   |                        | flounder   |   |  |
| 1122 | 238 |  |  | on top of first finger ridge                              | 100% sand with piles of algae                           | 100% soft bottom       |            |   |  |
| 1127 | 236 |  |  |   | sand, out of algae zone                                 |                        | lizardfish |   |  |
| 1129 | 240 |  |  |   | sand, sparse rubble                                     |                        | lizardfish | pencil urchins, demosponge  |  |
| 1135 | 241 |  |  |   |   |                        | flounder   | test of Clypeasterid sea biscuit  |  |
| 1139 | 244 |  |  | heading down N slope of ridge 1                           | bioturbation, 5-10 cm mounds                            |                        |            |   |  |
| 1141 | 244 |  |  |   | sand w/ piles of dead algae                             |                        | razorfish  |   |  |

|  |                                    |                       |   |  |                            |                     |                     |                         |                      |
|--|------------------------------------|-----------------------|---|--|----------------------------|---------------------|---------------------|-------------------------|----------------------|
| 1145   | 246                                |                       |   | in valley between two ridges             | sand, no algae             |                     |                     |                         |                      |
| 1149   | 246                                |                       |   |  | sand, bioturbation         |                     |                     | numerous pencil urchins |                      |
| 1201   | 236                                | 25 19.1326            | 83 37.4564  | end of transect - second ridge also sand | 100% soft bottom, sand     | 100% soft bottom    | cowfish             | numerous pencil urchins |                      |
| <b>Date</b>                                  | 8/27/2007                          |                       |   |  |                            |                     |                     |                         |                      |
| <b>Location</b>                              | Pulley Ridge- southern HAPC        |                       |   |  |                            |                     |                     |                         |                      |
| <b>ROV Dive #</b>                            | 7                                  |                       |   |  |                            |                     |                     |                         |                      |
| <b>Video Tape #</b>                          | 7                                  |                       |   |  |                            |                     |                     |                         |                      |
| <b>Station #</b>                             | 24                                 |                       |   |  |                            |                     |                     |                         |                      |
| <b>Transect Description- Length, Heading</b> | 653 m, 90 dg; 1 transect heading E | Annotation- John Reed | HBOI J. Reed Site- 16-VIII-98-2: 2 mile trawl, 6" cobble, 49 sp. of sponges, echinoderms, red and green algae; no multibeam of site |  |                            |                     |                     |                         |                      |
| <b>Time</b>                                  | <b>Depth (ft)</b>                  | <b>Latitude</b>       | <b>Longitude</b>  | <b>Notes</b>                             | <b>Habitat Description</b> | <b>Habitat Type</b> | <b>Fish Species</b> | <b>Invertebrates</b>    | <b>Human impacts</b> |

|      |     |                |             |   |  |   |                         |  |
|------|-----|----------------|-------------|---|--|---|-------------------------|--|
| 1344 | 244 | 25°<br>06.9052 | 83° 37.0860 | no tracking;<br>on bottom,<br>40 ft<br>visibility;<br>heading E | sand w/ 80%-100 %<br>cover rubble, <5 cm<br>cobble, Halimeda<br>hash, no ledges, no<br>pavement; dominant<br>species- red, brown,<br>green algae, few<br>demosponges,<br>Eucidaris | 80%<br>dense<br>rubble,<br>cobble on<br>sand                              | sparse                  | 10 cm Anadyomene,<br>Rhodymenia?<br>Halimena? Red<br>algae, no<br>gorgonians, no<br>scleractinia,<br>Verdigellas?,<br>Lobophora?,<br>Spatoglossum?,<br>sparse macro<br>demosponges |
| 1348 | 244 |                |             |   | same   |   |                         | pencil urchins-<br>Stylocidaris or<br>Eucidaris  |
| 1354 | 244 |                |             | tracking<br>restored  | same   |   | green<br>band<br>wrasse |  |
| 1357 | 244 |                |             |   | same   |   | saddle<br>bass          | Petrosiidae?,<br>Anadyomene,<br>Eucidaris common,<br>Cinachyra?  |
| 1359 | 244 |                |             |   | same   |   |                         | 5 cm<br>spherical, encrusted<br>demosponges<br>common, numerous<br>spp, choristida?,<br>Cinachyra?,<br>Lobophora, red<br>algae,  |
| 1402 | 244 |                |             |   | sand; flat, no relief,<br>some 10 cm mounds of<br>sediment- sipunculids<br>or annelids   | sand,<br>microbial<br>surface<br>layer,<br>bioturbati<br>on; 100%<br>soft | nada                    | urchins,<br>Rhodymenia?  |

|      |     |            |             |                 |   |      |                             |  |  |
|------|-----|------------|-------------|-----------------|---|------|-----------------------------|--|--|
| 1405 | 244 |            |             |                 | sand, current slight to S, sandy, Halimeda? Hash, bioturbation, no Anadyomene                             | same | juv snapper, maybe mutton   | Eucidaris                                    |  |
| 1408 | 244 |            |             |                 | sand, rubble, bioturbation  |      |                             |  |  |
| 1411 | 246 |            |             |                 |   |      |                             | Petrosid or Haplosclerid                     |  |
| 1414 | 246 |            |             |                 | sand; microbial film? on surface, bioturbation, echinoderm Clypeasterid tracks                            |      | saddle bass & unid flatfish | Eucidaris                                    |  |
| 1423 | 248 |            |             |                 | same, dominant fauna-sparse demosponges <5 cm, urchins  |      |                             | lg sheet red algae-Halimena?, poecilosclerid |  |
| 1425 | 247 |            |             |                 | same  |      | blue gobies                 |  |  |
| 1430 | 247 |            |             |                 | same; 1 m fish burrow, with surrounding microbial film; 1 m circular areas of brown microbial mats common | same | saddle bass                 | microbial film                               |  |
| 1435 | 247 |            |             |                 | same  |      |                             | lg red hermit crab                           |  |
| 1439 | 247 |            |             |                 | same, 1-2 m circular microbial mats common  | same |                             | Eucidaris common                             |  |
| 1442 | 246 |            |             |                 | sand, bioturbation, algal debris  |      |                             | clump Sargassum; Eucidaris                   |  |
| 1445 | 244 | 25° 06.919 | 83° 36.6974 | end of transect | same  | same |                             |  |  |

## APPENDIX 2

In situ video and digital still images from NOAA NURP *Superphantom* ROV survey of Pulley Ridge, August 2007.

Figure 1. Site 1- Sand habitat. (Photo 1133)



Figure 2. Site 1- Sand/cobble habitat. (Photo 1149)

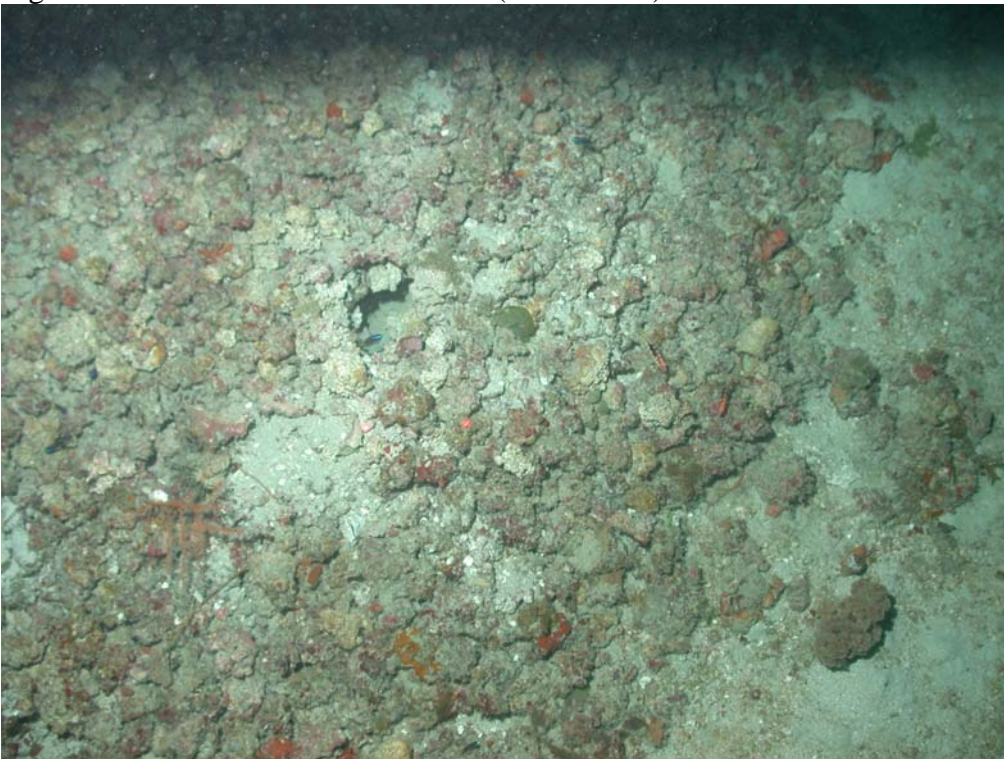




Figure 3. Site 1- Patch reef with *Antipathes* black coral (center), *Cirrhipathes* whip coral (right), and various demosponges. (Video- 014)



Figure 4. Site 1- Patch reef with large gorgonians (*Swiftia exerta*) and numerous reef fish (jackknife, scamp, angelfish). (Video 007)

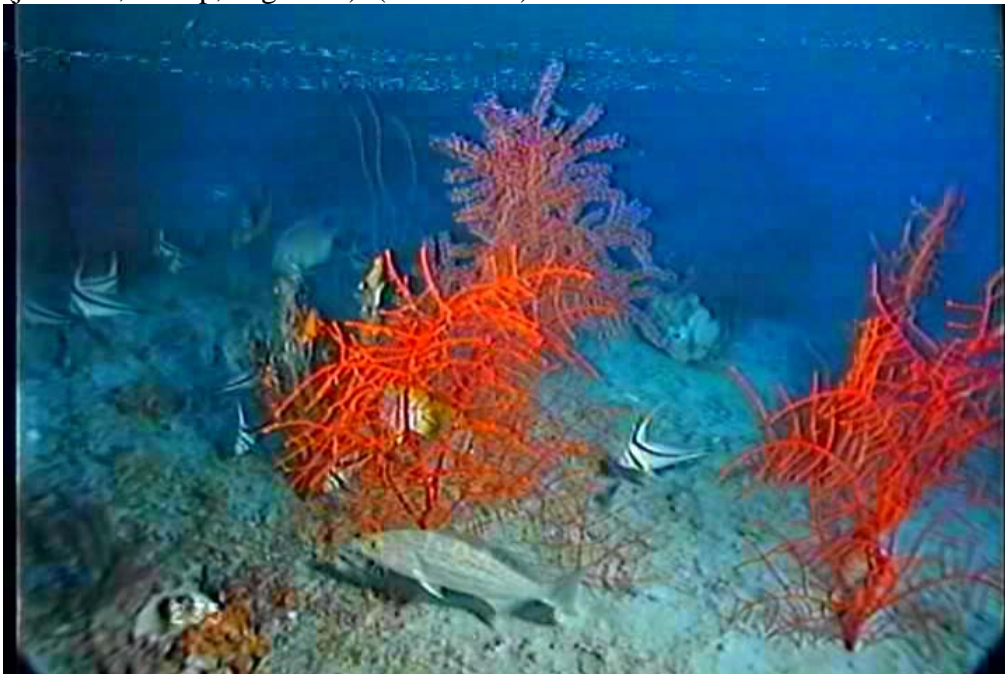


Figure 5. Site 2- Sand habitat. (Photo 1178)



Figure 6. Site 2- Patch reef habitat with boulders and dense reef fish. (Photo 1179)

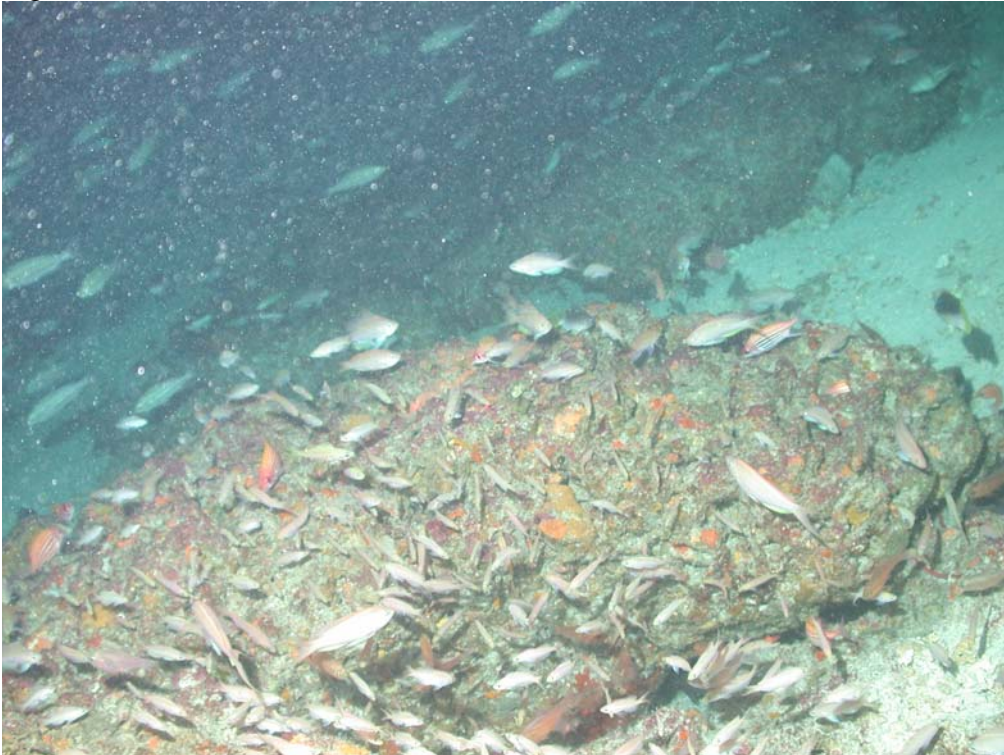


Figure 7. Site 2- Reef ledge habitat with *Antipathes* black coral, numerous encrusting sponges and red algae, and speckled hind (center). (Photo 1212)

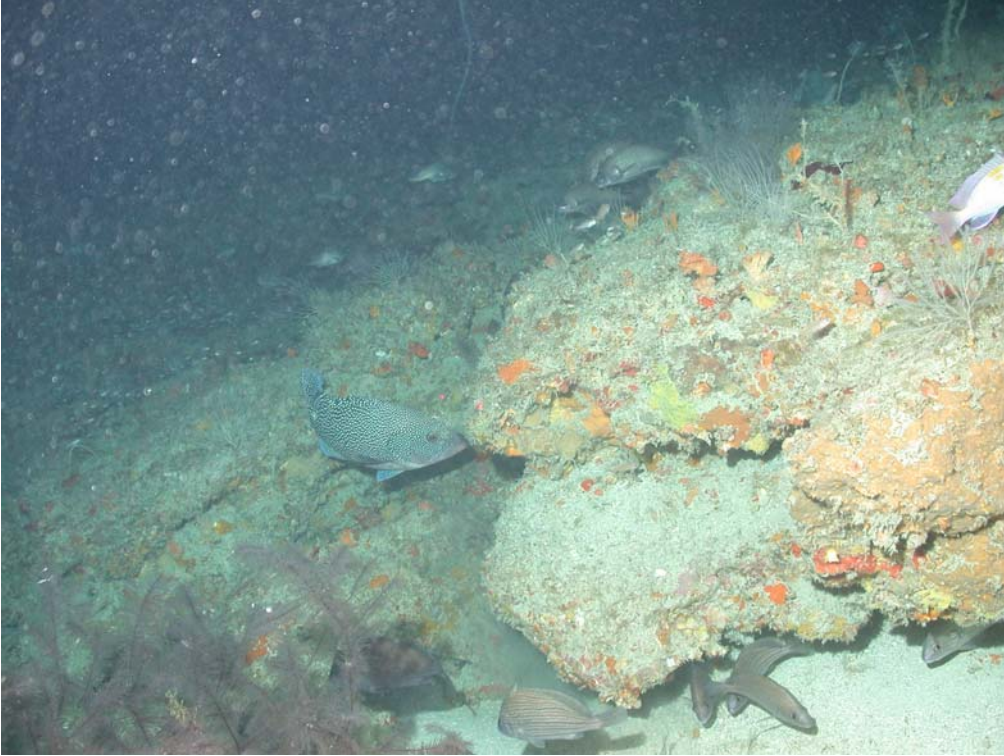


Figure 8. Site 2- Reef ledge habitat with dense *Antipathes* black coral, sponges, and lobster. (Photo 1224)

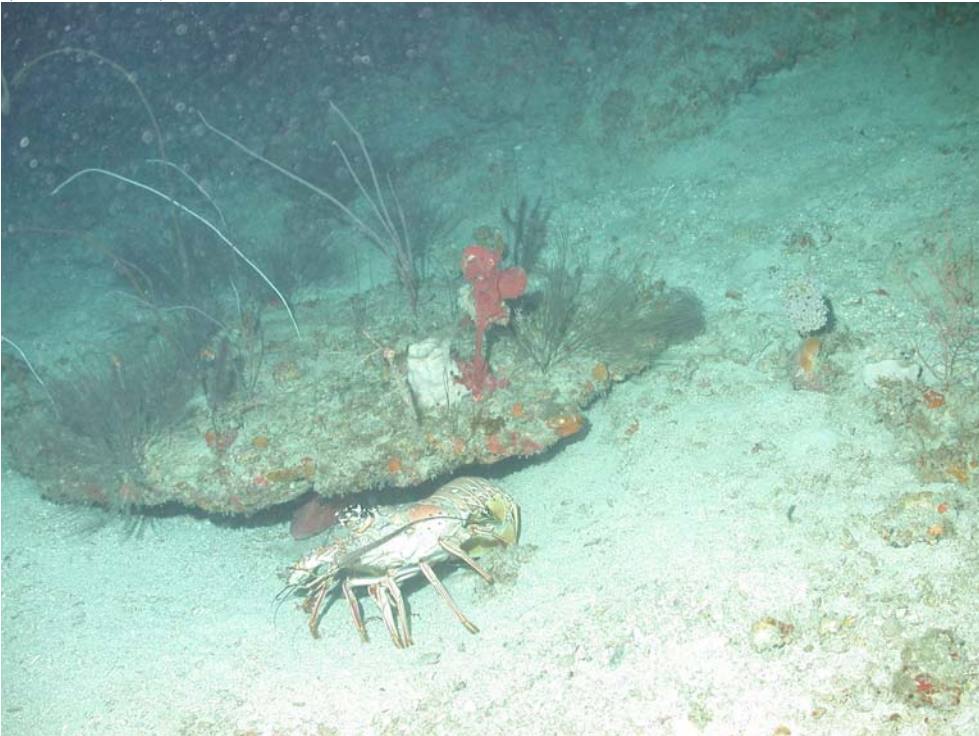


Figure 9. Site 3- Sand bottom habitat with *Caulerpa floridana*. (Photo 1256)



Figure 10. Site 4 (Naples Sinkhole)- Rugged vertical rock wall with vase and plate Hexactinellid glass sponges (lower), Lithistid cup sponges, and slit shell (*Perotrochus*, center left). (Photo 1308)

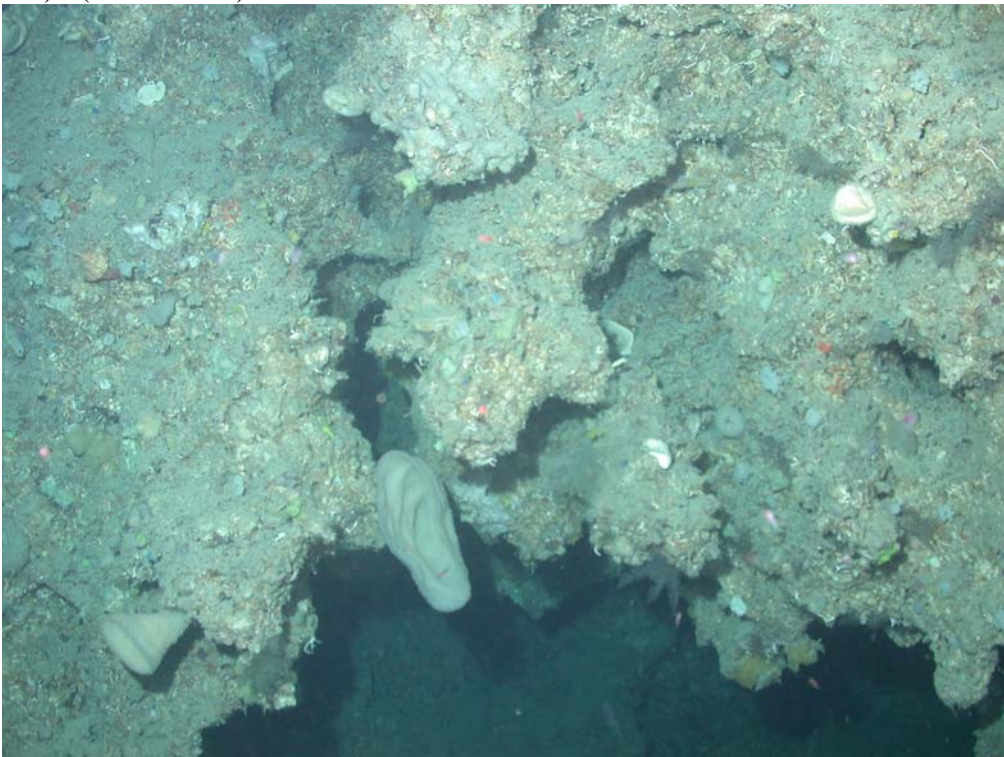


Figure 11. Site 4 (Naples Sinkhole)- Snowy grouper on vertical wall. (Photo 1295)



Figure 12. Site 4 (Naples Sinkhole)- *Madracis mirabilis* scleractinian coral on rock wall. (Video 008)

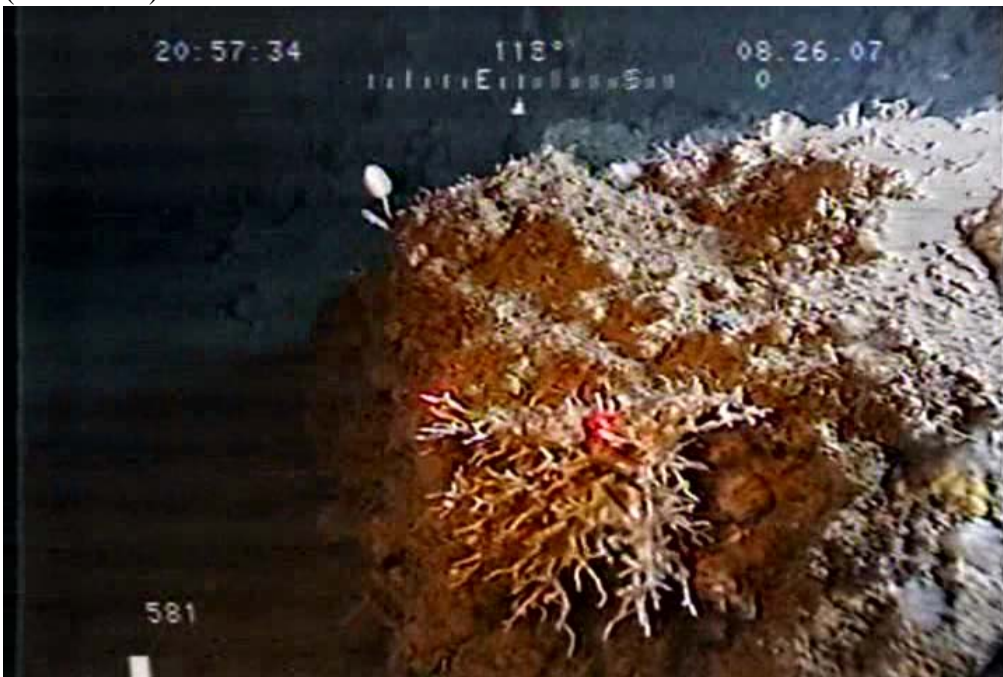


Figure 13. Site 5- Sand/cobble habitat with algal cover of *Dasya* sp. (left), *Peysonnellia* sp. (top), and *Verdigellas peltata* (right). (Photo 1383)



Figure 14. Site 5- Sand/cobble habitat with sponge, algal cover. (Video 009)



Figure 15. Site 6- Sand habitat with bioturbation. (Video 001)



Figure 16. Site 7- Sand habitat with pencil urchins (*Eucidaris tribuloides*). (Video 011)



Figure 17. Site 7- Sand habitat with red alga *Haloplegma duperreyi*. (Photo 1445)



Figure 18. Site 7- Sand habitat with red alga *Rhodymenia?* sp. and *Eucidaris tribuloides* pencil urchin (Photo 1505)

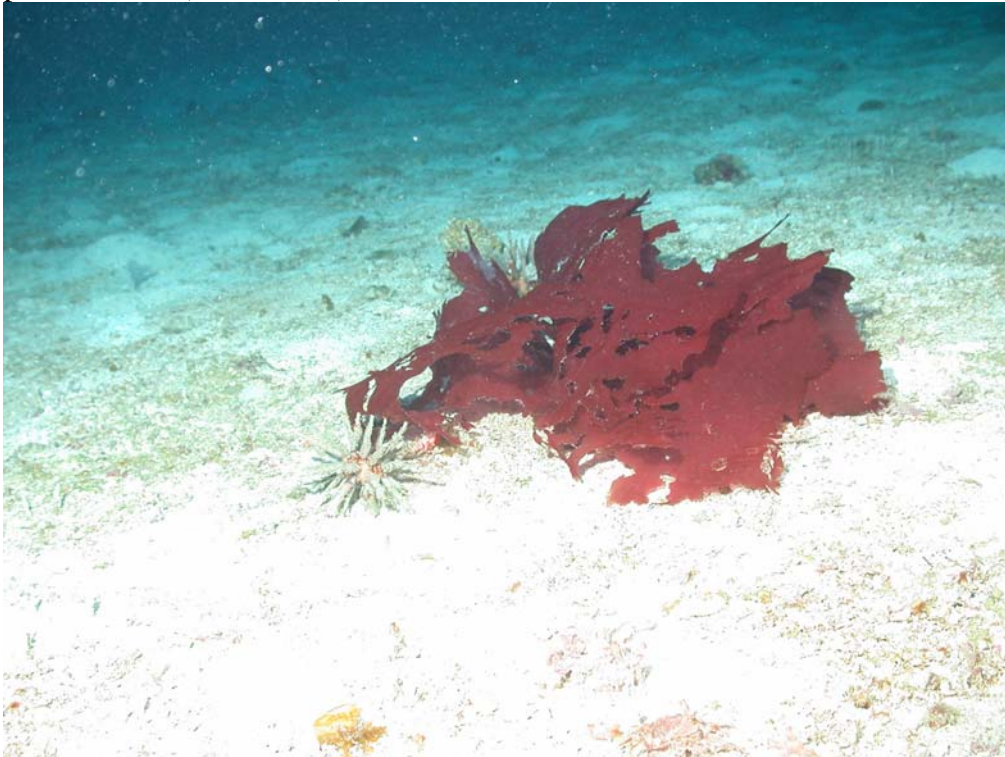


Figure 19. Site 7- Cyanophyta algal mat on sand bottom. (Video 013)

