NOAA Office of Ocean Exploration

Final Report

I. OVERVIEW

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University of Southern Mississippi
University of the Azores

Award Period: From 1 July 2004 To 30 June 2005 (extended to 30 April 2007)

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II. Summary

1. Abstract

This report describes submersible observations and collections made during an OE expedition along a transect centered on the Latitude 31º30' line, in depths from 55 to 1000 m. The sampling extended from previous work along that transect (including some funded by OE and other NOAA offices) that sampled from the coast out to 55 m. This report describes observations of fishes made from submersible, description of habitats and bottom types, analysis of infaunal invertebrates collected by the submersible and a Young grab, analysis of the fauna inhabiting some sponges and tunicates, and analysis of isotope composition of coral samples to determine paleo-oceanographic conditions and coral growth rates.

2. Purpose of Project:

a. Describe issue that was addressed

The Blake Plateau and the Southeast Continental Slope:

The Blake Plateau, a feature that dominates the continental margin off the southeastern U.S, interrupts the continental slope with a relatively gently sloping topography from 700 to 1100 m depth (Fig. 1). Much of the Blake is relatively flat hard bottom (Popenoe and Manheim 2001), but at the northern end lies an area of extremely rugged relief (the Charleston Bump) that has received attention because of its importance in Gulf Stream dynamics and fisheries (Sedberry et al. 2001; Govoni and Hare 2001; Sedberry et al. OE Bump final report). In spite of recent exploration of the Charleston Bump (Sedberry et al. 2005), relatively little is known about the deep continental slope of the southeastern U.S., relative to shelf habitats. The recent work on the Charleston Bump and adjacent Florida-Hatteras Slope has coincided with, or resulted from, development of deepwater fisheries for golden crabs (Geryonidae), groupers (Serranidae), wreckfish (Polyprionidae) ocean perches (Scorpaenidae), tilefishes (Malacanthidae), alfonsinos (Berycidae), roughies (Trachichthyidae), and other groups (Sedberry et al. 2001; Wenner and Barans 2001). Ecological studies aimed at understanding the assemblages that co-occur with fishery species, and which play roles in food chain dynamics and fish production, have been little studied.

Studies of western Atlantic slope habitats north of Cape Hatteras and south of Cape Canaveral have found increased biomass and productivity between areas of topographic relief (canyons) relative to more tranquil open slope areas (Musick et al. 1975; Crabtree et al. 1991). Studies have also compared more productive soft bottom slope habitats of the Middle Atlantic Bight (Cape Cod to Cape Hatteras) with soft bottom habitats in deep waters

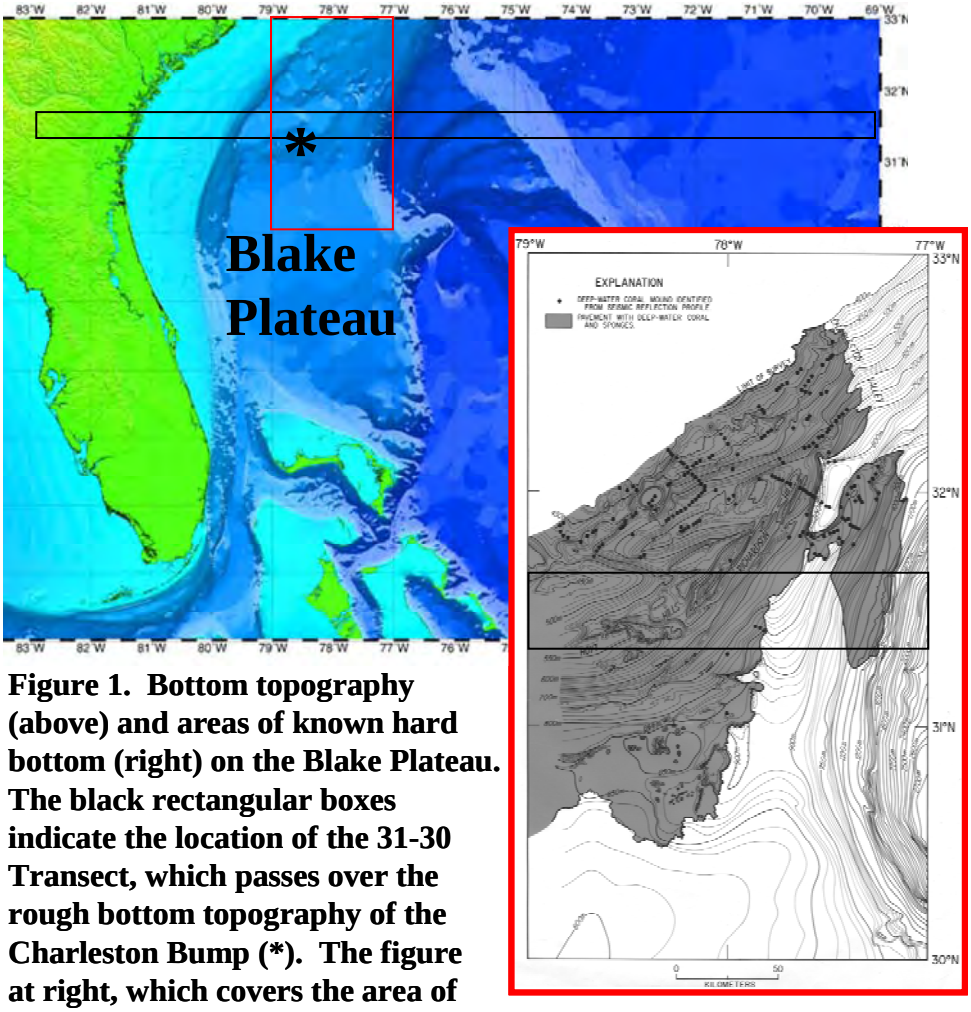


Figure 1. Bottom topography (above) and areas of known hard bottom (right) on the Blake Plateau. The black rectangular boxes indicate the location of the 31-30 Transect, which passes over the rough bottom topography of the Charleston Bump (*). The figure at right, which covers the area of the red rectangle on the figure above, is from Manheim and Popenoe (2001).

of the tropics, and have included community and trophic ecology comparisons from temperate and subtropical regions (Sedberry and Musick 1978; Anderson et al. 1986; Crabtree et al. 1991). Differences in species composition and trophic structure of fish communities, and morphology of the deep-sea fish faunas have been attributed to differing levels of nutrient and/or oxygen concentrations between demersal habitats of the two regions and other attributes associated with the presence of bottom topography such as canyons, seamounts, ridges and hard bottom (Sulak and Ross 1996). Although the Blake Plateau may serve as an important transition zone between tropical and temperate deep-sea faunas, it has been little studied because of the difficulty of sampling with traditional sampling gear.

Hard Bottom Habitat and Regional Biogeography:

The continental shelf off the southeastern U.S. is often referred to as the South Atlantic Bight (or SAB), which is defined herein as the continental shelf and slope between Cape Hatteras and Cape Canaveral and out to the edge of the Exclusive Economic Zone (or EEZ). Although hard bottom habitats, consisting of rock outcrops and living coral patches, occur scattered along the continental shelf of the SAB, little research effort has been directed at deep-water rocky habitats (Anonymous 1985). Hard bottom habitats on the continental shelf and upper slope of the SAB support drastically different fish faunas than do soft bottom habitats in similar depths and thermal regimes (Wenner 1983; Sedberry and Van Dolah 1984). It is likely that these differences extend to the deeper waters of the Florida-Hatteras Slope, Blake Plateau and beyond. Thus, deepwater rocky bottom habitats such as those found on the Blake Plateau (Fig. 1) may support greater biomass and diversity of fishes than that found on adjacent soft bottom areas. For this reason, demersal fisheries of the Blake concentrate on hard bottom areas.

The hard bottom shelf of the SAB supports tropical and subtropical reef fishes. Many of these fishes are species that have extended their ranges northward from the Caribbean, taking advantage of rocky reef habitat and relatively stable thermal regimes of the SAB. It is unknown if the ichthyofauna associated with deep hard bottom of the Caribbean extends its range northward along the hard bottom habitat of the Blake Plateau. Similarly, the faunal affinities between the rocky bottom of the Blake Plateau and rocky North Atlantic islands such as Bermuda and the Azores is not known, although fishery landings [e.g. wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), red porgy (*Pagrus pagrus*), etc.] indicate many similarities (Sedberry et al. 1999). "Islands" of suitable habitat, such as the Bahamas and Charleston Bump, may provide "stepping stones" to allow the distribution of deep, rocky-bottom fishes from the Caribbean to the eastern Atlantic. Faunal study of deep hard bottom habitats in the Caribbean, Blake Plateau and across the North Atlantic are needed to determine patterns of species distributions, dispersal and zoogeographic affinities.

Recent studies have shown decreasing average size of species and individuals within species of deep-sea fishes from north to south along the middle continental slope (Sulak and Ross 1996). An obvious contradiction to this trend is found in the occurrence of concentrations of large species such as wreckfish, barrelfish (*Hyperoglyphe perciformis*) and red bream (*Beryx decadactylus*) on mid-slope depths on the Blake Plateau. Wreckfish have supported large fishery landings [in excess of 4 million lbs in 1990 until the South Atlantic Fishery Management Council (SAFMC) established catch restrictions (Sedberry et al. 1994). This high concentration of biomass on the Blake Plateau corresponds to the location of the high-relief bottom topography. It is unknown if deeper or less rugged hard bottom of the Blake Plateau east of the Bump also supports a high biomass of fishes and other organisms.

Oceanography, Life History, Recruitment:

The relationship between oceanography and fisheries production on the Blake Plateau is not well understood. An additional enigma is that the very currents that cause the upwellings that increase productivity (Bane et al. 2001) should carry away the pelagic eggs, larvae and juveniles of fishery species such as wreckfish that spawn on the Bump, leaving questions regarding the recruitment of fishes, corals and other species to the Blake Plateau. There may be downstream eddies that retain early life stages in a "nursery area" associated with the Bump, or recruitment to the area may come from upstream in the Caribbean. Successful recruitment of corals and other species may occur only in areas of reduced current flow. Fine-scale mapping of species' distributions and hydrography over a variety of bottom types and depths is needed to determine factors affecting successful recruitment in fishes, corals and other organisms under the Gulf Stream on the Blake Plateau.

Downstream from the Blake Plateau are several seamounts and archipelagos, including those associated with the mid-Atlantic ridge. The Azores islands and nearby banks provide hard bottom habitat within the axis of the Gulf Stream as it drifts toward northern Europe, and these shallow parts of the mid-Atlantic ridge support fisheries for species that also occur on the Blake Plateau. Recent exploratory work on the Azores is available for comparison with data from the Blake Plateau, and collection of data from the Blake Plateau can serve as a

foundation for future explorations to compare deepwater faunas across the North Atlantic. Current projects in the eastern North Atlantic include the OASIS project (www.rrz.uni-hamburg.de/OASIS/) which is focused on an interdisciplinary characterization of seamounts, including exploratory fishing. Some projects are integrated with the Census of Marine Life (www.coml.org) and include the MARECO project (www.efan.no/midatlcensus/). Observations conducted near the Azores include studies on João de Castro Bank using Portuguese AUVs (www.horta.uac.pt/projectos/asimov/; www.horta.uac.pt/projectos/marov/index1.html). These projects are focused on habitat mapping, as we proposed to do on the Blake Plateau in this project, but are concentrating initially on shallower depths. Collaborative studies of deeper habitats will result in deep exploration of coral banks, fish habitats and other living resources, as well as an understanding of the role of the Gulf Stream in recruitment processes in the deep North Atlantic. Studies of João de Castro Bank provide the potential for interesting comparison with the Blake Plateau because of the recent origin, volcanic activity and different geology of the Bank. Colleagues from the Department of Fisheries, University of the Azores, are currently sampling this bank with fishing gear, with plans for increased sampling, providing data for the eventual extension of the "Latitude 31-30 Transect" across the North Atlantic.

Habitat for Deepwater Corals and Associated Species:

We know little about the effect of variable substrates, relief and current regimes on distribution, abundance and growth of coral patches and mounds on the Blake Plateau. High-resolution mapping of habitats and corals is needed to determine environmental variables that influence the growth of deep coral banks in areas such as the Blake Plateau that are affected very little by fishing. Similar work has been suggested for other coral habitats in the Gulf Stream (McDonough and Puglise 2003), particularly in areas of high impact from bottom fishing. Our previous submersible observations on the Blake Plateau have shown "coral fields" that consist of small colonies spaced roughly equidistant to one another. The colonies were of similar size and presumed age (based on preliminary analysis of 2003 collections from the OE Charleston Bump project). This pattern is not likely random and could suggest a great deal about widespread natural disturbance events, community succession, coral growth patterns, the factors that control coral density, and by extension, habitat richness for other species like fishes.

Deep water corals are recently the subject of increased research interest. Two primary motivations include conservation of deep water coral habitats and the corals' potential use as a paleoclimate proxy. However, all deep water scleractinian and gorgonian corals thus far analyzed are in oxygen isotopic disequilibrium with seawater at ambient measured temperatures, and unlike some other corals, the offset from equilibrium is variable, thus deep water corals have limited utility as paleotemperature proxies (e.g. Smith *et al*., 2000). As a result, some attention has now been focused on other geochemical proxies in both scleractinian and gorgonian corals (e.g. Adkins *et al*., 1998, Sherwood *et al.*, 2005).

A relatively common, intermediate to deep water coral that has not been extensively investigated with respect to stable isotopes are the stylasterid hydrocorals, which are often referred to as lace corals. The research presented here represents initial investigations into the carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope properties of stylasterid corals as measured sequentially through ontogeny. As the potential utility of deep water paleotemperature data is significant, it is hoped that this research represents a foundation for the future development of a novel paleoclimate proxy.

Preliminary coral work on the Blake Plateau raises additional questions for study. For example, why were there large areas of exposed rock that had no high-relief epibionts? Is this due to occasional physical disturbances such as coldwater intrusions, periodic sediment scouring, or biological constraints such as nutrient availability? Fishing gear that is destructive to coral is not used on the Blake Plateau, yet coral does not grow on what appears to be suitable habitat. We have already done considerable low-resolution mapping (sensu McDonough and Puglise 2003) that can begin to address this question, but additional mapping and higher resolution mapping is needed.

In a recent review, McDonough and Puglise (2003) indicated the following critical data needs for deepwater coral species and biotopes: 1) locating and mapping deep-sea corals; 2) understanding more about coral biology and ecology; and 3) using specific deep-sea coral species as indicators of climate change. Our previous work on the Charleston Bump has addressed these data needs in a preliminary manner, and the research we proposed for this project included expanding this preliminary knowledge to other parts of the Blake Plateau. Analysis of corals from sites along the Gulf Stream is critical for understanding global climate. A possible approach to addressing climate change would be to find a particular location such as the Blake Plateau that has significant variation in current flow (or other climate factors) and contains living and fossil corals that are long lived, such as the solitary *Stylaster erubescens* (Adkins et al. 1998). Such areas occur on the Blake Plateau.

Low-resolution maps (>10m pixel size) are required to identify broad areas that may contain deep-sea corals

(McDonough and Puglise 2003). We currently have several sonar and other habitat maps from early work (e.g. Popenoe and Manheim 2001) and recent OE explorations. These maps indicate the presence of deepwater corals, or substrates likely to support corals (e.g. Fig. 1). The SEAMAP (Southeast Area Monitoring, Assessment and Prediction) bottom-mapping program and SEADESC (Southeast United States Deep Sea Corals) project are in the process of charting deep coral areas, but data from the Blake Plateau are sparse and resolution is poor, as many were collected from surface ships before accurate positioning was available. These preliminary mapping efforts include sites on the Charleston Bump that have been considered as MPAs, as well as some shelf-edge reefs (55-200 m) that are currently under consideration by the SAFMC as MPAs. Additional data that are needed include high-resolution maps of coral colony density and morphology over small areas with variable substrates and current regimes.

Trophic Links:

The variability in composition and relief of bottom features of the Blake Plateau (Popenoe and Manheim 2001) poses the question of whether substrate type, vertical profile or complexity of structure is the most important determinant of the structure of associated faunal assemblages and biomass. Although the ichthyofauna of continental and insular slopes and adjacent deep-sea waters have been studied for areas to the north and south of the Blake Plateau (Sulak 1982), no comprehensive faunal surveys of fishes have been conducted on the Blake Plateau. In addition, few data are available on trophic and community relationships in the habitat that supports wreckfish and the apparently high biomass of large fishes. Basic questions regarding the biology of the species remain. What behavioral interactions result in high concentrations of large fishes in a small area, in spite of fishery removal of large specimens. What are the trophic pathways supporting these organisms? Little is known regarding the habitat requirements for wreckfish, and the mechanisms whereby a large population of large fishes (many in excess of 1 m total length and 20 kg weight) exist in a relatively food-poor deep-sea environment.

Studies of feeding habits of fishes of the Middle Atlantic Bight continental slope, including limited *in situ* observations, indicate that high demersal fish biomass on the slope is supported by food chains that incorporate migration of mesopelagic animals to productive surface waters at night (Sedberry and Musick 1978; Goldman and Sedberry 2007). These nektonic organisms then migrate downward to cool waters during the day in open ocean waters. On the continental slope, daytime depths for these species coincide with the bottom depth of the slope, and these vertically migrating animals become an important food source for demersal fishes (Sedberry and Musick 1978). The expansive area of the Blake Plateau provides a broad area of impingement upon the sea floor of migrating meso- and bathypelagic animals. Limited observations of stomach contents (Weaver and Sedberry 2001; Goldman and Sedberry 2006) indicate that deep-sea pelagic species are important prey for fishes, and the occurrence of a high biomass of wreckfish on the Blake Plateau may result from enhanced food availability provided by migrating pelagic organisms [a high-energy food source (Childress and Nygaard 1973; Donaldson 1976; Steimle and Terranova 1988)]. Because wreckfish and other large demersal fishes often regurgitate stomach contents upon capture, *in situ* observations may be useful to determine the importance of mesopelagic fishes in food chains on the Blake Plateau.

Human Impacts:

Very recently, researchers have examined antimicrobial resistance patterns in terrestrial and marine species. In a sampling of 50 sharks captured off the coast of Louisiana, about 60% harbored multidrug-resistant bacteria. Fishes may be subject to the problem of antimicrobial resistance in wildlife species that, theoretically, have never been exposed to the synthetic drugs that induce antimicrobial resistance (Dr. Mark Mitchell, LSU, pers. comm.). To date, this phenomenon has been examined only in coastal species, with some samples from relatively remote regions (Belize) that are presumed to have little impact from antimicrobial agricultural and medical practices. However, antimicrobial resistance in remote coastal areas may be a result of runoff from agricultural and aquaculture sources. The extent of antimicrobial resistance with increasing distance from terrestrial or coastal sources is unknown. Sampling at increasing distances from shore on the Blake Plateau would enable us to measure antimicrobial resistance along a gradient from presumed terrestrial sources.

Much of the work in this field has been done with migratory species such as sharks, which confounds determination of sources of antimicrobial resistance. Demersal deep-sea fishes could provide material for better understanding the spread of antimicrobial resistance in marine ecosystems. As antimicrobials that find their way into terrestrial runoff are probably the cause of the problem, increasing distance offshore should show a diminishing occurrence rate, but this has not been tested for non-migratory species such demersal deep-sea fishes.

Previous work has been conducted on sediment contaminants of the region, along a transect from the coast

to the shelf edge. This research has shown decreasing levels of contaminants across the shelf (Hyland et al. 2006). Little is known about the fate and deposition of contaminants in deeper water under the Gulf Stream, as no comparative data are available from the Blake Plateau.

Proposed Project Priorities

This project was aimed at addressing many, but not all, of the problems and questions discussed above, by exploring and determining faunal change along a gradient that included increasing depth and distance from land, along with variable temperatures and bottom complexity. Submersible and associated oceanographic and photo-documentation gear were used to describe habitats, oceanography, fish and invertebrate assemblages, in order to compare faunas from different habitat and oceanographic regimes. Our research priority was to explore little-known habitats and to make new discoveries, and to collect specimens and data to test the following hypotheses:
1. The density of fishes is controlled by habitat characteristics; including depth, type of substrate and its orientation, and the presence of sessile invertebrate species.
2. Wreckfish and other species are concentrated on the Blake Plateau because a high-energy food source, i.e. vertically migrating mesopelagic cephalopods and fishes, impinge upon the bottom and are concentrated by bottom topography and associated currents into an area where large bottom fishes feed upon them.
3. Faunal transition and human impacts between the continental shelf and abyss are influenced by transitions in characteristics such as depth, temperature, currents and distance from land, as well as by abrupt changes such as a shift from soft to hard substrates or low to high relief.

b. Project Objectives

The primary goal of the project was to determine the composition, density and diversity of biota as they relate to habitat characteristics and distance from terrestrial influences. Our goal was to map, explore and describe deep habitats, particularly hard bottom habitats, along a transect from the estuary to the abyss, including description their use by marine organisms and the adaptations these organisms have for specialized habitats. We proposed to examine the effects of gradual change (e.g. depth) vs. abrupt change (sand to rock) in physical features on associated faunas. We addressed this goal by attempting following objectives, with varying success:

1. Use sonar to map features of the shelf edge, Florida-Hatteras Slope, Blake Plateau, Charleston Bump and Blake Escarpment off South Carolina and Georgia.
2. Explore complex and unique habitats such as caves, overhangs, depressions, coral mounds, pinnacles, and pavements with submersible and bottom sampling gear deployed from surface ship, and visually document and describe habitats and faunal assemblages in depths from 400-2000 m; compare faunas associated with different depths, bottom features and hydrography (e.g. current velocity), in terms of community structure, feeding guilds, growth and morphology. Data collected during this effort were to be compared to existing shallow-water databases the PIs have compiled.
3. Examine cross-shelf and slope patterns in the structure of macroinfaunal assemblages in relation to environmental factors (depth, seafloor landscape, physical properties of sediment, levels of organic matter in sediments, water-column characteristics).
4. Collect new and unusual species for taxonomic study and educational purposes.
5. Obtain corals for determining growth rates that will assist in conservation of deepwater coral banks and in determination of growth rates in the deep sea and factors that influence growth.
6. To compare faunal assemblages under the Gulf Stream on the Blake Plateau with habitats that lie upstream in the Bahamas and downstream in the eastern North Atlantic seamounts.
7. Collect DNA samples from corals, mollusks, decapods and other organisms to elucidate patterns of recruitment.
8. Compare observations to similar ones made by collaborators working ?downstream? in the Azores and nearby banks.
9. Develop educational materials (web, classroom curricula, video productions) from the research.

The sampling that we conducted obtained specimens and video-taped observations to address these objectives, but few were fully obtained. Weather and mechanical approaches prevented getting all sampling done, and no funds were made available for sample processing. Some objectives and tasks were completed in detail (particulary by graduate students), but much additional work remains to be done on the collections, particularly in making the connections with other sampling programs.

The approach we attempted was to explore diverse habitats and species assemblages along a transect from the southeastern coast to the edge of the Blake Plateau, in depths from 10 to 1000 m. Building upon shallow-water data collected in a variety of habitats, some of which encompass existing and proposed Marine Protected Areas (MPAs), and sampled deeper portions of the outer shelf and upper slope to examine the effects of habitat, protective management, terrestrial runoff, oceanographic features, and physical gradients on faunal assemblages. Central to this OE proposal and several complementary programs was a "Latitude 31-30" theme that focuses scientific investigation, ocean science education, and resource management along a belt transect at this latitude. Complementary programs include regional research, monitoring, education and resource management programs within NOAA (Southeast Regional Taxonomic Center-SERTC; Marine Resources Monitoring, Assessment and Prediction-MARMAP; Southeast Area Monitoring, Assessment and Prediction-SEAMAP; Gray's Reef National Marine Sanctuary-GRNMS; National Centers for Coastal Ocean Science/Center for Coastal Environmental Health and Biomolecular Research-NCCOS/CCEHBR; South Atlantic Bight Synoptic Offshore Observational Network-SABSOON; Southeast Atlantic Coastal Ocean Observing System-SEACOOS; Carolinas Coastal Ocean Observing and Prediction System-CaroCOOPS; NOAA Fisheries initiatives (e.g. Marine Fisheries Initiative; Charleston Bump Project); and others.

Along this transect centered on 31º30'N latitude exists a substantial source of research and monitoring data (Fig. 2). Proceeding seaward from several monitored coastal reserves (e.g. ACE Basin NERRS, Sapelo Island NERRS), the states of South Carolina and Georgia operate extensive monitoring programs coordinated with offshore monitoring that GRNMS sponsors and that the South Carolina Department of Natural Resources (SCDNR) and NOAA conduct. The SCDNR and NOAA programs include regional fishery monitoring stations and a survey of environmental conditions and infaunal communities along transects extending from the coast to the Charleston Bump (about 450 m). Previous OE investigations in the Transect area have examined fish and invertebrate communities on shelf edge (55-200 m) and Charleston Bump (400-600 m) reefs (Sedberry et al. 2004; Sedberry et al. 2005). Little is known of habitats and organisms beyond the Florida-Hatteras Slope, particularly those offshore of the Charleston Bump (Fig. 2). There are also complementary oceanographic initiatives underway in the shallower shelf waters along this corridor, including the South Atlantic Bight Synoptic Offshore Observational Network (SABSOON), a network of towers instrumented with oceanographic equipment for studying water movements and their influence on primary and secondary production in the SAB. Also, as part of ongoing research by collaborating NOAA scientists (Hyland et al. 2006), surveys of macroinfauna and chemical contaminants in sediments have been conducted within this same corridor from the mouth of Sapelo Sound out to the shelf break (100 m depth). A comparison of results of the historical research with those of the present study was made to examine broad-scale spatial patterns across the shelf and continental slope.

Another key objective was to document levels and patterns of biodiversity for the benthos of this region. Blake and Grassle (1994) found that the diversity of benthic slope fauna was much higher off the Carolinas in comparison to similar depths in the Middle Atlantic Bight. A station at 800 m on the slope east of Charleston SC produced the highest diversity ever recorded for the marine environment and supports the view that the region is probably an important reservoir for marine biodiversity. Understanding the levels and patterns of biodiversity in the Nation's coastal waters is an important goal of NOAA and the Ocean Exploration program.

Existing cooperative research programs along the Latitude 31-30 Transect offer an extraordinary opportunity to work with OE to coordinate scientific investigation, ocean science education, and conservation in an expanded deepwater exploration. This project was an attempt to sample deeper sites along that transect, and to collect samples for future collaboration among scientists, teachers, students and managers to further understand the complex oceanography and habitats that support essential ecosystems, diverse communities, and fisheries off South Carolina and adjacent states. It is hoped that this OE project will continue to serve as a catalyst to cement relationships among investigators from several institutions that have been conducting research along the Latitude 30-30 Transect, and will further exploration of the deep end of the Transect.

3. Approach:

a. Methods and Work Performed

We used a variety of technological tools and methods to map and describe bottom features of the Florida-Hatteras Slope, Charleston Bump and Blake Escarpment. The research platform was the R/V SEWARD JOHNSON, equipped with a SEA LINK submersible, remotely-operated vehicle (ROV), deep-sea trawl winch, oceanographic winch and associated deck gear to deploy sampling gear. Sampling included sonar survey, submersible dives and supplementary removal sampling with nets and dredges.

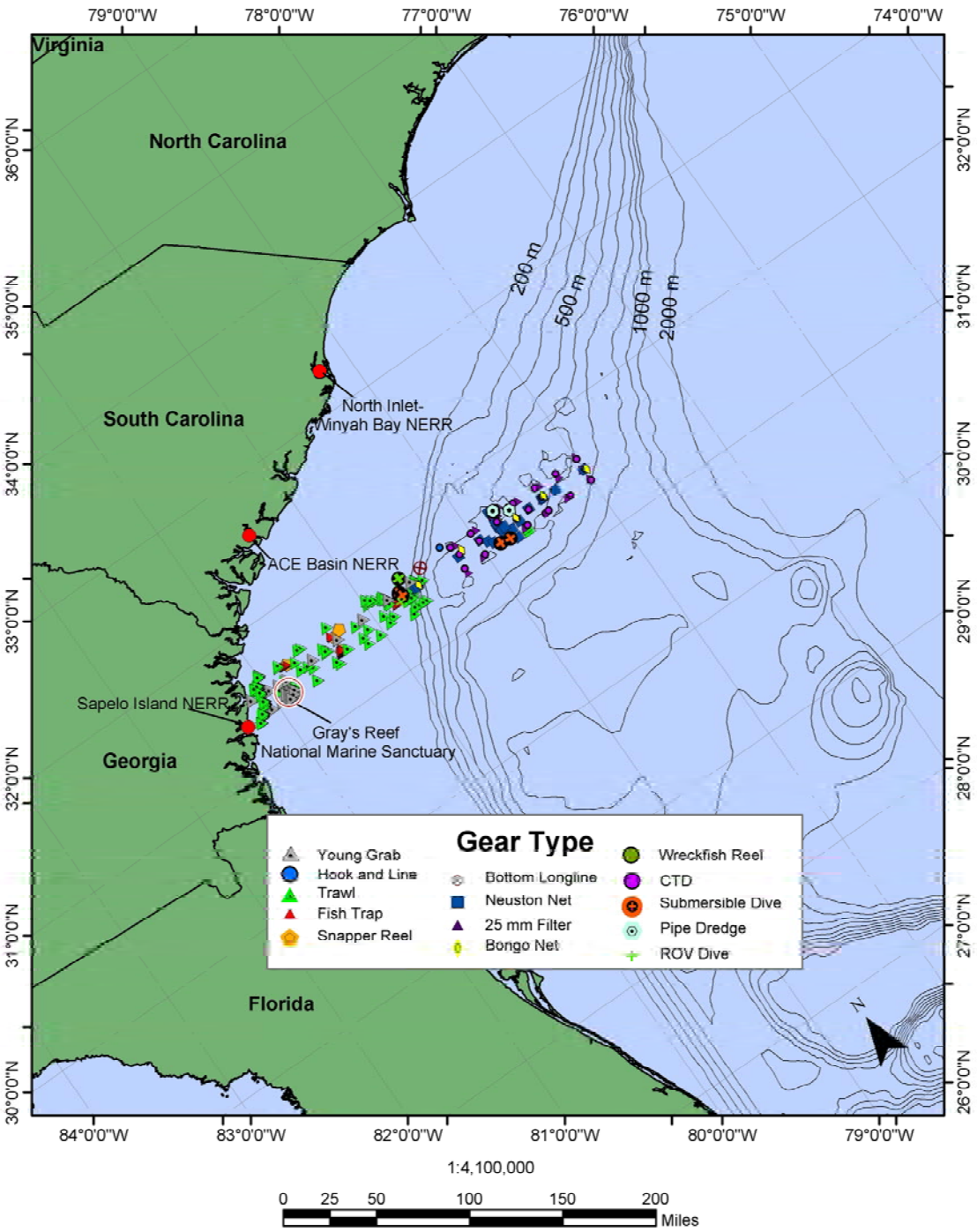


Figure 2. Location of existing samples along the 31-30 Transect known to the investigators. This includes samples collected under various NOAA programs (e.g.

Submersible Transects:

Twelve sites along the transect extending from our previous OE dive sites (Fig. 2) out to the 1000 m depth contour were selected for submersible dives; however weather conditions (including Hurricane Gaston, which formed on the study area during the cruise) and other problems resulted in some dives and sampling being conducted away from the Transect (Fig. 3; Table 1).

Table 1. Sample dates, locations and gear deployed.

Date	Site	Lat (N)	Long (W)(m)	Approx. Depth Activity	
20-Aug	Ft. Pierce FL				Depart
21-Aug	Sponge Cliff	31º14.7708'	78º57.1512'	578	Fathometer, Dive 3460, Grab, Plankton, CTD
22-Aug	Sponge Cliff	31º14.7708'	78º57.1512'	578	Dives 3461, Dipnet, Night Light & Trap, Fathometer
	Wreckfish Cave	31º 19.1136'	78º 50.5770'	460	Grab, Plankton, CTD
23-Aug	Wreckfish Cave	31º 19.1136'	78º 50.5770'	460	Grab, CTD, Dipnet, Pipe Dredge, Fathometer, U/W for Charleston for sub parts, Beam Trawl.
24-Aug	Wreckfish Cave	31º 19.093'	78º 50.201'	525	Beam Trawl, Night Light & Trap, Dive 3462, Plankton, Fathometer
	Barrelfish Cliff	31º 23.5812'	78º 35.8836'	591	Fathometer, Dive 3463, Grab, Hook & Line
25-Aug	Popenoe's Coral Mounds 1	31º 25.1214'	77º 51.4170'	736	Night Light & Trap, Fathometer, Dive 3464 (no video), Grab
	Popenoe's Coral Mounds 2	31º 24.2280'	77º 49.0158'	760	Pipe Dredge, Dive 3465, Grab
26-Aug	Sandy Tongue	31º 33.1458'	77º 28.5372'	895	CTD, Plankton, Fathometer, Dive 3466, Dipnet
	Deep Flats	31º 48.6'	77º 31.2'	800	Fathometer, Dive 3467, Plankton, CTD, Pipe Dredge

Table 1. Continued.

Date	Site	Lat (N)	Long (W)(m)	Approx. Depth Activity	
27-Aug	Charleston Manheim's	31º 48.6'	77º 34.8' 800		Offload personnel Weather day, operations suspended. Dipnet
28 Aug	St. Augustine N			60	Weather day, operations suspended. Dipnet
29 Aug	St. Augustine N	30º 01.800'	80º 16.20'	60	Fathometer, Dive 3468
	Jacksonville N	30º 25.200'	80º 12.60'	60	Fathometer, Dive 3469
30 Aug	Cutthroat Cliff	30º 17.000'	79º 20.30'	850	Plankton, Fathometer, Dive 3470, Night Light & Trap
	St. Augustine N	30º 01.800'	80º 16.20'	60	Dive 3471
	Red Snapper Sink	29º 44.440'	80º 44.875'	18	Fathometer
31-Aug	St. Augustine S	29º 52.80'	80º 16.80'	60	Plankton, CTD, Fathometer, Dive 3472 (no video)
	Flagler Scarp	29º 40.0'	80º 12.0' 60	60	Fathometer, Dive 3473
1-Sep	Ft. Pierce				Media event

Prior to initiating dive and other operations, the surface support ship transected the area with a Knudsen 3.5/12kHz (dual frequency) deep water high-powered precision echosounder and dGPS to confirm historical depth and contour data and provide additional bathymetry data for each sampling and dive area.

Submersible survey techniques consisted of timed (4-min) videotaped transects, used for fish and sessile invertebrate counts. Habitat data were recorded on all transects, and included depth, temperature, visibility, conductivity, current and habitat type. Prior to conducting dives, habitats were classified as:

1. soft sediment
2. soft sediment with rock rubble
3. carbonate hard bottom
4. hard bottom with rock rubble
5. mixed bottom
6. pavement
7. coral rubble
8. live coral
9. high-relief ledge
10. wall
11. low-relief ledge
12. boulder.

Upon subsequent analysis of videotapes, habitats were reclassified (see results, below), and additional

classifications were constructed for analysis of fish distributions (see results, below).

On each dive, we attempted the following, with varying success:

1. Use photographic, video, audio and written note to quantify fish species composition and abundance along transects and at points. Use downward-looking and forward-looking video cameras for records of transects;
2. Collect specimens of large epifauna for determining composition of symbiotic assemblages.
3. Collect corals and mollusks for age determination and/or genetic study.
4. Collect voucher specimens of megabenthic epifauna.
5. Collect specimens of unusual or difficult taxa for museum collections (ichthyocide, scoop, suction).
6. Collect specimens of deepwater fishes and invertebrates corals for museum and DNA archives, and for study of antimicrobial resistance.

Transects for quantitative assessment of fishes and large epifaunal invertebrates were initiated at features of interest noted from historical sonar data (e.g. Gloria Atlas, Popenoe and Manheim 2001). Because of strong currents, upwelling and downwelling, it was usually difficult to position the submersible on the feature of interest. Some of the most spectacular scarp features we attempted to sample are in areas that are subject to currents that affected submersible operations, grab sampling and trawl sampling.

Upon landing on the bottom for each dive, the surface ship provided a heading for specific features from georeferenced sonar maps. Prior to sampling, the pilot estimated visibility. Survey techniques consisted of videotape recordings with forward-looking (45º angle to the bottom) cameras along each transect. Transects were continued for 4 min, with position measurement taken at beginning and end for distance measurements (m) to calculate densities of organisms. A panoramic recording of the habitat was made during stops between transects and during collection of organisms.

Although the primary objective of each transect was to record videotape on which to subsequently count fishes and sessile epifauna, we also used observer notes to describe the fauna and behavior of organisms in relation to habitat features. Observations of fish behavior were also noted. These observations were recorded onto a Personal Digital Assistant (PDA) during the dive, and uploaded into a computer database after each dive. During stops to obtain position fixes, we collected specimens of dominant sessile epifauna (corals, hydroids, sponges, etc.) for positive identification in the laboratory. Permanent records of each transect were made using digital still and video cameras. Still images were used to document the characteristics of the habitat and to corroborate visual observations and digital video recordings. In addition, a vertically-oriented digital still camera was used to obtain photoquadrats that were to be used to calculate percent cover of hard substrates by sessile biota. Audio recordings of observations were made concurrently with the video and still camera records. The submersible cruised slow enough to ensure clear images on the video (0.5 m/s = 1.8 km/hr = 1.1 mi/hr or less). Each camera system had laser metrics in the recorded images, to judge transect width, quadrat size and organism size in the images. Parallel beam lasers were used to give scale at a distance, and a central offset laser allowed the determination of distance from the sub.

We used the submersible manipulator arm to collect sediment samples (including rocks) and samples of dominant sessile organisms from various habitats. Biological specimens were preserved aboard ship in 70% ethanol or 10% formalin and labeled appropriately. We also used the manipulator arm collect selected sponges and corals for study of associated species. We used the submersible's suction tube to collect epifauna from sessile megafauna and from quadrats (0.1 m^2) deployed on the rock surfaces. We attempted to obtain at least three replicate suction, scoop and sessile megafauna samples from each habitat type observed on each dive.

Population estimates of fishes, corals and sessile megafauna were derived from transects using a mean density value for the total area covered during a transect. Spatial distribution within a transect was analyzed using appropriate non-parametric tests. Density comparisons among areas were statistically analyzed using the non-parametric Kruskal-Wallis test (Sokal and Rohlf 1995).

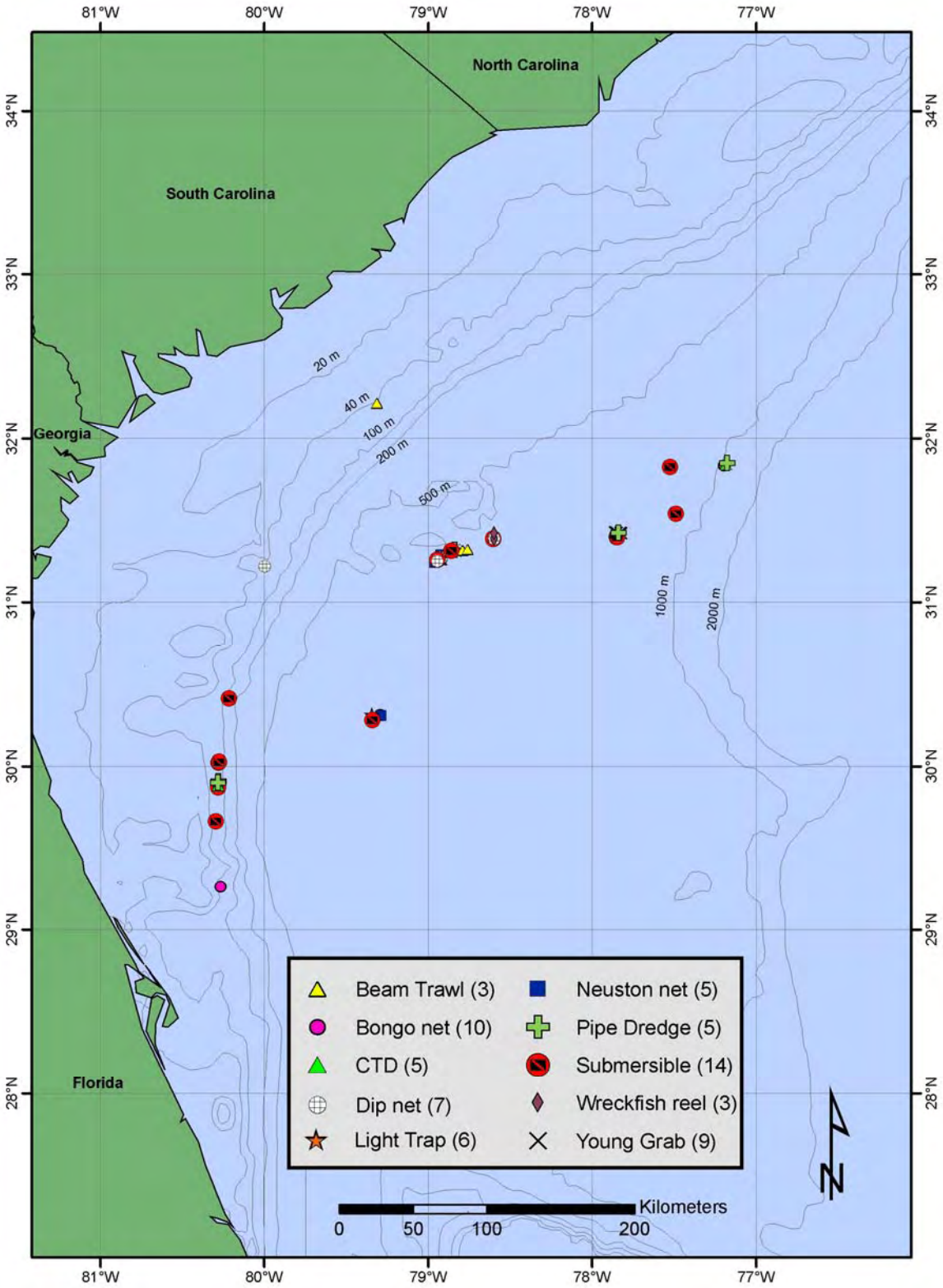


Figure 3. Location, type and number of samples collected along the 31-30 Transect and other areas during the expedition.

Benthic Sampling in Soft-Bottom Sediments:

To address the benthic ecology objectives, synoptic sampling of benthic macroinfauna and environmental variables was conducted at or near each dive site. Samples of benthic fauna were collected using a combination of scoop sampler, and/or suction tube deployed from the manipulator arm of the submersible. We used sediment grabs deployed from the ship at six sites along the Transect, between the 1000 and 2000 m depth contours, where the submersible cannot be used (>1000 m depth). A Young grab (0.04 m2) was used to collect samples for comparison with samples collected from 10-200 m on previous cruises. Replicate samples (we attempted a minimum of three) were collected at each dive and grab site for analysis of benthic fauna. All benthic samples were sieved at sea through a 0.5mm sieve and material remaining on the sieve transferred to a storage container, and preserved in 10% buffered formalin stained with Rose Bengal. An additional sample of sediment was attempted at each site for analysis of sediment granulometry and total organic carbon content. A CTD cast was also made at each station (dive site or grab site) to obtain measurements of water depth, salinity, dissolved oxygen, and pH. Photographic and video images from the submersible and depth recordings from the ship's fathometer were used to help evaluate the landscape of the seafloor.

Coral Biology and Ecology:

We used sonar records to direct submersible transects along habitats likely to contain corals, and recorded videotransects for quantitative counts of coral density, descriptions of coral morphology and descriptions of oceanographic and bottom conditions found in areas of coral growth. Submersible observations were supplemented with collections that gave us a species inventory as well as specimens to determine growth and reproduction. Coral specimens will were also collected to be examined for symbionts in order to determine species, interactions.

Dives for fish observations and macroinfauna collections were used to record videotransects of coral densities along a large-scale transect from shallower (400 m) to deeper (1000 m), covering substrates ranging from low relief to high relief and within the main axis of the Gulf Stream and to the east of the main current. These tapes can be used to compare coral density, colony height, and extent of dead/broke coral and rubble in relation to measured current speeds and observed bottom types during future analysis. These data will enable us to construct high-resolution maps at close range from plan view photographs and still images from digital videotapes recorded at fixed distances (determined by conditions) above the bottom. We will then conduct comparisons across different environments by doing this in multiple transect locations over a variety of habitats. Preliminary analysis of videotaped transects from our previous OE work on the Charleston Bump area of the Blake Plateau indicated that the corals colonies appear to be distributed roughly equidistant to one another, and are similar in height and perhaps. This non-random could suggest a great deal about the frequency of perturbations that perhaps scour colonies from the bottom, and we will attempt to observe and measure environmental conditions. We examined coral density and "clean" exposed rock in term of physical characteristics such as currents and nutrient availability. Admittedly, a few such static observations may not reveal the cause of coral growth patterns, but patterns should emerge by repeated observations of corals and physical conditions under which they grow. The videotapes to conduct these studies were collected and archived, but not analyzed (other than for gross descriptions of habitats, see results below), due to budget limitations.

We collected dead and fossil corals along with live specimens and hydrographic and oceanographic data. Growth patterns noted in living and dead corals were compared to determine if existing conditions can explain the growth patterns in terms of previous die offs and coral composition cues that may indicate oceanographic conditions that caused kills. The corals described here were collected using the submersible *Johnson Sea Link* (*JSL*) on an OE cruise from August 2 to August 16, 2003 and August 20 to September 1, 2004 (present study).

Coral collections were made using suction, scoop, or were removed from rock samples taken from the bottom by claw. Depth, water temperature, and location were all noted at time of capture. Corals were determined to be alive at capture based on the lack of overgrowths, intact white surfaces, and when possible, the presence of soft tissue found by probing into the cyclosystems. Water samples were collected using a Niskin bottle rosette attached to a conductivity, temperature, and depth meter (CTD), as well as bottom water samples taken from the *JSL* sub directly at the coral collection localities. Coral sampling was opportunistic, based on observation from the submersible and was not systematic with respect to stylasterids (the target group for isotope analysis). The two coral colonies (denoted as T10031039 and T100313034.9) analyzed for stable isotopes in this paper were collected on *JSL* Dive 3408 August 6, 2003, from a depth of approximately 500 m. The two colonies were

collected several hundred meters apart. Additional colonies collected in 2004 have been archived for future analysis.

Samples were sorted, rinsed in sea water, and dried on board the *Seward Johnson* where they were stored at ~4°C. Samples were stored dry until they were bisected and/or thick or thin sectioned on a slow speed diamond wafering saw. Samples were mounted on slides using Crystalbond thermal epoxy. Those corals to be analyzed for stable carbon and oxygen isotopes were ground into thick-sections of approximately 1.5 mm and sampled on a Merchantek/New Wave EO XYZ-axis computer-controlled micromill. All growth measurements of sectioned samples were conducted using the digital measuring software of the Merchantek/New Wave EO micromill. Measurement of overall height of intact colonies was made using digital calipers.

Samples measured at the Savannah River Ecology Laboratory stable isotope facility (specimen T10031039 – lower transect) were analyzed using a Thermo GasBench II and Delta+ XP continuous flow isotope ratio mass spectrometer (CF-IRMS) following the methods of Jimenez Lopez and Romanek (2004). Working standards were analyzed every 5 samples, to determine analytical precision. Data are reported relative to the Vienna Pee Dee Belemnite (VPDB) standard in parts per mil (‰). Precision was estimated to be ±0.18‰ (1σ) for $\delta^{13}C$ and ±0.33‰ (1σ) for $\delta^{18}O$, based on standards in the sample batch (within run: n=9).

Samples measured at the University of Alabama, Department of Geological Sciences Stable Isotope Laboratory (specimens T10031039 – upper transect and base-to-tip within-increment sampling and all analyses of T100313034.9) were analyzed using dual inlet methods, with CO_2 extracted using a common acid bath on an in-line micro extraction line coupled to a Thermo Delta+ IRMS. Data are reported as above with a precision estimate of ±0.1‰ (1σ) for both $\delta^{13}C$ and $\delta^{18}O$ (n=310).

Water samples were measured for their oxygen isotope composition at the Savannah River Ecology Laboratory stable isotope facility by CO_2 equilibration using the GasBench II. Precision was estimated to be ±0.37‰ within-run (1σ, n=16), based on internal laboratory standards compared to VSMOW.

We constructed high-resolution maps of each transect. Each map included habitat type and coral species. Such maps can be used in future analyses to help elucidate the factors that influence growth and distribution of corals, as well as the relationships of associated fishes, crustaceans and other species that utilize coral banks and colonies as habitat. We also collected oceanographic data in order to enhance knowledge of the physical parameters that effect the distribution and extent of deep-sea corals. We observed and recorded the underlying geology of coral banks and areas of coral colonies, to complement DNA and aging work to understand colonization and succession in coral assemblages. We used the submersible to collect and analyze species composition of corals and assemblages of closely-associated species (analyses to be completed in the future).

Use of corals to determine climate change depends on what the potential the corals we collect have as climate proxies. There still needs to be a much better understanding of the chemical systematics, and we still have much to learn about the average age of these corals. If we can determine that some corals this area live for a long time (~100 yrs), which is a reasonable assumption (Adkins et al. 1998), the next step would be to collect living specimens from an area of fairly well-known climate such as the outer Blake Plateau, and see how well the isotope and trace metal content reflects known local conditions, and then explore how far back in time these living corals could go. We collected these corals at suitable sites to for future studies of climate change.

Sponge Symbionts

Sponge specimens (n=15) were collected during dives on this expedition, and combined with samples from previous OE expeditions for analysis. In 2002, dives were completed from 27 July to 5 August at seven shelf-edge and upper-slope locations off northern Florida and South Carolina, in depths ranging from 50 to 950 m. Dive sites were named St. Augustine Scarp, Jacksonville Scarp, Julian's Ridge, Scamp Ridge, Charleston Lumps South, Charleston Lumps North, and Georgetown Hole. Dives conducted from 3 to 13 August, 2003, ranged from 49 to 607 m at the Charleston Bump southeast of Charleston, South Carolina, and on the adjacent shelf-edge. Additional dives were completed during the current expedition in the Charleston Bump area from 19 August to 1 September, 2004, in depths ranging from 500 to 900 m (Tables 1, 2). For comparative purposes, two sponges were collected from 16 km offshore of Charleston, SC, at 30 m depth by SCUBA.

Sponges were collected using a mechanical claw or scoop sampler attached to a mechanical arm on the submersible. Upon collection, each sponge was immediately placed in a large Plexiglas container on a rotating conveyer belt on the submersible. A coordinating lid was closed over each container immediately after collection to avoid any loss of associated fauna. Collection of the two sponges by SCUBA was done by placing a plastic bag over the sponge, which was cut at its base.

Upon return to the research vessel, each sponge was photographed using a Nikon CoolPix 990 digital camera to obtain a permanent record of external characteristics. Prior to preservation, sponges collected in 2004

were placed into plastic bags containing seawater. After conditions in the bag became anoxic, the sponge and faunal associates that evacuated the sponge were placed in collection bottles, fixed in a 10% formalin-seawater solution for 24 hours (2002 sponges were kept in formalin for about four months), and then preserved in 70% ethanol, identical to procedures followed for sponges collected in 2002 and 2003.

Specimens of *Ircinia campana* were selected for an additional study to examine the spatial distribution and overall abundance of symbionts within individual sponges. Specimens were cut into basal and distal portions immediately after collection and placed in separate containers.

Sponge specimens selected for collection were dependent upon many factors, including what the submersible encountered and the storage capacity on the submersible. In addition, while video transects were generally representative of the site, the goal of the cruises was to characterize reef habitat, and therefore an effort was made to remain near the hard-bottom regions and avoid sandy or muddy habitats. In general, the bottom type appeared similar to previous reports (Struhsaker 1969; Barans and Henry 1984).

In the laboratory, sponges were rinsed over a 0.5 mm sieve to collect any fauna present on the specimen's exterior. Next, three volume measurements were made following methods used by Villamizar and Laughlin (1991). The "wet volume" was measured by volume displacement of the sponge after gently squeezing out the excess water. This method is commonly used as a measure of sponge volume (e.g., Westinga and Hoejtes 1981; Crowe and Thomas 2001). A "wrapped volume" was measured by volume displacement of the sponge wrapped in self-sealing polyethylene wrap. Finally, following dissection, sponges were dried in a Barnstead Thermolyne 30400 furnace for 42 h. and sponge dry volume displacement and dry weight were determined. The volume of channels and meanders was obtained by subtracting the dry volume from the wet volume. The atrial volume was calculated by subtracting the wet volume from the wrapped volume (this volume was only used to calculate total volume). Total volume was obtained by adding the atrial volume and the channels and meanders volume.

Sponges were dissected to obtain any associated organisms within the sponge material. A caliper was used to take 10 arbitrary measurements of sponge wall thickness and 15 arbitrary measurements of canal diameter. Due to the overwhelming abundance of the polychaete *Haplosyllis spongicola* in *Ircinia campana* and *Topsentia* sp., the worms were placed in a Fulsom plankton splitter and split into halves or quarters depending on the sample size, before counting the individuals. The number counted was then multiplied by the number of times the sample was split to obtain a whole count. Three test runs with a known amount of worms were conducted with the splitter to ensure that the sample would be split evenly; samples were within 85%, 93% and 96% of the correct number.

Specimens were sorted into major taxonomic groups, identified to the lowest possible taxonomic level, and counted. Because the amphipod *Leucothoe spinicarpa* is known to represent a species complex, it was referred to as *L*. cf. *spinicarpa* in this study (Theil, 2000). Expert taxonomists at the South Carolina Department of Natural Resources were consulted during the identification process and five arbitrary samples of symbionts were counted and identified for quality control. All five samples passed quality control with at least 95% correct identifications.

Sponges were identified using photographs and spicule preparations. Preparations were done using a bleach digestion technique, in which small fragments from both the surface and deeper parts of the sponge were placed in a small petri dish, and a small amount of bleach (sodium hypochlorite) was added and allowed to dissolve the organic components (See Hooper 2000). The bleach was then carefully diluted with deionized water, and pipetted onto a glass slide. Wax section preparations were also used to determine the structure of the mineral skeleton following methods of Hooper (2000). Hooper and Van Soest (2002) was used to identify the sponges based on spicule and section preparations. Experts at the Sponge Taxonomy and Ecology Workshop (August 15-25, 2005) at the Smithsonian Tropical Research Institute were consulted while identifying these sponges. During this workshop, most specimens were confirmed to the genus level, with the exception of one sponge of the order Hexactinellida and one sponge that was identified as *Tethy*a sp. at the workshop. However, further investigation revealed that this placement (*Tethya*) was due to slide contamination. Presently, this sponge is referred to as *Cliona* sp.; this generic placement, however, has not been confirmed.

For simplicity, sponge species with more than one individual were labeled with A, B, C, etc. in order to keep track of individual specimens throughout the analyses. These labels do not indicate different species (e.g., *Ircinia* A, *Ircinia* B, *Ircinia* C, etc. all represent specimens of *Ircinia campana*), but rather replicates.

Because of unequal sample sizes and few numbers of sponge species, no statistical test was conducted to look for significant differences among hosts. Due to the different volumes of sponge specimens, the abundance of symbionts was adjusted to the abundance per 500 ml of host. To permit comparisons among sponges of different sizes, this density was used in all analyses requiring abundance with the exception of diversity and evenness calculations and faunal percentages of each taxon.

Diversity was calculated using the Shannon-Wiener index (H'):

$$H' = -\text{sum } p_i (\log2(p_i)),$$

Where $p_i = n_i/N$ and N is the total number of individuals of all species and n_i is the number of individuals of a single species. Pielou evenness (J') was calculated as:

$$J' = H' / \log S,$$

where S is the number of species. Standard error was also calculated for diversity and evenness by bootstrapping the diversity and then calculating variance as:

$$S^2_{H'} = \frac{\text{Sum } n_i \log (n_i)^2 - (\text{Sum } n_i \log (n_i))^2 / N}{N^2} + \frac{s - 1,}{2N^2}$$

$$S^2_{J'} = S^2_{H'} / (\log S)^2 ,$$

Standard Error = sqrt ($S^2_{H'}$) / sqrt (n).

Species richness was calculated using the formula devised by Margalef (1958):

$$d = (S-1) / \log_e N,$$

where S is number of species in the sample and N is the number of individuals in the sample. Diversity and evenness values, as well as the percentage of each taxon, were obtained using a program that was written by Tim Snoots at the South Carolina Department of Natural Resources in the software package SAS (SAS/STAT user's guide). The variance and standard error were calculated using the statistical software R (download available at www.r-project.org)

Linear regressions using the statistical software program R were conducted to examine density and taxon number relationships with canal diameter, total volume, and volume of the channels and meanders of the host species (for hosts with more than two representatives). All data used for the linear regressions were found to be normally distributed using the Shapiro-Wilks normality test in R. Results of regressions are given with the F-statistic, and degrees of freedom in subscript (e.g., $F_{df,\ df} = x$), as well as the p-value.

Regressions including all sponge and tunicate specimens were conducted using various methods. Linear regressions were conducted using R, while the program Table Curve 2D (user's guide available at www.systat.com) was used to fit a polynomial equation to the data for such parameters as canal diameter and volume with the dependent variables of abundance and diversity of symbionts. Curvilinear regressions were conducted based on findings by Villamizar and Laughlin (1991) that relationships between symbiont abundance and sponge size and characteristics may not be linear. Multiple regression was also used to look at the influence of sponge characteristics on the diversity and abundance of symbionts. Analyses were done using backwards stepwise regressions in the program JMP (JMP statistics and graphics guide, 1995). Due to deviations from normality, log transformed variables were used for both the polynomial regressions and the backwards stepwise regressions, with the exception of density, which was ranked. One variable, sponge wall thickness, could not be transformed to pass normality tests; a non-parametric regression of Kendall's robust regression was used to test thickness for a relationship with diversity and density.

Both normal and inverse cluster analyses were based on the abundance (per 500 ml of host) of shared symbiont species. Both cluster analyses were done using the hierarchical unweighted pair-group method using arithmetic averages (UPGMA) with the Bray-Curtis similarity coefficient in the statistical package R.

The numerical coefficient C_n, used by Westinga and Hoejtes (1981), was used in this study to compare specimens within and between species and to compare to findings by Westinga and Hoejtes (1981) who examined *Spheciospongia vesparium*. The coefficient uses percentages and therefore allows for comparisons between samples of different volumes. To calculate C_n, the number of individuals of each taxon associated with each host was expressed as a percentage of the total number of individuals per host. Pairs of hosts were compared by recording the smaller percentage for each instance of co-occurrence and then summing these percentages. The acquired value (C_n) gives similarity of the two hosts' symbiont fauna, with one or 100% being most similar and zero being most dissimilar.

Analysis of Variance was used to detect differences in abundance between the distal and basal portions of the three Ircinia campana sponges. Analyses were conducted in the program R.

Antimicrobial Resistance:

The isolation of antimicrobial-resistant bacteria from human and veterinary hospitals has generated interest because the development of "super-bacteria" presents a health risk to patients in these facilities (Adetosoye 1980). The misuse of antibiotics in the treatment of domestic livestock has also received attention because of the risk of introducing antibiotic-resistant bacteria into the food chain. To date, few studies have evaluated wild animal populations for antibiotic-resistant bacteria (Hudson et al. 2000). Wild animal populations may serve as sentinels to evaluate environmental health. The purpose of this part of the Exploration was to determine if deep-water teleosts from a relatively pristine environment harbor bacteria with resistance patterns to antibiotics routinely used by medical and veterinary health professionals.

We collected fishes from varying depths and distances offshore for examination of antimicrobial resistance in deep-sea fishes that (theoretically) should never have been exposed to synthetic drugs. We concentrated on non-migratory demersal species such as adult wreckfish, berycids, macrourids, morids and congrids. We collected apex predators and other demersal fishes to determine the role of food chains and dispersal in the spread of antimicrobial resistance to remote populations.

After fish specimens were collected using submersible or beam trawl (see below), ante-mortem samples were collected from the kidney (preferred), anus or cloaca using a Culturette (Bekton Dickinson Microbiology Systems, Sparks, MD 21152). Once the sample was collected, the swab was immediately placed into liquid nitrogen (LN2) for storage. The approach to the coelomic cavity (kidney sample) followed sterile techniques to prevent the introduction of contaminants. To achieve this, the fish was placed in right lateral recumbency and a sterile preparation of the lateral body wall done using 70% ethyl alcohol. The lateral body wall was removed using standard necropsy techniques. The swimbladder was incised with sterile scissors or a scalpel, and the kidney identified. A Culturette was introduced into the anterior kidney to collect the sample. Again, the swab was placed into LN2 for storage. Once all of the sampling was completed, the samples were transported on LN2 to the LSU School of Veterinary Medicine, Baton Rouge, for processing. Unfortunately, the laboratory was struck by hurricanes in the weeks following the cruise, and all samples were lost, so this part of the study was not completed.

Additional Collections:

In addition to submersible collections, we deployed sampling gear from the surface (Table 1). We deployed sediment grabs as described above, and used small pipe dredges (24 in diameter) to collect living and dead coral, other invertebrates and sediment and rock samples. We also deployed a small beam trawl (10 ft), unsuccessfully, to capture small mobile organisms. The beam trawl worked when tested in shallow water, but was lost when used on the Black Plateau, apparently hanging in the rocks.

These sampling gears were deployed primarily in depths beyond those that can be sampled by the *Sea Link* submersible (>1000 m), and to obtain samples when the submersible was not available during charging, maintenance and down time. We also obtained plankton (60 cm bongo and 2 m neuston) samples. During non-diving periods we also conducted bottom mapping, as described above, using the ship's fathometer. We performed CTD casts and continuous bottom sounding/recording, and continuous flow-through surface temperature and fluorometry, ADCP, depth and position recording.

Plankton sampling (1 x 2-m neuston frame with 947-? mesh; 60-cm bongo frame with 947-? and 504-? mesh) were directed toward thermal fronts and surface features noted on satellite SST images. The SCDNR/NOAA-funded program that is looking at the importance of the Charleston Bump as a spawning and nursery area for highly migratory fishes such as swordfish and tunas has revealed the presence of very young sailfish on the Charleston Bump and we conducted additional sampling on this OE cruise to obtain additional material for determining age, spawning location and spawning time for sailfish and other highly migratory fishes. We also deployed two sizes of light traps to collect fish larvae and other plankton. We conducted nightlighting and dipnetting stations to collect educational materials. Plankton, dipnet, nightlight and light trap samples were archived in the Southeast Regional Taxonomic Center for future analysis.

Education and Outreach:

Project investigators prepared pre-cruise educational materials for the Ocean Exploration web site and teacher institutes. Web materials were also posted "live" (e.g. daily logs), and we prepared post-mission summaries for posting on educational web sites (e.g. Oceanica). Web materials were directed at the general public; NOAA supporters; nongovernmental science, conservation and education organizations; policymakers; educators and students interested in ocean science. In addition, we prepared materials for press releases, and

compiled data summaries that can be useful to management agencies (e.g. the South Atlantic Fishery Management Council) for educating the public about marine issues and their management.

The scientific party prepared web essays that provided all the necessary background information for this mission, including the mission plan and information on habitats, species, biodiversity and management. We provided maps of sample locations, images of organisms known to live there, and descriptions of hypotheses to be tested during the mission. We described what we planned to do, and why it is important to conduct these studies. We described the technology used and how each piece of equipment collects data that help achieve the mission objectives. Additional background materials included biographies of the participants and links to web sites that detail their research. Topical essays provided detail on specific aspects of the research, such as the importance of deep coral reefs as hot spots of biodiversity and fish production, the communities associated with specific habitat features, growth rates of corals, the problems associated with fishing on populations of deepwater fishes, mesopelagic habitats and organisms, and other topics of interest within the expertise of the project team. We also provided daily mission logs from sea for posting on the OE web site. These included event-driven logs, scripted logs, personal reflections, logs of opportunity, and summaries of daily and mission-wide events. In these logs we described significant observations, along with the methods use to make them. Scripted logs were planned and written in advance of the cruise, but posting coincided with scheduled cruise activities. They were modified as needed if the daily activity plan changed, or if observations necessitated updating the scripted log. Logs reflected the science mission, interesting findings and interesting personal reflections or situations.

All written educational materials were supplemented with still photographic images, video clips, graphs, maps and charts. Most illustrative material will be obtained on the cruise, but the investigators also have many existing images that can be used to illustrate educational materials.

In addition to pre-cruise and "live" logs, we prepared science summaries for undergraduate and graduate students, to be posted on the Project Oceanica web site at the College of Charleston (e.g. http://oceanica.cofc.edu/summaries.htm). Post-mission educational materials have links to pre-cruise and "live" sites, as well as to science summaries prepared as samples were analyzed and reports written.

The mission had an educator-at-sea, representing informal (public aquarium) education. The educator reviewed daily emails from students, teachers and the public and composed replies based on her own expertise or interviews with scientists and crew. In addition, many of the mission scientists were also educators, and assisted in preparing educational materials.

Curriculum development was done by contractors employed directly by OE, but who used information collected during the Expedition.

b. Project Organization and Management

This project was managed by the Principal Investigator, George R. Sedberry. He was also Chief Scientist on the cruise. Reed Bohne, Gray's Reef National Marine Sanctuary, was Co-PI. Primary Participants contributed as follows:

Clark Alexander, Skidaway Institute of Oceanography, participated in proposal preparation and provided geological advice.

Fred Andrus, University of Alabama, assisted in proposal preparation, provided protocols for coral and water sampling, and processed coral and water samples for determining isotope composition.

Stacia Fletcher, formerly of the South Carolina Aquarium, participated in proposal preparation and helped arrange for the teacher at sea. She resigned from the Aquarium prior to the project start date, and could not participate in the expedition.

Matt Gilligan, Savannah State University, participated in proposal preparation.

Jeff Hyland, NOAA NCCOS, participated in proposal preparation, sample design, sample analysis and report preparation. He provided staff (J.D. Dubick and Cindy Cooksey) to participate in field operations and/or lab analysis of benthic samples. He managed infaunal sampling, sample processing, data analysis and report preparation.

Gui Menezes, University of the Azores, participated in proposal preparation and provided valuable advice about deep rocky ecosystems.

Mark Mitchell, Louisiana State University, assisted in proposal preparation and provided the protocols and materials to collect samples for antimicrobial resistance analysis.

Leslie Sautter, College of Charleston, participated in field work and helped develop educational materials and project reports. She presented results of the project at several scientific and educational meetings.

Additional project personnel assisted in field work and laboratory analysis. Pamela Jutte (formerly of SCDNR) directed analysis of invertebrate samples from sponges and corals. Graduate Research Assistant Cara Fiore (College of Charleston) processed those samples and prepared project reports and presentations. Susan DeVictor, assisted in field work and took amazing photographs of specimens. Many of the photographs were used for educational materials developed during and after the cruise, and will appear in future publications.

Educator-at-Sea Katrina Bryan (South Carolina Aquarium) assisted at sea and developed web logs and presentations based on scientific results, personal experience on the cruise and interviews of cruise participants.

We acknowledge with grateful thanks the other members of the Scientific Party aboard the R/V Seward Johnson (Table 2). In addition to all of these people helping with all aspects of field work, Lenny Collazo and Jeff Jenner helped organize data and web/outreach imagery and materials. J.D. Dubick organized benthic sampling. Kelly Filer assisted in fish sampling and processing and Cara Fiore sampled sponges and corals. Sarah Griffin assisted in GIS analysis and Rachel King assisted in invertebrate sample processing. Josh Loefer was cruise logistician and helped with fish sampling. He was assisted by Scott Meister, Paulette Mikell and Byron White. Christina Ralph and Zeb Schoberned helped with videotape annotation and Jessica Stephen constructed the database and kept data organized.

Laboratory and data analysis assistance was provided by Chris Romanek, Miguel Etayo, Joe Lambert and Lindy Paddock. Stephen Cairns (Smithsonian Institution) assisted in coral identification and Rich Styles and Dara Hooker (University of South Carolina provided oceanographic advice.

Missy Partyka, Steve Ross and Andrea Quatrini (all of University of North Carolina at Wilmington) contributed to habitat descriptions, based on our analysis of videotapes for the NOAA SEADESC project (Partyka et al. 2007).

Table 2. List of cruise participants and their affiliations

Participant	Participant's Organization	Participants Supporting Funding Agency
Katrina Bryan	South Carolina Aquarium	South Carolina Aquarium, NOAA OE
Lenny Collazo	NOAA/NCDDC	NOAA
Susan DeVictor	SCDNR	NOAA OE, NOAA Fisheries
Joshua (J.D.) Dubick	NOAA/NOS/NCCOS	NOAA NOS
Kelly Filer	College of Charleston	NOAA OE, NOAA Fisheries
Cara Fiore	College of Charleston	NOAA OE, NOAA Fisheries
Sarah Griffin	College of Charleston	NOAA OE, NOAA Fisheries
Jeff Jenner	NOAA/NCDDC	NOAA
Rachel King	SCDNR	NOAA OE, NOAA Fisheries
Josh Loefer	SCDNR	NOAA OE, NOAA Fisheries
Scott Meister	SCDNR	NOAA OE, NOAA Fisheries
Paulette Mikell	SCDNR	NOAA OE, NOAA Fisheries
Christina Ralph	College of Charleston	NOAA OE, NOAA Fisheries
Leslie Sautter	College of Charleston	NOAA, College of Charleston Project Oceanica
Zeb Schobernd	College of Charleston	NOAA OE, NOAA Fisheries
George Sedberry	SCDNR	SCDNR, NOAA OE, NOAA Fisheries
Jessica Stephen	SCDNR	NOAA OE, NOAA Fisheries
Byron White	SCDNR	NOAA OE, NOAA Fisheries

Letters of acknowledgement (LOAs) and permits that allowed us to sample fishes, corals and live rock were provided by the NOAA Fisheries Southeast Regional Office and NOAA Office of Sustainable Fisheries. The research described herein complied with all laws of the United States. Support was provided by grants from the NOAA Office of Ocean Exploration. Additional support was provided by Grants NA03NMF4720321 and NA17FF2874 from the NMFS Special Programs Office, and MARMAP Grant 52WCNF6006013. NOAA Marine and Aviation Operations provided ship time for bathymetry mapping, and the crews of the NOAA Ships Whiting

and Thomas Jefferson collected and processed bathymetry data used to select stations.

c. Data Organization, Processing and Archiving

Submersible tracking data were collected, processed and archived by the submersible and ship's crew. In addition, NOAA data managers Lenny Callazo and Jeff Jennings recorded paper dive logs and videotape catalogues. We kept separate digital data files ("sampling data logs") on each cruise activity, recorded by collection number, dive number, date, time, depth, location and gear or activity. During submersible dives, data and observations were recorded on hand-held computers (personal digital assistants) so that individual observation logs could be easily digitized. During the cruise we collected the following digital data:

1. 3.88 GB of VIDS data, including continuous measurements of location (GPS); surface water temperature, salinity, fluorescence; weather; acoustic Doppler current profile (ADCP).
2. 97.60 MB of precision echosounder data.
3. 1.11 MB of CTD data.
4. 42.30 MB of submersible navigation data.
5. 39.50 MB of sampling data logs, including field data for locations of all sub and ship collections in MS-ACCESS database.
6. Approximately 40 hours of digital videotape, including a 106 KB submersible video annotation file.
7. Several thousand digital still images taken from submersible-mounted and hand-held digital still cameras, or captured from digital videotape.

Thirteen submersible dives were completed, and a variety of sampling gear was deployed from the surface ship, to collect plankton, benthos and fishes (Tables 1, 13, 14). Several types of collections were made during submersible dives. These included organisms, rocks, sediments and water samples.

Data were processed according to task, as described above. Data are archived in a Microsoft ACESS database housed at SCDNR. Copies of videotapes are archived there and at NOAA-OE.

4. Findings:

a. Accomplishments and Findings

Thirteen submersible dives were completed, and a variety of sampling gear was deployed from the surface ship, to collect plankton, benthos and fishes (Tables 1, 13, 14). Because of weather conditions, some submersible dives were not conducted in the targeted deepwater habitats (>200 m) and will not be reported herein. Dives not reported on were conducted on shelf-edge reefs that have been the subject of our previous OE studies and reports. Eight successful dives with observable videotape were conducted in deep water.

Several types of collections were made during submersible dives. These included organisms, rocks, sediments and water samples. In addition to sampling, several daily logs were completed for the expedition web site, and a media day was conducted in Ft. Pierce FL. Details of education and outreach activities conducted during the expedition can be found below.

Several dives and *in-situ* bottom activities were missed because of technical problems with the sub (leaking hatch; lost tracking) or ship (broken tow winch). In addition, videotapes and digital images were not recorded on a few dives because of electronic malfunctions that did not become obvious until after completion of the dive. We also missed some dives and were not able to dive at some planned locations because of the weather. In spite of these difficulties, the ship, sub and scientific crew maintained a persistent and positive attitude and accomplished most of the objectives.

Habitats and Submersible Tracks

Habitats were described from selected deep (>200 m) dives that had good visibility and quality of recorded videotape. Dive locations are in Table 1 and Fig. 3.

Dive 3460 - Due to the short time spent on the bottom during this dive, very few mobile organisms were observed (Fig. 4). These included a squalid shark and a number of brittle stars. The sessile community was made up of primnoid corals, *Leiopathes* black coral, multiple sponges and a group of stalked crinoids. *Laemonem*a sp. and *Polymixia* sp. were observed by science divers though were not captured on video. The physical habitat consisted of a relatively flat terrain made up of hard-pan with a thin veneer of sandy sediments. The dive was

aborted due to a failure with the tracking system so available positions may be inaccurate.

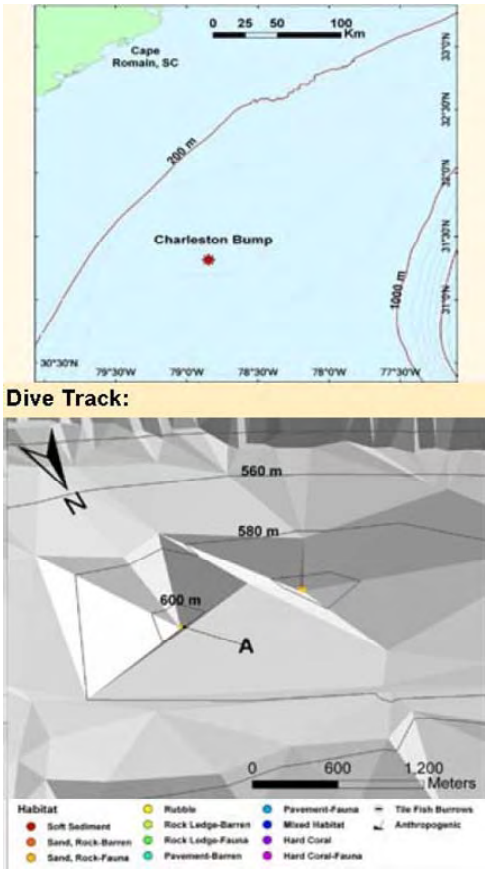


Figure 4. Dive location (above left) and dive track (below left) for JSL Dive 3460. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom image (above right) shows sea lilies recorded at the location indicated (below right). For further details on this figure, see Partyka et al. (2007).

Dive 3461 - Numerous fishes were observed during the course of this dive including *Laemonema melanurum*, *Nezumia sclerorhynchus*, *Polyprion americanus*, *Squalus* spp. and *Scyliorhinus retifer*. Mobile invertebrates were less common, but included pencil urchins, spiny orange urchins, sea stars, a slip shell and an octopus. The sessile invertebrate community was diverse and densely populated. Hard and soft corals, such as *Stylaster* (see below for results of isotope analysis on this coral), cup corals, primnoids, whip corals and isidids dominated most of the area. A variety of sponges and anemones were abundant. A large black coral completely covered in colonial anthozoans was also observed. This dive began in a dense, low-relief (<1m) mixed habitat community covered in a combination of coral rubble and fine sediments (Fig. 5). Initial rock ledge habitats encountered were made up of low-relief, large manganese slabs which gave way to a towering wall. The entire wall was covered in a dense community of sponges and soft corals. The top of the wall was a flat, mixed habitat plateau with a combination of oxidized sediments, hard-pan rock and manganese slabs.

Dive 3462 - There were a variety of fishes observed during this dive (Fig. 6), though all were seen in low numbers. These included *Helicolenus dactylopterus*, *Laemonema melanurum*, *L. barbatulum* and *Polyprion americanus*. All of these fishes were seen in rock ledge habitats. There were fewer mobile marine invertebrates such as squid, large red shrimp and sea stars. The sessile invertebrates were diverse and patchy throughout the dive. Mixed habitat areas and the plateau above the large wall were covered in small stony corals, a variety of sponges, hydroids, fly trap anemones, primnoids, small isidid bamboo corals and occasional *Leiopathes* and *Paramuricea* corals. Other rock ledge habitats were predominantly small stony corals with a few sponges. The dive began over a mixed habitat area with a mixture of hard-pan bottom and sandy sediments giving way to a rough, broken rock ledge habitat covered in small hard corals and sponges. Large sand dunes, lined with chunks of rubble and manganese slabs, led to the base of an enormous rock feature. This wall was almost barren of fauna along its

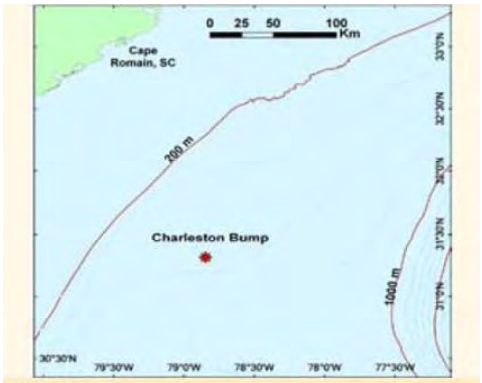
face and completely covered in fauna along its uppermost ledge. In a number of places, the face of the wall was broken into deep caverns and crevices. The plateau of the feature was mostly mixed habitat covering a hard-pan, rocky area with a thin veneer of sediment.

Dive 3563 - Few fishes were observed during this dive (Fig. 7), the majority of which were encountered during the second half of the dive. *Beryx decadactylus* were the most common, followed by *Polyprion americanus* and *Chaunax* spp. A single species of sea star was the only mobile marine invertebrate observed on the videotape. The sessile invertebrate community, however, was diverse and densely populated. The most common macrofauna were cup-shaped sponges, fan-shaped sponges, *Stylaster* and numerous hydrozoans. This dive took place along an extensive, high-relief, rocky scarp. The surface of the scarp varied from moderately sloped (~40º) jagged exposures of rock, to sheer-faced walls with few overhangs, to enormous slabs of rock with deep caverns and large overhangs. The entire area was covered by a dense cover of attached macrofauna that varied little in composition throughout the course of the dive. Dense piles of coraline rubble and coarse sands were present at the base of some ledges while other areas appeared to be scoured clean.

Dive 3465 - A number of fishes were seen during the course of this dive (Fig. 8), though the majority of them were represented by single individuals. Some of the species observed included *Nezumia sclerorhynchus*, *Nettenchelys exoria*, *Merluccius albidus*, *Hoplostethus occidentalis* and *Trachyscorpia cristulata*. Mobile invertebrates were limited and represented by pancake urchins, brittle stars and a large red shrimp seen swimming across the bottom. Small macrofauna were difficult to see when the sub was not stationary, however higher-relief fauna like bamboo and black corals were more easily distinguished. Only one large sponge was seen during the course of this dive. This dive began in a rubble strewn habitat along a shallow ridge-line. Transects continued up a steep slope (50-60º) over a mixed habitat with a dense layer of coral rubble with some small living corals and attached fauna. The top of the ridge was covered with a thick dead coral matrix with less than 5% living coral. The dive proceeded down the slope and over a relatively flat area with a series of small ridges and rises alternating between low-relief mixed habitats and expanses of coral rubble with sparsely attached fauna. The dive continued to another steep rise (~70º) covered in dense dead coral, primarily *Lophelia pertusa*, with attached macrofauna at its summit. Crinoids, sediment, coral, rocks, and sponges were collected.

Dive 3466 - A large number and diversity of fishes were recorded during this dive (Fig. 9). The most common species were *Synaphobranchus affinis*, *Physiculus* spp. and an unidentified eel. Other species included *Chlorophthalmus agassizi*, *Nezumia sclerorhynchus*, *Fenestraja plutonia*, *Centroscyllium fabricii* and an unidentified shark possibly of the family Chlamydoselachidae. Mobile invertebrates were less common but included *Chaceon* crabs and small red shrimp. A single large white anemone and a single venus flytrap anemone were the only attached macrofauna observed on this sandy habitat. The entire dive took place over a series of rolling sand dunes, 2-3 meters in relief, with a rippled surface. The sands making up these dunes were of fine to medium coarseness and bright white in color. In some areas the sediment was covered with a thin film of brownish-green material and the occasional piece of *Sargassum*. An eel, other fishes, an anemone, sand and a crab were collected.

Dive 3467 - A large number and variety of fishes was observed during the course of this dive (Fig. 10). The most common were *Synaphobranchus affinis* and *Centroscyllium fabricii*. These were typically observed in association with the soft substrate habitat encountered at the beginning of the dive. Other species included *Myxine glutinosa*, *Nezumia sclerorhynchus* and *Chlorophthalmus agassizi*. These species were seen in a variety of habitats throughout the dive. Mobile invertebrates were represented by a large number of urchins in the soft substrate and rubble areas, abundant brittle stars in rubble and coraline habitats as well as a large red crab. Attached macrofauna were scarce for the majority of the dive but were found in high concentrations attached to the rocky coral substrate at the end of the dive. These included small cup corals and sponges, hydroids, *Stylaster*, and soft corals. No large sponges or gorgonians were observed during this dive. The majority of the dive was spent on a gently sloped plain of soft sediments mixed with dense rubble with very little relief. A large rock outcrop and a densely consolidated dead coral mound were encountered near the end of the dive and were of moderate relief (1-3 m). The hard coral habitat was defined by a dense matrix of consolidated dead coral rubble with very little living coral (<5%). Most of the rubble appeared to be from *Lophelia pertusa*. Sediment, coral, an eel, other fishes, and rocks were collected.



Dive Track:

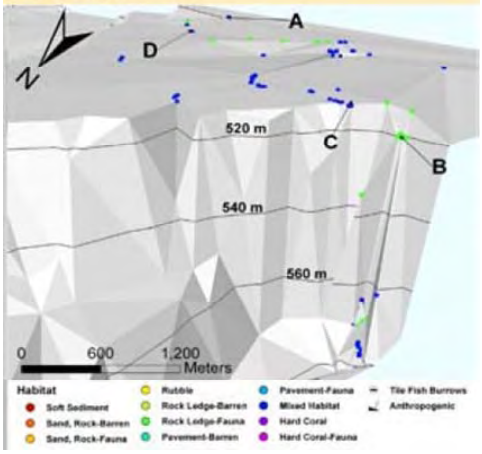


Image A: Mixed Habitat
31° 13.806' N, 78° 55.056' W

Image B: Rock Ledge-Fauna
31° 15.390' N, 78° 56.316' W

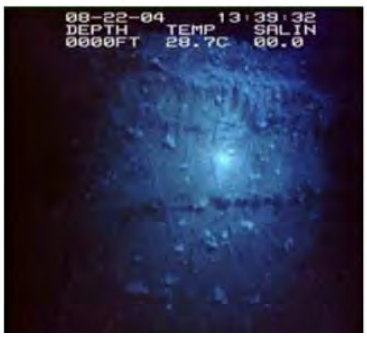


Image C: Mixed Habitat
31° 15.426' N, 78° 56.244' W

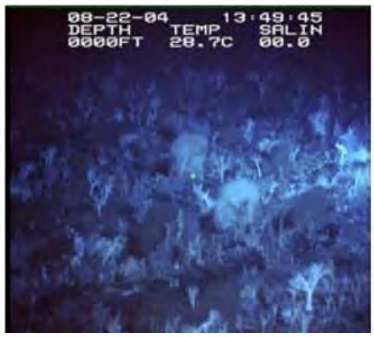


Image D: Mixed Habitat
31° 15.078' N, 78° 55.098' W

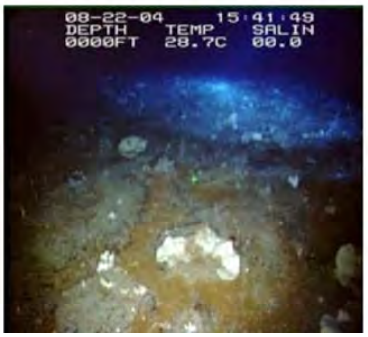
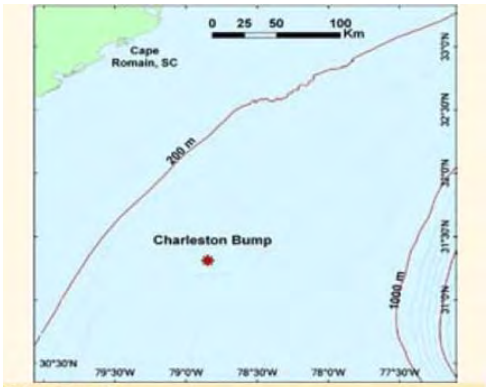


Figure 5. Dive location and dive track for JSL Dive 3461. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows two habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).



Dive Track:

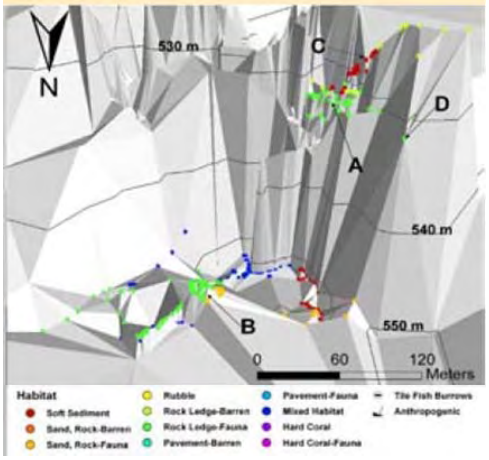


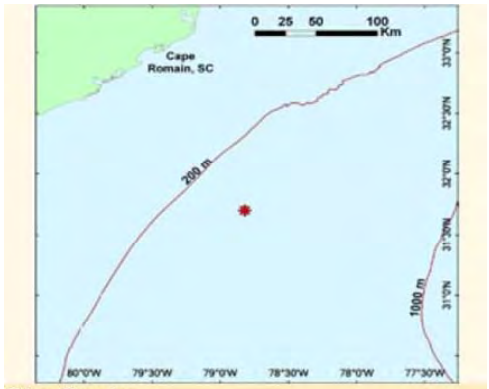
Image A: Rock Ledge-Fauna
31° 18.816' N, 78° 51.636' W

Image B: Rock Ledge-Fauna
31° 18.912' N, 78° 51.564' W

Image C: Soft Substrate
31° 18.822' N, 78° 51.654' W

Image D: Rock Ledge-Fauna
31° 18.852' N, 78° 51.666' W

Figure 6. Dive location and dive track for JSL Dive 3462. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows two habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).



Dive Track:

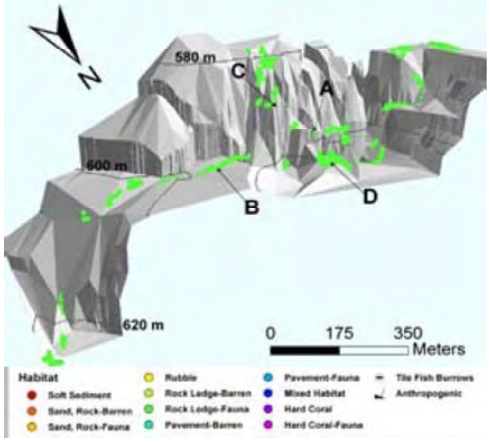


Image A: Rock Ledge-Fauna
31° 23.142' N, 78° 36.156' W

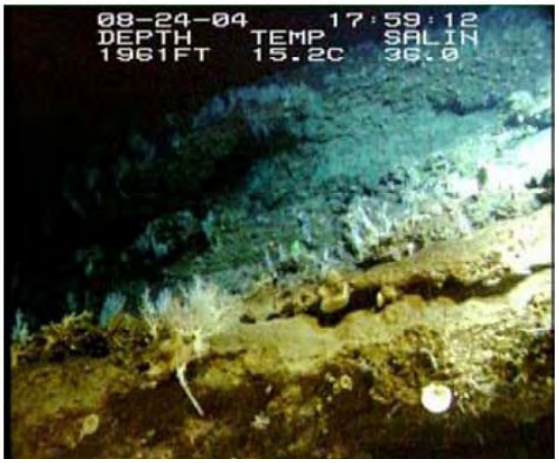
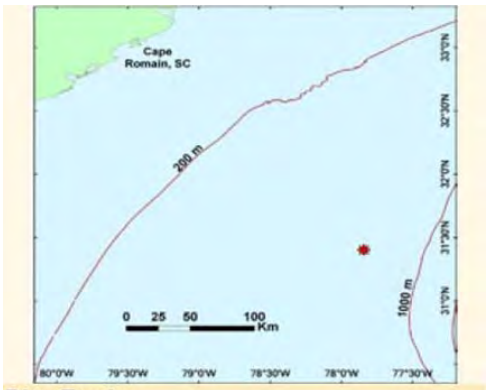


Image B: Rock Ledge-Fauna
31° 23.166' N, 78° 35.994' W

Image C: Rock Ledge-Fauna
31° 23.148' N, 78° 36.096' W

Image D: Rock Ledge-Fauna
31° 23.148' N, 78° 36.162' W

Figure 7. Dive location and dive track for JSL Dive 3463. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows two habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).



Dive Track:

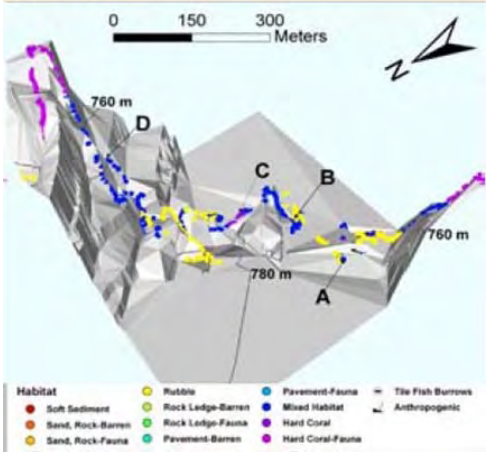


Image A: Mixed Habitat
31° 23.898' N, 77° 51.096' W

Image B: Rubble
31° 23.922' N, 77° 51.018' W

Image C: Hard Coral-Barren
31° 23.970' N, 77° 50.958' W

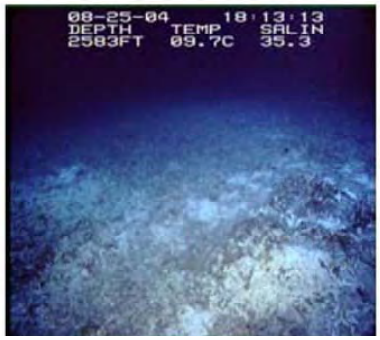
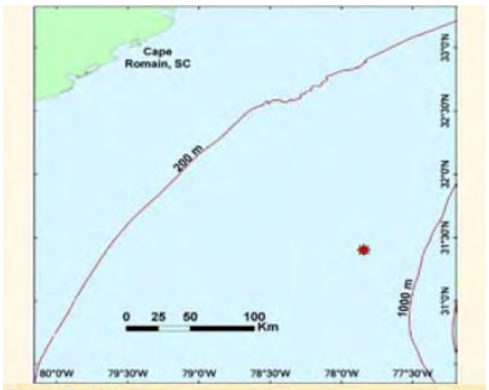


Image D: Mixed Habitat
31° 24.096' N, 77° 50.874' W

Figure 8. Dive location and dive track for JSL Dive 3465. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows three habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).



Dive Track:

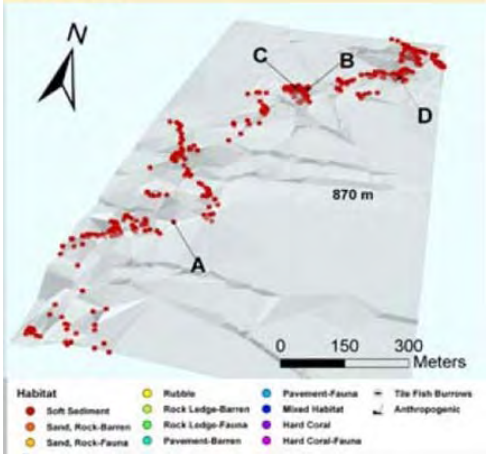


Image A: Soft Substrate
31° 33.426' N, 77° 29.310' W

Image B: Soft Substrate
31° 33.636' N, 77° 29.256' W

Image C: Soft Substrate
31° 33.636' N, 77° 29.256' W

Image D: Soft Substrate
31° 33.690' N, 77° 29.178' W

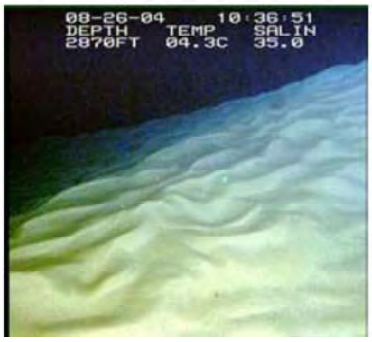
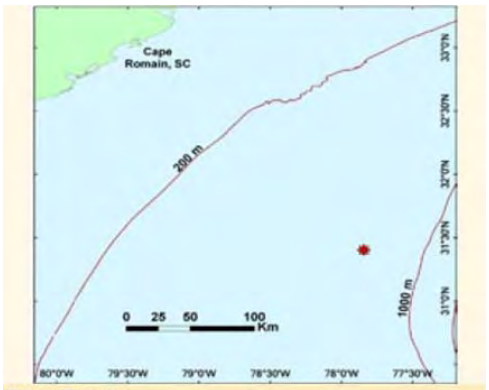


Figure 9. Dive location and dive track for JSL Dive 3466. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows the habitat that dominated during the dive. For further details on this figure, see Partyka et al. (2007).



Dive Track:

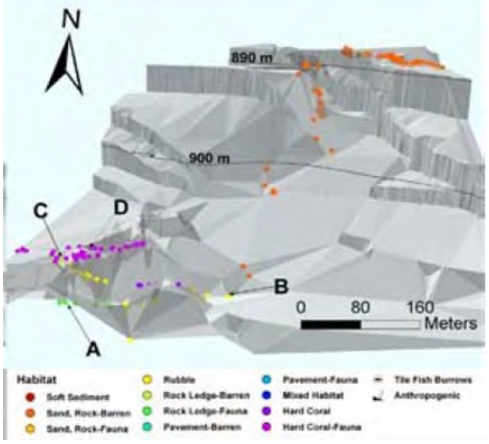


Image A: Rock Ledge-Fauna
31° 49.500' N, 77° 31.386' W

Image B: Rubble
31° 49.476' N, 77° 31.266' W

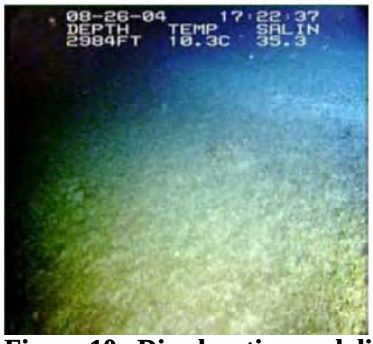


Image C: Rock Ledge-Barren
31° 49.488' N, 77° 31.368' W

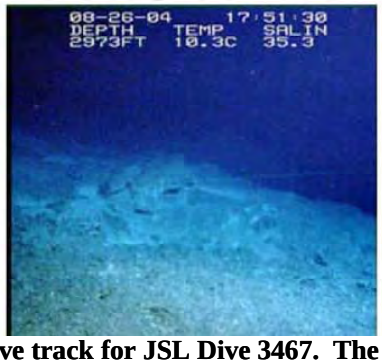


Image D: Hard Coral-Fauna
31° 49.470' N, 77° 31.320' W

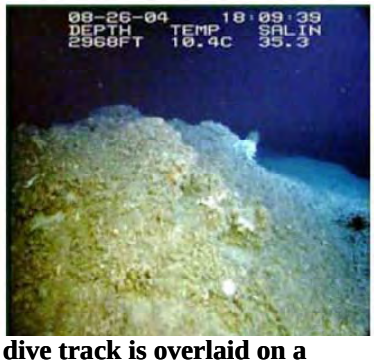


Figure 10. Dive location and dive track for JSL Dive 3467. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows four habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).

Dive Track:

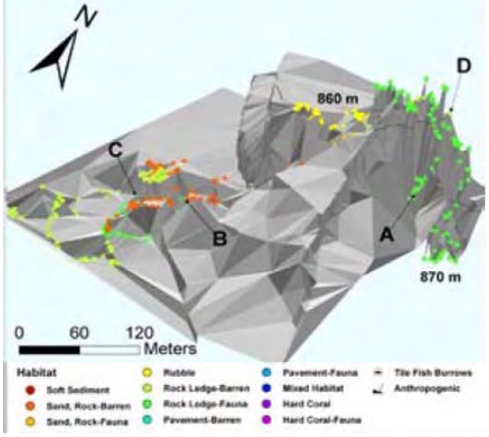


Image A: Rock Ledge-Fauna
30° 17.106' N, 79° 20.148' W

Image B: Sand/Rubble/Rock-Barren
30° 17.034' N, 79° 20.226' W

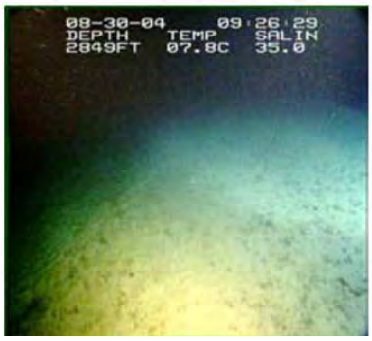


Image C: Rock Ledge-Fauna
30° 17.142' N, 79° 20.154' W

Image D: Rock Ledge-Barren
30° 17.154' N, 79° 20.160' W

Figure 11. Dive location and dive track for JSL Dive 3470. The dive track is overlaid on a three-dimensional image of bottom topography created from historical sonar data. Bottom type classification in the dive track was determined from analysis of videotape recorded during the dive. The bottom images shows two habitats that dominated during the dive. For further details on this figure, see Partyka et al. (2007).

Dive 3470 - Few species of fishes or mobile invertebrates were observed during the course of this dive (Fig. 11). The eel *Synaphobranchus affinis* was common and seen regularly throughout the course of this dive. Other species such as *Laemonema barbatulum* and an unidentified cusk eel were only seen occasionally. Pancake urchins were the most common mobile marine invertebrates observed in the area, although one rocky outcrop was covered in small gastropods. The macrofaunal community was relatively depauperate during most of the dive with a few species of sponge and small stands of *Enallopsammia* coral. The rock ledge habitat at the end of the dive had a more diverse population of attached fauna including large *Keratoisis* bamboo corals, *Parantipathes* and *Bathypathes* black corals, stalked crinoids and various sponges. This dive began in a sand/rubble/rock habitat with very little slope and/or relief with some large rocks. This habitat gave way to an expanded area of exposed rock substrate with and without attached macrofauna. Though the rock surface was jagged and of moderate-relief, there were very few actual rock ledges. There was also a large flat plain covered in dense coral and stone rubble mixed with fine sediments. The dive concluded at the edge of a steep slope (~45º) covered in soft sediment with areas of exposed bedrock jutting out as ledges. The attached macrofauna of this habitat was dominated by large *Keratoisis* bamboo corals and small growths of *Enallopsammia* hard corals. Sand, a sponge, snails, coral, a crinoid and fishes were collected.

Fishes Observed on Videotaped Transects

A total of 31 fish taxa (Table 3) were observed during videotaped transects in deep water (>200 m). An additional 36 taxa were observed at shelf edge reefs that were not the target of the present study, and are not reported on further.

Table 3. Fish taxa and number of individuals observed during deepwater dives, by dive number.

Dive Number:	3460	3461	3462	3463	3465	3466	3467	3470
Beryx decadactylus		1		11				
Breviraja sp.						1		
Caelorinchus sp.		24	2	2	5	2	15	2
Chaunax stigmaeus				4				
Chlamydoselachus anguineus						1		
Chlorophthalmus agassizi			1		1	1	3	
Conger oceanicus				1				
Ophidiidae								2
Fenestraja plutonia						2		
Gempylidae					1			
Helicolenus dactylopterus			1					
Hoplostethus occidentalis					2			
Hyperoglyphe perciformis		1						
Laemonema barbatulum		6						
Laemonmea melanurum	1	3	3	4				
Laemonema sp.								
Merluccius albidus					1			
Myxine sp.							3	
Phycis chesteri						9	2	
Physiculus sp.						6		
Polymixia nobilis	2	1	2					
Polyprion americanus		1	1	1				
Scorpaenidae (*Trachyscorpia cristulata*?)					1			
Scyliorhinus retifer		1						
sharks unid.	1	1	1		1	1	6	1
Synaphobranchis kaupi					4	44	50	45
Unknown		5	12	7	8	21	5	4
Gonostoma sp.?				1		1		
Venifica sp.					2			
Phycis sp.						1		
Sladenia shaefersi							1	

Some taxa appeared to be restricted to certain habitats, or showed some habitat preference (Table 4). Most observations were of single specimens, but some taxa were commonly found. Rattails of the genus *Caelorinchus* were found in several habitats, but may represent more than one species. Synaphobranchid eels appeared to prefer low-relief habitats, and were often seen hovering over sand and low flat areas. Moras (*Laemonema* sp.) preferred hard bottom. Fishery species such as *Beryx decadactylus,* and *Polyprion americanus* preferred rugged bottom.

Table 4. Fish taxa and number of individuals observed during deepwater dives, by habitat. Habitats include manganese-phosphorite pavement, carbonate hard bottom, soft sediment, low ledge, high ledge, mixed (coral, soft, hard), nearly vertical walls and coral rubble.

	Mn-phos Pavmnt	CO_3^{2-} HB	Soft Sed.	Low Ledge	High Ledge	Mixed	Wall	Coral Rubble
Beryx decadactylus					1			
Breviraja sp.			1					
Caelorinchus sp.	23	11	2		2			4
Chaunax stigmaeus					2			
Chlamydoselachus anguineus			1					
Chlorophthalmus agassizi		2						
Conger oceanicus								
Ophidiidae								
Fenestraja plutonia			1					
Gempylidae								
Helicolenus dactylopterus				1				
Laemonema barbatulum	5							
Laemonmea melanurum	3				2			
Laemonema sp.								
Merluccius albidus								
Myxine sp.								
Phycis chesteri		2	4					
Physiculus sp.			6					
Polymixia nobilis				1				
Polyprion americanus							1	1
Scorpaenidae (*Trachyscorpia cristulata*?)								1
Scyliorhinus retifer	1							
sharks undet.		3						
Synaphobranchis kaupi		49	30		1	5		7
Unknown	8	4	8		6	1	3	9
Additional taxa observed in the water column or incidentally (not on transects).								
Gonostoma sp.?								
Hoplostethus occidentalis								
Hyperoglyphe perciformis								
Venifica sp.								
Phycis sp.								
Sladenia shaefersi								

Very few mesopelagic fishes were observed from the submersible. Often small, flitting silvery organisms were briefly observed, but it could not be determined if they were fishes. We did not observe large concentrations of mesopelagic fishes near the bottom during the day, but the submersible lights and our inablitly to identify small rapindly-moving organisms prevented us from quantifying the abundance of mesopelagic fishes and other organisms during the day.

Stable Carbon and Oxygen Isotope Profiles in Deepwater Stylaster erubescens *Coral*

The study area for this exploration included the Charleston Bump, located in the northwest corner of the Blake Plateau (Fig. 1) off the coast of South Carolina and Georgia. It is a Miocene structural feature that rises abruptly in ramps and scarps from 700 to 400 meters below the sea surface. It is composed largely of limestone paved in manganese-phosphorite, making it highly resistant to erosion. The Bump is located within strong Gulf Stream current flow, thus the sea floor here is devoid of nearly all fine-grained sediment. The Gulf Stream is deflected by the Bump and downstream turbulence forms the Charleston Gyre. Upwelling caused by the Charleston Gyre creates an area of increased productivity north of the Bump off the coast of North Carolina. For a more complete geologic and oceanographic description of the region see Popenoe and Manheim (2001).

Although some areas near the Charleston Bump contain significant amounts of *Lophelia* corals, including large fossil mounds, and some small solitary scleractinian taxa, the most abundant corals found in the dives conducted in this project were of the family Stylasteridae. Detrital corals were also dominated by stylasterids. *Stylaster erubescens* is the most common species yet identified on the Charleston Bump, and along our transect. The density of stylasterid colonies here was widely variable, with some areas having nearly all available substrate occupied, while other areas have comparatively large expanses of apparently suitable substrate unoccupied. The corals were often separated in roughly equidistant increments and were of a similar height and size in any given region, although the spacing and size varied among locations.

Stylaster erubescens (Fig. 12) is an ahermatypic branching colonial coral found in several, possibly discontinuous, regions of the North Atlantic ranging from the Denmark Straight off Southeastern Greenland to the Florida Straights between South Florida and Cuba. Depths range between about 150 m to 1400 m, with most occurring between 650-850 m (Cairns 1986). They favor environments of high current flow that are generally free of suspended sediment.

These corals form aragonitic skeletons, as do most of the Stylasterdae (Cairns et. al. 1992). Although branching can be complex and delicate, most examples from the Latitude 31-30 Transect have only a few comparatively robust branches. Branching typically occurs perpendicular to the direction of current flow, with the

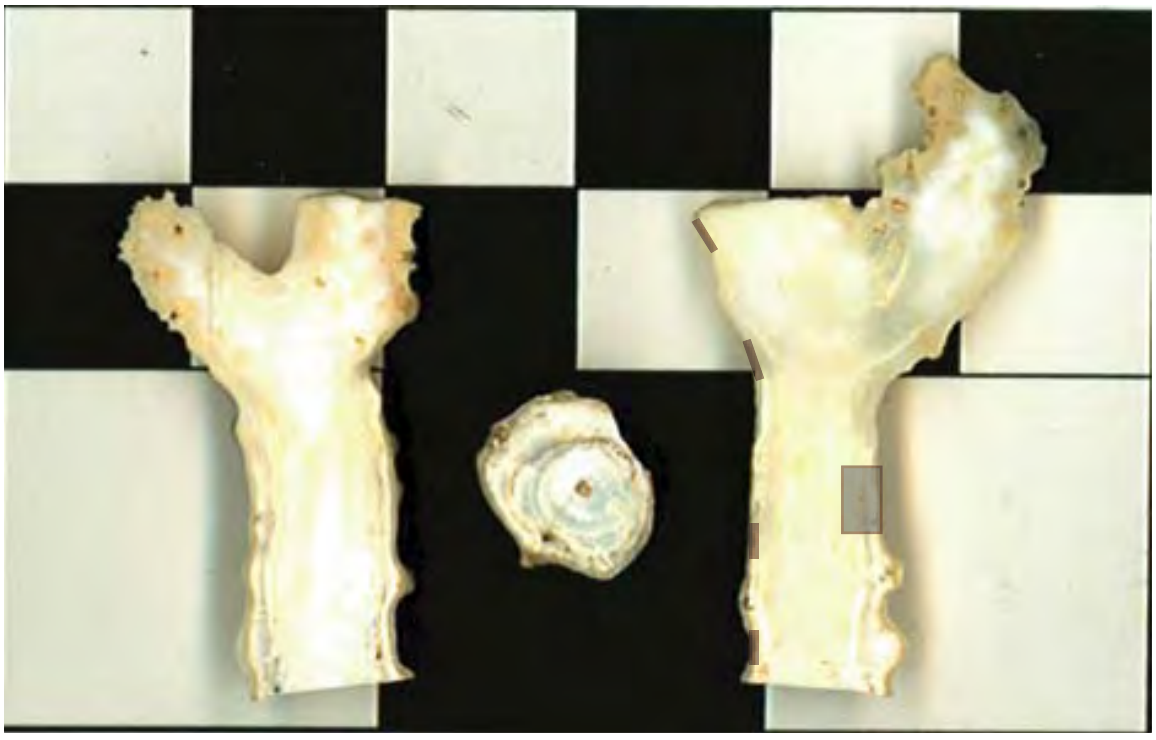


Figure 12. Stylasterid coral colony (specimen T10031039) collected from the Charleston Bump in during an OE Expedition in 2003. Small squares are 1 cm. Grey areas represent sampled regions described in the text. The cross section at center is the location of the lower isotope transect.

cyclosystems facing upstream to facilitate suspension feeding. Heights of colonies collected from the Charleston Bump range in size from 3 to 10.9 cm, with an average height near 5 cm. A commensal polychaete worm often creates a tube within the coenosteum. When abandoned, this tube may be filled with carbonate precipitated by the colony (Cairns 1986). Colonies usually attach to a fixed hard substrate, although they are observed to grow on other coral skeletons, including detrital stylasterids, which were observed at the Charleston Bump during collection, however most colonies attached to the manganese-phosphorite substrate directly.

Comparatively little information is published with respect to age, growth rate, reproduction, biomineralization patterns and chemistry, or other similar characteristics of this or closely-related deep water taxa. What literature exists often focuses on shallow water examples of hydrocorals.

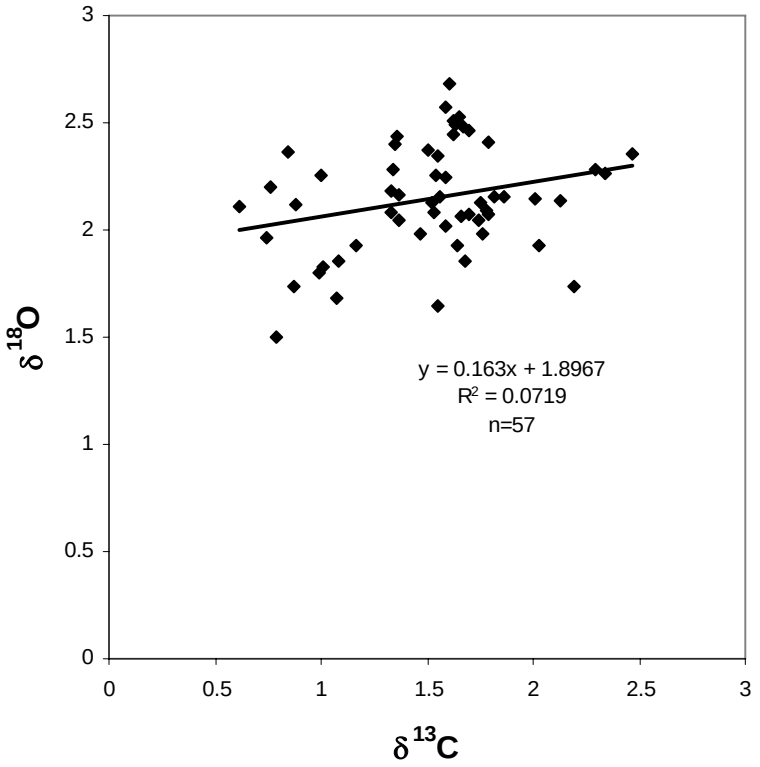


Figure 13. $\delta^{18}O$ versus $\delta^{13}C$ values for all coral samples.

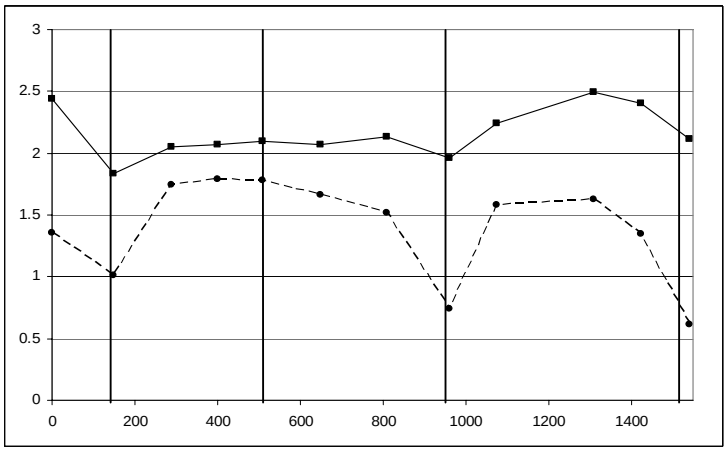
Results from $\delta^{13}C$ and $\delta^{18}O$ analyses on both colonies are presented in Fig. 13-15. The linear relationship between $\delta^{13}C$ and $\delta^{18}O$ from all analyses combined (n=56) is plotted in Fig. 13. The R^2 of the regression is 0.0719, with a slope of 0.16 and an intercept of 1.89. The greatest total range $\delta^{13}C$ is 1.8‰ and in $\delta^{18}O$ it is 1.2‰ in both colonies and all transects combined.

Ontogenetic profiles of $\delta^{13}C$ and $\delta^{18}O$ are plotted in Fig. 14, with two (panels A and B) being generated from different locations within the same colony (T10031039). The profiles from coral T10031039 oscillated in generally sinusoidal patterns, whereas T100313034.9 contained more abrupt variation punctuating plateaus in $\delta^{13}C$ and $\delta^{18}O$ values. Maxima and minima in these oscillations and discontinuities $\delta^{13}C$ and $\delta^{18}O$ inconsistently coincided with incremental growth contact zones. Some other incremental contact zones occurred at intermediate $\delta^{13}C$ and $\delta^{18}O$ values.

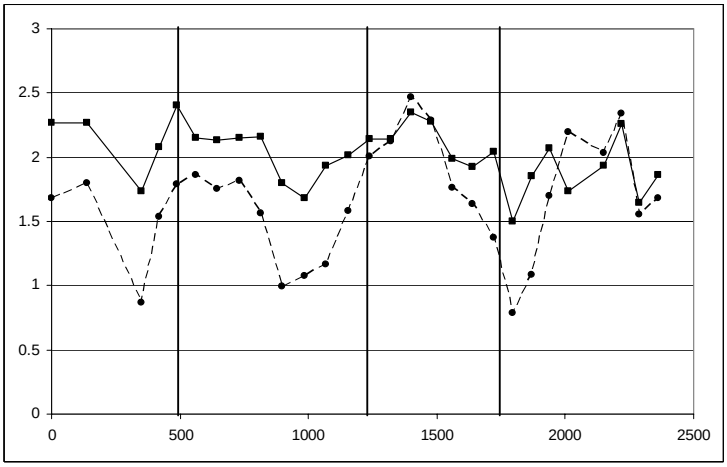
The two isotope profiles generated from the same colony (T10031039) had mean $\delta^{18}O$ values of 2.08‰ (upper transect) and 1.99‰ (lower transect) and $\delta^{13}C$ of 1.27‰ (upper transect) and 1.65‰ (lower transect). The upper transect in T100313034.9 had a $\delta^{18}O$ range of 0.66‰ and a $\delta^{13}C$ range of 1.17‰. The lower transect's ranges were 0.9‰ and 1.68‰ respectively. The profile from the other colony (T100313034.9) had a mean $\delta^{18}O$ value of 2.33‰ and $\delta^{13}C$ of 1.38‰, and ranges of 1.7‰ and 0.9‰ respectively.

Figure 15 presents $\delta^{13}C$ and $\delta^{18}O$ data measured along a single growth increment, near the outer margin of the skeleton, from near the base of the colony to near the tip of a growing branch. No variation in $\delta^{18}O$ greater than analytical precision limits (0.1‰, 1) was measured. $\delta^{13}C$ varied by 0.9‰ in these within-increment samples.

A.



B.



C.

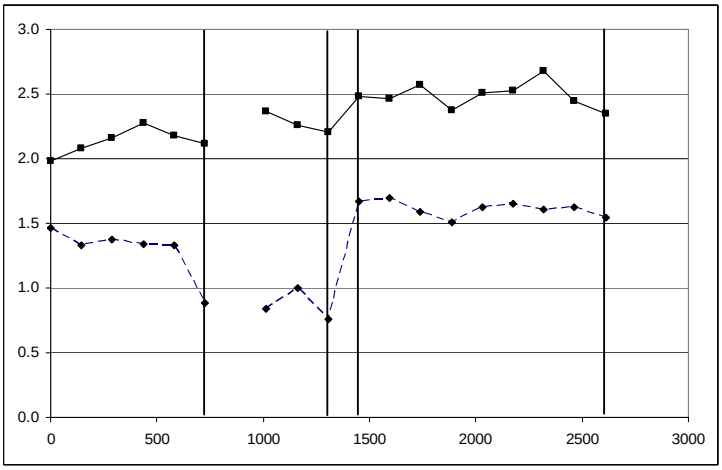


Figure 14. $\delta^{18}O$ (solid) and $\delta^{13}C$ (dashed) for A: upper transect of coral T10031039, B: lower transect of T10031039, and C: T100313034.9. Vertical bars represent growth band contacts. Distances (x-axis) are in microns from the edge of the colony perpendicular to incremental growth banding.

Bottom water samples collected from the *JSL* were plotted on a map of the collection area in Fig. 16 and in Table 5, along with depth of collection. The mean $\delta^{18}O$ value for all seawater samples made during the dives was 0.85‰. The range in $\delta^{18}O$ was 0.7-1.1‰. Water $\delta^{18}O$ at the collection site was 0.7‰, and the temperature was 8.5°C. Observed bottom water temperatures during the two-week 2003 cruise ranged between 8.5-14° C.

Carbon and oxygen isotope distributions in *S. erubescens* appear significantly different than those of deepwater scleractinian corals known to be in isotopic disequilibrium with seawater (see Smith *et al*. 2000; Adkins *et al*., 2003). Unfortunately, the variability in temperature and current conditions at the Charleston Bump collection area prevent conclusive assessment of equilibrium oxygen isotope fractionation in *S. erubescens*. Weber and Woodhead (1972) report an unnamed species of shallow water stylasterid from the Australian Great Barrier Reef grew in oxygen isotope equilibrium. This conclusion was based on the relationship between mean annual water temperature and $\delta^{18}O$ values measured in unspecified portions of the coral skeletons, assuming constant regional $\delta^{18}O_{water}$ values. Mienis and colleagues (2002) state in a conference abstract that deep-water *Stylaster sp*. from the North Atlantic appear to grow in oxygen isotope equilibrium with seawater, but no data have been published. No detailed assessments or data concerning oxygen isotope fractionation in stylasterids exists in the literature.

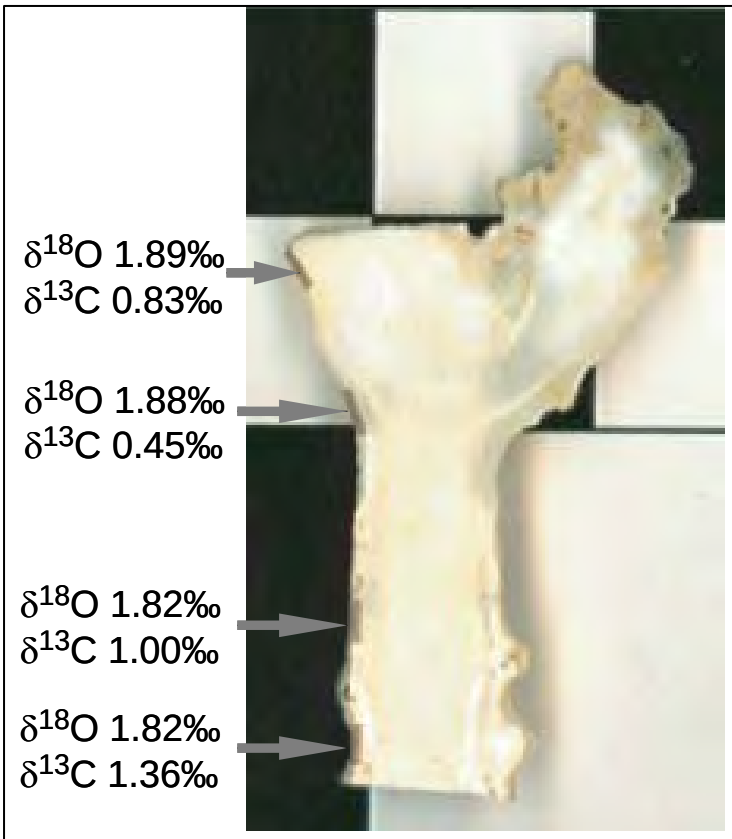


Figure 15. $\delta^{18}O$ and $\delta^{13}C$ measurements in a single increment from base to near the tip of sample T10031039.

Table 5. Depth, bottom temperature, and $\delta^{18}O$ for the dive sites in Fig. 16 where bottom water samples were collected.

Depth	Temperature	$\delta^{18}O$
504m	8.5° C	0.7‰
518m	8.9° C	0.7‰
411m	9.5° C	0.7‰
567m	14° C	1.1‰
541m	14° C	1.1‰
568m	14° C	1.0‰
555m	12.5° C	0.9‰

The relationship between $\delta^{13}C$ and $\delta^{18}O$ (Fig. 13) is less linear (lower R^2) in *S. erubescens* than that measured in deep water scleractinian corals (e.g. Adkins *et al.* 2003; Smith *et al.* 2000; Spiro *et al*. 2000). In azooxanthellate scleractinians, the strong linearity between $\delta^{13}C$ and $\delta^{18}O$ is ascribed to "vital" effects that are variously argued to be a function of kinetic fractionation (McConnaughey 1989) or a function of pH in the fluid from which precipitation occurs (Adkins *et al.* 2003). Another difference is that *S. erubescens'* range in $\delta^{13}C$ (1.8‰) and $\delta^{18}O$ (1.2‰) is smaller than that seen in deep water scleractinians, where the ranges are commonly greater than 4-5‰ in both $\delta^{13}C$ and $\delta^{18}O$ within a single colony (Adkins *et al*. 2003; Smith *et al*. 2000; Spiro *et al.* 2000). This difference is more striking when it is noted that most of these scleractinian corals come from locations with very stable temperature and currents, which is in contrast to the potentially more variable conditions at the Charleston Bump. As discussed below, the range in $\delta^{18}O$ in *S. erubescens* is consistent with observed temperature variation near the collection site.

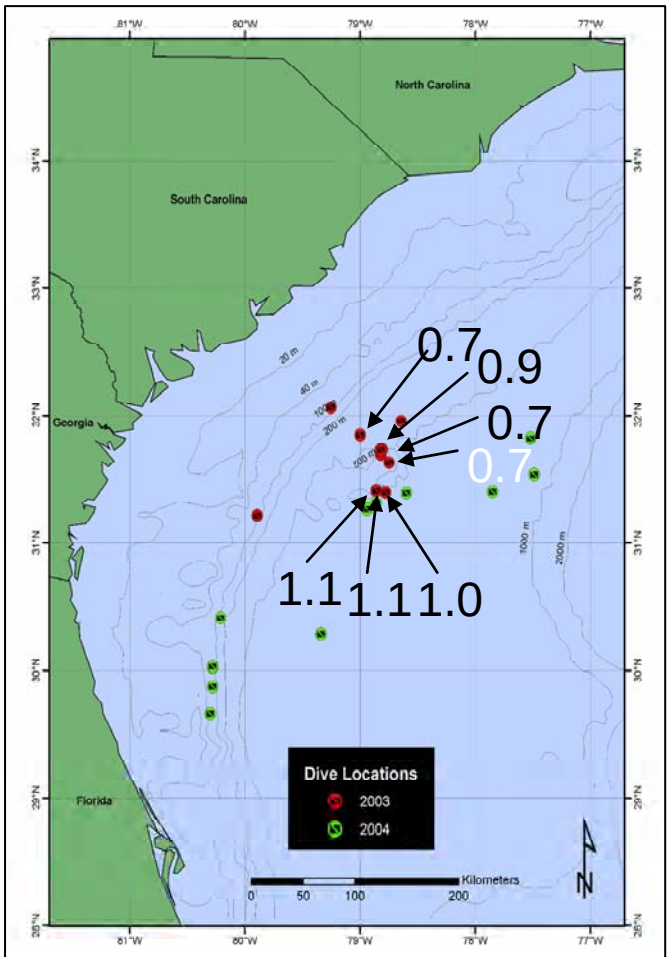


Figure 16. $\delta^{18}O$ values measured in bottom water collected from the *JSL* submersible. Corals were collected at the dive site labeled in white.

Little $\delta^{18}O$ variation was noted within an increment measured from the base to near the tip of a growing branch of the *S. erubescens* colony (Fig. 15). Variation in $\delta^{18}O$ was less than 0.1‰, which is within analytical reproducibility (1σ). As skeletal growth rates near the tip of a branch are likely to be greater than at the base, this result suggests that fractionation is unrelated to rate of extension, unlike may be the case in some branching scleractinian corals (e.g. Mortensen and Rapp 1998; Spiro *et al.* 2000), where there a negative correlation to growth rate has been noted $\delta^{18}O$. $\delta^{13}C$ values in *S. erubescens*, in contrast to $\delta^{18}O$, do vary in these same samples. However, there does not seem to be any clear systematic increase or decrease in $\delta^{13}C$ value as a function of proximity to the base or growing tip.

Ontogenetic $\delta^{13}C$ and $\delta^{18}O$ profiles follow a roughly sinusoidal distribution that inconsistently occurs in tandem with visible growth increments (Fig. 14). The mean $\delta^{18}O$ value of both profiles from sample T10031039 were identical to within precision limits (1σ: 2.08‰ in the upper transect and 1.99‰ in the lower transect), while the mean $\delta^{13}C$ values differ by 0.38‰. The amplitude of the $\delta^{18}O$ oscillations in the lower transect was greater than the upper, with the maximum range in the upper being greater by 0.24‰. The variation was greater in $\delta^{13}C$ where the upper profile's range was 0.38‰. The greater isotopic range in the lower transect is expected due to the higher spatial resolution of the sampling. The lower transect was micromilled at a mean sampling interval of 87 µm, while the upper was sampled at 140 µm. It appears that transects from different regions within a single colony contain similar oxygen isotope profiles. The $\delta^{13}C$ profiles vary more widely between the base and tip of the colony than do the $\delta^{18}O$ profiles. This is similar to the within-increment experiment (Fig. 15, previous paragraph) where $\delta^{13}C$ values varied from base to tip while $\delta^{18}O$ did not.

A more difficult to explain variation between the two intra-colony profiles is the correlation between growth increments and isotopic oscillations (Fig. 14). In the lower transect (Fig. 14B), the outermost increment transition

(near 500 µm from the edge) corresponds to an oscillation maximum, but all other increment contacts in that transect occur at intermediate isotope values. The increment correlation is more regular in the upper transect where each increment contact coincides with either a minimum or maximum but one maximum does not correlate with any visible increment. This may a function of the variables that control patterns of skeletal growth.

The factors that cause visible growth increments in accretionary aquatic carbonate skeletons varies widely (Rhoads and Lutz 1980), and can include biotic factors within the organism itself, or external environmental or climatic conditions. Some commonly observed causes include seasonal temperature variation, light cycles, nutrient availability, oxygen deprivation, and spawning stress among others. In deepwater organisms, variability in light and temperature are often minimal. The Charleston Bump's location with the Gulf Stream however, may provide a source of regular seasonal variation in temperature and nutrient availability, but the lack of *in situ* measurements of these variables, caused by the difficulties presented by deep water monitoring, makes such assessments speculative and qualitative. Scleractinian deep water corals, even in very stable environments, often display enigmatic growth banding.

The difference between the two *S. erubescens* colonies' isotopic profiles may be instructive with respect to growth periodicity. The profile in T100313034.9 differs from those in T10031039, in that it the isotopic values do not oscillate as clearly as in the other colony (Fig. 14). Whereas both transect profiles in T10031039 oscillate, the profile T100313034.9 contains sharper discontinuities that tend to coincide with growth band contacts. This may indicate that growth ceases periodically and in at least some instances, a visually apparent growth zone (or "check") is formed. Unfortunately, due to a lack of time-series environmental data at this depth at the Charleston Bump it is not possible to assess what, if any, change in environmental conditions impacted the coral in a way that may have caused this growth cessation. Furthermore, growth may not occur uniformly throughout a colony. It is possible that one portion of the skeleton is growing when other regions are not, thus producing separate increment profiles in different parts of the same colony. This may partially explain the differences between the increment-isotope correlations in the two profiles of colony T10031039.

Environmental conditions on the sea floor at Charleston Bump have only been measured in a comparatively few, discrete dives on submersibles. During the two cruises involved in the coral aging aspects of this project, current speed and water temperature varied appreciably. All of the dives in which corals were sampled were between 400 and 600 m in depth. Within this depth range, bottom current speed commonly varied between 06-08 m/s while temperature varied between 8.5-14°C. There was no consistent linear trend in which bottom temperatures decreased with depth. It is not known if this spatial variation is indicative of a similar range in temporal variation. Similarly, a comparatively wide range of bottom $\delta^{18}O_{water}$ values were measured (Fig. 16), varying by as much as 0.4‰ over a relatively short distance. It is likely that these values also change over time.

As all of these parameters are influenced directly or indirectly by the Gulf Stream, it is likely that they vary seasonally. Gulf Stream flow and position shifts seasonally and inter-annually (e.g. Hogg, and Johns 1995). The flow conditions at the Bump are governed not only by the total flow of the Gulf Stream, but the relative position of the Charleston Bump to the different flow regimes within the current. Furthermore, turbulence formed by the relief in the southernmost part of the Bump creates changeable conditions downstream.

These limited data permit only a general comparison between measured temperatures and $\delta^{18}O_{water}$ values versus estimated isotopic temperature, but such a comparison suggest that it is possible that *S. erubescens* fractionates in, or uniformly offset from, oxygen isotope equilibrium. All of the following isotope temperature estimates are based on the oxygen isotope temperature equation (a) in Grossman and Ku (1986), using $\delta^{18}O_{water}$ = 0.7‰, as measured on the sample from the collection dive. The total range of temperatures observed on this project in 2003 was 5.5° C (8.5-14°C), which is identical to the range of estimated oxygen isotope temperatures. Assuming spatial variability in temperature at least partially reflects temporal variability in this area, this result supports the temperature dependent isotope distributions in these corals. In terms of absolute temperature estimates, however, the isotopic data suggest a range of 11° -16.5° C, which is 2.5° C warmer than observed temperatures, possibly indicating an offset from equilibrium. Without time-series data, a more conclusive comparison is not feasible.

The only time-controlled data available are those for water temperature and $\delta^{18}O_{water}$ at the moment of collection as compared to the most recently grown portion of the coral skeleton. Estimated oxygen isotope temperature at the margin of the corals was 12.1°C (upper transect of T10031039), 12.9°C (lower transect of T10031039) and 14°C (T100313034.9), while temps at collection were 8.5°C for both of these corals ($\delta^{18}O_{water}$ = 0.7‰). This 3.6-5.5°C difference may represent, at least in part, an offset from equilibrium fractionation. Variable growth rate within and between colonies may also explain some of this difference. Growth rate may vary along the colony from base to tip, thus one sample may represent a greater time-average than the other. A similar difference may exist between colonies. Additionally, the isotope profile of colony T100313034.9 contains

discontinuities that may indicate previous growth stoppages, as discussed earlier, and thus the outer portion of the colony may not have grown in the time immediately before capture.

The data presented here give reason to suspect that *S. erubescens* grows in, or offset from, oxygen isotopic equilibrium with ambient seawater and thus may serve as a temperature proxy. More detailed time-series environmental data from a coral collection site or, alternatively, corals from a more hydrodynamically stable environment must be sampled in order to test this statement more conclusively.

Oscillations in $\delta^{13}C$ and $\delta^{18}O$ suggest that at least some portion of a seasonal cycle is recorded in *S. erubescens*, thus environmental time series data may be contained with these isotopic profiles. Further research is required to better assess the meaning of the visual growth banding in these corals to better control for the timing of growth.

As the role of deep water circulation and vertical mixing are increasingly the focus of paleoclimatological research, stylasterid corals may potentially offer a useful proxy that avoids some of the complexities inherent in deep water scleractinian corals. We suggest that research continue to better evaluate the potential utility of *S. erubescens*, and similar stylasterid corals, as a paleoclimate and environmental proxy.

Sponge and Other Symbionts

A total of 17 sponges and three ascidians were collected and thoroughly dissected to analyze their symbiotic communities (Fig. 17, Table 6). The tunicates were initially thought to be sponges of the genus *Chondrilla*; however, upon further detailed taxonomic identification, the specimens were determined to be colonial tunicates in the genus *Didemnum*. The tunicates' symbiotic assemblages, though not the main subject of this study, were still used in the analyses for comparative purposes.

Eight species of sponge were collected: five *Ircinia campana*, three *Topsentia* sp., three *Geodia* sp., and two *Cliona* sp. In addition, one specimen of each of the following taxa was collected: *Erylus* sp., *Characella* sp., *Apylsina archeri*, and *Schulzeviella* sp. (Table 6). A total of 26,710 symbionts comprising 236 species were collected from all host specimens (Table 7). Another sponge, *Pheronema* sp., was collected and identified, but due to time constraints, the sponge was not dissected for identification of symbionts.

Table 6. List of each specimen collected with the corresponding collection site, year latitude and longitude.

Sponge Species	Site	Year	Latitude	Longitude
I. campana A	Near Charleston, SC	2004	32.54	-79.71
I. campana B	Near Charleston, SC	2004	32.54	-79.71
I. campana C	St. Augustine Scarp North, FL	2004	30.67	-82.39
I. campana D	St. Augustine Scarp South, FL	2004	29.88	-80.28
I. campana E	St. Augustine Scarp, FL	2002	29.94	-80.28
Geodia sp. A	Mystery Site 1, SC	2004	30.63	-79.73
Geodia sp. B	Charleston Lumps, SC	2002	32.61	-78.31
Geodia sp. C	Popenoe's Coral Mounds 1	2004	31.39	-77.85
Characella sp.	Popenoe's Coral Mounds 1	2004	31.39	-77.85
Schulzeviella sp.	Popenoe's Coral Mounds 2	2004	31.67	-80.27
Pheronema sp.	Cutthhroat Cliff	2004	30.28	-79.34
Topsentia sp. A	St. Augustine Scarp, FL	2002	30.00	-80.28
Topsentia sp. B	St. Augustine Scarp South, FL	2004	29.88	-80.28
Topsentia sp. C	Tattlertown, SC	2003	32.06	-79.25
Cliona sp. A	Jacksonville Scarp, FL	2002	30.40	-80.21
Cliona sp. B	Jacksonville Scarp, FL	2002	30.40	-80.21
Erylus sp.	Julians Ridge, SC	2002	32.34	-79.04
Apylsina archeri	Georgetown Hole, SC	2002	32.85	-78.25
Tunicate A	Razorback, SC	2003	31.21	-79.88
Tunicate B	St. Augustine Scarp, FL	2002	29.99	-80.28
Tunicate C	St. Augustine Scarp South, FL	2004	29.88	-80.28

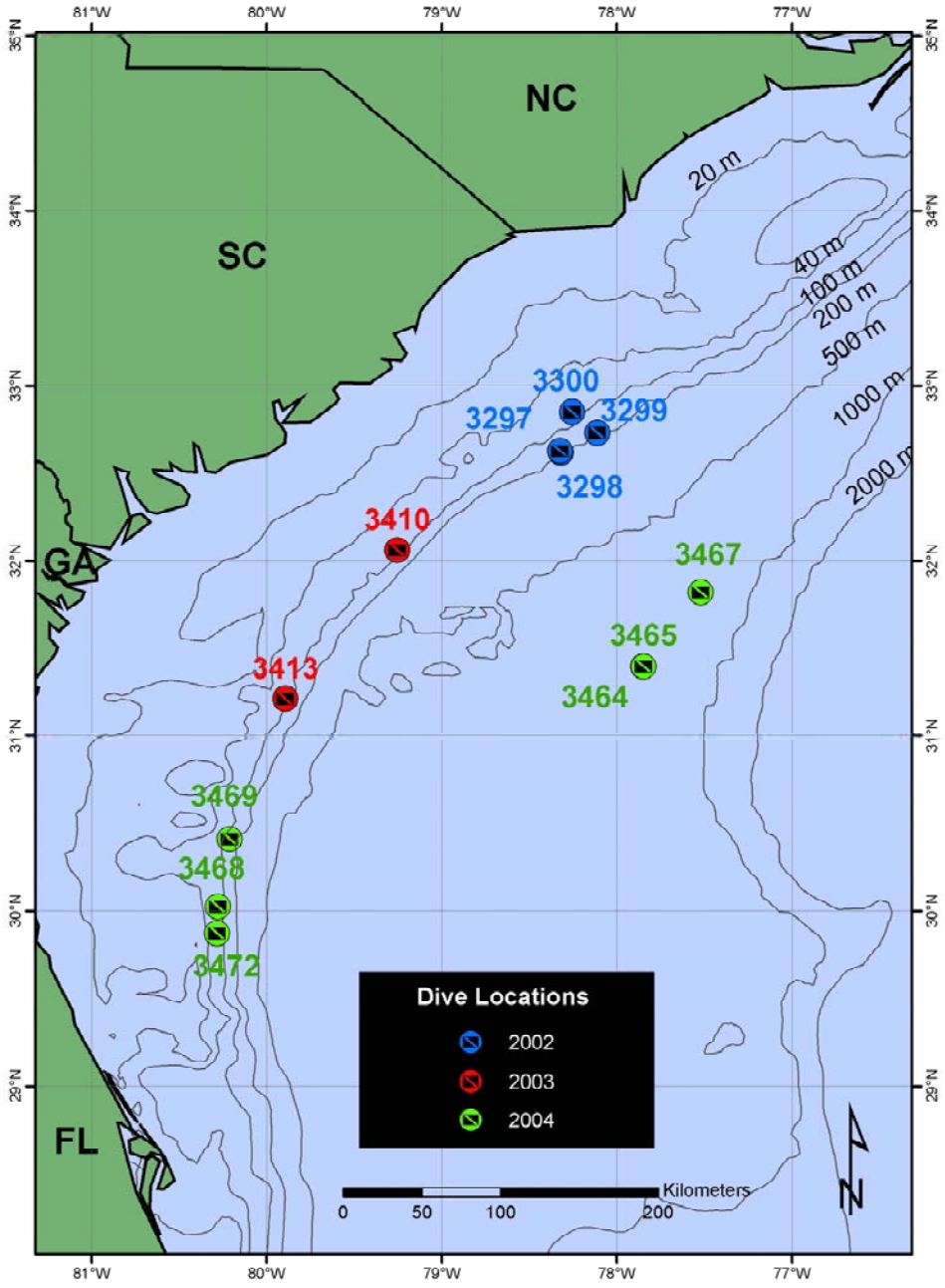


Figure 17. Dive locations of the submersible the Johnson Sea Link II in the South Atlantic Bight for the three years in which sponges were collected. Dive numbers correspond to the following sites: 3468, 3472 = St. Augustine Scarp, 3469 = Jacksonville Scarp, 3413 = Razorback , 3410 = Tattler Town, 3298, 3297 = Charleston Lumps South, 3299 = Charleston Lumps North, 3300 = Georgetown Hole, 3464, 3465 = Popenoes Coral Mounds 1 and 2, 3467 = Deep Flats.

Table 7. Diversity (H'), evenness (J'), species richness (SR), total abundance, and density for each sponge or tunicate specimen.

Sponge Species	H'	J'	SR	Abundance	Density
I. campana A	2.53	0.57	4.29	2188	3053
I. campana B	0.46	0.09	3.71	3166	5647
I. campana C	0.43	0.1	2.65	3610	1340
I. campana C	0.04	0.01	1.37	8384	3732
I. campana D	4.24	0.92	5.62	72	117
Geodia sp. A	0.81	0.81	0.72	4	0.73
Geodia sp. B	2.99	0.94	3.03	14	3
Geodia sp. C	0.92	0.92	0.91	3	0.16
Characella sp.	2.64	0.83	2.62	23	6
Schulzeviella sp.	2.24	0.53	3.7	128	18
Topsentia sp. A	0.05	0.02	1.21	3777	1360
Topsentia sp. B	0.75	0.18	3.05	971	459
Topsentia sp. C	0.11	0.04	1.02	931	336
Cliona sp. A	0.69	0.25	1.09	251	211
Cliona sp. B	0.85	0.27	1.59	157	110
Erylus sp.	1.48	0.27	1.43	523	301
Apylsina archeri	3.05	0.75	3.89	141	100
Tunicate A	4.72	0.85	8.74	164	92
Tunicate B	2.22	0.83	5.62	74	673
Tunicate C	3.94	0.78	6.21	173	198

Habitat and Sponge Taxonomy - *Ircinia campana* (Demospongia, Dictyoceratidae), a vase-shaped sponge with collagenous filaments instead of spicules (Fig. 18), was commonly found at shelf sites such as St. Augustine Scarp (52 – 58 m), as well as just offshore of Charleston (18 m), South Carolina. The reef at St. Augustine Scarp consisted of many large boulders creating ledges and caves. Large sponges, such as *I. campana* and the loggerhead sponge, *Spheciospongia vesparium*, were commonly seen, as well as many encrusting sponges, antipatharian corals (*Stichopathes* sp.), and fishes. The Charleston reef was characterized by low relief, and a sandy substrate with few scattered sponges and corals. *I. campana* possessed a well-

Figure 18. Whole specimen of *Ircinia campana*, collected from St. Augustine Scarp in 2004 (A) and collagenous filaments (B, 20x magnification).

defined canal system, which had an average canal diameter of 1.4 mm. Individuals of the polychaete *Haplosyllis spongicola* were found in these canals and in the sponge material.

Topsentia sp.(Demospongia, Halichondriidae), an orange, mound-shaped sponge (Fig. 19), was collected from St. Augustine Scarp (51 - 55 m) and Tattler Town (77 m). This sponge was very dense and had a hard, stony texture, characteristic of the genus, and was densely packed with three sizes of oxea spicules. The canals were relatively small in diameter (mean = 1.2 mm) and there were fewer canals than seen in *I. campana*. Tattler Town did not have a well-defined reef, but rather low relief and a bottom that varied between sediment and flat pavement. A few scattered but unidentifiable sponges were seen.

Figure 19. A whole specimen of *Topsentia* sp. held over a 5 gallon bucket (A) and below that is a cross section of the same specimen (B).

Two specimens of *Cliona* sp. (Demospongia, Clionidae) (Fig. 20) were collected from Jacksonville Scarp (57 m), approximately 57 km north of St. Augustine Scarp. The reef at Jacksonville Scarp was similar to the reef at St. Augustine Scarp in that it was well-defined with some large boulders and large sponges; however, there were not as many of either as at St. Augustine Scarp. The Jacksonville reef also had areas of soft bottom with partially buried boulders, and each *Cliona* sp. was collected in this habitat. *Cliona* sp. was a white globular sponge, with some yellow coloration in the choanosome of the sponge. Both specimens showed spicules characteristic of the genus *Cliona* (tylostyles, anthosigmas and spirasters); however, this genus has only been documented previously as a boring sponge, with the exception of a few species such as *C. celata* which have one massive growth stage. Although spicules and sponge material were found throughout the sponge, most of the sponge skeleton was found in the outer layer of the sponge

(ectosome), while the choanosome consisted primarily of sediment. Having a large amount of sediment in the choanosome (interior of sponge) of *Cliona* sp. made it difficult to distinguish canals; however, some scattered canals were seen and had an average diameter of 1.5 mm.

One specimen of *Erylus* sp. (Demospongia, Geodiidae) was collected from Julians Ridge (194 m). The reef at Julians Ridge consisted of soft and hard bottom, with some large boulders and scattered small sponges. *Erylus* sp. was a brown, mound-shaped sponge, with a hard ectosome comprised of aspidasters, and the choanosome contained oxeas, triaenes, and oxyasters.

The tube sponge, *Apylsina archeri* (Demospongia, Apylsinidae), was collected from Georgetown Hole (194 m), north of the Charleston Bump. The reef at Georgetown Hole contained some large boulders with crevices, with soft and hard bottom. A few sponges, such as *Ircinia campana*, were also observed. *A. archeri* contains collagenous fibers instead of spicules (Fig. 21), similar to *I. campana*; however, *A. archeri* was a stiffer sponge and had a rougher texture and fewer canals than *I. campana*.

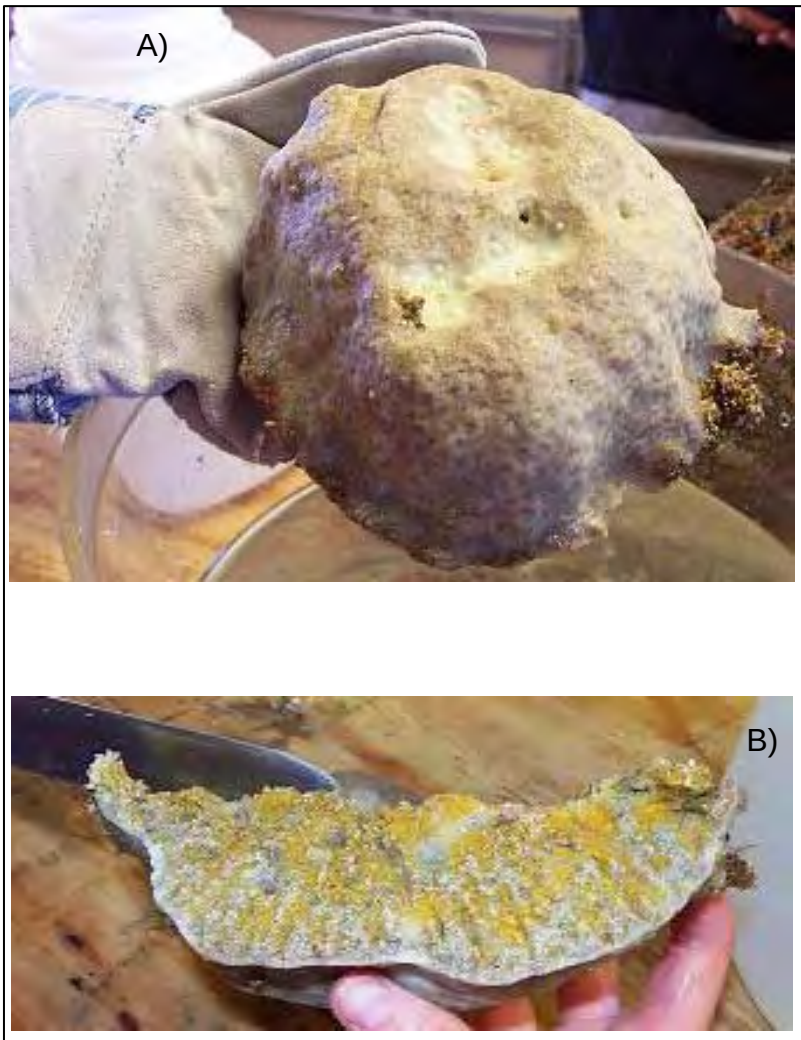


Figure 20. The top photo (A) shows a whole specimen of *Cliona* sp. and the bottom photo (B) shows a cross section of the same specimen.

Three specimens of *Geodia* sp. (Demospongia, Geodiidae) were collected from three different sites: Charleston Lumps (194 m), Popenoes Coral Mounds 1 (778 m), and Cutthroat Cliff (875 m). Charleston Lumps consisted of scattered large broken rocks on a soft bottom. Ledges and overhangs were formed by broken rocks near tops of pinnacles and mounds. Some small corals and sponges were seen. Popenoes Coral Mounds 1 had a mostly flat topography with soft bottom and large amounts of coral rubble. There was little relief at Popenoes Coral Mounds and at Cutthroat Cliff, which was mostly soft bottom with scattered rock rubble. *Geodia* sp. is in the same family as *Erylu*s sp. (Geodiidae) and similarly contains a thick, hard ectosome made of sterrasters, and choanosome of oxeas, triaenes and oxyasters. *Geodia* sp. was massively shaped with one central osculum (Fig. 22), and contained a well-developed system of canals, with spicules that often appeared to protrude into the canals (average diameter of 1.5 mm).

The sponge *Characella* sp. (Demospongia, Pachastrellidae), was a white cup-shaped sponge tightly packed with spicules (Fig. 23). The spicules consisted of an abundance of oxeas and a few scattered calthrops; the only microscleres found were microxeas. *Characella* sp. was collected from Popenoes Coral Mounds 1 (775 m).

Figure 21. In situ image of *Apylsina archeri* at Georgetown Hole just before collection.

The glass sponge *Schulzeviella* sp. (Hexactinellida, Pheronematidae) was collected from Popenoes Coral Mounds 2 (770 m), which was similar in habitat to Popenoes Coral Mounds 1, with large amounts of coral rubble, on which the sponge was found, and little relief aside from a few small corals and sponges. Motile invertebrates such as shrimps, crabs, and ophiuroids were seen, as well as an adult eel. The genus *Schulzeviella* is characterized by an atrial sieve plate (Fig. 24), and basal monaxones with clavate distal ends, although only one such spicule was found. There are some major differences between the specimen collected in the current study and the only known species in the genus, *S. gigas*. First, the anchorate basalia look more similar to those reported for *Pheronema* than for *Schulzeviella*; also, the pinular pentactines are longer and thinner than those documented for *S. gigas*. In addition, only one size class of amphidiscs were seen in *Schulzeviella* sp., while there are four sizes of amphidiscs in *Schulzeviella gigas*. The average canal diameter of *Schulzeviella* sp. was 1.8 mm. This is the first record of *Schulzeviella* outside of the South Pacific.

The second glass sponge collected in the current study belongs to the genus *Pheronema* (Hexactinellida, Pheronematidae), which is characterized by an open or expanded atrial cavity, as well as long basalia spicules (Fig. 25*). Pheronema* sp. contains an array of amphidiscs, as well as other characteristic spicules such as pinular pentactines, choanosomal pentactines, mesouncinates, microhexactines, and anchorate basalia. *Pheronema* sp. was collected from Cutthroat Cliff (951 m). The long basalia spicules found in both *Pheronema* sp. and *Schulzeviella* sp. allowed these sponges to attach to the soft and rubble bottom on which they were found.

The three tunicates, *Didemnum* sp., were collected from St. Augustine Scarp (55-60 m) and Razorback (46 m). The reef at Razorback contained flat pavement and rock rubble, and a few scattered sponges. These colonial tunicates contained spicules similar to spherasters, which are found in sponges of the genus *Chondrilla*. Didemnum sp. had a thin outer layer and many crevices, forming canals in which the individual zooids lived (Fig. 26).

Symbiont Diversity and Abundance among Hosts - For the three specimens of *I. campana* that were bisected, no significant difference in abundance or diversity of symbionts was seen between the basal and distal regions (Diversity, $F_{1,1} = 102$, $p = 0.06$; abundance, $F_{1,1} = 1.9$, $p = 0.4$).

Diversity values varied greatly between and within host species (Fig. 27, Table 7). The diversity of *Ircinia* symbionts varied tremendously within this species ($H' = 0.04 – 4.24$; $J' = 0.01 – 0.92$); of particular interest was the difference between the two specimens collected within 7 m of each other from just offshore of Charleston, South Carolina (specimens A and B). All three *Topsentia* sp. had relatively low diversity ($H' = 0.05 – 0.75$) and evenness ($J' = 0.02 – 0.18$). Both *Topsentia* sp. and *I. campana* specimens were generally dominated by the polychaete *Haplosyllis spongicola*, with the exception of *I. campana* E, which did not exhibit dominance of any one symbiont. *H. spongicola* accounted for at least 90% (up to 99%) of symbiont numbers in all *Topsentia* sp. specimens and four *I. campana* specimens that were dominated by the polychaete, creating a large difference in number between *H. spongicola* and the rest of the symbiont species.

The symbiont community of the two *Cliona* sp. were similar to *Topsentia* sp. and *Ircinia campana*, and had a relatively low diversity of symbionts (H' = 0.69, 0.85; J' = 0.25, 0.27 respectively) as well as high abundances of *Haplosyllis spongicola* (mean = 179). The abundance of symbionts dropped rapidly after *H. spongicola*, with the second most abundant symbiont numbering 20 for *Cliona* sp. A, and seven for *Cliona* sp. B. However, neither *Cliona* sp. specimen's symbiont abundance values were as great as those found for *Topsentia* sp. and *Ircinia campana* (except for *I. campana* E).

Similar *to Cliona* sp., *Erylus* sp. had high abundances of *H. spongicola* (n = 512), with only a few other symbionts. The diversity was relatively low (H' = 1.48; J' = 0.27), and there was a large difference in number between the most abundant symbiont (*H. spongicola*), and the second most abundant symbiont (*Colomastix halichondriae*, n = 13).

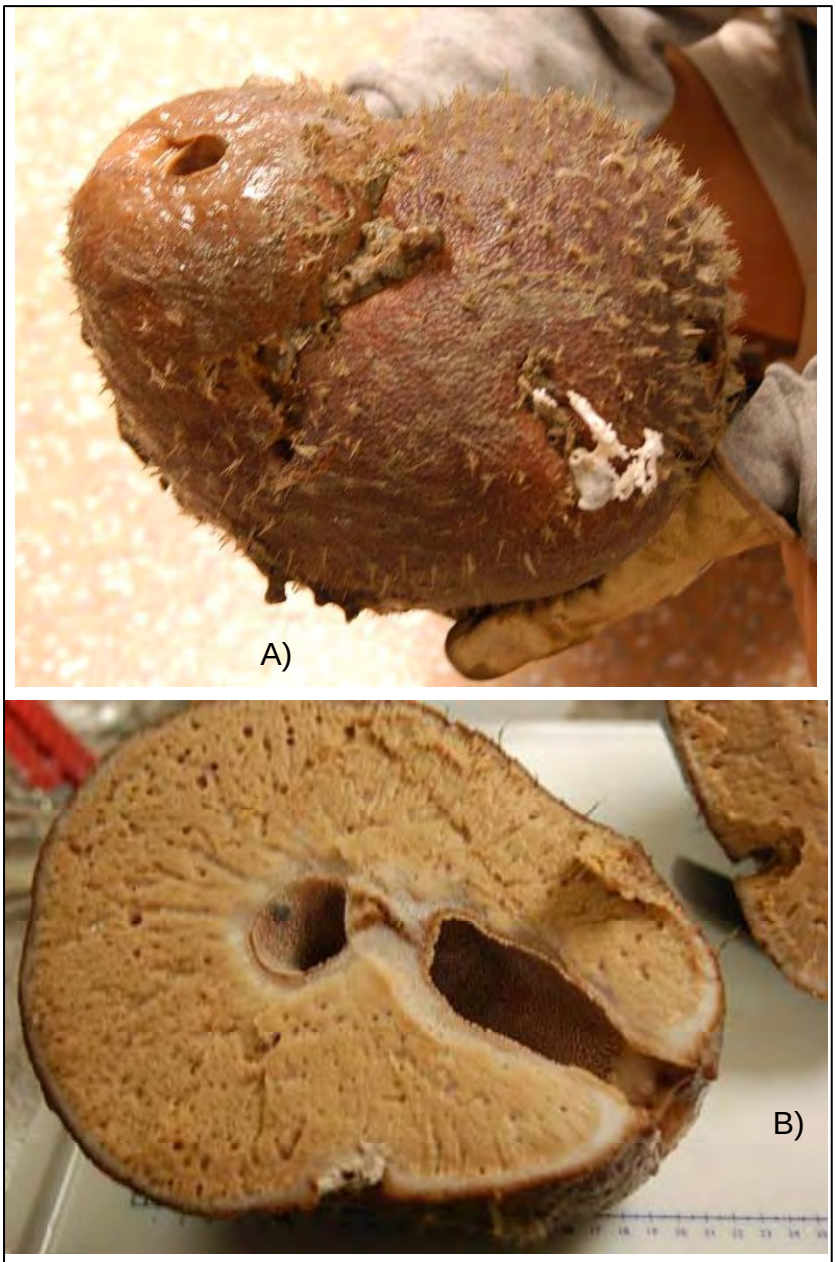


Figure 22. Whole specimen of *Geodia* sp. (A) and a cross section of the same specimen (B) (scale is in cm).

Apylsina archeri had a relatively high diversity (H' = 3.05; J' = 0.75), and was one of two sponges to contain a fish (Gobiidae). *Haplosyllis spongicola* was also present in *A. archeri*, but abundances of this polychaete (n = 22) were not nearly as high as seen in some of the other sponge specimens (1,000 - 6,000 individuals). There was not as large of a gap in number between the most abundant (n = 22) and second most abundant (n = 12) symbionts for *A. archeri* as observed in previous sponges.

Diversity and abundance of symbionts associated with the slope sponges also varied greatly. Specimens of *Geodia* sp. had relatively high evenness (J' = 0.81 – 0.94), and one specimen had relatively high diversity (H' = 2.99); however, few total symbionts were found in each specimen of *Geodia* (n = 4, 14, 3, respectively, Fig. 27). The sponge *Characella* sp., which had no visible canals, had a relatively high diversity (H' = 2.64). There were, however, few overall symbionts (n = 22), and relative to I*. campana* and *Topsentia* sp. there was a small

difference between the most abundant symbiont species (40% of symbionts) and the rest of the symbiont species (< 11%).

The glass sponge *Schulzeviella* sp., despite the dominance of ophiuroids (n = 80), also had a relatively high diversity (H' = 2.24; J' = 0.53). The abundance of symbionts dropped rapidly after the dominant *Ophioprium* sp. (62%), with the second most abundant symbiont species accounting for 11% of total symbionts. *Schulzeviella* sp. contained a fish, the juvenile eel *Dysommina rugosa*. *Schulzeviella* sp. is also the only sponge to have three small crinoids living in it. In addition, *Schulzeviella* sp. had the greatest variety of higher-level taxa including a variety of polychaetes, amphipods, isopods, crabs, echinoderms, sipunculids, gastropods, and a fish, amounting to 128 symbionts among 18 species.

The tunicate specimens had relatively high symbiont diversity (H' = 2.22 – 4.72) and evenness (J' = 0.78 – 0.85) compared to sponge samples; in fact, only one sponge (*I. campana* E) had higher symbiont diversity than two of the three tunicates. No particular symbiont species was dominant, with the largest difference being 7% between the most abundant and second most abundant symbiont species.

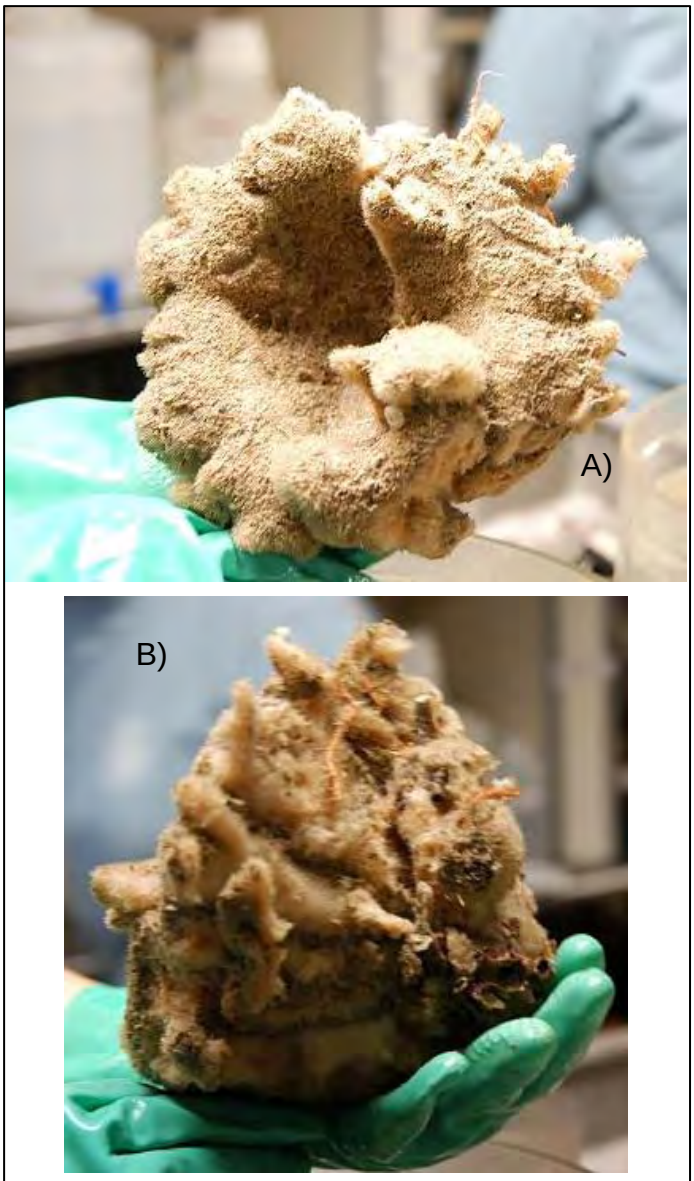


Figure 23. Top view of whole specimen of *Characella* sp. (A) and a side view (B).

Taxonomic Composition of Symbiont Communities - The total percentage of each taxon found was calculated for sponges and tunicates (Figure 28). Within sponges, polychaetes were the overwhelmingly dominant symbionts (93%), followed by amphipods (4%), with the rest of the taxa groups each contributing 1.5% or less. Tunicates, on the other hand did not exhibit dominance by any one particular taxa. The most abundant taxon was the Amphipoda (32%), followed by the Polychaeta and Decapoda (each 28%), and the Isopoda (9.3%), with the remainder of the taxa each contributing less than 1% to the total symbiont taxa. While the Polychaeta were the most common overall symbiont taxon, their abundance varied greatly among hosts (Figs. 29 and 30). Within species, large differences in polychaete abundance were also found among *Topsentia* sp. specimens and among *Ircinia campana* specimens (Fig. 30). In addition, the abundances of polychaetes in these two species were higher than other sponges, ranging from 891 to 5825 individuals per sponge. The majority of these polychaetes were *H. spongicola* (75 - 99%, except for *I. campana* E, for which *H. spongicola* = 35%). The polychaete family Syllidae was most commonly observed across all host taxa and depth, with the genus *Syllis* being particularly abundant (after *H. spongicola*). Other commonly encountered polychaete families were Nereidae, Phyllodocidae, Polynoidae, Terebellidae, and Eunicidae. Polychaetes were found in all hosts except for two *Geodia* sp. specimens. In fact, *Geodia* sp. contained very few symbionts overall (n = 4, 14, 3).

Amphipods were also very common across all host taxa (Fig. 31), with the exception of *Topsentia* sp. (C), one *Geodia* sp. (C), and *Characella* sp., which did not contain any amphipods. *Ircinia campana* and the tunicate specimens generally had higher amphipod abundances (30 - 606 per 500 ml, except *I. campana* D [5 per 500 ml]) relative to the other taxa (2 - 32 per 500 ml) (Fig. 31). *Leucothoe cf. spinicarpa* was the most commonly encountered amphipod, being associated with 13 of the 14 sponges that contained amphipods. The amphipod *Ericthonius brasiliensis* was also found in high abundances, especially in the two *I. campana* specimens (A and B) collected from 30 m offshore of Charleston, SC.

Figure 24. Whole specimen of *Schulzeviella* sp. The atrial sieve plate can be seen in the upper left corner of the sponge as a series of holes arranged in a circle.

Decapods were encountered in a variety of host species, and their densities again were highly variable (Figure 32). Decapods were especially abundant in the tunicates (22 - 263 per 500 ml; 17 - 26% of symbionts), and were mostly comprised of snapping shrimps (i.e., *Synalpheus townsendi*, *Synalpheus minus*). All three tunicates also contained at least two brachyuran crabs, while one contained 13. One sponge, *I. campana* A, shared a high abundance of decapods (35 per 500 ml) with the tunicates, and similarly contained crabs and snapping shrimps. In addition to *Ircinia campana* and the tunicates, shrimps of the genus *Synalpheus* were only in the three *Topsentia* sp. specimens. One shrimp, *Caridea* sp., was found in *Geodia* sp. B, and the shrimp *Periclimanaeus wilsoni* was found in *I. campana* D. The rest of the decapods identified were a variety of brachyuran and anomuran crabs, and there were few shared symbiont species among hosts. Two species that were seen in more than one host were the brachyuran crabs *Pilumnus flori*dans (found in *Didemnum* sp. A and C, and *A. archeri*) and *Micropanope urinator* (found in *Didemnum* sp. A, *Topsentia* sp. B, and *Schulzeviella* sp.). In addition, anomuran crabs were found in *I. campana* A, *I. campana* B, *Topsentia* sp. B, *Didemnum* sp. A, and *Didemnum* sp. B. Of the anomuran crabs, only the hermit crab *Pagurus carolinensus* was observed in more than one host (*I. campana* A, *I. campana* B, and *Topsentia* sp. B).

Isopods were most commonly found in *Ircinia campana* and tunicate specimens (Fig. 33). *Stenetrium bowmani* was the most widely encountered isopod, accounting for most of the abundance of isopods in I. campana and the tunicates (0 – 100% and 71 – 100%, respectively). *Joeropsis coralicola* was also common; it was observed in *I. campana* A and C, *Topsentia sp*. A and B, *Schulzeviella* sp., and all tunicates Several sponges did not contain any isopods: *Geodia* sp. A and C, *Erylus* sp., *Characella* sp., and *Cliona* sp. A and B.

When present, mollusks were found in relatively low abundances, with the exception of two Ircinia campana specimens (A and B) (Fig. 34). Gastropods were only found in *I. campana* A and B, and *Schulzeviella* sp., but comprised most of the abundance of mollusks (86%), with the gastropod *Parviturboides interruptus* being particularly abundant in *I. campana* A and B (95 and 100% of mollusks respectively). Bivalves were also found,

though in low numbers, in *I. campana* (B, C, and D), *Erylus* sp., *Topsentia* sp. (B and C), and one tunicate (A). In addition, one opisthobranch, *Doriopsilla pharpa*, was found in *Geodia* sp. (C).

Echinoderms were also seen across host taxa (Fig. 35), with ophiuroids being especially abundant (Appendix 1). *Ircinia campana* (A, B, and D), *Schulzeviella* sp., and the tunicate C, in particular, had high abundances of ophiuroids (n = 3 - 80). *Ophiothrix angulata* dominated the ophiuroid assemblage found in *I. campana*, the tunicates, and *Topsentia* sp., while the ophiuroids *Ophionereis* sp. and *Ophiolepis* sp. were also occasionally observed. Ophiuroids found in the deeper-living host specimens (i.e., *Characella* sp., *Geodia* sp., and *Schulzeviella* sp.) belong to the known deep-sea genus *Ophioprium*. *Schulzeviella* sp. also harbored three unidentified crinoids. Two juvenile urchins, *Eucidaris tribuloides* and one unidentified urchin, occurred in separate tunicate hosts. One unidentified holothurian was found in *I. campana* E.

Symbionts encountered in low numbers (< 5) and in five or fewer hosts were considered rare symbionts. Fishes were found only twice: a goby, *Risor rubber*, in *Apylsina archeri* and a juvenile eel (*Dysommina rugosa*) in *Schulzeviella* sp. Two amphipods found in *Geodia* sp. (C) may represent a new species of the genus *Stegacephaloides*. *Geodia* sp. (A) harbored the tanaid *Cryptocopoides* sp., a species for which little ecological information is known. Other species categorized as rare included certain echinoderms, such as crinoids, and the holothurian, as well as the tanaid *Apseudes cf. bermudeus*. A complete list of all species encountered can be found in Fiore (2006).

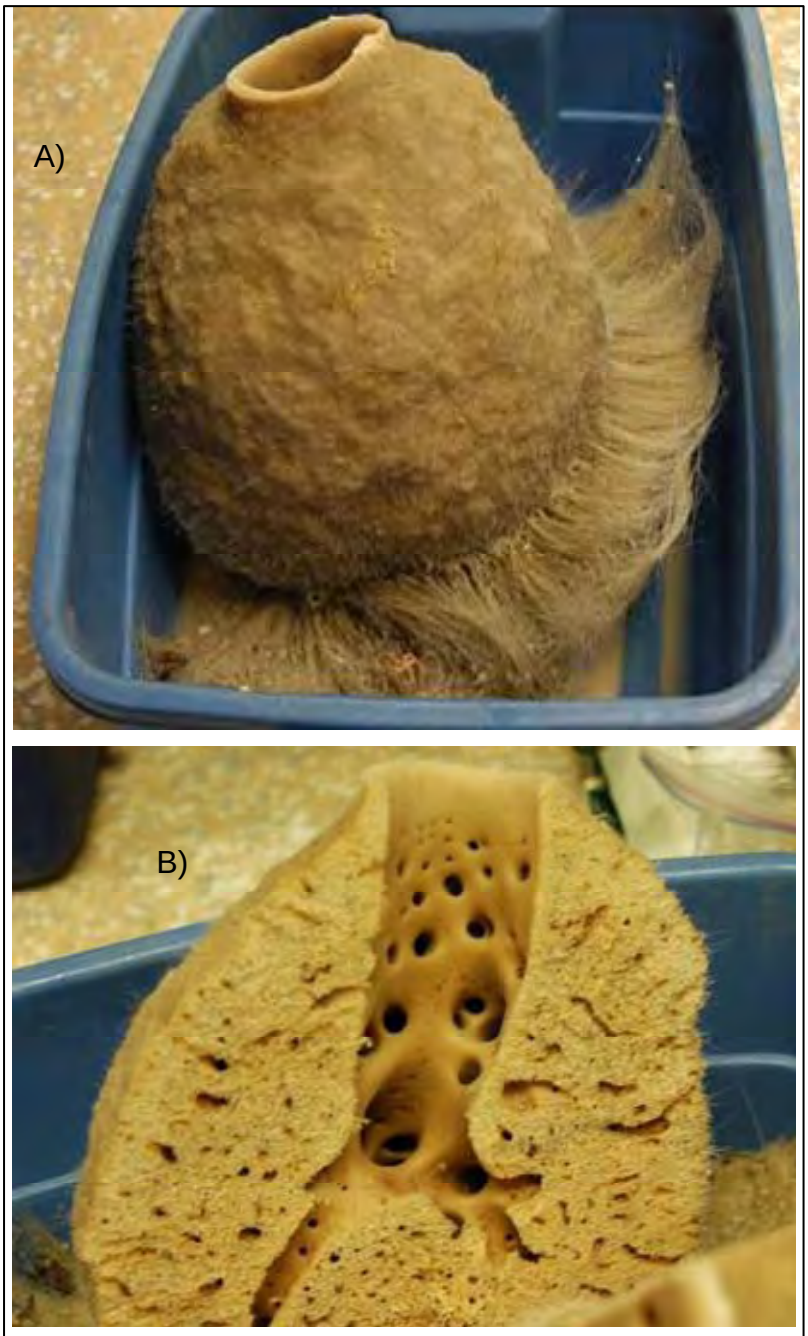


Figure 25. Whole specimen of *Pheronema* sp. in a 20 gallon container (A) and a cross section of the specimen (B).

Community Similarity Analyses - Normal cluster analysis of hosts according to their symbiont community composition and density yielded a dendrogram with four possible "groups" (Fig. 36). As one might expect, all three tunicate specimens clustered into a single group (I). Group II consisted of the deep-water sponges *Characella* sp. and *Schulzeviella* sp., but did not include the similarly deep-water, but ungrouped, *Geodia* sp. The third group (III) consisted mainly of *Ircinia campana* (with the exception of one *I. campana* found in group IV), with the addition of one *Topsentia* sp. Group IV was mixed, including primarily those sponges having a relatively low dominance by *Haplosyllis spongicola* (with the exception of *Topsentia* sp. B and C).

Figure 26. Cross section of the colonial tunicate *Didemnum* sp. collected from St. Augustine Scarp in 2004.

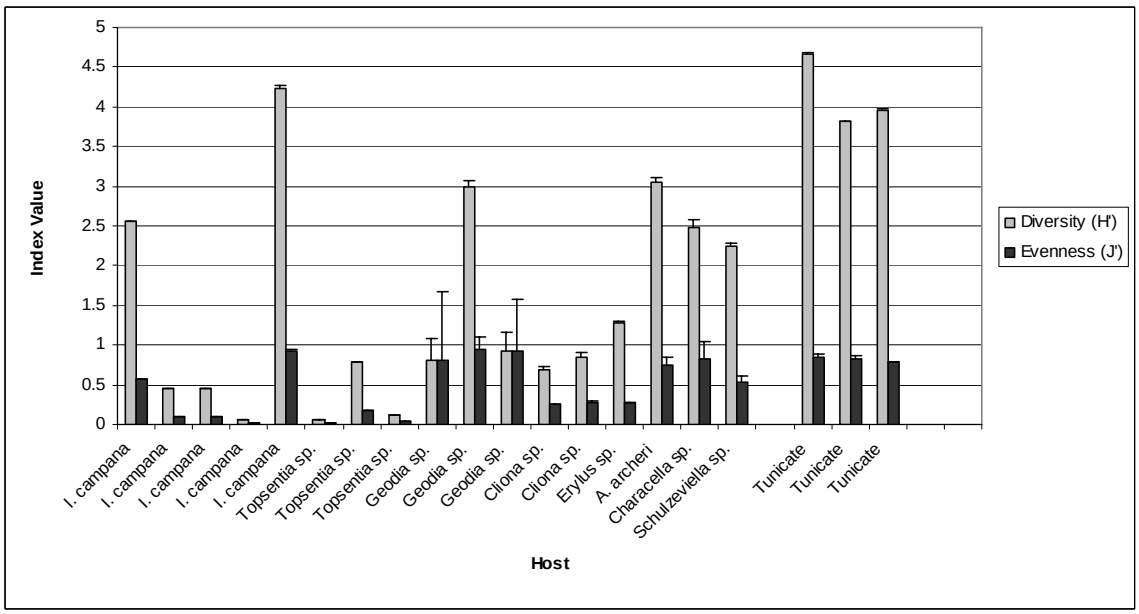
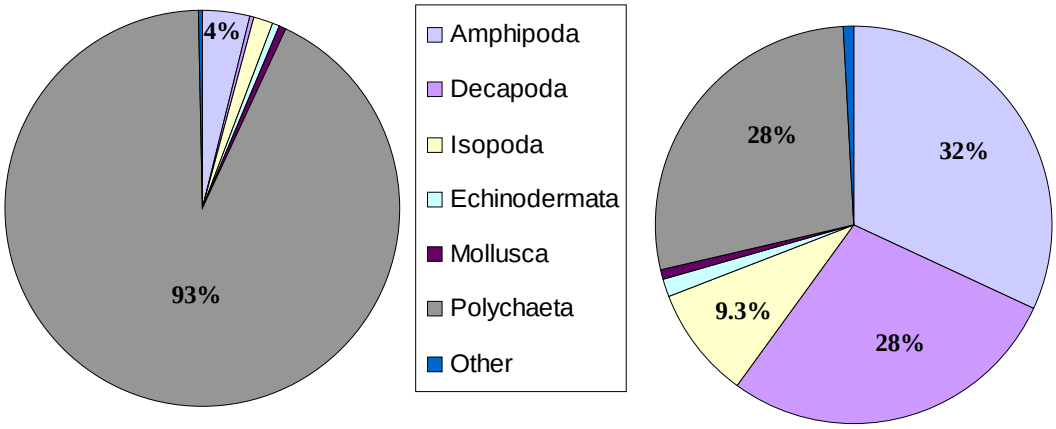


Figure 27. Diversity (Shannon index) and Evenness values for each sponge and tunicate host (labeling A, B, C, etc. corresponds to Tables 6 and 7).



A. Sponges B. Tunicates

Figure 28. Total percentage of each symbiont taxon for a all sponges (A) and all tunicates (B). Percentages not labeled in figure A include Isopoda (1.5%), Echinodermata (0.5%), Decapoda (0.3%), and Other (0.3%). Percentages not labeled in figure B include Isopoda (9.3%), Echinodermata (1.3%), Mollusca (0.7%), and Other (0.7%).

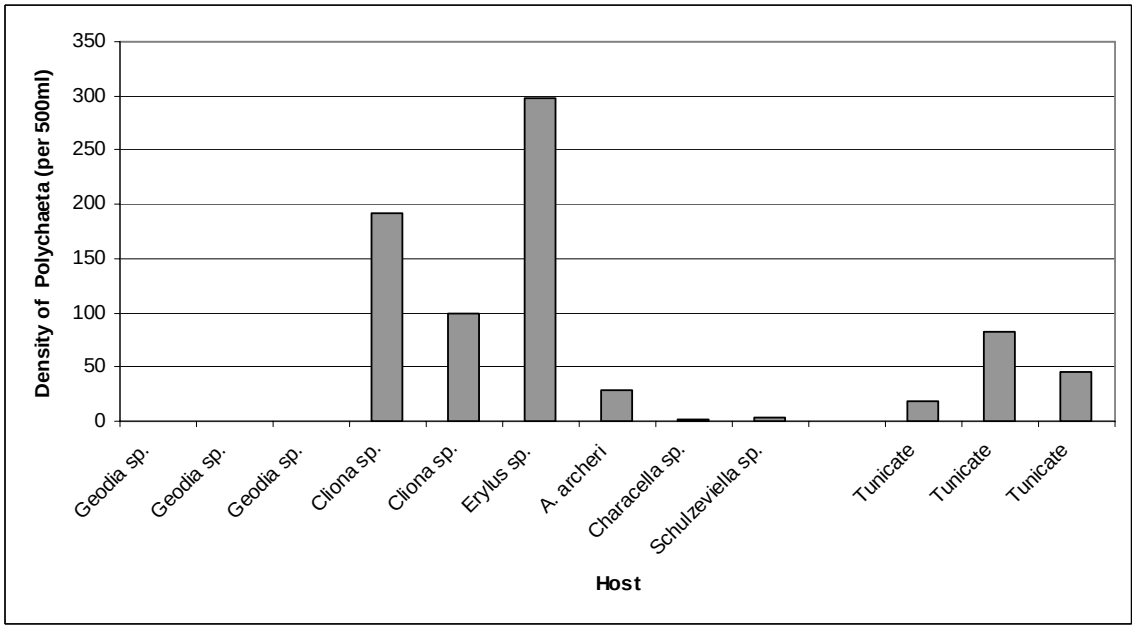


Figure 29. Calculated abundances of polychaetes per 500 ml for all host specimens except *I. campana* and *Topsentia* sp.

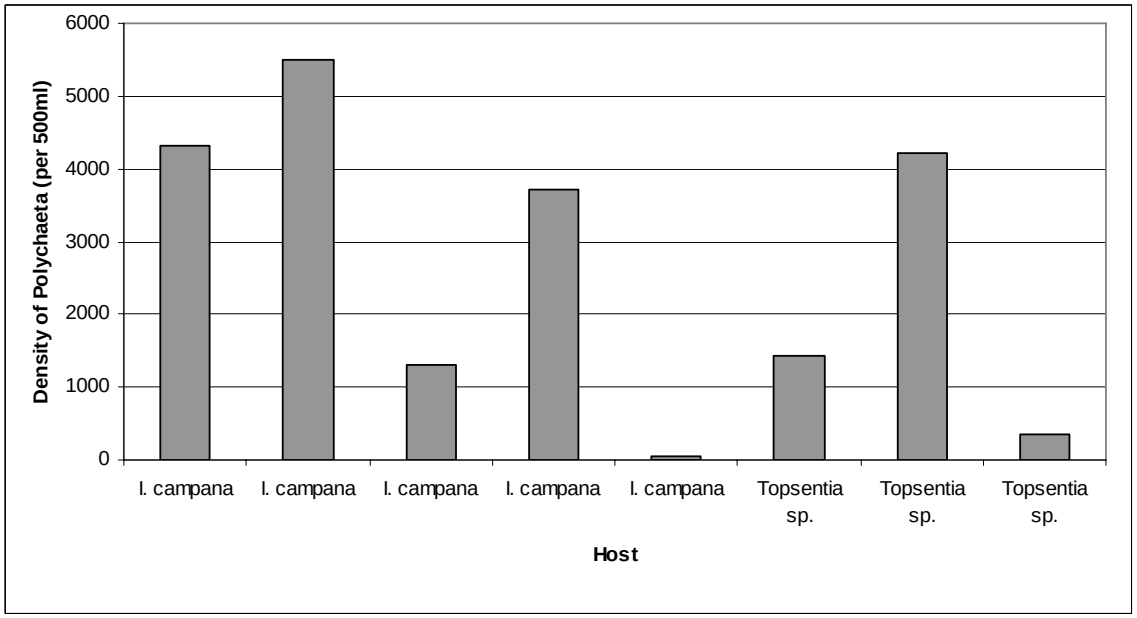


Figure 30. Calculated abundances of polychaetes per 500 ml for the sponges *Ircinia campana* and *Topsentia* sp.

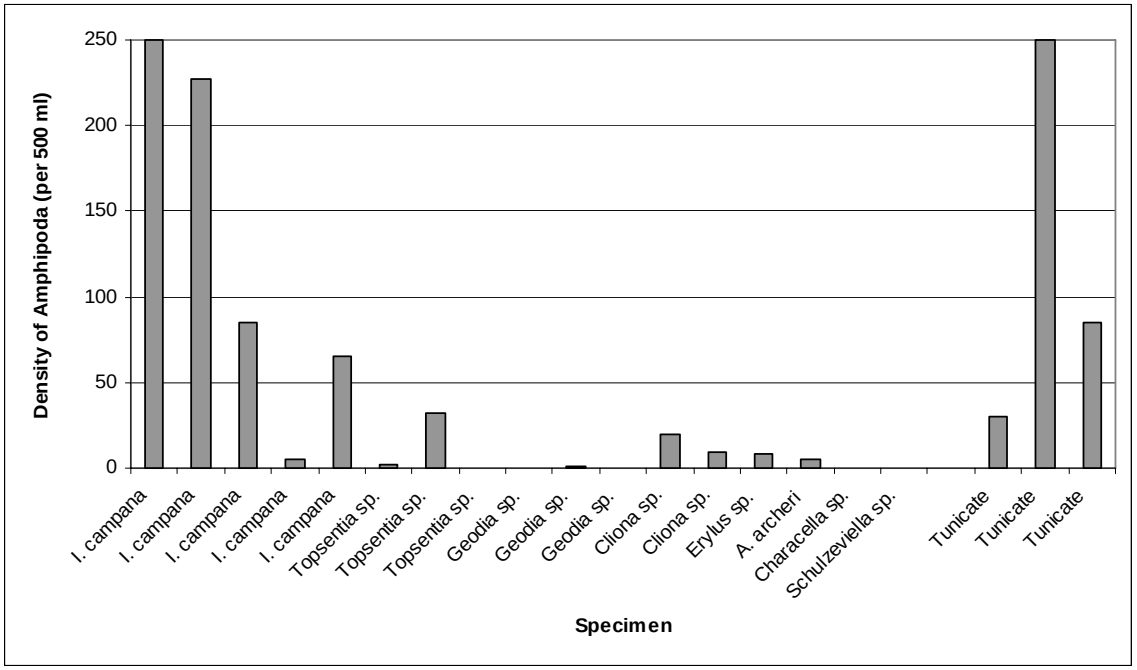


Figure 31. Calculated abundances of amphipods per 500 ml for each host specimen.

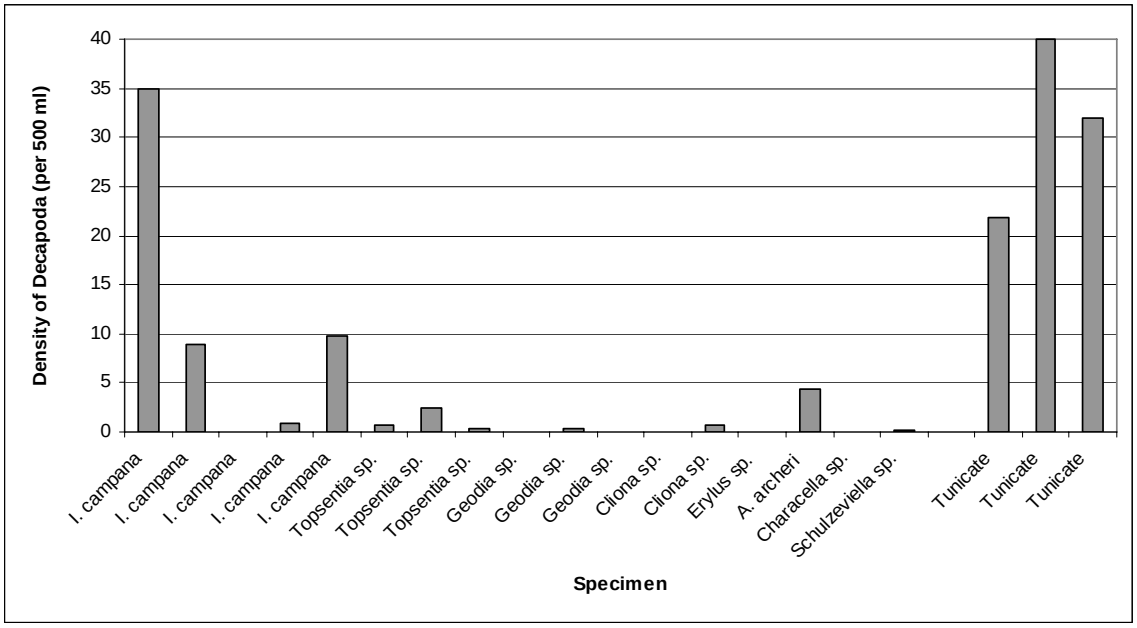


Figure 32. Calculated abundances of decapods per 500 ml for each host specimen.

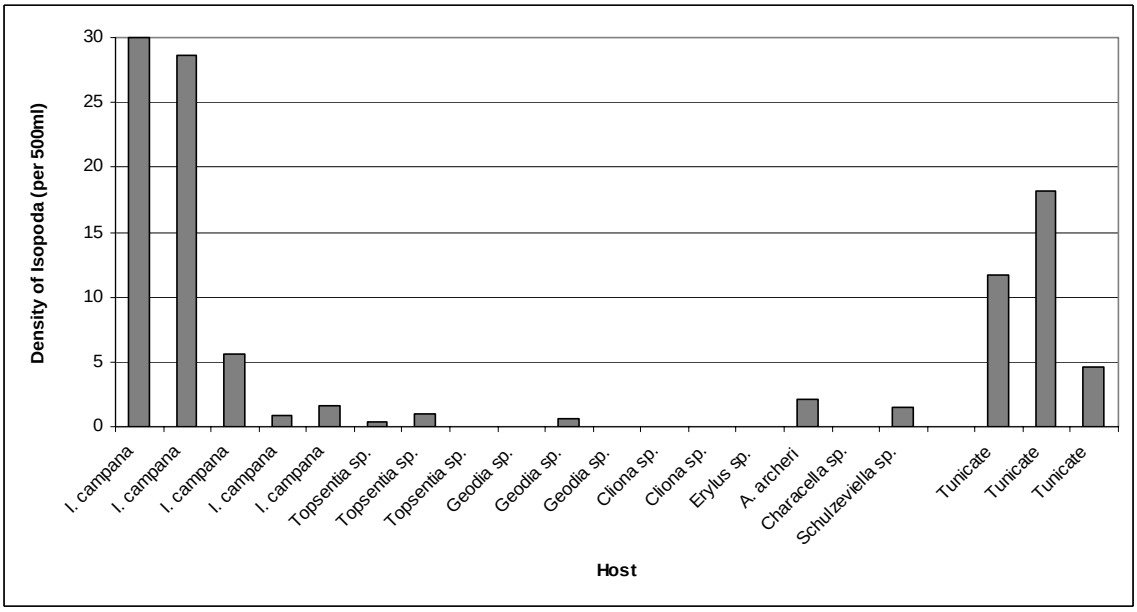


Figure 33. Calculated abundances of isopods per 500 ml for each host specimen.

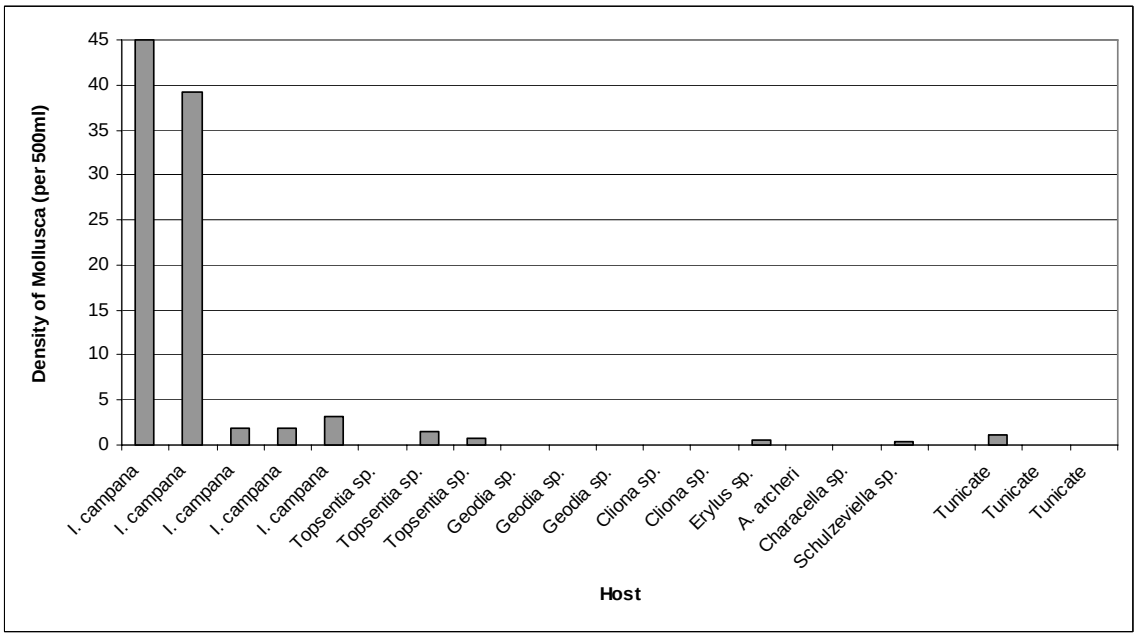


Figure 34. Calculated abundances of mollusks per 500 ml for each host.

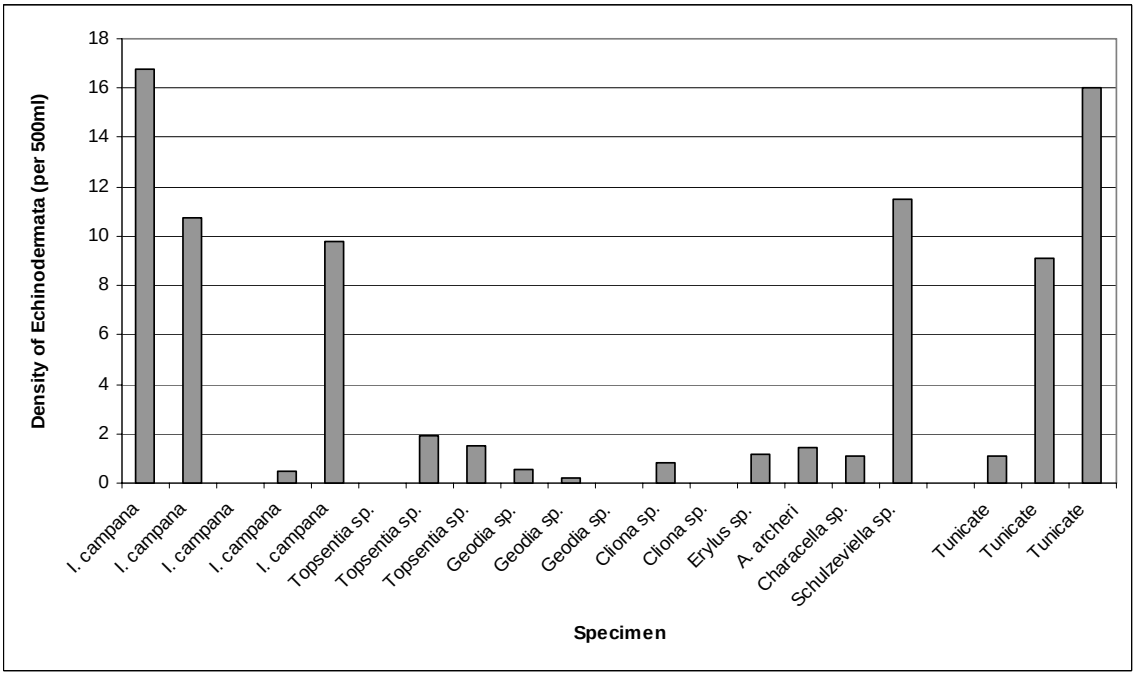


Figure 35. Calculated abundances of echinoderms per 500 ml for each host specimen.

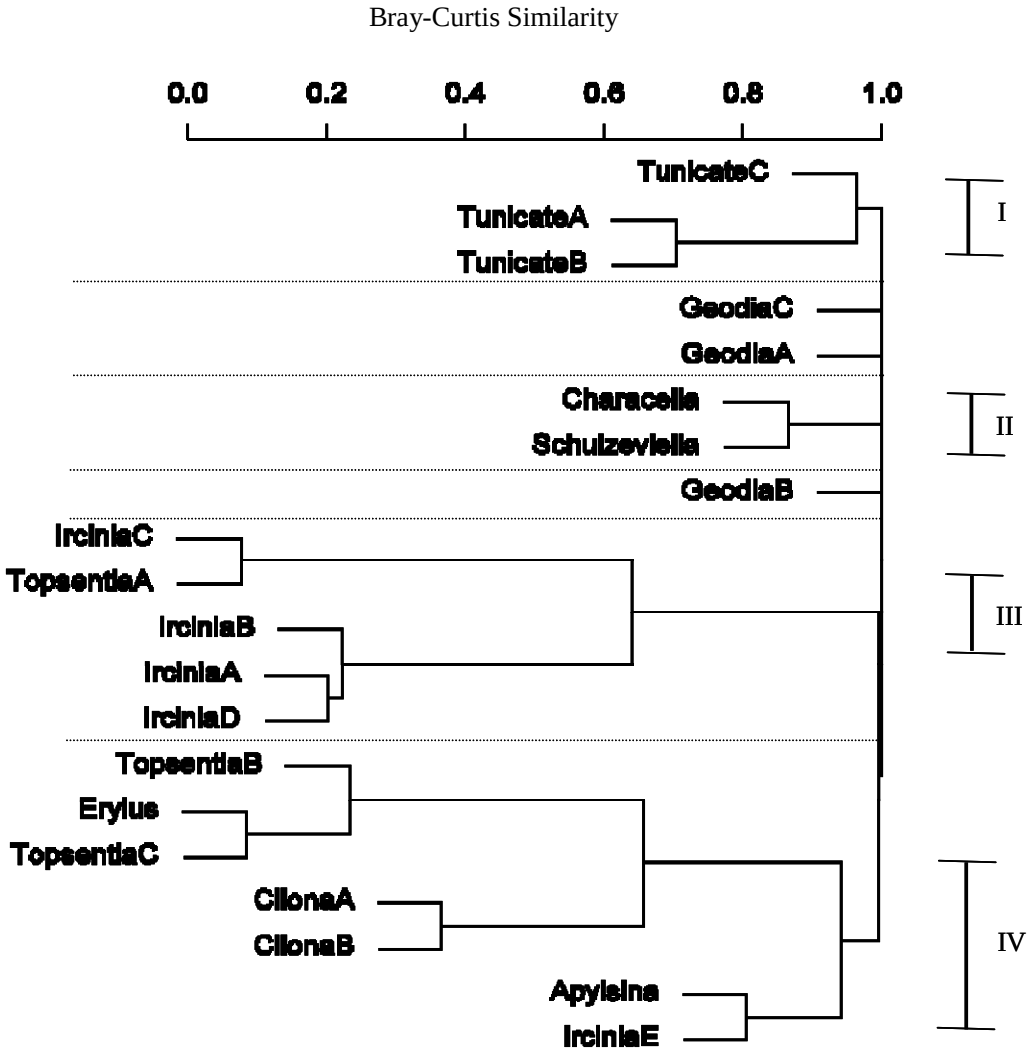


Figure 36. Normal cluster analysis of symbiont communities using hierarchical clustering and Bray-Curtis similarity based on density of symbiont species. I, II, III, and IV are the major groups recognized.

Inverse cluster analysis (Fig. 37) revealed that Echinodermata and Decapoda, as well as Isopoda and Amphipoda, often co-occurred in the same host, while Polychaeta and fishes exhibited minimal overlap with the other groups. Mollusks were found commonly with diverse other taxa.

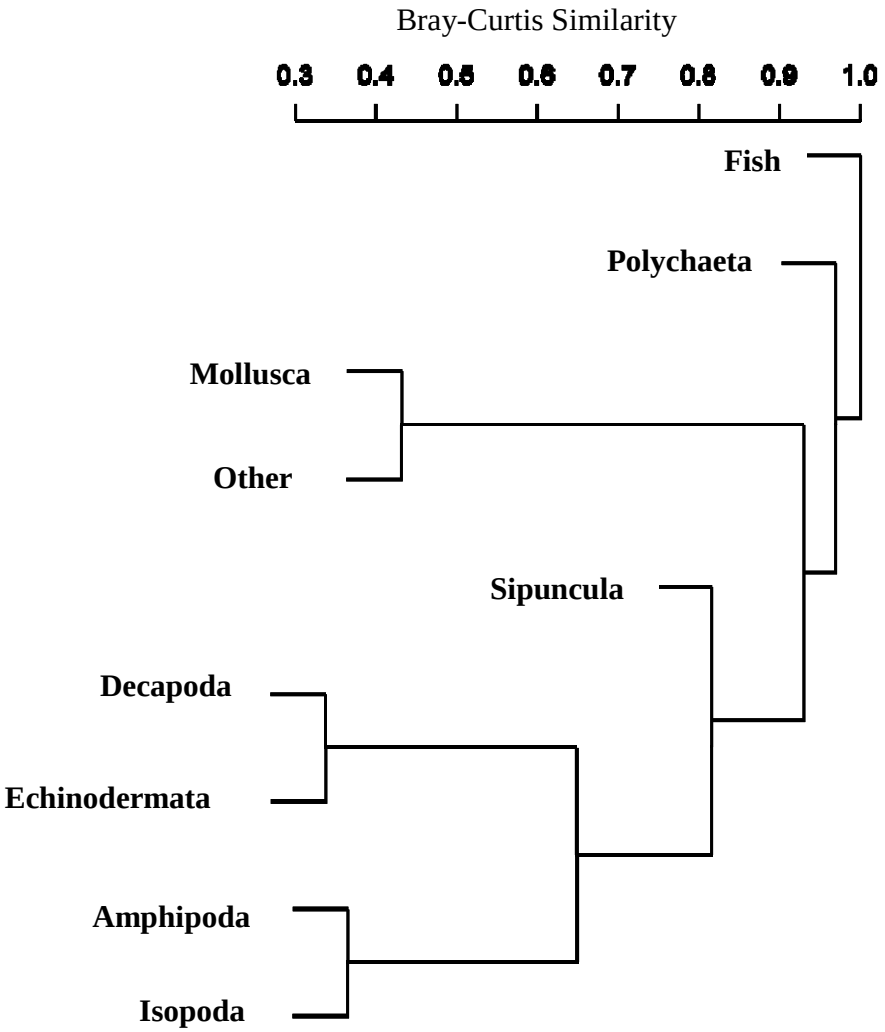


Figure 37. Inverse cluster analysis of main symbiont taxa using hierarchical clustering and Bray-Curtis similarity. Sipuncula also includes Nemertea, but these were very few. "Other" consists of any organisms that do not fit into the other listed taxa (e.g., tanaids, pycnogonids).

Similarity values (C_n) calculated for the five species containing replicates (*Ircinia campana, Topsentia* sp., *Geodia* sp., *Cliona* sp., and *Didemnum* sp.), measured some variability within host species, as suggested by the normal cluster analysis. When utilizing C_n, high taxonomic dissimilarity between the *I. campana* specimens collected in 2002 (E) and the rest of the specimens was found, while *I. campana* specimens A - D were relatively similar to each other (76 – 99%) (Table 8a). Two specimens (A, B) were collected from within 7 m of each other at the same time near Charleston, SC, and were 77% similar. High taxonomic similarity (99%) was also found between two specimens (C, D) that were from the same site (St. Augustine Scarp). Similarly, high taxonomic similarity was seen among the three *Topsentia* sp. specimens (Table 8b), which all had at least 90% similarity to each other. *Cliona* sp. specimens were also highly similar to each other with respect to symbiont composition (93%). In contrast, the three tunicate specimens had relatively low taxonomic similarity (Table 8c). In the case of both the *Topsentia* sp. samples and the tunicates, no two specimens were collected during the same year. The same calculations were conducted for three *Geodia* sp. specimens; however, there was no similarity ($C_n = 0$) among any of the specimens.

Table 8. Similarity in fauna among individuals of *Ircinia campana, Topsentia* sp. and *Didemnum* sp., using the numerical coefficient C_n. The letters for each speciment correspond to specimens labeled in Table 6. The *Cliona* sp. are not given in a table, but were 93% similar.

Ircinia campana

	A	B	C	D	E
A	---	---	---	---	---
B	77.0	---	---	---	---
C	77.0	94.3	---	---	---
D	76.0	69.4	99	---	---
E	8.5	0.79	21.9	16.7	---

Topsentia sp.

	A	B	C
A	---	---	---
B	90.6	---	---
C	99	90.3	---

Didemnum sp.

	A	B	C
A	---	---	---
B	32	---	---
C	31	43	---

Effects of Host Characteristics on Symbiont Communities - Relationships between physical characteristics of the hosts (Table 9) and symbiont community metrics varied by species. Linear regressions conducted in the present study were based on limited replicates of host species, and therefore are interpreted as preliminary results. There was no relationship between total abundance and total volume in *Topsentia* sp. ($F_{1,1} = 0.33$, $p = 0.67$), *I. campana* ($F_{1,3} = 2.21$, $p = 0.20$) or *Didemnum* sp. ($F_{1,1} = 1.68$, $p = 0.2$). The number of symbiont taxa significantly increased ($F_{1,1} = 131$, $p = 0.05$) with the volume of channels and meanders for *Didemnum* sp. (Fig. 38), while no relationship was seen for *I. campana* ($F_{1,3} = 0.36$, $p = 0.5$) or *Topsentia* sp. ($F_{1,1} = 0.03$, $p = 0.88$). Similarly, a significant relationship was found when the number of taxa was regressed with the total volume of the host for *Didemnum* sp. ($F_{1,1} = 75$, $p = 0.07$, Fig. 39), but there was no significant relationship for *I. campana* ($F_{1,3} = 0.07$, $p = 0.80$) or *Topsentia* sp. ($F_{1,1} = 15.3$, $p = 0.15$).

Relationships between available habitat and host size were examined by regressing the volume of channels and meanders, where most symbionts were found, and total volume, the amount of possible habitat. A significant positive relationship between the volume of channels and meanders, a measure of habitable space, and the total volume of the hosts was observed for the tunicate ($F_{1,1} = 131$, $p = 0.05$, Fig. 40) and *I. campana* ($F_{1,3} = 26.5$, $p = 0.014$, Fig. 41), but no trend was found for *Topsentia* sp. ($F_{1,1} = 0.005$, $p = 0.95$) (Table 9).

Multiple regression analyses using all host specimens found significant relationships between the diversity and density of symbionts with respect to host (sponges and tunicates) morphology. When log-transformed symbiont diversity was used as the dependent variable, only canal diameter was found to be significantly correlated with diversity ($F_{1,16} = 0.4$, $p = 0.03$). For symbiont densities (rank transformed), canal diameter again was found to be significant ($F_{1,18} = 4.4$, $p = 0.049$). In both cases the regressions yielded low regression coefficients.

Additional linear regressions between host and environmental characteristics and symbiont density and diversity also yielded significant relationships with respect to canal diameter of the hosts. Density (rank transformed) and diversity (log transformed) were found to be significantly correlated to canal diameter (log transformed); however, low regression coefficients were found (diversity, $F_{1,18} = 5.6$, $R2 = 0.24$, $p = 0.028$; density, $F_{1,18} = 4.4$, $R2 = 0.20$, $p = 0.048$).

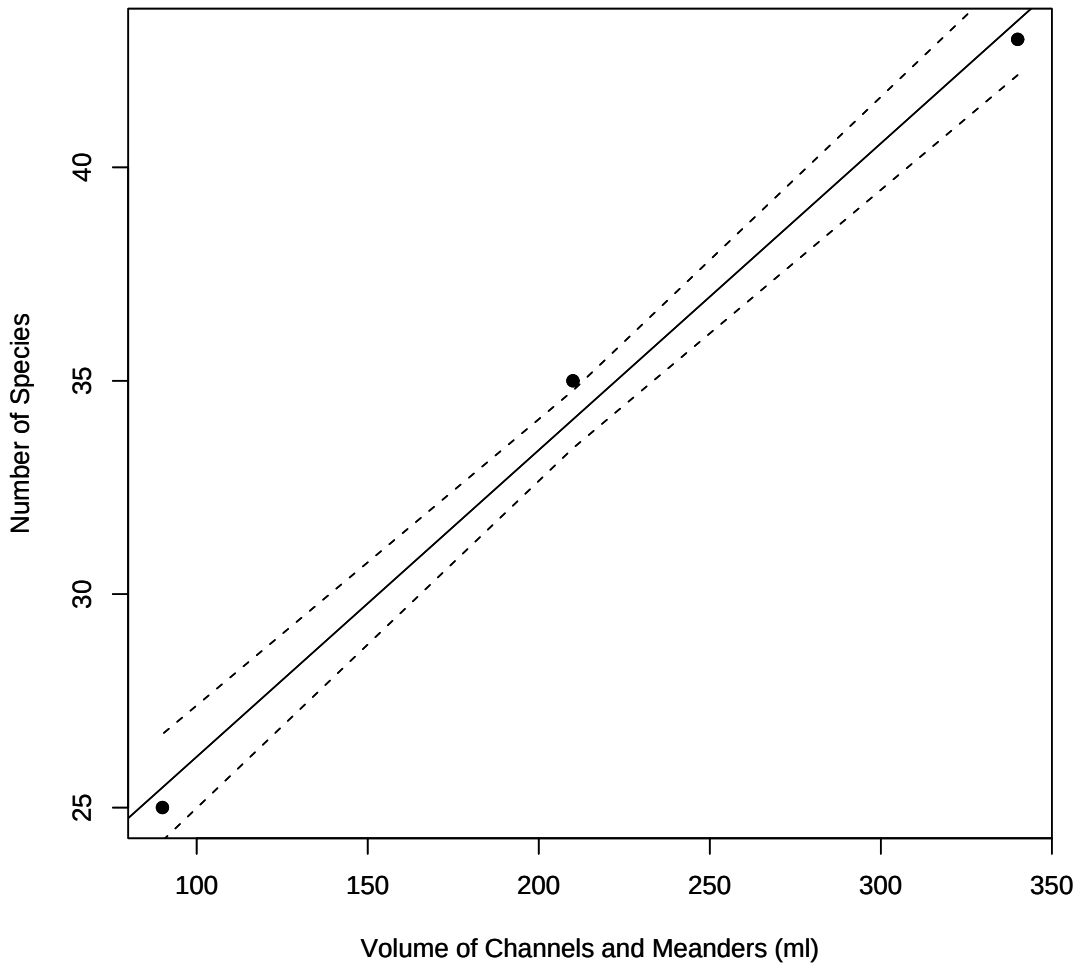


Figure 38. Linear regression of symbiont species number and the volume of channels and meanders in the tunicate *Didemnum* sp. (R2= 0.98, p= 0.05), 95% confidence intervals are shown

Polynomial regressions yielded two slightly significant trends between canal diameter of the hosts and density (per 500 ml) and diversity of symbionts. The regression between canal diameter and diversity of symbionts showed a positive effect (F1, 18 = 6.0, p = 0.02, Fig. 42), while density decreased with increasing canal diameter (F1, 18 = 6.9, p = 0.01, Fig. 43). Diversity and density showed no significant relationship with the channels and meanders volume (F1, 18 = 1.5, p = 0.23; F1, 18 = 1.3, p = 0.25, respectively). Host total volume showed no relationship with symbiont density or diversity (F1, 18 = 1.5, p = 0.3; F1, 18 = 0.04, p = 0.9 respectively); there was also no significant relationship between symbiont density or diversity with depth (density, F1, 18 = 0.90, p = 0.15; diversity, F18, 19 = 0.5, p = 0.47) or latitude (density, F1, 18 = 1.9, p = 0.18; diversity, F1, 18 = 0.9, p = 0.07).

Non-parametric regression using Kendall's robust method yielded a non-significant negative relationship between thickness and symbiont density (tau = 0.04, n = 20, p = 0.81), and between thickness and diversity (tau = -0.23, n = 20, p = 0.15).

Table 9. List of each specimen collected with the corresponding volume of channels and meanders (CM-Vol), total volume (T-vol), average canal diameter (C-diam), average thickness (Thick), and dry weight (Dry Wt).

Sponge Species	CM Vol (ml)	T-Vol (ml)	C-diam (mm)	Thick (mm)	Dry Wt (g)
I. campana A	273	358.3	1.4	50.22	48.12
I. campana B	10	280.3	2.0	20.00	41.34
I. campana C	774	1347	1.15	16.15	73.32
I. campana C	546	1123	1.1	27.03	76.74
I. campana D	229	307	1.4	50.22	16.79
Geodia sp. A	1183	2736	1.5	34.05	372.70
Geodic sp. B	1484	2309	1.4	50.22	388.25
Geodia sp. C	4213	9411	1.6	47.90	1280.00
Characella sp.	750	1845	0	22.78	157.50
Schulzeviella sp.	735	3479	1.8	50.22	103.60
Topsentia sp. A	988	1388	1.0	170.00	254.00
Topsentia sp. B	636	1057.7	1.2	98.07	247.20
Topsentia sp. C	349	1385.3	1.3	127.87	368.30
Cliona sp. A	348	593.6	1.2	77.25	285.10
Cliona sp. B	453	711.3	1.7	84.60	290.10
Erylus sp.	458	867	1.4	50.22	78.92
Apylsina archeri	191	701	1.4	50.22	24.72
Tunicate A	340	893	2.8	6.86	75.10
Tunicate B	90	55	1.4	50.22	74.49
Tunicate C	210	437	2.2	4.59	90.87

Discussion - Sessile invertebrates such as sponges have been documented as an abundant and important component of benthic epifaunal communities (Wenner et al. 1983; Barans and Henry 1984). Sponges provide habitat for an array of invertebrates as well as provide habitat and a food source for many fishes (Wenner 1983; Sedberry 1988). However, the ecology and distribution of sponges in warm-temperate deepwater reefs off the southeastern United States has not been well-studied due to the difficulties associated with sample collection. To date, assessments of sponge communities on the shelf and slope off the southeastern U.S. has been limited by collection techniques. Samples collected by trawl or dredge have produced extensive species lists (Wenner et al. 1983; Wenner et al. 1984; Wendt et al. 1985; Van Dolah et al. 1987), but an examination of bottom type and general epifaunal community in the area has not been possible. Likewise, still photography and video surveys have provided detailed images of these deepwater reefs (Barans and Henry 1984; Wenner and Barans 2001; Griffin 2005), but due to the difficulties of sponge taxonomy, these assessments do not permit definitive identifications. The symbiotic communities associated with sponges have been well-studied in shallower waters (e.g., Pearse 1932; Biernbaum 1981; Westinga and Hoejtes 1981; Crowe and Thomas 2001), but these associations in deeper waters have not been evaluated. The current study represents the first effort to collect these deepwater sponges, complete thorough taxonomic identifications of the specimens and their associated fauna, and assess habitat preferences.

The topography of the continental shelf and slope off of the southeastern United States is variable, with ridges and scarps as well as flat sediment and pavement (Barans and Henry 1984; Wenner and Barans 2001). The shelf is interspersed with areas of relief, referred to as live-bottom, and consists of large rocky outcrops, heavily covered with sessile invertebrates (Struhsaker 1969). In contrast, the upper-slope habitat is largely characterized by a smooth sediment bottom (Struhsaker 1969). The distribution and abundance of sessile invertebrates reflect this variability, with greater densities and diversities of sessile organisms generally found on hard substrates with at least some relief, as opposed to a completely flat bottom (Wenner et al. 1983; Bright et al. 1984; Griffin 2005). Sponges in particular have been noted for their abundance on hard-bottom habitats (Struhsaker 1969; Wenner et al. 1983; Barans and Henry 1984; Van Dolah et al. 1987; Griffin 2005); however, few studies have looked in detail at both the sponges and their habitats.

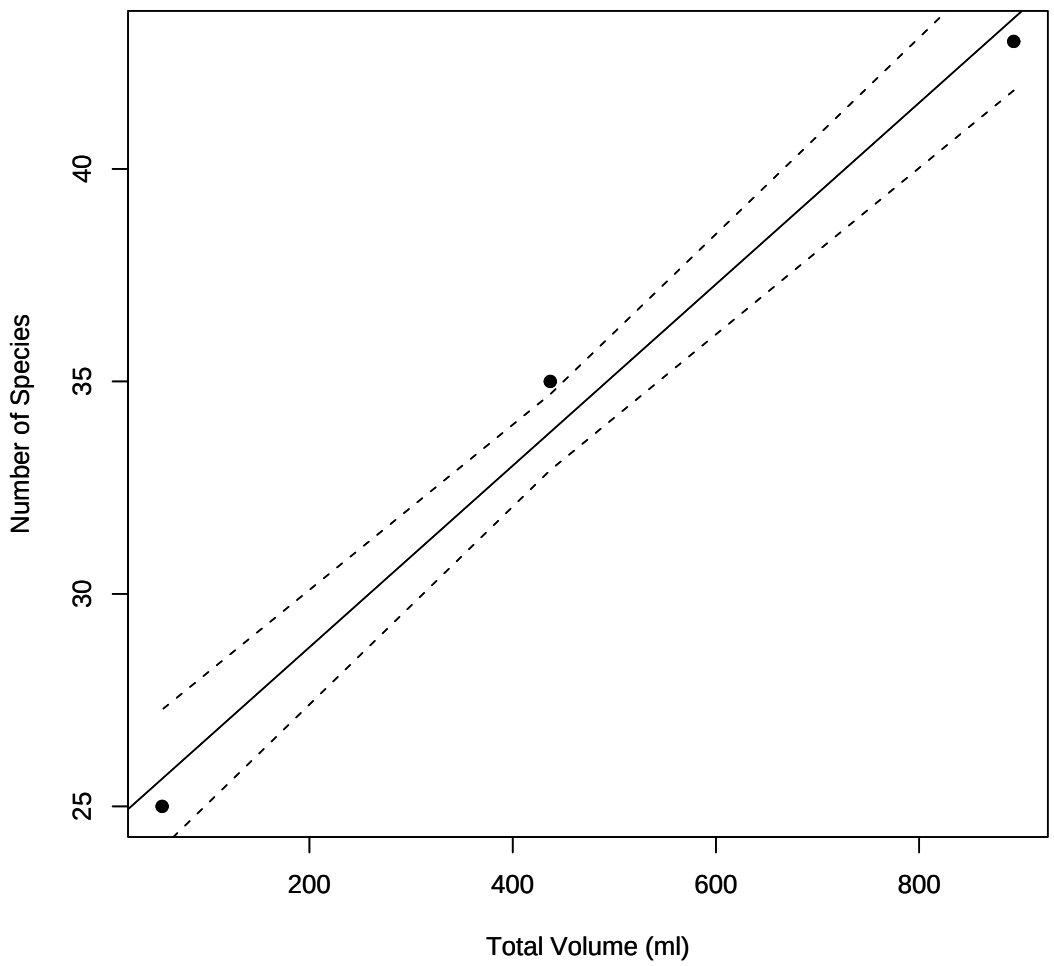


Figure 39. Linear regression of total volume (ml) and symbiont species number (R2=0.97, p=0.07) for the tunicate *Didemnum* sp., 95% confidence intervals are shown.

In the present study, 17 sponges comprising eight species were identified from the shelf and slope off Florida, Georgia, and South Carolina. Some specimens collected for this study have been reported in previous assessments of the benthic fauna of this region (Wenner et al. 1983; Wendt et al. 1985), including some common genera, such as *Ircinia, Apylsina, Cliona*, and *Topsentia*, as well as many rarer taxa, such as *Characella, Geodia, Pheronema*, and *Schulzeviella*. The sponges *Ircinia campana* and *Cliona celata* were commonly observed and collected in the current study and were found by Van Dolah et al. (1987) and Wendt et al. (1985) in high abundances off the southeastern U.S. In addition, the genera *Ircinia* (including *I. campana*), *Apylsina, Cliona, Geodia* and the tunicate genus *Didemnum* were reported by Wenner *et al.* (1984) in a study concentrating on the inner to middle shelf region from Georgia to South Carolina. However, as the goal of the study by Wenner *et a*l. (1984) was to thoroughly assess the diversity of sponges and other invertebrates of the region, it is surprising that the present study obtained five sponge genera not reported by these studies: *Erylus, Topsentia, Characella, Schulzeviella*, and *Pheronema*. Although some of these sponges may have not been reported by previous studies due to the greater depth sampled in the current study, the need for more detailed assessments of the epifauna of this region is apparent.

The distributions of species examined in the current study may be restricted to specific habitats by factors such as depth, temperature or bottom type requirements. In the current study, *Ircinia campana* was collected up to a depth of 58 m, which is deeper than what previous studies have reported (Pearse and Williams 1951; Wenner et al. 1983; Fernando and Sven 2003). In an overview of invertebrate communities observed during submersible dives (Griffin 2005) where specimens from the present study were collected, *I. campana* was documented at

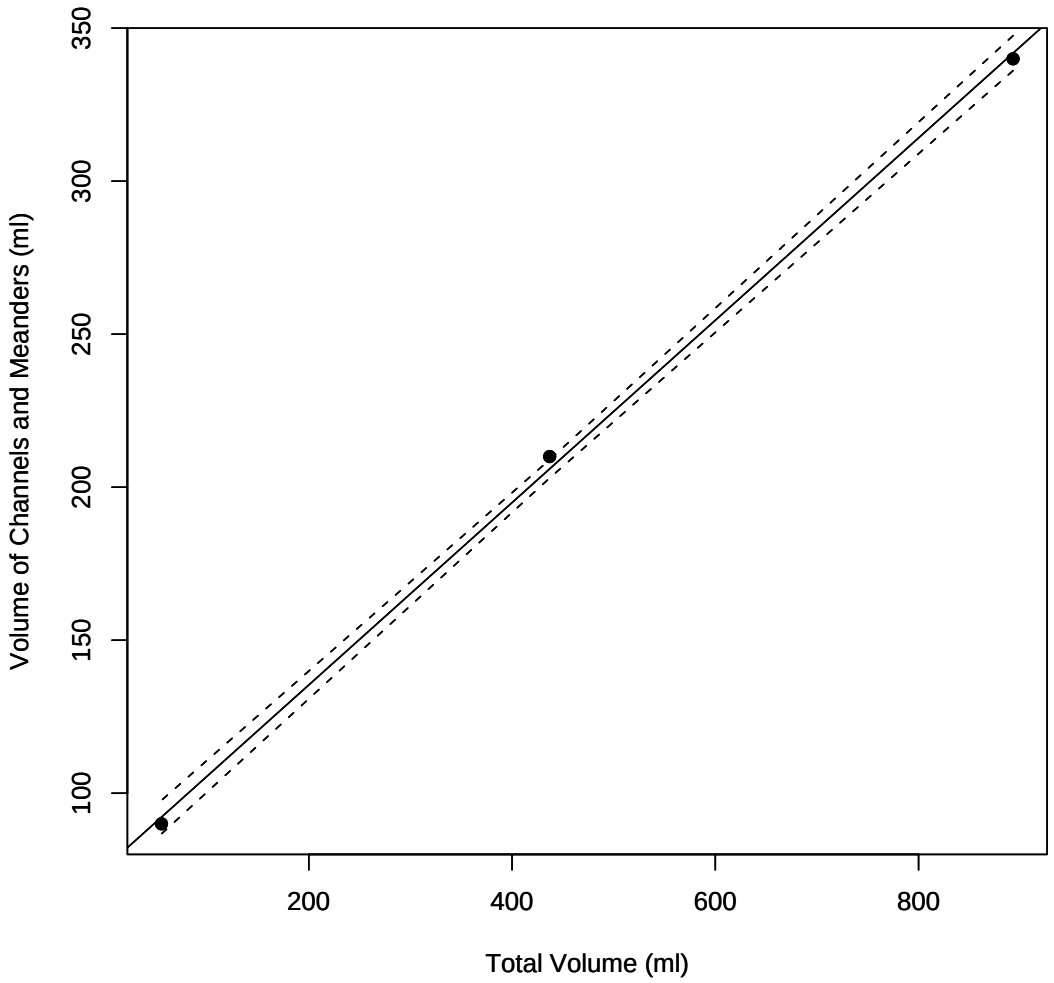


Figure 40. Linear regression of total volume (ml) with the volume of channels and meanders (ml) for the tunicate *Didemnum* sp. (R2= 0.98, p= 0.05), 95% confidence intervals.

depths up to 70 m from the shelf-edge reefs from Florida to South Carolina. Griffin (2005) noted that the range of some organisms such as *I. campana* may be extended to greater depths and to more northern regions than previously thought due to the warming and stabilizing influence of the Gulf Stream along the continental shelf edge. There may be similar effects on range for other species in the current study, such as *Apylsina archeri*, and *Topsentia* sp., which have been commonly documented in warm water habitats, such as the tropical Atlantic or Pacific, the Red Sea and the Mediterranean (Sven and Ernesto 2003; Beatriz et al. 2004; Micha et al. 2004), but less often in cooler temperate waters (Van Soest 1994).

The distribution of *Geodia* sp. specimens were particularly interesting, inhabiting a wide depth range from 194 m to 875 m. Since other species with replicate collections in the current study did not vary greatly in habitat depth or temperature, it is difficult to assess what influential factors may account for the distribution of these species without the addition of a further study component that would specifically look for the specimens in other habitat types. *Geodia* sp. distribution may be influenced most by bottom type and temperature, as specimens were collected only from sites with a mixed bottom of sediment and rocky rubble and with a narrow temperature range from 7.7°C to 13.3°C. Temperature was documented as an important factor in sponge distribution by Griffin (2005), who found the largest densities of *Ircinia campana* within 18.0 - 21.0°C and no *I. campana* within the 12.0 - 15.0°C temperature range. Although sufficient data are not available from the current study to make definitive assessments, habitat type and temperature seem to be the most likely factors affecting *Geodia* sp. distribution.

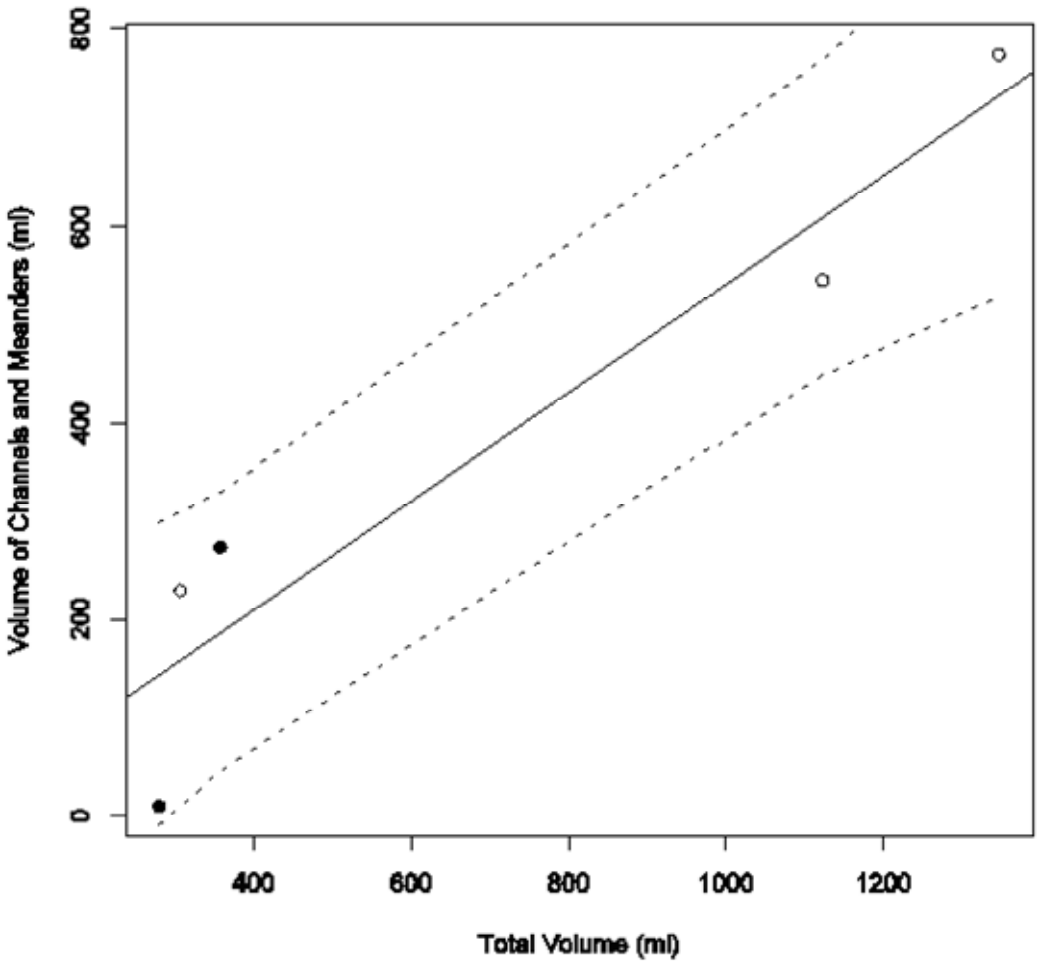


Figure 41. Linear regression of the volume of channels and meanders (ml) with the total volume (ml) for the sponge *Ircinia campana* (R2= 0.89, p= 0.014), 95% confidence intervals are shown. Filled circles represent specimens collected from 18 m and open circles represent specimens from 52 to 58 m.

Sponges found on the upper slope, such as *Characella* sp., *Schulzeviella* sp., and *Pheronema* sp., may also be limited in range by factors such as temperature, depth or habitat type. *Schulzeviella* sp. and *Pheronema* sp. each possess basalia spicules for attaching to a substrate, and so would likely not be capable of a secure attachment on a hard bottom habitat, while such spicules would be very effective on a soft sediment bottom or rubble and sediment mixture. The spicule configuration of these species may therefore influence the distribution patterns. In addition, factors such as temperature or settlement cues cannot be discounted without more detailed future studies.

Interestingly, the two glass sponges, *Pheronema* sp. and *Schulzeviella* sp., both represent new records for the region. *Pheronema* sp. has been documented previously in the northwestern and mid-Atlantic, and in the Caribbean, while *Schulzeviella* sp. has only previously been documented in the South Pacific (Tabachnick and Menchenina 2002). In addition, *Schulzeviella* sp. is likely an undescribed species due to significant differences between the specimen collected in the current study and the only other documented species in the genus, *S. gigas*. Unfortunately the scope of the present study did not address whether the sponge and tunicate specimens identified to the generic level were new records or undescribed species because an in-depth taxonomic evaluation of each specimen must be completed, comparing to the other known species in the genus.

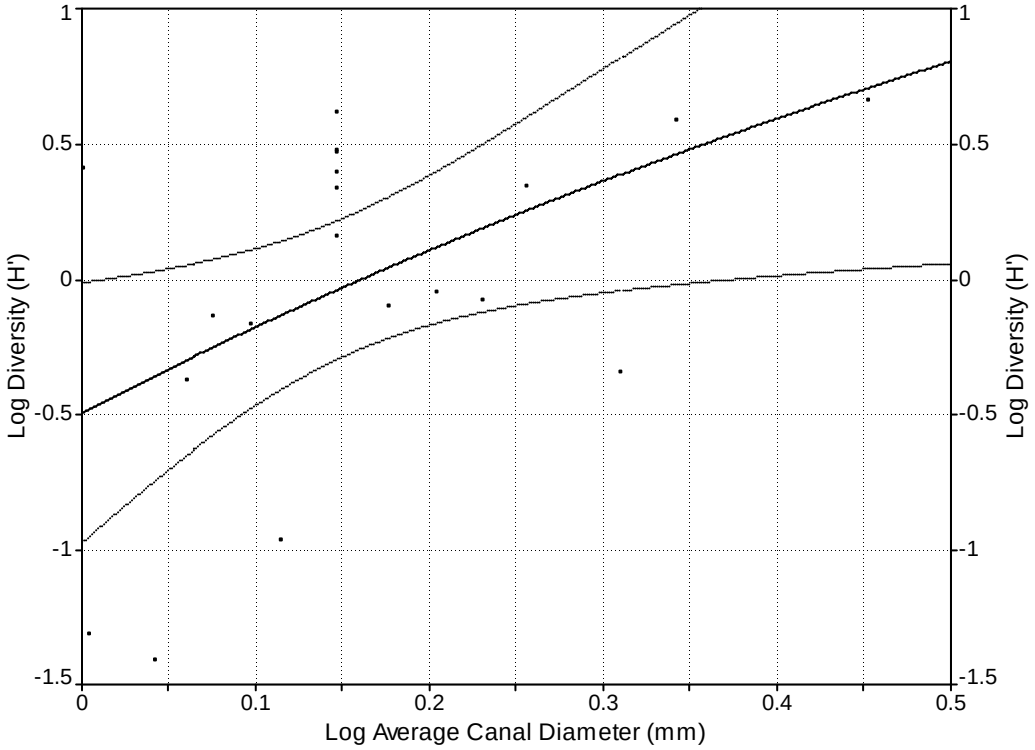


Figure 42. Curvilinear regression using log transformed diversity and log transformed canal diameter for all host specimens; 95% confidence intervals are shown. The regression equation is y = a + be-x (a = 2.8, b = -3.3, R2 = 0.25, p = 0.02).

Previous documentation of sponges of the class Demospongiae (Van Soest 1994) indicates that some sponges collected in the present study from cool-temperate waters at the northern shelf sites may be at or near the limit of their range, such as *Erylus* sp., *Topsentia* sp., and *Apylsina archeri*. Of the demosponges in the present study, only the families Clionidae and Irciniidae have cosmopolitan distributions. The genus *Ircinia*, however, along with *Geodia, Topsentia, Apylsina*, and *Erylus* have tethyan distributions, indicating occurrence of these sponges in all three oceans, with distinct warm-tropical diversity centers. These can then be sub-divided into a wide-spread tethyan distribution (a few species can be found in colder waters), such as *Geodia, Ircinia* and *Topsentia*, and those restricted to tropical and subtropical regions, such as *Erylus. Apylsina*, which is predominantly found in the Caribbean, has a disjunct distribution, because it is found on both sides of the Atlantic and in the east Pacific.

Due to the flow of warm water from the Gulf Stream and areas of cold upwelling water at the Charleston Bump, the region investigated in the current study may represent a convergence zone for many sponge genera with tropical and sub-tropical ranges such as *Apylsina* and *Erylus*, and those inhabiting colder waters (e.g., *Cliona* sp., *Geodia* sp., *Hexactinellida*, and likely others that were not included in the current study), allowing for a diverse assemblage of sponges.

The symbiotic relationship between sessile hosts such as sponges and associated small invertebrates has been examined by many previous studies and is well-investigated in shallow waters (Pearse, 1932; Frith, 1976; Westinga and Hoejtes, 1981; Ribeiro et al., 2003). Such studies have provided information on mutualistic, commensalistic, and parasitic relationships between sponges and their associated taxa such as ophiuroids, amphipods, polychaetes, and snapping shrimps (Hendler 1984; Crowe and Thomas 2001; Magnino and Gaino 1998; Rios and Duffy 1999). Certain ecological information pertaining to these symbionts, such as parental care or eusocial behavior, have also been observed in sponges (Duffy 2000; Theil 2000). However, sponge symbiont composition, as well as factors affecting symbiont communities (e.g., seasonality, currents, habitat type), are likely

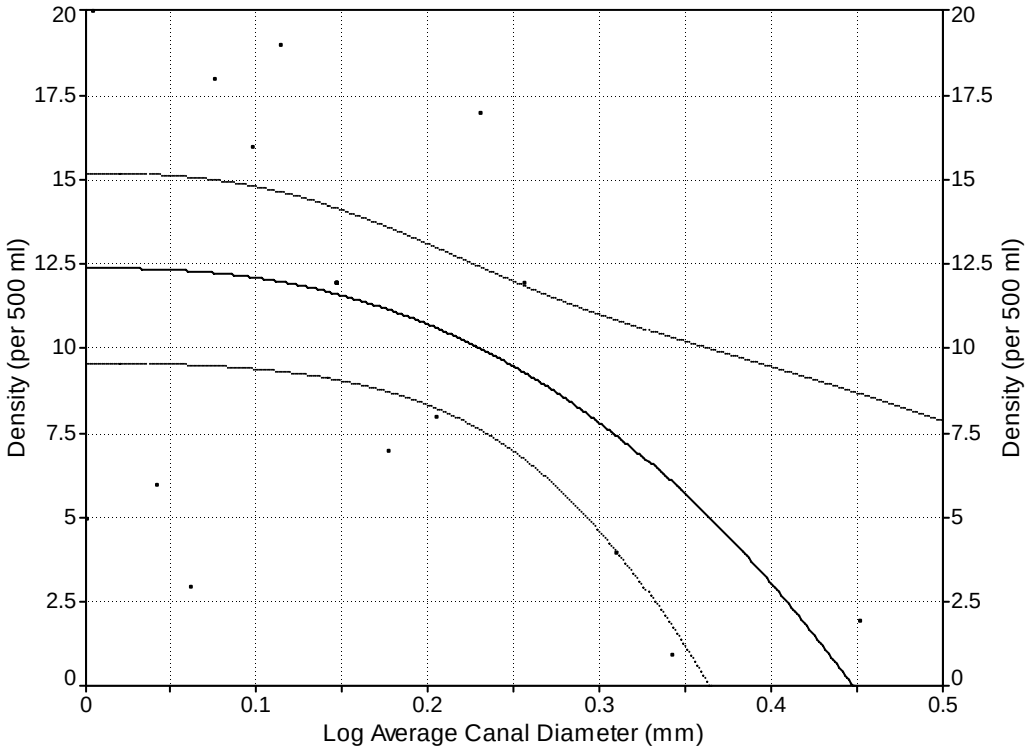


Figure 43. Polynomial regression using ranked density and log transformed canal diameter for all host specimens; 95% confidence intervals are shown. The regression equation is y = a + bx2.5 (a = 12.4, b = -92.3, R2 = 0.28, p = 0.01).

to differ between shallow water (<100 m) and deep water sponge communities, and an examination of deep water sponges and their symbionts, particularly off the southeastern U.S., is lacking. This study presents the first in-depth look at sponges and their symbionts inhabiting the continental shelf and slope off of the southeastern United States.

Sponge symbionts observed in the current study included commensal organisms such as the amphipods *Leucothoe cf. spinicarpa* and *Colomastix* spp., and the ophiuroids *Ophiothrix* spp., and organisms that have been considered parasitic such as *Haplosyllis spongicola* and *Synalpheus* spp., as well as a variety of other taxa that may be commensal or inhabit the sponge by chance. Information on tunicate symbiotic communities, which have not been studied as extensively as sponge communities, were also investigated in the current study. While studies such as Wenner et al. (1983) documented a large abundance of tunicates on the continental shelf, there have been few studies examining tunicate ecology (e.g., Svavarsson 1990; Dalby 1996). In addition, the current study has added to the limited knowledge on macrosymbiontic communities associated with glass sponges. Most studies that have documented glass sponge symbionts have been conducted at abyssal depths (e.g., Beaulieu 2001a; Beaulieu 2001b [~ 4,000 m]) or in the Antarctic (Kunzmann 1996). A similar symbiont community was found in *Schulzeviella* sp. relative to other studies examining glass sponge symbionts. Polychaetes including terebellids and syllids, amphipods including Lysianassidae, as well as crinoids and ophiuroids were common in *Schulzeviella* sp. examined in the present study and to deep sea sponges of the genus *Hyalonema* (Beaulieu 2001a). A study of recruitment to glass sponge stalks found that the two most abundant taxa were calcareous foraminifera and a serpulid polychaete (Beaulieu 2001b). However, the current study is the first to document a fish (*Dysommina rugosa*) associated with a glass sponge.

An evaluation of diversity values from the current study (H' ranged from 0.04 to 4.72) found similar trends of variability between and within host species as reported in previous studies. Duarte and Nalesso (1996) reported diversity values (H') for the sponge *Zygomycale parishii* ranging from 1.7 to 6.1 at one site and 3.8 to 6.3 at

another site in Brazil. Ribeiro et al. (2003) examined another sponge from Brazil, *Mycale microsigmatosa*. A total of 2,235 individuals were found associated with 19 specimens of *M. microsigmatosa* (mean H'=3.0 and J'=0.7). A larger sieve (1 mm) was used relative to the current study to collect the associated fauna, which may account for some difference in diversity values between the present study and Ribeiro et al. (2003); however, it would be expected that the diversity of symbionts documented by Ribeiro et al. (2003) would be lower than in the current study due to the larger sieve size. Diversity values of the sponge symbiont communities examined in the current study were generally much lower than values reported by Ribeiro et al. (2003) and Duarte and Nalesso (1996); one *I. campana* specimen (E) and the tunicates had higher H' values (Fig. 27).

Diversity values of the symbiotic communities from four of the five *I. campana* specimens from the current study were similar to those documented by Wendt et al. (1982) (H'= 0.71), even though several specimens in the current study were collected from deep waters. In both studies, the diversity was low mainly due to the overwhelming abundance of the syllid polychaete *Haplosyllis spongicola*. Wendt et al. (1985) also studied the sponges *Haliclona oculata* and *Cliona celata*, collected off the coast of Georgia at 20 m. *H. oculata*, like *I. campana*, was dominated by *H. spongicola* and had low diversity values (mean H'= 0.64) and a high number of symbionts (13,140, n=3), while *C. celata* had relatively high diversity (mean H'= 3.4) and fewer numbers of symbionts (2,685, n=3). The sponges (*I. campana, H. oculata*, and *C. celata*) examined by Wendt et al. (1985) were collected at a similar depth and habitat to two sponges in this study (*I. campana* A and B), which may explain some of the similarity among the *I. campana* specimens. Specimens collected by Wendt et al. (1985) were also similar in symbiont composition to *I. campana* specimens from much deeper (58 m) and different habitats, suggesting that factors such as host characteristics or larval dispersal may be important in shaping the symbiotic community of these sponges.

Dominance of certain taxa, such as amphipods and polychaetes, were important in shaping the symbiont communities of many host specimens. The most abundant taxon by far was Polychaeta (Fig. 28), with the family Syllidae being the most abundant. Many host specimens collected from the shelf, including *I. campana*, *Topsentia* sp., *Erylus* sp., and *Cliona* sp., were dominated by a particular syllid, *H. spongicola*. Sponges collected from the shelf also harbored many similar polychaete families, although species varied greatly. Polychaete assemblages in the deeper sponge specimens, *Characella* sp. and *Schulzeviella* sp., were similar to each other and to shallower specimens in that syllids and terebellids were common. However, most syllids and terebellids found in the deeper species were different species than those found in shallower specimens. Often, due to damage during sponge dissection or lack of taxonomic keys, these polychaetes were unidentifiable beyond the family level. It is evident from the polychaete assemblages alone that the hosts examined in the current study contained diverse communities that can differ greatly between host species and possibly with depth.

Trends in symbiont dominance across sponges and tunicates varied among host species. The taxon Amphipoda was commonly observed (15% of symbiont taxa) among all sponges and tunicates. In fact, crustaceans, in general, were found commonly, particularly in host specimens not dominated by polychaetes. *Ircinia campana* and the tunicates, in particular, harbored many crustaceans, predominately amphipods (Figs. 24-26). A similar trend was seen with the abundance of ophiuroids, with high abundances in *I. campana*, the tunicates as well as in *Schulzeviella* sp. (n = 80). While the present study and Wendt et al. (1985) found polychaetes to be the most abundant symbiont across most host taxa, exceptions have been reported where crustaceans were most dominant in host taxa (Frith 1976; Westinga and Hoejtes 1981; Villamizar and Laughlin 1991; and Ribeiro et al. 2003). The difference in symbiont taxa dominance is likely a result of the difference in biogeographical regions in which the studies were conducted, since Wendt et al. (1985) and the present study were the only ones mentioned above that were conducted off the southeastern U.S., while the others were conducted in the Caribbean. One factor that may account for these differences is that the source populations for symbionts likely differ between the southeastern U.S. and the Caribbean, notwithstanding the Gulf Stream potentially bringing tropical colonizers to hosts examined in the present study. Nonetheless, similarities in the presence of major symbiont taxa among host species in the present study, as well as previous studies (Westinga and Hoejtes 1981; Wendt et al. 1985; Ribeiro et al. 2003), likely reflect the general suitability of these sponges and tunicates as habitats.

Variation in symbiont abundance and diversity within a host specimen has been noted in previous studies. Magnino and Gaino (1998) noted large differences in associate abundance between apical and basal regions of the sponge Loisina paradoxa; however, no statistical analyses were reported. In the current study, no significant differences were found in abundance or diversity between the basal and distal portions of the bisected I. campana, which may be a result of the small sample size (n = 3). Qualitatively, larger symbionts such as decapods and large amphipods or isopods were generally found in the basal portion of the sponges, likely due to the shape of the sponge (vase-shaped), which resulted in most sponge material being at the base. Although no

significant relationship was observed, large variations in values were found among the three sponges, and more samples might lead to a different conclusion.

Dominance of particular species was also seen in many host species, particularly *I. campana* and *Topsentia* sp., which were dominated by the polychaete *H. spongicola*. Dominance by *H. spongicola* was also noted by Wendt et al. (1985) for the sponges *I. campana* and *Haliclona oculata*, although Wendt et al. (1985) reported much higher abundances of *H. spongicola* in *I. campana* (64,000 – 95,000 individuals/sponge) than were found in the present study (n = 7 – 8,325). Dominance of this polychaete in sponges has also been documented by Reiswig (1973) and Magnino and Gaino (1998) in sponges from the Caribbean and Indian Ocean, respectively. While this polychaete has been documented outside of sponges in sediments and on hard substrates (Wenner et al. 1983; Uebelacker and Johnson 1984), the overwhelming abundance in some host species and not others in the present study, and the fact that it has been documented to use its sponge host for food (Magnino and Gaino 1998) indicate that there is some host preference. Interestingly, these high abundances of *H. spongicola* do not appear to have a significant negative effect on its sponge host (Neves and Omena 2003); however, it is still thought to play a major role in structuring polychaete communities (Neves and Omena 2003) and possibly the whole symbiont community within sponges.

The amphipods *Leucothoe cf. spinicarpa* and *Colomastix* spp. were dominant species among the amphipods, and were found in *I. campana*, *Topsentia* sp., and *Cliona* sp. Interestingly, neither of these species was found in the deeper specimens collected in the present study, including *Characella* sp., *Geodia* sp., and *Schulzeviella* sp. Both of these amphipods have been commonly documented as sponge commensals in shallow waters (Wendt et al. 1985; Theil 2000; Crowe and Thomas 2001); perhaps there is a distance limit to their juvenile dispersal, or nutritional or thermal limitation in their ranges. In addition, two amphipods were collected from *Geodia* sp. C which may represent an undescribed species of the genus *Stegacephaloides*. Although further investigation is needed to verify the new species, this is a reminder of how much is yet to be learned by examining sponge symbiont communities, particularly in deep water where little work has been done.

Ericthonius brasiliensis (Amphipoda) was also frequently encountered, and as with *L. cf. spinicarpa* and *Colomastix* spp., only in shelf host specimens and mainly in *I. campana*. The two *I. campana* (A and B) from the shallow waters off Charleston had one main difference in the composition of symbiont communities; one specimen (*I. campana* A) had a particularly high abundance of the amphipod *E. brasiliensis*. Abundances and composition of amphipods can vary greatly seasonally (Biernbaum 1981), which may include *E. brasiliensis*. The two sponges considered in the current study were collected at the same time during the spring, indicating that something other than seasonality is influencing the abundance of the amphipod. *Ericthonius brasiliensis* is not considered a true sponge commensal like many other sponge-associated amphipods; this organism is only found on the outside of sponges, most likely eating algae and other organic material. However, in two different samples in this study, *E. brasiliensis* was found in a canal inside of *I. campana*, indicating that they may take refuge within the sponge. Although it is unknown how commonly *E. brasiliensis* inhabits the interior of the sponge, or how much of the life cycle is spent inside the sponge, results from this study suggest *E. brasiliensis* may be a commensal organism in some species.

Also of interest, *I. campana* (A) had a higher species count (41) than *I. campana* B (24 species), although their respective total volumes did not differ greatly (A = 359 ml, B = 280 ml). The difference in species number may indicate that more species may be able to share this host (*I. campana* A) due to its lower abundance of *H. spongicola* relative to *I. campana* B, C, and D.

Ophiuroidea is another group commonly documented in sponges (Hendler 1984; Wendt et al. 1985; Hendler et al. 1995). The genus *Ophiothrix* was found commonly in the present study as well as in previous studies (Wendt et al. 1985; Hendler et al. 1995). *Ophiothrix lineata* has been documented as having a mutualistic relationship with the sponge *Callyspongia vaginalis* (Hendler 1984), in which the ophiuroid feeds on potentially fouling detritus on the sponge. It is possible that a similar relationship could exist with sponges such as *Ircinia campana, Characella sp., Schulzeviella* sp., or the tunicates, *Didemnum* sp. The ophiuroids associated with *Characella* sp. and *Schulzeviella* sp. are not well known ecologically, other than that they are a deep-sea species (Fell 1960).

Many of the Tanaidacea found in the current study are also not well known ecologically. Tanaids were generally found in *I. campana* and *Didemnum* sp., while *Erylus* sp. and *Geodia* sp. (A) also harbored a few individuals. One such tanaid that was seen occasionally was *Apseudes cf bermudeus*, which can usually be found in live bottom habitats off the southeastern United States (Heard et al. in prep.). Another tanaid found in the current study was *Cryptocopoides* sp. There is very little information available about this genus; it presently contains two species, one found in the Atlantic and the other in the Pacific (Heard et al. in prep). Previous studies examining sponge symbionts have generally not mentioned tanaids, likely due to their low abundances.

Continued collection of deep water sponges presents the opportunity for studying additional rare and undescribed species or those for which ecological information is lacking.

Results of the community similarity analyses generally reflected the abundances and composition of symbionts among hosts mentioned above. For example, I. *campana, Topsentia* sp., and *Cliona* sp. specimens each showed high numerical similarity (C_n) within species (75 – 99% except for *I. campana* E), largely due to their dominance by *H. spongicola*. This is particularly striking when compared to findings by Westinga and Hoejtes (1981), who reported similarity values among *Spheciospongia vesparium* specimens as ranging from 58.8 to 90.7%. The lower similarity coefficients observed in *S. vespara* and in *Didemnum* sp. in the current study (31 – 43%) are due to low species overlap among host specimens even though they all had high diversity values. The cluster analyses, although differing in some respects from C_n-based comparisons, also appeared to reflect the dominance of *H. spongicola* among *I. campana* and *Topsentia* sp. (Group III), and to a lesser extent Group IV. On the other hand, Groups I and II were not shaped by one dominant species but rather similarity in abundances of certain symbionts (Group I) or the presence of a few shared species (Group II). Group I indicated that while the tunicates do not have a large overlap in symbiont species (as shown by their C_n values) they were still more similar to each other with respect to symbiont communities than to the sponges. This is a particularly interesting result since they are compared to such a wide range of sponges having varying morphologies and collected from different depths. Group II sponges, *Characella* sp. and *Schulzeviella* sp., both harbored a high abundance of ophiuroids (n = 4 [18%], 80 [62%], respectively), as well as low abundances of syllid polychaetes, indicating that although there were some major differences in species composition (e.g., *Characella* sp. had no amphipods, isopods, or crinoids, which were found in *Schulzeviella* sp.), there were enough shared symbiont species to make them more similar to each other than the other host specimens. In addition, *Characella* sp. and *Schulzeviella* sp. were collected from much greater depths (778 and 770 m, respectively) than the specimens in the other three groups, which may be a factor in their similar symbiont communities. However, since the *Geodia* sp. specimens, which were collected from similar depths, did not group with *Characella* sp. and *Schulzeviella* sp., depth does not appear to be a large factor in shaping these symbiont communities.

Many host specimen-pairs had higher similarity values (C_n) than might be expected when compared to the cluster analysis; in fact, symbiont community similarities as determined by normal cluster analysis and calculation of C_n may seem to conflict at times. One must keep in mind that the cluster analysis is a multivariate statistic taking into account differences not only in symbiont species occurrences, but also their relative densities. The similarity coefficient C_n, on the other hand, is based solely on the percent abundance of shared symbiont species. This inherent difference between the two statistics likely accounts for the observed conflicts.

Both cluster analyses and the percent composition of symbiont taxa suggested that variation in the symbiont community of sponges and tunicates examined in the present study are likely influenced by host characteristics and habitat type. For example, the similarity of symbiont communities in the tunicate specimens, shown by the dendrogram, may in part be due to the many folds and crevices that allow such a diverse assemblage of symbionts to take advantage of the refuge and of the water flow passing through the tunicates. Since sponges also provide refuge and water flow, there is clearly a significant difference between inhabiting sponges as opposed to *Didemnum* sp. Many of the folds found in the tunicates were wider and more open than most canals observed in the sponges, which may account for some differences in symbiont composition, including allowing larger symbionts such as the crabs and snapping shrimps that were observed in the present study to colonize these tunicate hosts. The cluster of *Ircinia campana* specimens and the close grouping of the *Cliona* sp. specimens (group IV) also suggest that there is some influence of host characteristics on the associated symbiont community. The ungrouped *Geodia* sp. was a result of the low abundance of symbionts, and the fact that there was no overlap in symbiont species composition among *Geodia* sp. specimens.

Trends in symbiont populations, which can vary with year and habitat, such as recruitment and source populations, may account for the cluster of *Characella* sp. and *Schulzeviella* sp., which are not similar morphologically, but were found in similar habitats, and thus are likely exposed to similar potential sponge-colonizers. Group IV on the dendrogram is also likely a result of habitat because all of the specimens were collected from the shelf-edge, ranging from Florida to South Carolina.

The inverse cluster appeared to reflect similar factors, including host and habitat characteristics. However, these similarities were not as apparent as the relationships seen in the normal cluster. Amphipods and isopods, in general, have similar requirements for shelter and resources, so it is logical that they would often be found together. Decapods and echinoderms, due to their larger relative size may have similar requirements in terms of the size requirement for a host. However, chance encounters, as well as surrounding habitats, likely also influence what kinds of symbionts will colonize sponges and tunicates.

Differences in symbiont communities among host specimens, particularly in specimens living in close proximity (e.g., *I. campana* A and B), lead to questions about what is driving the abundance and composition of invertebrate assemblages within sponges of all taxa. The high variability observed may be a result of the source of potential colonizers. If the source of the majority of symbionts (larval or adult) is from the surrounding sediments, symbiont differences in hosts collected from varying substrates would be expected to differ. However, large symbiont community differences were observed in the current study in sponges collected very close to each other on the same substrate, so sediments cannot be the only source of symbionts. On the other hand, if potential colonizers settle from the water column, more variation in symbiont communities would be expected as some larvae travel longer distances than others, and this would include larvae from a large region. The Gulf Stream might broaden the source of potential colonizers by including those from tropical regions. Physical parameters of the environment, such as temperature and salinity, did not vary significantly among sites, and were not considered to be important factors in structuring the overall symbiont communities; however, local bottom currents, which in some areas along the shelf can be very strong, may be a factor affecting variability of colonizers among hosts. Strong currents could make it difficult for larvae to settle or to identify settlement cues. Such currents could also carry larvae from distant regions.

Mode of dispersal for some symbionts is known, at least generally. For example, peracarids such as amphipods and isopods brood their embryos through all larval development, and snapping shrimps such as *Synalpheus* spp. have a reduced or absent free-swimming larval period (Dobkin 1965). For symbionts such as these, dispersal to a new host is very limited (Westinga and Hoejtes 1981; Theil 2000). On the other hand, most syllid polychaetes reproduce by epitoky in which a stage of the adult swims into the water column to reproduce. This results in the formation of swimming larvae. Although epitoky would be expected to maximize dispersal, its magnitude would be dependent on the duration of time in the water column and the current speed. However, specifics of dispersal, such as how many individuals (adults or larvae) released from a sponge find a sponge host, and what distances are involved are largely unknown.

Other factors that may affect the settlement and colonization of symbionts could include the morphology of the sponge or cues from established symbionts that influence later arrivals. Secondary metabolites produced by sponges have most often been studied as possible predation deterrents (e.g., Pennings et al.1994; Pawlik et al. 2002), but they may also provide a settlement cue for some symbiotic invertebrates (Dimock and Davenport 1971). While this study did not assess the role of chemical cues in the host-symbiont relationship, they could be an important factor affecting the faunal communities associated with sponges, and warrant further examination in future studies.

In addition, the composition of symbiont communities may be driven by the population dynamics of the symbionts rather than by characteristics of the sponges. For example, the variability may be due to differences in cohort strength for various would-be symbionts. In addition, while general larval modes are known for major taxa, it is not known how much, if any, of the faunal assemblage hatched within the sponge versus settled as a larva or juvenile from the water column (Westinga and Hoejtes 1981). Many of these interesting questions related to the abundance and diversity of symbionts could be addressed with detailed studies in the field and laboratory, ideally with larger sample sizes.

Morphology may limit the composition and/or density of symbionts that can settle, or symbionts may prefer a host based on characteristics that affect water flow or food (Frith 1976; Pawlik 1983). Geodia sp. provides an interesting example of the role of sponge morphology on symbiont communities. The three specimens collected constituted the largest and third largest total volume (9511 ml and 2736 ml), but contained the fewest species. Interestingly, the shallow *Geodia* sp. specimen contained 22 symbionts (nine species) as compared to only three and four symbionts found within the other specimens. Depth may play a role in the differences found between these specimens; however, due to limited sample sizes, a definitive explanation is not possible. Unique morphological characteristics of *Geodia* sp. may result in low numbers of symbionts relative to other sponges. The surface of this sponge is extremely hard and relatively thick, making the central osculum the only way in and out of the sponge (for all but micro-organisms), which may inhibit many potential colonizers. While dissecting these sponge samples, the spicules were relatively large and often protruded into canals and chambers (Figure 16); such a habitat may be undesirable for many small invertebrates.

The two specimens of *Cliona* sp. were collected from a mostly soft sediment habitat with some low relief and hard-bottom, and the benthos may serve as a source for many of the polychaetes found in these sponges. These two specimens were dominated by *H. spongicola* and contained relatively few species overall, which may be due to the loosely consolidated consistency of these sponges. The outer surface of *Cliona* sp. was smooth and appeared to provide most of the structural support for the sponge. The interior was mostly sediment-packed with

spicules and few distinguishable canals, which may lead to low species richness and relatively low abundance of symbionts.

Previous studies have reported high abundances of symbionts within branching or fistulose sponges (Pearse 1932; Frith 1976; Biernbaum 1981) and with increasing volume of channels (Villamizar and Laughlin 1991). Therefore, the large network of channels and meanders that are readily accessible due to the porous nature of the tunicate *Didemnum* sp. and pliable and porous nature of *Ircinia* may allow these host species to be more accessible to large and small motile fauna such as crustaceans and echinoderms than other hosts. *Topsentia* sp., on the other hand, contains distinct canals throughout the specimens, but has a very tough and stony consistency, likely making access more difficult for larger animals (e.g. > 2.8 mm). *Topsentia* sp. also has no central osculum, further blockading the interior from larger inquilines. High abundances of *Haplosyllis spongicola* and low abundances of other taxa in *Topsentia* sp. may be an indication of this sponge's inhospitable environment for most animals.

Two of the deepest sponges collected, *Characella* sp. and *Schulzeviella* sp., harbored a high abundance of ophiuroids, particularly *Shulzeviella* sp. *Characella* sp. differed from *Schulzeviella* sp. in that the specimen analyzed was much smaller (*Characella* sp. = 1845 ml, *Shulzeviella* sp. = 3479 ml, total volume) and contained no visible canals. Such morphological characteristics may explain why *Characella* sp. contained only 22 individuals comprised of eight species, while *Schulzeviella* sp. had 19 species with 128 individuals. *Schulzeviell*a sp. was very pliable and contained many canals and meanders. The entire specimen was only loosely held together and would provide a habitat easily navigated by most motile invertebrates. The morphological characteristics of Schulzeviella sp. may result in the higher abundances of polychaetes and other taxa relative to *Characella* sp.

The close associations between mobile invertebrates and sponges led Westinga and Hoetjes (1981) to maintain that a sponge can be characterized as an ecological community, a description that several researchers have similarly commented upon (Tyler and Bohlke 1972; Uebelacker 1977; Peattie and Hoare 1981; Villamizar and Laughlin 1991; Ilan et al. 1994). In addition, sponges have been compared to islands with regard to the species-area relationship, which states that larger islands will have more species than smaller ones (MacArthur and Wilson 1967). Preliminary comparisons of host size and species number revealed a positive relationship between host volume and symbiont diversity for the tunicate *Didemnum* sp. Collection of additional data for this tunicate will likely elucidate this relationship. Since *Ircinia campana* did not exhibit a significant increase in the number of symbiont species with increasing volume, but the volume of channels and meanders did increase with increasing total volume, this suggests that as habitat (volume) increases, the new habitat may be claimed by the dominant species *Haplosyllis spongicola* before another species can colonize the habitat. However, a positive relationship between species richness and habitat (host) size has been documented in previous studies. Uebelacker (1977) found significant correlations between the number of species associated with the Bahamian sponge *Gelliodes digitalis* and the sponge size (mass, volume, surface area, length and circumference) ($R2 = 0.61\text{-}0.71$, $n = 29$). A logarithmic model was used for all the relationships in his study, although an untransformed model was investigated. Similar results were reported by Westinga and Hoejtes (1981) for the sponge *Spheciospongia vesparium*. The number of associated taxa was found to increase logarithmically with the sponge volume, and the abundance of symbionts and their biomass were proportional to sponge volume, indicating that all available habitable space is occupied. However, the logarithmic relationship documented by Westinga and Hoejtes (1981) only holds for sponges with a volume less than 14 L. Villamizar and Laughlin (1991) also assessed symbiont/host relationships in two vase sponges, *Apylsina lacunosa* and *A. archeri*. Correlation values between volume measurements and species number varied between 0.395 and 0.536, with the highest value belonging to A. archeri for species number and volume of channels and meanders. The relatively low correlation values were attributed to the small sample size (n=10-35) and small specimen sizes, with the caveat that there may be a minimal value for which a relationship can be detected. The morphology of specimens evaluated was also noted as a possible factor in the relationship (Villamizar and Laughlin 1991). Massive sponges such as *G. digitalis* and *S. vespara* have a proportional increase of the volume of channels with overall size, and cavities within the sponge increase with sponge volume. Similar morphology and size effects may also be factors influencing symbiont communities in certain sponges evaluated in the current study, such as *I. campana* and *Geodia* sp.

Both Duarte and Nalesso (1996) and Ribeiro et al. (2003) found linear relationships between species richness and sponge volume. However, a clear significant trend for diversity and evenness with volume was found in only one of the studies (Duarte and Nalesso 1996). Overall, the earlier studies and the present study suggest that a relationship between sponge volume and species number does exist; however, the relationship may be more difficult to decipher for different sponge morphologies, and no clear trend may exist across species. However, trends within host species are likely to exist between host volume and species number.

Additional analyses of host characteristics and symbiont density and diversity revealed few significant relationships. However, the lack of relationships may be a result of the varied size and morphology of the hosts, in addition to the limited sample size available for analysis. It should be noted that since canal diameter appeared to influence symbiont density and diversity, albeit in opposite directions, it is likely that additional samples will yield a clearer relationship.

Aside from species-area relationships, the hosts examined in the present study do function as isolated communities in additional ways. A food web consisting of filter and deposit feeders, spongivores, and carnivores exists within many of the hosts examined in the current study. For example representatives from the polychaete families Nereidae, Arabellidae, Lumbrineridae, Eunicidae, Goniadidae, Glyceridae, and Phyllodocidae were found in most Ircinia campana specimens. These polychaetes all contain jaws that could easily capture small amphipods, isopods, tanaids, or worms. Another trophic guild of polychaetes that were found among many host specimens consisted of surface deposit feeders and filter feeders such as Terebellidae, Sabellidae, and Serpulidae. In the sponge *Schulzeviella* sp., two polychaete families were seen that were not found in any other specimen: Dorvilleidae and Cossuridae. Neither of these families are well known taxonomically or ecologically (Uebelacker and Johnson 1984). Most cossurids are likely detritovores, while dorvilleids may be carnivores and detritovores (Uebelacker and Johnson 1984). Most host specimens harbored two trophic levels in the symbiont communities, with top predators consuming smaller worms, as well as small/juvenile amphipods, isopods, and shrimp. There are also other carnivores (such as *H. spongicola*) which mainly eat their host, as well as filter/deposit feeders which gather food from the influx of water and organic material through their host. Such trophic dynamics have been noted in previous studies that characterize the sponge as a community (Peattie and Hoare 1981; Neves and Omena 2003).

In isolated communities such as islands, speciation can occur faster relative to the source population, and certain behavior can evolve due to the restriction of gene flow. Unlike real islands, sponges are in close and constant contact with possible source populations such as the sediment and the water column, which likely restrains to some extent speciation within the host. However, ecological behavior likely due to inhabiting a small and distinct area have been documented. Snapping shrimps, *Synalpheus* spp., which are commonly found in sponges and among reefs in the Caribbean (Reed et al. 1982). Species of *Synalpheus* also appear to have restricted gene flow, allowing for local differentiation among populations within sponges collected near Panama (Duffy 1992). In addition, Duffy et al. (2000) reported eusocial colony organization has arisen in sponges at least three times in the genus Synalpheus. As eusociality has arisen rarely among animals, the snapping shrimps associated with sponges present a perfect opportunity to study a still poorly understood behavior (Duffy et al. 2000).

A different ecological behavior that likely evolved from living in small spaces is exhibited by the amphipod *Leucothoe cf. spinicarpa*, a commonly documented sponge commensal (Theil 2000; Crowe and Thomas 2001). It may competitively exclude conspecific females from a small host such as a solitary tunicate, but in a large, highly-branched sponge, such as *Haliclona* spp. and *Halichondria* spp., there may not be such strict competition for space (Theil 2000). Furthermore, extended parental care also only seen in the solitary tunicates as opposed to the sponges examined by Theil (2000), indicating that discrete microhabitats such as those found in a solitary tunicate may be more conducive to the evolution of parental care and territoriality. An interesting direction of research may be to examine different sponge species to see if such differences occur.

Sponges in the current study have been shown to provide important habitat for a diversity of invertebrate organisms and a few vertebrates, and can be considered as ecological communities. Many further studies are needed, however, to better understand complex host-symbiont relationships. One suggestion for future studies examining the sponge and tunicate communities off the southeastern U.S. is to collect a range of host species from one site at each of the three habitat types described in the current study (northern and southern shelf-edge and the upper slope) for identification. With additional samples from one area, a more comprehensive overview of the species assemblages in these areas would be gained. In addition, sponge and tunicate identifications from such an analysis would be a useful reference tool for future video surveys, could minimize the habitat disturbance caused by excessive collections. Another interesting study would be to compare sponge morphology in regions with strong currents, such as the slope and Charleston Bump, with sponges inhabiting regions with relatively weak currents, such as the inner shelf, to determine if there are differences in growth form or stiffness between the two regions (see Palumbi 1986), as well as to examine possible resultant differences in their symbiont communities.

Conclusions Regarding Symbionts - Although the current study presented data on a limited set of sponge samples due to the use of a submersible for sample collection, this analysis provided a basis for future studies through an examination of sessile invertebrates that play an important role in habitat structure in this region. The present

study represents the first detailed look at sponges collected from 50 to 950 m off the southeastern United States. Several taxa collected were in common with previous assessments in this region although four different genera were collected in the current study. It is likely that future research in this region will yield more species as either new records to the region or new species to science.

While there is still a great deal to learn about sponge-symbiont dynamics, findings from this study have shown that the sponges and at least one colonial tunicate inhabiting the continental shelf and slope along the southeastern United States provide important habitats for a multitude of invertebrates, as well as the occasional vertebrate. The associated invertebrate communities depend on their host for shelter from predation and commonly as a food source, either directly or indirectly by the host's water circulation. Symbiont communities were found to vary greatly between host species. A diverse and abundant source of hosts may maintain the biodiversity of this area and provide safe habitats for reproduction of some species that are important trophic links to larger consumers. These living islands also provide us with a useful model for studying ecological and evolutionary questions.

Infauna

Infauna collected during the August 2004 Ocean Exploration cruise to the Charleston Bump and adjacent Blake Plateau are being studied by Jeff Hyland, Cindy Cooksey and J.D. Dubick of NOAA/NOS/CCEHBR (Charleston). The objective of this work is to describe infauna of the Charleston Bump and to compare faunal assemblages in depths from 400-905m along the Latitude 31-30 Transect with previously described shallow-water assemblages. In 2004, a total of eight stations were sampled for benthic macroinfauna (Fig. 44). The original sampling goals included the collection of benthic infauna at a greater number of sampling sites. However, due to downtime from inclement weather and equipment failures, the available sampling windows were focused more on the higher-priority photo-surveying of live-bottom areas with the submersible, and thus the sampling of infauna was limited to these few stations. Two of the eight stations were sampled with a Young Grab (0.04m2) and the remaining six stations were sampled with the Johnson Sea-Link grab scoop (0.03m2; Table 10). A subset of these eight stations, B1 and B4, was selected for further processing, based on their potential utility as a source of data for describing meaningful spatial patterns in the benthos. These stations were sampled with the Young grab and thus will allow direct comparison of benthic infauna from the Charleston Bump with historic benthic infaunal data collected by us in the Gray's Reef National Marine Sanctuary and surrounding shelf waters on prior surveys, using the same sampling methods. Additionally, these two stations correspond closely to the 31-30 Transect and thus can be compared to data from shallower stations sampled along this same corridor as part of these earlier surveys.

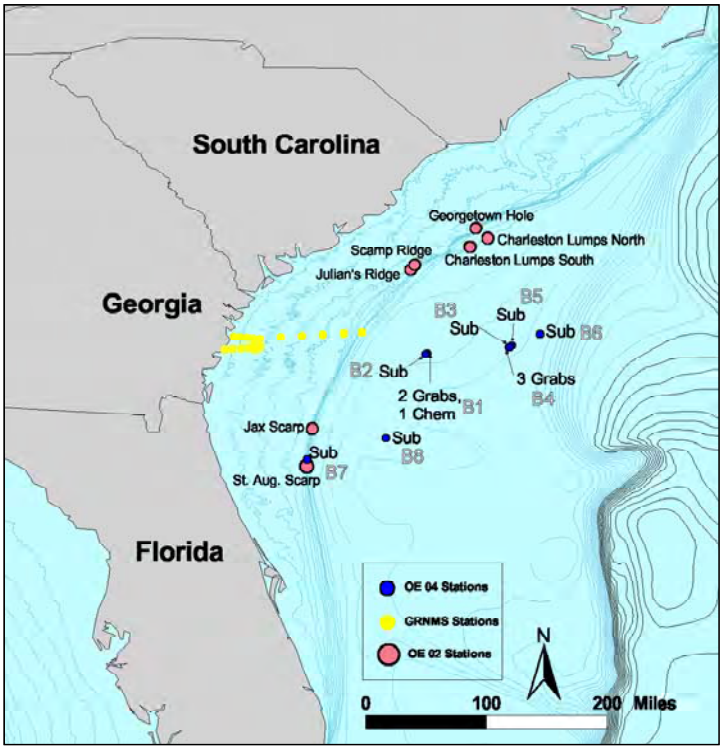


Figure 44. Benthic infauna sampling stations in during the 2004 OE cruise, and additional sites used for comparison. Samples were collected using submersible (Sub) or Young grab (grabs).

Samples from all eight slope stations were live-sieved in the field (0.5 mm screen) and fixed with 10% buffered formalin. Upon their return to the laboratory, samples were transferred to a 70% alcohol solution for long-term preservation. The two replicate samples from B1

and three replicate samples from B4 were processed (under contract to Barry Vittor & Associates) for the purposes of this study and the remaining samples were archived. All five of the selected samples have been fully processed, including sorting and taxonomic identifications to the lowest practical level (species where possible). Table 11 provides a brief summary of results.

The diversity and abundances of benthic fauna in these samples were much lower than sites at shallower shelf depths along the Latitude 31-30 Transect. For example, Hyland et al. (2006), who used the same methods in earlier surveys conducted along the shelf portion of the transect (the yellow-coded stations in Fig. 44), reported average densities of 11,743-1,550/m^2, species richness values of 29-50 taxa/grab, and H' diversity of 3.24-4.89 at inner to outer-shelf depths < 100 m. Cross-shelf patterns in these variables were reported as follows: increasing H' with increasing depth; higher species richness at mid-shelf depths (including stations within the Gray's Reef National Marine Sanctuary) in comparison to inner- and outermost stations, which is a pattern thought to be related more to topographic complexity than to depth or shoreline proximity; and densities that were highest at the innermost station off the mouth of Sapelo Sound and lowest at the outermost station along the shelf break (100 m) (Hyland et al. 2006). The very low densities observed at the deeper slope depths in the present study (200-650/m^2 at 515-526m, 50-75/m^2 at 720-738m) are consistent with the above density pattern. However, the low numbers of species and diversity were surprising — much lower than values found at slope to rise depths off South Carolina in prior studies (e.g., Blake and Grassle 1994) — and remain unexplained. A CTD cast taken near Station B1 did not reveal any unusual oceanographic conditions (e.g., temperature = 15.01 °C, salinity = 36.02 psu, DO = 4.96 mg/L). DO, though slightly depressed, was not reflective of either anoxic or hypoxic conditions and was well above a reported benthic hypoxic-effect threshold of about 1.4 mg/L (e.g., Diaz and Rosenberg 1995).

As in shallower shelf portions of the Latitude 31-30 Transect, the deeper slope stations in the present OE 2004 survey were inhabited predominantly by annelids and crustaceans. Dominant infauna at slope Station B1 included the polychaetes *Lumbrineris latreilli*, *Mediomastus ambiseta*, *Mediomastus* spp., Onuphidae and Sabellidae; the crustaceans *Leptognathia* sp. and *Rildardanus laminose*; and unidentified nemerteans. Dominant fauna at the deeper slope station B4 included tubificid oligochaetes, the polychaete *Scoloplos rubra*, crustaceans of the family Melitidae, and an aplacophoran mollusk. It is interesting that tubificid oligochaetes, the polychaetes *Lumbrineris latreilli* and *Mediomastus ambiseta*, and members of the polychaete genus *Scoloplos*, which are often associated with environmental disturbance and impaired benthic assemblages (e.g., Pearson and Rosenberg 1978), are dominant taxa in these offshore samples. It is difficult to provide an accurate interpretation of these results given the limited sampling of benthic infauna and corresponding abiotic environmental variables on this cruise.

Table 10. OE 2004 benthic macroinfaunal station information.

Benthic Stations	Type	Depth (m)	Latitude	Longitude	Comments
B1	Grab	520	31 19'	78 50'	2 grab samples and 1 chemistry sample
B2	Sub	552	31 18'	78 51'	3 replicate samples from Sub scoop
B3	Sub	778	31 23'	77 51'	3 replicate samples from Sub scoop
B4	Grab	720	31 25'	77 49'	3 Grabs, no chemistry
B5	Sub	787	31 24'	77 50'	3 sub scoops (2 scoops per bucket =0.06 m2)
B6	Sub	874	31 33'	77 29'	3 replicate samples from Sub scoop
B7	Sub	63	30 01'	80 16'	3 replicate samples from Sub scoop
B8	Sub	868	30 17'	79 20'	3 replicate samples from Sub scoop

Table 11. OE 2004 benthic macroinfaunal results. H' diversity calculated with base 2 logarithms.

Sample	Depth (m)	# Ind/m2	# Taxa	H' Diversity	J' Evenness
B1/Rep 1	515	650	11	1.7	0.7
B1/Rep2	526	200	6	1.7	1.0
B4/Rep1	738	75	2	0.6	0.9
B4/Rep2	722	50	2	0.7	1.0
B4/Rep3	720	50	2	0.7	1.0

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b. Inventory of Activities

The following activates were completed during field work (see also Table 1, Table 12 and Fig. 3)

Beam Trawl Tows	3
Bongo Net (Plankton) Tows	12
CTD Casts	5
Dip Net Stations	5
Dip Net With Night Light Stations	2
Grab (Young) Stations	9
Light Trap (Large) Stations	3
Light Trap (Small) Stations	3
Neuston Net Tows	5
Pipe Dredge Tows	4
Submersible Dives	13
Wreckfish Reel (Vertical Line Fishing) Deployments	3

Table 12. Inventory of activities conducted during the cruise.

Gear	Latitude	Longitude	Date	Depth (m)
Beam Trawl	32.21542	-79.31263	8/23/2004	40
	31.31813	-78.78952	8/24/2004	520
	31.32235	-78.75917	8/24/2004	512
Bongo Net	31.27552	-78.91673	8/21/2004	549
	31.27552	-78.91673	8/21/2004	549
	31.25333	-78.93508	8/21/2004	508
	31.25333	-78.93508	8/21/2004	508
	31.83142	-77.19658	8/26/2004	988
	31.83142	-77.19658	8/26/2004	988
	30.31137	79.29448	8/30/2004	828
	30.31137	79.29448	8/30/2004	828
	29.26328	80.26738	8/31/2004	73
	29.26328	80.26738	8/31/2004	73
CTD	31.25797	-78.93610	8/21/2004	555
	31.28308	-78.92818	8/21/2004	556
	31.32003	-78.84083	8/22/2004	515
	31.83633	-77.18325	8/26/2004	1002
	29.88080	80.28148	8/31/2004	
Dip Net	31.32003	-78.84083	8/22/2004	530
	31.25212	-78.94420	8/22/2004	510
	31.38487	-78.59897	8/24/2004	505
	31.55095	-77.48548	8/26/2004	866
	31.22008	79.99775	8/28/2004	
Dip Netting - Night	31.27152	-78.92052	8/22/2004	576
	31.31875	-78.82582	8/23/2004	520
Light Trap - Large	31.27152	-78.92052	8/22/2004	576
	31.31875	-78.82582	8/23/2004	520
	30.31002	79.34322	8/30/2004	770
Light Trap - Small	31.27152	-78.92052	8/22/2004	576
	31.31875	-78.82582	8/23/2004	520
	30.31002	79.34322	8/30/2004	770
Neuston Net	31.24375	-78.96007	8/21/2004	357
	31.28938	-78.92300	8/21/2004	563
	31.31422	-78.84230	8/23/2004	520
	30.30422	79.28738	8/30/2004	828

Table 12. Continued.

Gear	Latitude	Longitude	Date	Depth (m)
Neuston Net	29.87453	80.27105	8/31/2004	
Pipe Dredge	31.32003	-78.83640	8/22/2004	530
	31.42155	-77.83933	8/25/2004	765
	31.84922	-77.17482	8/26/2004	976
	29.90807	80.27897	8/31/2004	86
	29.89960	80.28122	8/31/2004	
Submersible Dive	31.26692	-78.93145	8/21/2004	612
	31.25878	-78.94383	8/22/2004	581
	31.38595	-78.60332	8/24/2004	665
	31.31352	-78.85985	8/24/2004	542
	31.39738	-77.85012	8/25/2004	745
	31.39593	-77.84785	8/25/2004	783
	31.53713	-77.48908	8/26/2004	866
	31.82412	-77.52495	8/26/2004	900
	30.02190	80.27778	8/29/2004	52
	30.40967	80.21448	8/29/2004	51
	30.27593	79.33965	8/30/2004	836
	30.02508	80.27677	8/30/2004	63
	29.66473	80.29578	8/31/2004	53
	29.87063	80.28237	8/31/2004	60
Wreckfish Reel	31.38487	-78.59897	8/24/2004	505
	31.38677	-78.59797	8/24/2004	613
	31.42015	-78.59793	8/24/2004	730
Young Grab	31.26222	-78.92765	8/21/2004	629
	31.26287	-78.92003	8/21/2004	626
	31.32003	-78.84083	8/22/2004	520
	31.42395	-77.86178	8/25/2004	761
	31.42548	-77.85700	8/25/2004	765
	31.42120	-77.84992	8/25/2004	770
	31.42080	-77.82773	8/25/2004	738
	31.41835	-77.82587	8/25/2004	722
	31.41958	-77.82313	8/25/2004	720

c.. Inventory of samples collected

In addition to the samples reported in Tables 1 and 12 (above), many samples were collected during submersible dives, using the submersibles manipulator arm and associated suction sampler, scoop sampler, “chimney master” (http://www.rps.psu.edu/0301/deep.html) and sample buckets (Table 13). The chimney master was used to collect sponges with their associated fauna intact. The manipulator arm’s claw was used to collect rocks, corals and sponges. The suction sampler was used to collect sediments and fishes. *In situ* water samples were collected to compare isotope concentrations with those found in corals (see above). Details of each sample type are provided in Table 14.

Collections of poorly-known species, and observations of poorly-known fishes have been catalogued, and some have been published, including publications on rare snails and sharks. The catalogued collections will continue to be studied.

Table 13. Collections made during submersible dives.

Dive Number	Timed Transects	Scoop Samples	Chimney Master Samples	Claw Samples	Suction Samples	Water Samples
3460	1	2				
3461	5	2	1	1	4	
3462	4	4	1	4	5	1
3463	14	1		1	5	
3464	4	4		5	3	1
3465	4	5		2	4	1
3466	16	3		1	8	
3467	4	3	1	3	5	1
3468	9	7		1		
3469	1	3				
3470	5	10		2	6	
3471	41			2	2	
3472	8	2		6		
3473	14	10				

Table 14. Items collected during submersible dives.

Dive Number	Item Collected	Number Collected
3460	Sediment	1
3461	Crinoid	1
	Rock	1
	Sponge	2
3462	Coral	
	Crustacean	2
	Echinoderm	2
	Other	2
	Other Invertebrate	1
	Rock	1
	Sediment	4
3462	Sponge	2
3463	Crustacean	1
	Fish	2
	Rock	1
	Sponge	3
3464	Coral	3
	Crustacean	2
	Echinoderm	1
	Other	1
	Rock	1
	Sediment	3
	Sponge	2
3465	Coral	3
	Other	3
	Rock	1
	Sediment	4
	Sponge	1

Table 14. Continued.

Dive Number	Item Collected	Number Collected
3466	Crustacean	2
	Fish	3
	Other Invertebrate	2
	Sediment	4
3467	Coral	2
	Crustacean	1
	Echinoderm	1
	Fish	3
	Other	2
	Rock	1
	Sediment	4
3468	Rock	1
	Sediment	4
	Sponge	3
3469	Sediment	3
3470	Coral	3
	Echinoderm	4
	Fish	2
	Other Invertebrate	1
	Sediment	4
	Sponge	4
3471	Coral	1
	Crustacean	1
	Echinoderm	1
	Rock	1
	Sponge	1
3472	Echinoderm	2
	Other	1
	Other Invertebrate	1
	Rock	1
	Sponge	3
3473	Crustacean	2
	Other	1
	Other Invertebrate	1
	Sediment	1

d.. Publications, Web Sites and Presentations.

Publications

Caruso, J.H., S.W. Ross, G.R. Sedberry and K.J. Sulak. 2007. Deep-water chaunacid and lophiid anglerfishes (Pisces: Lophiiformes) off the south-eastern United States. J. Fish Biol. 70:1015-1026.

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Fiore, C.L. and Jutte, P.C. Submitted. Communities within communities: a look at sponges and their symbionts off the southeastern United States. Estuarine, Coastal and Shelf Science.

Fraser, S.B. and G.R. Sedberry. In press. Reef morphology and invertebrate distribution at continental shelf edge reefs in the South Atlantic Bight. Southeastern Naturalist.

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Sedberry, G. and P. Weinbach. 2005. Using GIS to investigate the Charleston Bump, pp 72-73 in: Sappington, N. (ed.), GIS in State Government, Volume One. ESRI, Redlands CA. ISBN 1-58948-134-8.
Sedberry, G.R., H.S. Meister and J.K. Loefer. 2007. First *in-situ* observation of a frill shark, *Chlamydoselachus* anguineus, and an additional record for the western North Atlantic. J. N. Carolina Acad. Sci. 123:127-132.
Sedberry, G.R., O. Pashuk, D.M. Wyanski, J.A. Stephen and P. Weinbach. 2006. Spawning locations for Atlantic reef fishes off the southeastern U.S. Proc. Gulf Carib. Fish. Inst. 57:463-514.

Graduate Theses

Filer, K. 2006. Age, growth and reproduction of the barrelfish, *Hyperoglyphe perciformis* (Mitchill, 1818), in the western North Atlantic. M.S. Thesis, College of Charleston. 98pp.
Friess, C. In prep. Life history and population genetics of red bream, *Beryx decadactylus* in the North Atlantic. M.S. Thesis, College of Charleston.
Fiore, C.L. 2006. Characterization of macrofaunal assemblages associated with sponges and tunicates off the southeastern United States. M.S. Thesis, College of Charleston. 122pp.
Goldman, S.B. In prep. Feeding habits of several deep-water reef fishes on the continental slope off the southeastern United States. M.S. Thesis, College of Charleston.
Griffin, S.B. 2005. Reef morphology and invertebrate distribution at continental shelf edge reefs in the South Atlantic Bight. M.S. Thesis, College of Charleston. 94pp.
Hooker, D.D. 2005. Estimates of geostrophic transport in the South Atlantic Bight (1992-2004). M.S. Thesis, University of South Carolina. 46pp.
Schobernd, C.M. 2006. Submersible observations of southeastern U.S. deep reef fish assemblages : habitat characteristics, spatial and temporal variation, and reproductive behavior. M.S. Thesis, College of Charleston. 85pp.
Schobernd, Z.H. 2006. Species assemblages, distribution, and abundance of serranids in the South Atlantic Bight, 1793-2004. M.S. Thesis, College of Charleston.
Wieber, K. In prep. Habitat associations of demersal fishes on the Charleston Bump and adjacent Blake Plateau. M.S. Thesis, College of Charleston.

Web Sites

In addition to the web sites created during the expedition, many additional educational and other types of web sites have been created using the results of the expedition. These include the following.

1. Octocoral guide: http://www.dnr.sc.gov/marine/sertc/octocoral%20guide/octocoral.htm

2. Project Oceanica contains detailed visual material geared toward specific educational audiences. They can be found at http://oceanica.cofc.edu/ and at http://www.dnr.sc.gov/marine/sertc/. Under the lead of Dr. Leslie Sautter (College of Charleston), project personnel and collaborators at the University of South Carolina finished construction of taxonomic galleries on the Fishes of the Charleston Bump and Blake Plateau and Echinoderms of the Charleston Bump (Project Oceanica web site). Work continued to develop the Metazoa Gallery for the ETTA cruise.

3. Transect 31-30 Estuaries to Abyss Home Page
http://oceanica.cofc.edu/EstuaryToAbyss/home.htm

This expedition home page on the Project Oceanica web site includes links to the 2004 ETTA Expedition Home Page, the Expedition Overview and Meet the Researchers on OE's site.

4. Photo Documentaries
http://oceanica.cofc.edu/EstuaryToAbyss/photodoc_menu.htm

This site contains image "slide shows" based on the ETTA Expedition, including the following documentaries:

"Video Annotation The First Step to Making Data out of Videos", by graduate students Christina Ralph and Zeb Schobernd, Grice Marine Laboratory, College of Charleston

"Using Geographic Information Systems at Sea", by graduate student Sarah Griffin, College of Charleston

"Data Collection on Boats and Submarines", by Jessica A. Stephen, South Carolina Department of Natural Resources

"Photo Gallery" (http://oceanica.cofc.edu/EstuaryToAbyss/photogallery_menu.htm)

"Rocks collected along the Latitude 31-30 Transect", by Leslie Sautter, Project Oceanica, Dept. of Geology, College of Charleston

"Macro-Invertebrate Organisms of the Blake Plateau", by Leslie Sautter, Project Oceanica, College of Charleston, in collaboration with: George Sedberry, Rachael King, Susan DeVictor, and Steve Stancyk. This comprehensive taxonomically-organized photo gallery will display images of all the macro-invertebrates collected or observed from the submersible during the ETTA expedition, along with those collected/observed during the Charleston Bump 2003 expedition. For each organism a series of captioned photos will be available, including close-up views of taxonomically-important characteristics. For several organisms there will be video clips from the submersible to show their habitat.

"Fishes of the Blake Plateau", by Leslie Sautter, Project Oceanica, College of Charleston, in collaboration with. George Sedberry and Dr. David Wyanski. This comprehensive taxonomically-organized photo gallery will display images of all the fish species collected or observed. Many video clips will be included along with multiple images of each species.

"Metazoa of the Blake Plateau", a set of short video clips that will be posted as part of the ETTA expedition. Many of these clips will also be included in the Photo Gallery.

"Seafloor Habitats along the 31-30 Transect", by Leslie Sautter, Project Oceanica, Dept. of Geology, College of Charleston. Rocky substrate habitats vary dramatically along the transect. Video clips will take the viewer on a tour of these habitats.

"Marine Photography" by Susan DeVictor, Southeast Regional Taxonomic Center, SC Dept. of Natural Resources.

Presentations

Andrus, C.F.T., C.S. Romanek and G.R. Sedberry. 2004. Geochemical cyclicity in colonial deepwater corals from the Charleston Bump, Blake Plateau. Annual Meeting, Geological Society of America, Denver CO (poster).

Andrus, C., C. Romanek and G.R. Sedberry. 2005. Geochemical cyclicity in colonial deepwater corals from the Charleston Bump, Blake Plateau. South Carolina Marine Educators Association, Pawleys Island SC (poster).

Andrus, C.F.T, G.R. Sedberry and C.S. Romanek. 2005. Geochemical Profiles of Corals from a Dynamic Habitat: Charleston Bump, NW Blake Plateau. Third International Symposium on Deep-Sea Corals Science and Management, Miami.

Andrus, C.F.T., C.S. Romanek and G.R. Sedberry. 2007. Incremental Growth in a Deep Sea Hydrocoral. First International Sclerochronology Conference, St. Petersburg FL.

Birdsong, J. McDonough, M. Nizinski, J. Potter, S. Ross, G. Sedberry and A. Shepard. 2005. Southeastern U.S. Deep Sea Corals Initiative (SEADESC): Characterizing Known Locations of Habitat-Forming Deep-Sea Corals in the South Atlantic Bight. Third International Symposium on Deep-Sea Corals Science and Management, Miami.

Fiore, C.L. and P.C. Jutte. 2005. Characterization of macrofaunal assemblages associated with sponges of the southeastern United States. Benthic Ecology Meetings, Williamsburg VA.

Filer, K. 2005. Age, growth and reproduction of the barrelfish, *Hyperoglyphe perciformis*. South Carolina Fishery Workers Association and South Carolina Division of American Fisheries Society joint meeting, Clemson, SC.

Filer, K. 2005. Age, growth and reproduction of the barrelfish, *Hyperoglyphe perciformis*. College of Charleston Marine Biology Graduate Student Colloquium.

Filer, K. 2006. Age, growth and reproduction of the barrelfish, *Hyperoglyphe perciformis*. Ocean Sciences Symposium, Honolulu.

Goldman, S. and G.R. Sedberry. 2005. Trophic Characterization of the Charleston Bump. South Atlantic Fishery Management Council, Charleston SC.

Goldman, S.T. and G.R. Sedberry. 2006. Feeding Habits of Some Fishes on the Continental Slope off the Southeastern United States. South Carolina Marine Educators Association, Charleston SC.

Goldman, S. and G.R. Sedberry. 2006. Feeding habits of several deep-water reef fishes on the continental slope off the southeastern United States: preliminary analysis. South Carolina Chapter, American Fisheries Society, Charleston SC.

Goldman, S. and G.R. Sedberry. 2007. Feeding habits of some demersal fishes on the continental slope off the southeastern United States. Joint Meeting of SC Fishery Workers Association, SC Chapter of AFS, and

Georgia Chapter of AFS, Tybee Island, Georgia. Poster.

Griffin, S. and G.R. Sedberry. 2005. Reef morphology and invertebrate distribution at continental shelf edge reefs off the U.S. southeast Atlantic coast. South Carolina Marine Educators Association, Pawleys Island SC (poster).

Lesher, A.T. and G.R. Sedberry. 2006. An Analysis of Larval Dispersal and Retention Within the South Atlantic Bight Using Satellite-tracked Drifters Released on Reef Fish Spawning Grounds. South Carolina Marine Educators Association, Charleston SC.

Meister, H.S. 2004. The Sargassum community of the western North Atlantic. NOAA Ocean Exploration Workshop, South Carolina Aquarium, Charleston.

Ralph, C. and G.R. Sedberry. 2004. Fish assemblages of deep reef habitats off the southeastern U.S: implications for management. South Carolina Marine Educators Association, Ridgeland SC (poster).

Rowe, J.J., and G.R. Sedberry. 2004. Integrating GIS with fishery survey historical data: a possible tool for designing marine protected areas Gulf and Caribbean Fisheries Institute, St. Petersburg FL.

Schobernd, Z. and G.R. Sedberry. 2004. Species assemblages, distribution and abundance of serranids in the South Atlantic Bight, 1973-2003. South Carolina Marine Educators Association, Ridgeland SC (poster).

Sautter, L.R. 2004. Exploring the Southeast U.S. Continental Margin: Submersible Dive Observations from the Continental Shelf Edge, Charleston Bump, and Blake Plateau. NOAA Ocean Exploration Workshop, South Carolina Aquarium, Charleston.

Sedberry, G.R. 2004. A summary of past, present and future research efforts on the Charleston Bump (EFH-HAPC). South Atlantic Fishery Management Council, Joint Coral and Habitat Advisory Panel meeting, Charleston SC.

Sedberry, G.R. 2004. Invertebrate slide show. South Carolina Marine Educators Association, Ridgeland SC.

Sedberry, G.R. 2004. Learning ocean science through ocean exploration: demersal fishes and fish habitats of the South Atlantic Bight. NOAA Ocean Exploration Workshops, South Carolina Aquarium, Charleston.

Sedberry, G.R. 2004. Offshore fisheries monitoring and assessment: overview of MRD programs. Marine Advisory Committee, SCDNR, Charleston SC.

Sedberry, G.R. 2005. Learning ocean science through ocean exploration: demersal fishes and fish habitats of the South Atlantic Bight. NOAA Ocean Exploration Workshops, South Carolina Aquarium, Charleston.

Sedberry, G.R. 2005. Research and monitoring by SCDNR along the 'Latitude 31-30 Transect'. Skidaway Institute of Oceanography, Savannah.

Sedberry, G.R. 2005. The role of the Charleston Bump in the life history of southeastern marine fishes. Seminar, Savannah State University.

Sedberry, George R. 2005. Research and Technology to Help Manage SC Offshore Fisheries. Wando High School Marine Science Club. Mt. Pleasant, SC.

Sedberry, George R. 2005. Fish and fish habitats off the South Carolina coast. James Island Charter High School, Charleston SC.

Sedberry, George R. 2005. MARMAP Monitoring and Research: Black Sea Bass, Associated Reef Fishes and Their Habitats in the South Atlantic Bight. Virginia Polytechnic Institute and State University Fisheries Program, Charleston.

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Sedberry, G.R. 2006. Demersal Deep-Reef Fishes and Their Habitats in the South Atlantic Bight. NOAA Ocean Exploration Educator Workshops, Center for Marine Science, UNCW, Wilmington NC.

Sedberry, G.R. 2006. Taking the pulse of some coastal ocean fisheries and fish habitats in the South Atlantic Bight: Postcards from the edge. Center for Ocean Sciences Education Excellence-Southeast. Skidaway Institute of Oceanography.

Sedberry, G.R. 2007 Demersal Deep-Reef Fishes and Their Habitats in the South Atlantic Bight. NOAA Ocean Exploration Educator Workshops, Georgia Aquarium, Atlanta.

Sedberry, G.R. 2007. Demersal Deep-Reef Fishes and Their Habitats in the South Atlantic Bight. NOAA Ocean Exploration Educator Workshops, South Carolina Aquarium, Charleston.

Sedberry, G.R. 2007. The role of the "Charleston Bump" in the life history of some southeastern marine fishes.

Seminar, University of South Carolina.
Sedberry, G.R. 2007. The role of the "Charleston Bump" in the life history of some southeastern marine fishes. Seminar, University of New England.
Sedberry, G.R. and P. Harris. 2005. SCDNR Research and Monitoring: Habitat Needs of Different Life History Stages of Managed Reef Species. South Atlantic Fishery Management Council, Charleston, SC
Sedberry, G.R., and A.T. Lesher. 2006. Postcards from the Edge: Messages in bottles and satellite-tracked drifters help us understand fish life cycles. National Marine Educators Association. Brooklyn NY.
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Sedberry, G.R. and J.A. Stephen. 2004. GIS analysis of fishery-independent data in relation to definition of Essential Fish Habitat, Habitat Areas of Particular Concern, and Marine Protected Areas in the South Atlantic Bight. NOAA Fisheries MARFIN Conference, New Orleans.
Sedberry, G.R. and J. Stephen. 2005. SCDNR Offshore Fisheries Research and Monitoring Data. SEACOOS Data Management Workshop, Baruch Institute, USC, Columbia SC
Sedberry, G., P. Weinbach, J. Stephen, J. Loefer, S. Griffin, H. Smillie, D. dos Reis and K. Dragaonov. 2005. SEAGEOFISH database site: the 'net benefit of a long-term fishery survey. South Carolina Marine Educators Association, Pawleys Island SC (poster).
Smith, D.M. and R.L. Nusbaum. 2005. Preliminary Results Of Petrographic And Scanning Electron Microscope Analysis Of Charleston Bump Phosphorite Coated Rocks, Atlantic Ocean. Geological Society of America, Abstracts with Programs, Paper 131-13.
Stephen, J.A and G.R. Sedberry. 2006. Tools for Managers: A GIS Analysis of Fishery-Independent Survey Data from the South Atlantic Bight. American Fisheries Society, Southern Division, San Antonio, TX .
Wyanski, D., G.R. Sedberry, J. Stephen and P. Weinbach. 2005. Using GIS analysis to map spawning locations of Atlantic reef fishes off the southeastern U.S.. South Carolina Fishery Works Association, Clemson SC.

e. Location and Status of Data Archive and/or Sample Storage

All data and videotapes are archived at the Marine Resources Research Institute, South Carolina Department of Natural Resources, 217 Ft. Johnson Road, Charleston SC 29412. Samples are archived there ase well, except for specimens that have been sent to experts, or which have been catalogued into collections of the Grice Marine Laboratory, 205 Ft. Johnson Rd., Charleston SC 29412. Some specimens have been deposited into the U.S. National Museum of Natural History, Smithsonian Institution.

III. Evaluation:

1. Accomplishments – Explain special problems, differences between scheduled and accomplished work

Several tasks were not completed because of limited funds to process samples after collection. However, these samples have been archived and are available for future work. Samples for analysis of antimicrobial resistance were not processed as a result of Hurricane Katrina effects on the LSU laboratory.

2. Expenditures:
   a. Describe original planned expenditures

Salaries:	$28,731
Fringe:	9,481
Contracts:	100
Travel:	3,500
Supplies:	3,361
Fixed:	0
Indirect:	4,827
TOTAL	$50,000

b. Describe actual expenditures

Salaries:	$12,948
Fringe:	3,024
Contracts:	22,383
Travel:	1,908
Supplies:	7,056
Fixed:	1,069
Indirect:	1,613
TOTAL	$50,000

c. Explain special problems, differences between planned and actual expenditures

The major differences between planned and actual expenditures were in personnel (and associated fringe and indirect) and contractual services. Through a requested and approved no-cost extension and budget re-alignments, we extended the project (at no cost) to 30 April 2007, and transferred funds from personnel (and associated categories) to contractual services, in order to contract with graduate research assistants at the College of Charleston to process samples and videotapes. We required additional supplies (software and media) to process videotapes, and moved some funds to Supplies for those needs. We did not use all travel funds and they were transferred to Supplies

3. Next Steps:

a. Planned or expected reports (professional papers, presentations, etc.)

Additional publications are planned from the unpublished thesis work cited above.

b. Brief description of need for additional work, if any (next project phase, new research questions, unaccomplished work, etc.).

Collected samples of invertebrates and fishes continue to be catalogued into collections at the Southeast Regional Taxonomic Center (SERTC) in Charleston, at the Grice Marine Lab, and at the U.S. National Museum of Natural History. It is expected that these collections will be studied and published on for decades to come.

Additional collections of sediments, rocks and organisms are needed in some areas with interesting geological formations. Submersible time will be sought to make those collections.

Existing cooperative research programs along the Latitude 31-30 Transect offer an extraordinary opportunity to coordinate scientific investigation, ocean science education, and conservation in an expanded deepwater exploration. This project was an attempt to sample deeper sites along that transect, and to collect samples for future collaboration among scientists, teachers, students and managers to further understand the complex oceanography and habitats that support essential ecosystems, diverse communities, and fisheries off South Carolina and adjacent states. It is hoped that this OE project will continue to serve as a catalyst to cement relationships among investigators from several institutions that have been conducting research along the Latitude 30-30 Transect, and will further exploration of the deep end of the Transect.

Prepared By: _____

Signature of Principal Investigator Date

b. Describe actual expenditures

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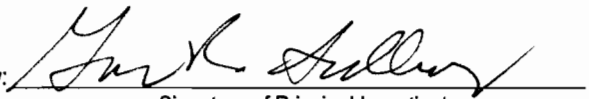
Prepared By:  5 Aug 07

Signature of Principal Investigator Date

Facilities & Administrative Costs Recalculation:
Grant Code
Project From The Estuary To The Abyss: Exploring Along The Latitude 31-30 Transect
Agency NOAA OE
PI: George R. Sedberry
Grant Number: NA0ROAR4600055
Award Period: 1 July 2004 - 30 April 2007

	Planned	Actual	Difference
Salaries & Wages	$ 28,731.00	$ 12,948.00	$ 15,783.00
Staff Benefits	$ 9,481.00	$ 3,024.00	$ 6,457.00
Travel	$ 3,500.00	$ 1,908.00	$ 1,592.00
Services	$ 100.00	$ 22,383.00	$ (22,283.00)
Services w/o F&AC (See Below)	$ -	$ 1,069.00	$ (1,069.00)
Commodities	$ 3,361.00	$ 7,056.00	$ (3,695.00)
Equipment	$ -		$ -
Student Aid	$ -		$ -
Facilities & Administrative Costs	$ 4,827.00	$ 1,613.00	$ 3,214.00
Total	$ 50,000.00	$ 50,001.00	$ (1.00)