Fishes associated with North Carolina shelf-edge hardbottoms and initial assessment of a proposed marine protected area

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FISHES ASSOCIATED WITH NORTH CAROLINA SHELF-EDGE HARDBOTTOMS AND INITIAL ASSESSMENT OF A PROPOSED MARINE PROTECTED AREA

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ABSTRACT

Fish community data are limited from deeper shelf-edge hardbottoms along the southeastern U.S. continental shelf. This lack of data hampers the design of recently proposed marine protected areas (MPAs) on the outer shelf of the southeastern U.S. During 2001–2004, sampling was conducted (57–253 m) to describe habitats and fish communities within and outside of the North Carolina proposed MPA (p-MPA) using the Johnson-Sea-Link submersible, remotely operated vehicles, otter trawls, and hook and line. Habitats observed included soft substrate or non-hardbottom (NH), a shipwreck ("Snowy Wreck"), low relief hardbottoms (LRH), boulder fields (BF), and high relief ledges (HRL), the latter of which were divided into three microhabitats. Non-metric, multi-dimensional scaling indicated that hardbottom fish assemblages were distinct from NH, and fish assemblages among microhabitats on HRL were different. In total, 152 fish species were documented. Thirty-five species were observed only on NH and 117 were observed on hardbottoms and the Snowy Wreck. Several species of anthiines were the most abundant fishes on most hardbottoms, whereas triglids, synodontids, and *Seriola* spp. were abundant on NH. Species richness was highest on HRL, and species composition was unique at the Snowy Wreck (238–253 m) and on BF. Future shelf-edge hardbottom research should include more standardized surveys using direct observations. Further, we recommend that the boundaries of the North Carolina p-MPA be redrawn to include more hardbottom habitat.

It is well established that hard or "live" bottom habitats (< 200 m depth) on the southeastern U.S. continental shelf (SEUSCS, Cape Canaveral, Florida to Cape Hatteras, North Carolina) and in the Gulf of Mexico are areas of enhanced biodiversity and productivity (Grimes et al., 1982; Wenner et al., 1983; Cahoon and Cooke, 1992). The hardbottom fauna along the SEUSCS represents an extension of a sub-tropical community into temperate latitudes (Miller and Richards, 1980) and includes economically and ecologically important fishes (Chester et al., 1984; Huntsman, 1994).

Many studies on SEUSCS hardbottom fishes concentrated on segments of the community, particularly economically important fishes (e.g., Chester et al., 1984; Sedberry and Van Dolah, 1984; Parker and Mays, 1998). When more complete species lists were reported, they often represented large areas, broad depth ranges, and/or did not include abundance or habitat data (e.g., Struhsaker, 1969; Miller and Richards, 1980; Grimes et al., 1982; Parker and Ross, 1986; Parker, 1990). Additionally, the sampling methods often used (e.g., trawls, traps, hook and line) excluded fauna and could not provide habitat information (e.g., Struhsaker, 1969; Miller and Richards, 1980; Grimes et al., 1982). These studies (and others) have contributed substantially to the knowledge of fishes and invertebrates inhabiting SEUSCS hardbottoms, but our understanding of these systems can improve with detailed habitat association (beyond reef versus non-reef) and abundance data for the entire fish community.

Data are even more incomplete on deeper, shelf edge hardbottoms (Chester et al., 1984; Parker and Mays, 1998). The shelf edge habitat (~50–100 m) is marked by many high profile reef features of diverse origins (e.g., Struhsaker, 1969; Barans and Henry, 1984; Riggs et al., 1996), and occurs in an area of strong currents. Factors, such as depth, current, rugged profile, and sampling costs largely account for the lack of sampling in these habitats. Therefore, little is known about life histories of deep reef fishes and their habitat compared to reef fishes occupying shallower depths (Parker and Mays, 1998).

Direct observations [i.e., submersible, remotely operated vehicle (ROV)] of shelf edge hardbottom fauna along the SEUSCS are particularly limited despite strong arguments that such techniques are the best way to investigate these habitats (Parker and Ross, 1986; Krieger, 1992; Starr et al., 1995; Connell et al., 1998; Cailliet et al., 1999). When direct observation methods are used in rugged, deep habitats, the view of the community structure is often much different than one derived from commercial or other surface deployed gear (Gutherz et al., 1995). With direct observations, fishes thought to be rare prove to be common and new geographic and/or bathymetric ranges are frequently observed (e.g., Parker and Ross, 1986; Dennis and Bright, 1988; Quattrini et al., 2004). Direct observations on deep reefs can provide important information on species composition, abundance, behavior, and associated habitats that is otherwise unattainable or highly biased.

A proposal to establish Marine Protected Areas (MPAs) for hardbottoms along the SEUSCS provided additional impetus for this study. MPAs can be a viable means, along with other methods, of managing reef habitats and associated fisheries (Bohnsack, 1993; Lindeman et al., 2000; NRC, 2001), despite continued debate (Shipp, 2003; Kaiser, 2005). In 2002, the South Atlantic Fishery Management Council (SAFMC) proposed a network of nine MPAs from North Carolina to the Florida Keys to help manage the snapper-grouper complex (snappers, groupers, porgies, jacks, tilefish, grunts, and sea basses), especially deepwater species (SAFMC, 2004). This fishery complex was targeted for MPA management because it is a multiple species fishery in which many species are overfished (NMFS, 2005), and traditional management methods (e.g., bag limits, size limits, closures, and quotas) have not adequately protected certain species (PDT, 1990; SAFMC, 2004).

The proposed boundaries for the MPA off North Carolina were established by recommendations from the public and advisory panels (Fig. 1) (SAFMC, 2004). With the exception of a single station from Parker and Ross (1986), there are no biological data published from within this proposed MPA (p-MPA). Only eight stations inside the p-MPA were classified for general habitat types (SEAMAP-SA, 2001). Lack of information about habitats and associated fauna in this area of the North Carolina outer continental shelf hampers the design of MPAs and evaluation of their success (NRC, 2001).

Our overall objectives were to describe the fish community of North Carolina shelf edge hardbottoms and to provide an initial assessment of the p-MPA using multiple gear methods, particularly direct observations. In this study, we: 1) generally describe hardbottom habitats, 2) describe species richness, distribution, and relative abundance on habitats, and 3) compare these data among habitats within and outside of the p-MPA. This initial assessment should facilitate future studies and allow a better evaluation of the North Carolina p-MPA boundaries.

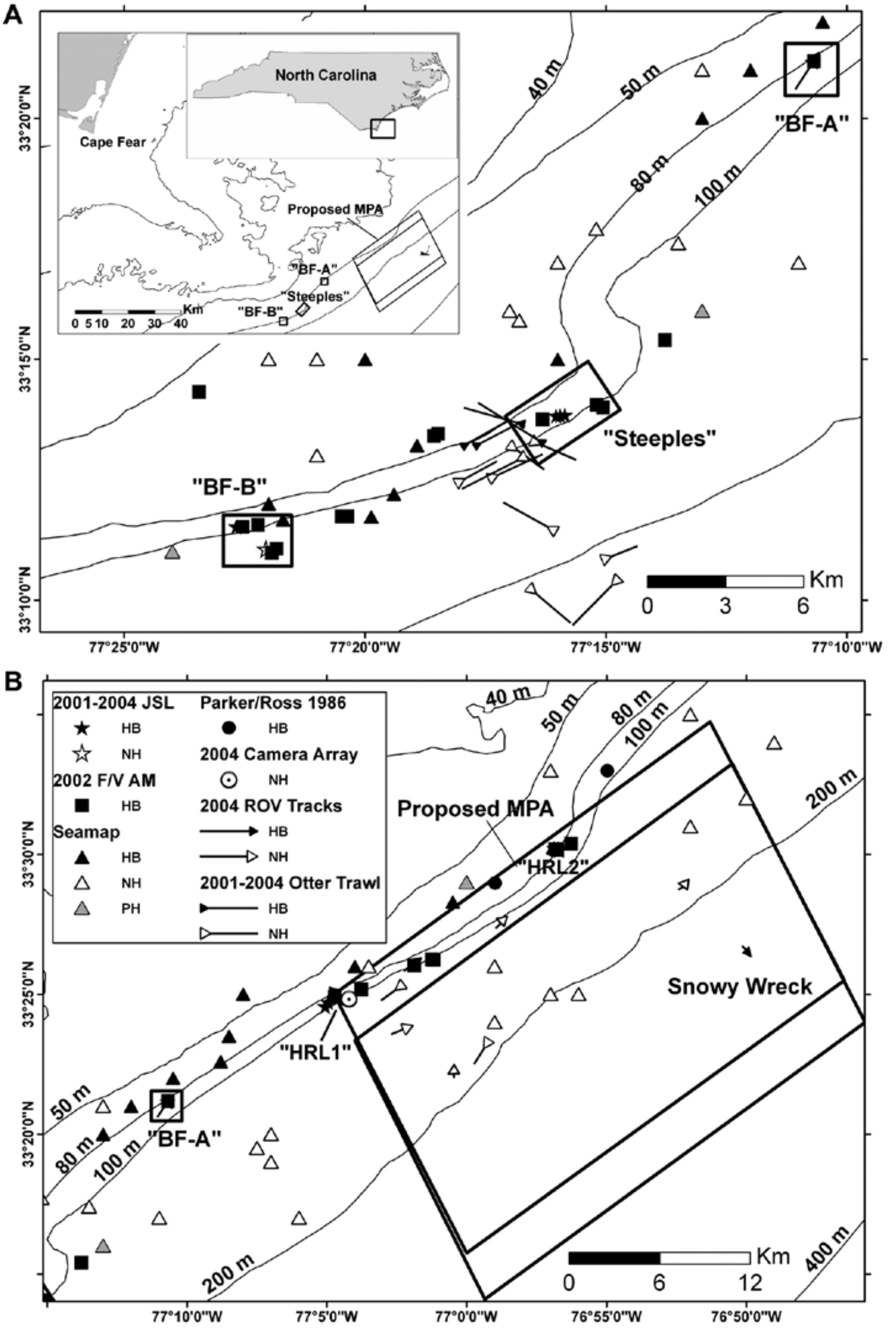

Figure 1. Stations (A) south of the proposed marine protected area (p-MPA) and (B) within the p-MPA off southern North Carolina. The South Atlantic Fishery Management Council proposed the two boundary options for this MPA. Parker and Ross (1986) and SEAMAP-SA (2001) stations are shown. ROV = remotely operated vehicle, JSL = JOHNSON-SEA-LINK, F/V AM = fishing vessel, HB = hardbottom, PH = probable hardbottom, NH = no hardbottom, BF = boulder field, HRL = high relief ledge.

Methods

Study Area.—Prior to sampling, potential shelf-edge hardbottom sites were assembled from a variety of sources (e.g., fishermen; our files; Parker and Ross, 1986; SEAMAP-SA, 2001), and the most promising of these were targeted for surveys. During 2001–2004, sampling was conducted on hardbottoms within and outside of the North Carolina p-MPA in 57–253 m depth, with most effort in shallower depths (57–130 m; Fig. 1).

The p-MPA (~590 km^2, ~55–275 m depth), with two boundary options, contains numerous hardbottoms and an isolated deepwater wreck (Fig. 1B). This wreck, called the "Snowy Wreck" for the large quantities of *Epinephelus niveatus* harvested, was discovered about 20 yrs ago and has been regularly fished by two or three commercial vessels (D. Aspenleiter, University North Carolina Wilmington, pers. comm.; M. Marhefka, Charleston, South Carolina, pers. comm.). Within the p-MPA, two hardbottom areas in particular, "High Relief Ledge 1" (59–118 m depth) and "High Relief Ledge 2" (69–88 m depth), were surveyed repeatedly, and the Snowy Wreck (238–253 m depth) was surveyed once (Fig. 1B).

Samples were also collected south of the p-MPA at "Boulder Field A" (72–93 m depth), "Boulder Field B" (84–129 m depth), and at the "Steeples" (73–111 m depth) (Fig. 1A). The "Steeples" is a high profile ledge system that is heavily fished by the commercial fleet (M. Marhefka, Charleston, South Carolina, pers. comm.).

Collection Methods.—The primary direct observation method used in this study was the Johnson-Sea-Link (JSL) submersible (Harbor Branch Oceanographic Institution). In September 2001, August 2002, 2003, and June 2004, the JSL was deployed onto hardbottom areas (Fig. 1) with dives lasting 1.5–4 hrs. The JSL covered as much of the habitat as possible, continuously videotaping on both wide angle and close up views with an externally mounted digital video camera. Two laser pointers (25 cm apart) were mounted on the camera and were used to measure fishes and habitat attributes. Depth, temperature, salinity, date, and time were recorded onto the external video at intervals of ≤ 1 scan s^{-1} via a real-time data logger (Sea-Bird SBE 25 or 19*plus*) attached to the submersible, which enabled us to calculate mean bottom temperature and salinity per dive. Scientists in the JSL bow and stern compartments operated hand-held digital video cameras to record images from their respective view ports. These videos were used as back up recordings and also aided in species identifications. Periodically during dives, the JSL collected specimens with a rotenone/suction device, and these helped ground truth identities of certain species in videos. Specimens were preserved at sea in 10% formalin seawater solution and were later identified and measured (mm standard length, SL).

Direct observation data were also collected using the Phantom S-2 ROV (National Undersea Research Center, University of North Carolina Wilmington). The Phantom ROV was deployed in April 2004 onto p-MPA hardbottoms and Boulder Field A (Fig. 1), with dives lasting 0.5–1.5 hrs. The ROV was towed by the surface vessel's drift across sites. The ROV was tethered 30 m from a down weight that was suspended ~10 m above the bottom. The ROV made a continuous transect on the bottom, continuously videotaping with a digital color video camera set on wide-angle view and tilted downward at a 0°–24° angle from horizontal. Periodically during transects, the ROV panned from side to side to view as large an area as possible or the camera zoomed in for a better view of a particular species or habitat feature. Additionally, a digital still camera mounted on the ROV captured images of fishes and invertebrates, which aided in identification of certain species. A Sea-Bird SBE 39 temperature-depth recorder was attached to the ROV during dives and logged data every 5 s, enabling us to calculate mean bottom temperature per dive. During August 2004, the Phantom ROV surveyed the Snowy Wreck and a non-reef site within the p-MPA. At the Snowy Wreck, the surface vessel kept stationary as the ROV covered as much of the wreck as possible. The ROV had 61 m of latitude from the down weight. On the non-reef dive during this cruise, the ROV transected the area as the ship drifted with the current. During both August 2004 ROV dives, digital video, digital still images, and water quality data were collected as described above.

A camera array was used once to collect direct observation data. It was deployed near High Relief Ledge 1 within the p-MPA in April 2004 (Fig. 1B). This array had four color digital video cameras mounted on a circular frame at 90° from each other. On bottom, the camera array recorded 30 min of video.

Direct observation data were supplemented by more traditional sampling. An otter trawl (4.9 m headrope, 38.1 mm mesh) was towed for 30 min at ~2 kts (3.7 km/hr) ground speed. This net was towed in non-reef areas and adjacent to hardbottoms in September 2001, August 2002, and April 2004 (Fig. 1). Trawl catches were preserved at sea in 10% formalin seawater solution and fishes were later identified and measured. All collected specimens were deposited in the North Carolina Museum of Natural Sciences. A commercial fishing vessel (Amy Marie) was employed to fish on hardbottoms concurrently with the August 2002 submersible cruise (Fig. 1). The fishing vessel conducted sonar surveys, anchored, and fished for 15 min–3 hrs. Two lines were dropped ~5 m from the bottom at every station. Each line terminated with two leaders of variable lengths, each with one hook (either 4/0, 13/0, 13/0 circle or 16/0) baited with dead *Decapterus punctatus* (Cuvier, 1829). All fishes collected were identified at sea by a scientist.

Habitat Descriptions.—Sampled habitats were classified following criteria given by Riggs et al. (1996) and SEAMAP-SA (2001). For all video data, four habitat types were classified: soft substrate [no hardbottom (NH)], low relief hardbottoms (LRH), boulder fields (BF), and high-relief ledges (HRL). NH habitats exhibited no slope and were composed of fine to coarse sand and/or shell hash. LRH were observed on bottoms of ~10°–25° slope that had a continuous cover of broken rock with < 2.0 m surface relief and no distinct edges (Fig. 2A). BF were observed on bottom of little to no slope that contained small patches of boulders or isolated boulders with < 2.0 m surface relief (Fig. 2B). HRL had slopes of 25°–90° with > 2.0 m surface relief, and had many boulders, overhangs, and rock walls with many crevices and caves. HRL were further divided into three microhabitat types: large rocks (LG), with vertical face profiles > 2.0 m, moderate rocks (MD), with vertical face profiles of 0.5–2.0 m, and small rocks (SM), with vertical face profiles < 0.5 m (Fig. 2C–E, respectively).

The presence of obligate reef species in otter trawl catches provided evidence for hardbottom habitat (SEAMAP-SA, 2001). Criteria for classification were as follows: three or more obligate reef fishes provided evidence of hardbottom (HB), two obligate reef species provided evidence of possible hardbottom (PH), and 0–1 obligate reef species provided no evidence of hardbottom (NH). Because the fishing vessel targeted high relief systems, stations that resulted in reef fish catches were determined to be HB.

Data Analyses.—To compare fish community structure among habitats, JSL and ROV videos were viewed multiple times to classify habitats and to count and identify fishes. Except at the Snowy Wreck, ROV wide angle transects were divided into 1.0–1.5 min segments during which all fishes were enumerated. To reduce the disparity between uncommon and abundant species, a fourth root transformation of fish abundances was used to downweight abundant relative to uncommon species (Clarke, 1993). A non-metric multi-dimensional scaling (MDS) ordination of ROV segments was constructed from a Bray-Curtis similarity matrix of fourth root transformed fish abundances (PRIMER 5.0). Prior to calculating the similarity matrix, segments in which no fishes were observed (mostly NH habitats) were removed from the data set; species represented by one individual among all habitats were removed; and *Seriola* spp. were removed because they commonly circled the JSL or ROV throughout dives across all habitats. Following the same methods, a second MDS plot was constructed to examine the ordination of the three microhabitats observed on HRL. One-way analyses of similarities [ANOSIM, (PRIMER 5.0)] and pairwise comparisons were used to detect differences among habitats and microhabitats. SIMPER analyses (PRIMER 5.0) were used to determine which species were responsible for the dissimilarity among habitats or microhabitats.

For additional comparisons among habitats, relative abundances (%) of fishes were calculated (# individuals/total # of individuals *100) by habitat type for both ROV and JSL data using only fish counts when the ROV or the JSL was transecting and the camera was videotaping on wide-angle view. Because ROV data were standardized, a Kruskal-Wallace (K-W) test, followed by a pairwise multiple comparison test [Dunn's Method: Sigma Stat 2.0] was used to compare ROV fish abundances among habitats and microhabitats. Additionally, species

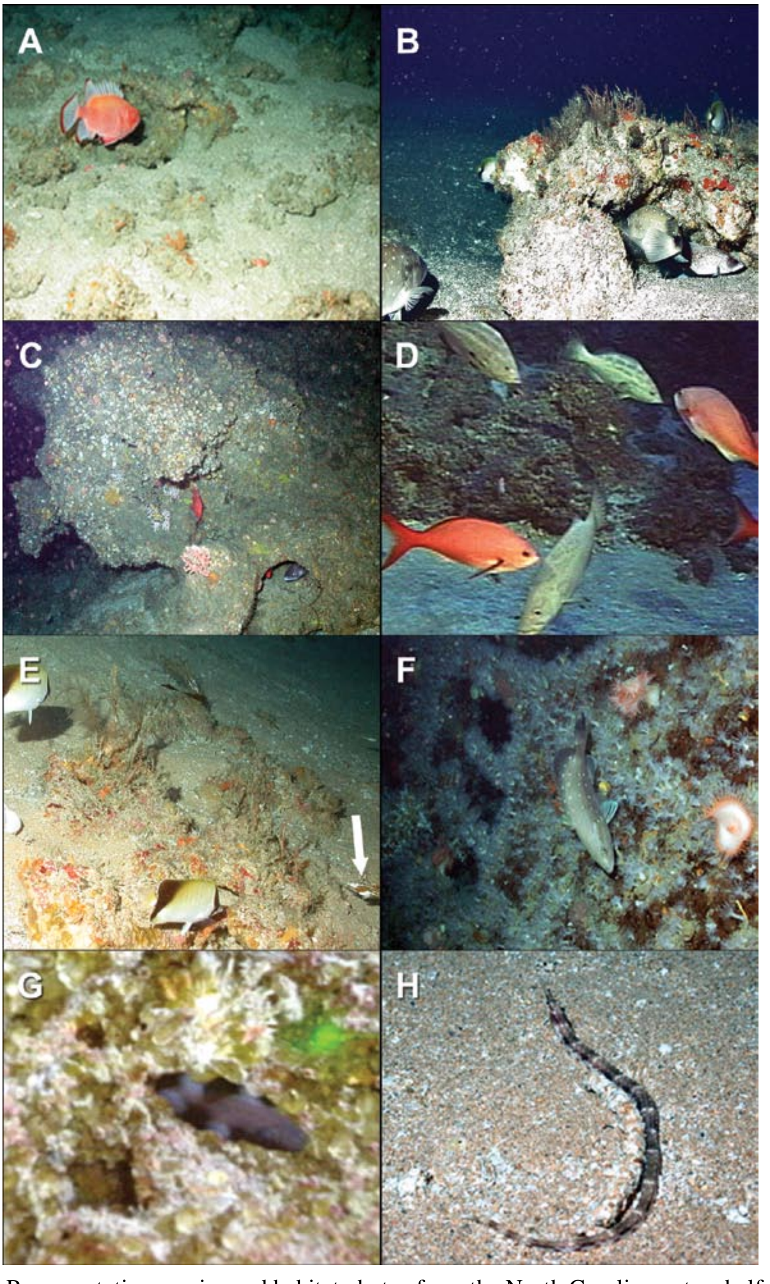

Figure 2. Representative species and habitat photos from the North Carolina outer shelf: (A) low relief hardbottom (117 m) with *Pristigenys alta*; (B) boulder field (82 m) with *Epinephelus niveatus* and *Rypticus saponaceus;* (C) large rock microhabitat (107 m) on a high relief ledge (HRL) with *Conger oceanicus* and *Corniger spinosus;* (D) moderate rock microhabitat (79 m) on HRL with *Mycteroperca phenax*, *Mycteroperca interstitialis*, and *Paranthias furcifer;* (E) small rock microhabitat (77 m) on HRL with *Chaetodon sedentarius* and *Serranus chionaraia* (denoted by white arrow); (F) *E. niveatus* on the Snowy Wreck (240 m); (G) *Stygnobrotula latebricola* (73 m); and (H) *Cosmocampus* cf. *profundus* on soft substrate bottom (109 m).

accumulation curves were plotted using only ROV data to compare species richness among habitats. The cumulative number of species per video segment in each habitat type was plotted chronologically by segment number. Logarithmic regression curves were fitted by habitat, and analysis of covariance (ANCOVA) followed by a Tukey HSD test was used to statistically test habitat differences (Statistica 7.0).

Depth ranges were calculated for each species combining all gear types. Each video segment and each otter trawl was represented by a median depth; obtained by adding the start and end depths and dividing by two. Depth ranges of each video segment did not exceed 6 m. Depth ranges of otter trawls did not exceed 47 m. A single depth was recorded at each hook and line station. Minimum and maximum depths from all methods represented the depth range for each species.

Results

Habitats and Sampling Effort.—Combining all methods in the entire study area, 47 stations were sampled on HB habitats in 57–128 m depth, 18 stations were on NH habitats in 74–250 m depth, and one station was sampled on the Snowy Wreck in 237–253 m depth (Table 1, Fig. 1). Fifteen otter trawl tows and 23 fishing stations were conducted in both HB (57–128 m) and NH (74–250 m) habitats. Of the ten ROV and 17 JSL dives (52 hrs of direct observations), six dives were conducted on NH, 16 on HRL, one on LRH, three on BF, and one on the Snowy Wreck (Table 1, Fig. 1). All three microhabitats were observed during most dives on HRL. All hardbottoms were sparsely covered with sessile and encrusting invertebrates, such as sponges, white hard corals, soft corals, black corals, bivalves, and hydroids. Garbage (e.g., plastic bags, plastic containers, aluminum cans), anchors, and fishing line littered hardbottoms to varying degrees at all stations.

Table 1. Number of stations sampled with different gears in habitats within and outside of the proposed marine protected area (p-MPA) off southern North Carolina. Mean temperature ranges (all SE < 0.0) were calculated from Sea-Bird data loggers. … = No data available, NH = no hardbottom, HRL = high relief ledge, LRH = low relief hardbottom, BF = boulder field, SW = Snowy Wreck, HB = hardbottom, JSL = Johnson-Sea-Link, ROV = remotely operated vehicle, CA = camera array, OT = otter trawl, HL = hook and line.

Location	Cruise date	Habitat	JSL	ROV	CA	OT	HL	Mean temp. range (°C)	Depth range (m)
Non-MPA	Sep 2001	NH				9		…	93–250
		HRL	1					…	75–98
		HB				2		…	63–100
	Aug 2002	NH	1					21.1	119–129
		BF	2					20.0–24.5	72–89
		HRL	2					17.8–18.2	73–111
		HB				2	23	…	57–128
	Apr 2004	BF		1				18.4	74–93
p-MPA	Aug 2002	HRL	2					20.1–23.2	67–94
	Aug 2003	HRL	7					17.7–21.0	71–118
	Apr 2004	NH		4	1	2		11.1–19.1	74–198
		LRH		1				19.7	76–123
		HRL		2				19.6–19.7	59–107
	Jun 2004	HRL	2					18.4	74–106
	Aug 2004	NH		1				20.1	104–112
		SW		1				9.6	237–253

The ROV dive at the Snowy Wreck confirmed that it was a steel hulled ship, ~37 m long, surrounded by sand that had many ripples and channels. The bottom depth of the wreck ranged from ~ 248 to 253 m, and the top of the wreck was at 237 m. The ship was largely intact and covered with encrusting invertebrates (Fig. 2F). Fishing line and cables were also observed on the wreck.

SEAMAP-SA (2001) classified general habitats at stations (~50–250 m) near our study sites, which are included to provide additional habitat distribution data (Fig.1). Within the p-MPA, seven SEAMAP-SA (2001) stations were NH and one was HB (Fig. 1B). Outside of the p-MPA, 14 SEAMAP-SA (2001) stations were HB, three were PH, and 17 were NH (Fig. 1A).

Bottom temperature and salinity data collected during ROV and JSL dives exhibited different levels of variability. Mean salinities (± 0.0 SE) were stable (36.2–36.7) among all JSL dives. On HB habitat in approximately the same depths (67–129 m), mean temperature (± 0.0 SE) varied among dives (Table 1). Mean temperature ranges on HB habitat were larger (17.7–24.5 °C) in August 2002 and 2003 than in April and June 2004 (19.1–19.7 °C, and 18.37–18.41 °C, respectively). In deeper water, at the Snowy Wreck (237–253 m), mean temperature was 9.6 °C and on NH habitats (150–198 m) in April 2004, mean temperatures ranged from 11.1 to 14.9 °C.

Species Composition and Abundance.—Over all stations (57–253 m) and methods, 152 fish species representing 56 families were documented (Table 2). Of these, 35 species were observed or collected only on NH habitats (Table 2). JSL and ROV video observations and JSL collections solely contributed 75 species to this list (Table 2). Otter trawls added 38 species, including bothids, paralichthyids, synodontids, triglids, and ogcocephalids (Table 2). These families were observed by the JSL and ROV, but most individuals could not be identified to species. The commercial fishing vessel collected four species that were not observed or collected by any other method: *Caulolatilus microps*, *Haemulon plumierii*, *Halichoeres bivittatus*, and *Scomberomorus cavalla*.

Depth distributions were documented for all species (Table 2). A few species spanned nearly the entire depth range of the sampling area, such as *Conger oceanicus* (97–240 m), *E. niveatus* (73–251 m), and *Urophycis regia* (124–241 m). An outer shelf group of primarily reef species occurred in < 130 m depth on all HB habitats, and certain species inhabited only the Snowy Wreck, in 238–253 m (Table 2).

MDS ordination of ROV video segments indicated distinct habitat and microhabitat groupings (Fig. 3). In total, 126 ROV video segments, yielding 45 species and 2886 individuals, were used in the overall habitat analysis. The habitat MDS plot indicated two groups: HB and NH (Fig. 3A). The 0.05 stress value indicated excellent representation of the relationships in two-dimensional space (Fig. 3A). Each HB habitat type, HRL, LRH, and BF, was significantly (ANOSIM, R > 0.575, P = 0.001) different from NH habitat. To examine differences among microhabitats, 40 ROV segments, yielding 45 species and 1958 individuals, were used in MDS ordination (Fig. 3B). The 0.11 stress value corresponded to good representation of the data (Fig. 3B). LG microhabitat was significantly (ANOSIM, R =0.624, P = 0.001) different from SM microhabitat. The dissimilarity (93%, SIMPER) between LG and SM microhabitats was driven by an abundance of anthiines, *Pareques* spp., *Corniger spinosus,* and *Sargocentron bullisi* in LG microhabitats and *Halichoeres* cf. *bathyphilus* and *Serranus phoebe* in SM microhabitats.

Overall differences in abundance and species richness among habitats and microhabitats were apparent with the ROV transect data. Fishes observed with the ROV were significantly (K-W, $P < 0.05$) more abundant on HRL, LRH, and BF habitats compared with NH. Within microhabitats on HRL, fishes observed with the ROV were significantly (K-W, $P < 0.05$) more abundant on LG microhabitat compared to SM. Species accumulation curves indicated higher species richness on HRL and lower richness on NH habitats (Fig. 4). Species richness was significantly (ANCOVA, $P < 0.05$) higher on HRL compared with other habitats and on LRH compared with BF and NH. Species richness observed with the JSL was not statistically compared because these data could not be standardized and there was more sampling on HRL; however, species richness observed with the JSL appeared to follow the same trend as seen with the ROV.

Direct observation methods revealed differences in species composition and relative abundances of species among habitats and microhabitats. Anthiines (Serranidae) were the most abundant (> 49%) fishes observed on most HB habitats, except during the ROV dive on the BF (Table 2). Anthiines were also more abundant on LG compared to SM microhabitats (Fig. 5). Anthiines could not always be identified to species because they occurred over reefs in dense, fast moving, mixed schools. Four

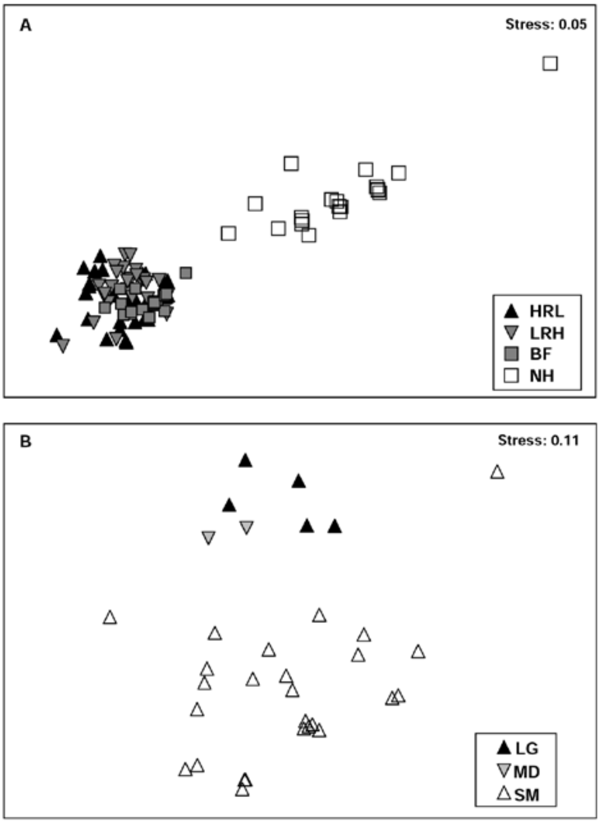

Figure 3. Multi-dimensional scaling plots of (A) general habitats and (B) microhabitats on high relief ledges. HRL = high relief ledge, LRH = low relief hardbottom, BF = boulder field, NH = no hardbottom, LG = large rocks, MD = moderate rocks, and SM = small rocks.

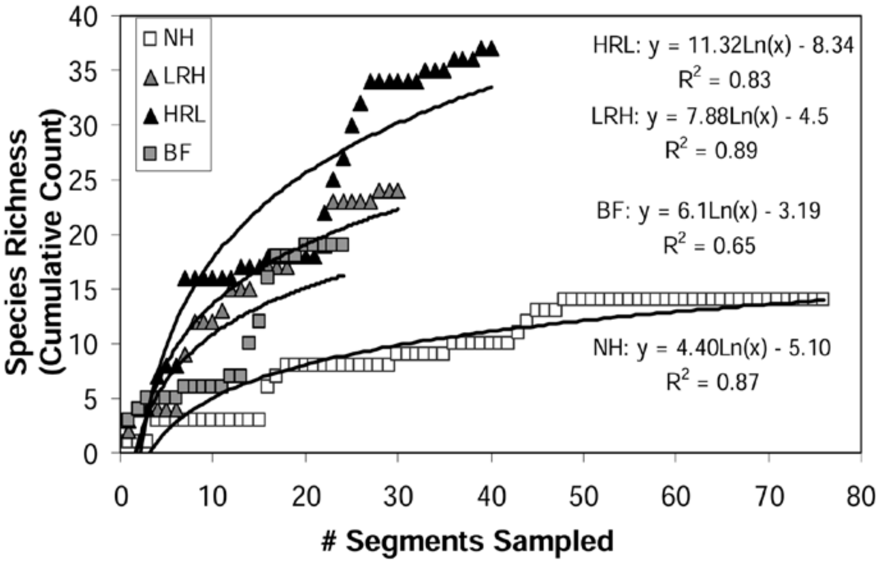

Figure 4. Species accumulation curves (fitted with logarithmic regressions) for habitats observed by the ROV. HRL = high relief ledge, LRH = low relief hardbottom, BF = boulder field, NH = no hardbottom.

species of anthiines were collected often from the same schools with the JSL's suction sampler: *Anthias tenuis*, *Hemanthias leptus*, *Hemanthias vivanus*, and *Pronotogrammus martinicensis*. Other abundant species observed on LG microhabitats included *Pareques* spp., (difficult to distinguish *Pareques iwamotoi* and *Pareques umbrosus*), *Sargocentron bullisi, Haemulon striatum,* and *Haemulon aurolineatum* (Table 2, Fig. 5A,C). *Chaetodon sedentarius*, *Serranus phoebe*, and *Halichoeres* cf. *bathyphilus* were abundant species observed on SM microhabitats on HRL (Table 2, Fig. 5B,D). Abundant species on LRH included *S. phoebe*, *Prognathodes aya*, *Pristigenys alta*, and *C. sedentarius* (Table 2). On the BF habitat, not only were there fewer anthiines, there were greater abundances of *P. alta*, *S. phoebe*, *C. sedentarius*, and *Halichoeres* cf. *bathyphilus* (Table 2). Of the commercially important species, *R. aurorubens*, *Seriola* spp., *E. niveatus*, *Mycteroperca phenax*, and *Mycteroperca interstitialis* were abundant on HB habitats (Table 2). On NH habitats, *Seriola* spp., *Ogcocephalus* spp., *Maurolicus weitzmani,* Triglidae, Peristediidae, and Synodontidae were abundant (Table 2).

In August 2004, a 97 min ROV dive was conducted at the Snowy Wreck. Transect time totaled 30 min because the ROV covered areas multiple times. On and near the wreck, *Anthias nicholsi* was the most abundant species (63%), followed by *E. niveatus* (13%), and *Laemonema barbatulum* (12%), while scorpaenids (8%) were more abundant on the sandy substrate around the base and off the wreck (Table 2). Only three other fish species (totaling 4% of observed fishes) were seen on the wreck: *Conger oceanicus*, *Hyperoglyphe perciformis*, and *Urophycis floridana* (Table 2).

Range Extensions.—Three *Stygnobrotula latebricola* were observed and videotaped with the JSL on HRL: one on 19 Aug 2003 (33° 24.97′ N, 77° 04.67′ W; JSLII 3422) in 73 m and two on 26 Aug 2003 (33° 24.95′ N, 77° 04.65′ W; JSLII 3435) in 72 m. These individuals were identified based on the following distinctive characters: blunt head, continuous dorsal and anal fins joining into a pointed caudal fin,

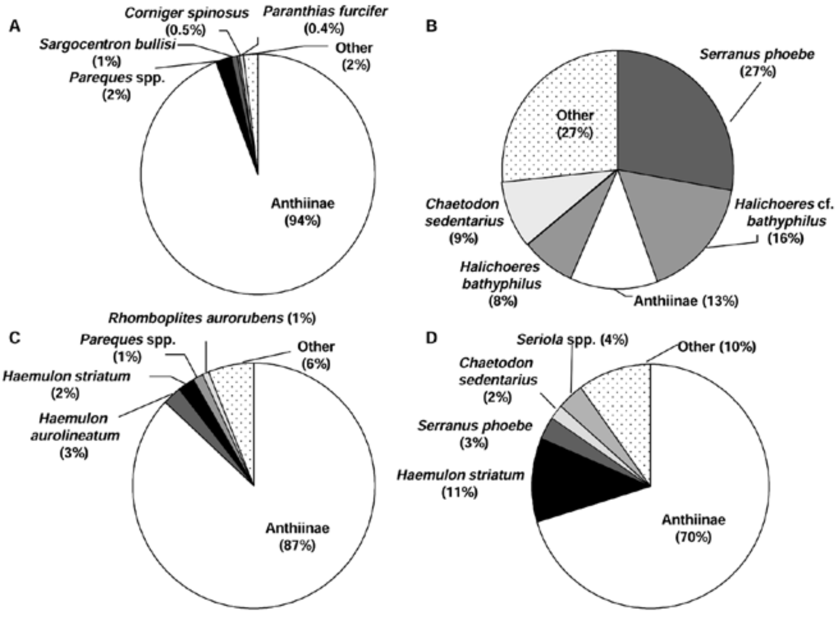

Figure 5. Top five taxa observed on microhabitats (A) large rock (LG) and (B) small rock (SM) with the ROV; and (C) LG and (D) SM with the JSL.

uniformly dark body and fins, and continuously undulating dorsal and anal fins. *Stygnobrotula latebricola*, a poorly documented species, was previously reported from south Florida (Robins and Ray, 1986) and the Bahamas to Curaçao (Böhlke and Chaplin, 1968). The reported maximum size of *S. latebricola* is ≤ 75 mm (Robins and Ray, 1986) and maximum depth is < 31 m (Florida Museum of Natural History, cat. no. 211355). One specimen, videotaped [JSLII 3422 (Fig. 2G)], was estimated to be 150 mm TL. The large size observed and deeper depth occurrences seem atypical; however, little is known of this species.

Five other species previously unreported from North Carolina waters were documented. Two *Serranus chionaraia* were videotaped (Fig. 2E) in the p-MPA on SM microhabitat in 77 m depth on 17 April 2004 (33° 30.23′ N, 76° 56.81′ W; ROV 001). Previously, *S. chionaraia* was reported from Florida and the northern Caribbean (Robins and Starck, 1961). Two *Lythrypnus elasson* (NCSM 40905; 10 and 14 mm SL) were collected on 14 June 2004 (33° 24.94′ N, 77° 04.64′ W; JSLI 4691) on LG microhabitat in 81 m, which also extends the depth range. *Lythrypnus elasson* was previously reported from the Bahamas (Böhlke and Robins, 1960), Cuba (Claro and Parenti, 2001), and the Gulf of Mexico (Williams and Shipp, 1980) in depths ≤ 36 m. *Lythrypnus* may inhabit deeper reefs in higher latitudes (Ross and Rohde, 2004). *Cosmocampus profundus* was tentatively identified (Fig. 2H) based on estimated ring counts, a long snout, coloration, benthic behavior, and depth (24 Aug 2004; 33°27.5′ N, 76° 58.8′ W; 109 m; ROV002C). If the identification is correct, this observation represents a range extension from eastern Florida, the Virgin Islands, and the Yucatán peninsula (Dawson, 1982). Our collections of *Citharichthys gymnorhinus* also represent range extensions; however, this is a topic of another report (Ross et al. unpub. data).

Table 2. Relative abundance (%) of fishes sampled with multiple gears by habitat. Fishes that were observed or collected and could not be quantified are denoted by an X. Species presence inside (I) or outside (O) the proposed marine protected area (p-MPA) or in both (B) areas is noted. Depth range is median minimum and maximum depths (in meters). ROV = remotely operated vehicle, JSL = Johnson-Sea-Link, OT = otter trawl, HL = hook and line, HRL = high relief ledge, LRH = low relief hardbottom, BF = boulder field, NH = no hardbottom, HB = hardbottom, SW = Snowy Wreck, * = relative abundance ≤ 0.05%, [c] = collected by JSL. Numbers in parentheses indicate ROV and JSL transect time (min), OT tows, or HL stations per habitat.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Myxinidae													
Myxine glutinosa Linnaeus, 1758				0.9								I	197
Mobulidae													
Manta birostris (Walbaum, 1792)						*						O	80–86
Muraenidae													
Undetermined			0.8	1.8		*					X	B	57–150
Gymnothorax spp.						*						B	72–113
Gymnothorax hubbsi Böhlke & Böhlke, 1977[c]						X						B	98
Gymnothorax moringa (Cuvier, 1829)	0.1					*						B	70–91
Gymnothorax polygonius Poey, 1875[c]			0.4			*						B	77–106
Gymnothorax saxicola Jordan & Davis, 1891				0.9						0.1		I	124–154
Muraena retifera Goode & Bean, 1882						X	X					B	76–87
Muraena robusta Osório, 1911	0.1					*						I	71–82
Ophichthidae													
Undetermined				1.8								B	150–154
Myrichthys breviceps (Richardson, 1848)						*						I	82
Ophichthus puncticeps (Kaup, 1860)										0.1		O	170
Congridae													
Ariosoma balearicum (Delaroche, 1809)										0.5		O	112
Conger oceanicus (Mitchill, 1818)[c]	0.1				0.3	X						I	97–240
Gnathophis bracheatopos Smith & Kanazawa, 1977									1.6			O	76

Table 2. Continued.

	ROV					JSL			OT		HL		
Taxa	HRL (50)	LRH (35)	BF (29)	NH (116)	SW (30)	HRL (465)	BF (89)	NH (56)	HB (4)	NH (11)	HB (24)	p-MPA	Depth range
Sternoptychidae													
Maurolicus weitzmani Parin & Kobylianski, 1993				16.2								I	151–153
Chlorophthalmidae													
Chlorophthalmus agassizi Bonaparte, 1840				1.8								I	195–197
Synodontidae													
Undetermined			0.4	18.0		*						B	77–194
Saurida spp.				X								B	154–196
Saurida brasiliensis Norman, 1935										24.5		I	124
Synodus spp.									1.6			B	74
Synodus intermedius (Spix & Agassiz, 1829)						*			1.6	3.9		B	76–124
Synodus poeyi Jordan, 1887									3.2	2.5		B	74–117
Synodus synodus (Linnaeus, 1758)				3.6		*			6.3			B	74–86
Trachinocephalus myops (Forster, 1801)									4.8	0.8		O	76–112
Ophidiidae													
Brotula barbata (Bloch & Schneider, 1801)						*	X					B	76–84
Lepophidium profundorum (Gill, 1863)										0.2		O	170
Lepophidium staurophor Robins, 1959										0.2		O	215–228
Bythitidae													
Stygnobrotula latebricola Böhlke, 1957						X						I	72–76
Moridae													
Laemonema barbatulum Goode & Bean, 1883					12.3							I	237–251
Phycidae													
Urophycis cf. *earllii* (Bean, 1880)							X					O	76

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Urophycis floridana (Bean & Dresel, 1884)					3.6							I	237–251
Urophycis regia (Walbaum, 1792)				0.9						2.7		B	124–241
Lophiidae													
Lophiodes reticulatus Caruso & Suttkus, 1979										0.1		O	170
Lophius gastrophysus Miranda-Ribeiro, 1915										0.2		I	124
Ogcocephalidae													
Halieutichthys aculeatus (Mitchill, 1818)									1.6	1.3		B	76–170
Ogcocephalus spp.				3.6				14.3				B	105–128
Ogcocephalus corniger Bradbury, 1980										0.1		O	170
Ogcocephalus parvus Longley & Hildebrand, 1940				1.8						0.2		B	110–150
Ogcocephalus rostellum Bradbury, 1980										0.1		I	124
Zalieutes mcgintyi (Fowler, 1952)										7.5		O	170–228
Holocentridae													
Corniger spinosus Agassiz, 1831[c]	0.6	0.3				0.3	0.1					B	70–113
Holocentrinae						0.3						B	70–103
Holocentrus adscensionis (Osbeck, 1765)	0.2					*	0.1				X	B	59–83
Sargocentron bullisi (Woods, 1955)[c]	0.7					0.5						B	71–106
Caproidae													
Antigonia capros Lowe, 1843										0.1		I	124
Syngnathidae													
Cosmocampus cf. *profundus* (Herald, 1965)				0.9								I	110
Hippocampus erectus Perry, 1810										0.4		O	107–117
Scorpaenidae													
Undetermined	0.1	0.7	0.4		7.8	0.1	0.4					B	71–251

Table 2. Continued.

Taxa	ROV HRL (50)	ROV LRH (35)	ROV BF (29)	ROV NH (116)	ROV SW (30)	JSL HRL (465)	JSL BF (89)	JSL NH (56)	OT HB (4)	OT NH (11)	HL HB (24)	p-MPA	Depth range
Pterois volitans (Linnaeus, 1758)[c]	0.1					*						I	70–99
Scorpaena agassizii Goode & Bean, 1896									3.2			O	79
Scorpaena brasiliensis Cuvier, 1829[c]						X						O	87
Scorpaena dispar Longley & Hildebrand, 1940[c]						X	X		1.6	0.1		B	73–112
Triglidae													
Undetermined				0.9				X				B	105–128
Bellator spp.				14.4								I	150–198
Bellator brachychir (Regan, 1914)										0.2		I	124
Bellator egretta (Goode & Bean, 1896)[c]								X		0.9		B	110–124
Bellator militaris (Goode & Bean, 1896)										0.2		O	100–112
Prionotus roseus Jordan & Evermann, 1887									1.6			O	76
Peristediidae													
Peristedion spp.				1.8								I	150–197
Triglidae/Peristediidae				16.2								I	150–153
Dactylopteridae													
Dactylopterus volitans (Linnaeus, 1758)	0.1	0.2	0.4			*	0.1					B	63–111
Acropomatidae													
Synagrops sp.				1.8								I	153–154
Serranidae													
Undetermined	0.2	0.2										B	
Anthiinae[1,c]	85.6	80.5	9.4			83.7	49.0					B	60–123
Anthias nicholsi Firth, 1933					62.8							I	238–251
Centropristis ocyurus (Jordan & Evermann, 1887)[c]						X						I	97
Cephalopholis cruentata (Lacepède, 1802)	0.1					0.1	0.1					B	70–99

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Cephalopholis fulva (Linnaeus, 1758)						*					X	B	60–71
Epinephelus adscensionis (Osbeck, 1765)						*					X	B	59–76
Epinephelus drummondhayi Goode & Bean, 1878						X	0.1				X	B	75–104
Epinephelus nigritus (Holbrook, 1855)						X					X	B	76–108
Epinephelus niveatus (Valenciennes, 1828)		0.5	0.8		12.9	*	1.7				X	B	73–251
Gonioplectrus hispanus (Cuvier, 1828)[c]	0.1					0.1						B	76–112
Hemanthias vivanus (Jordan & Swain, 1885)									1.6				
Liopropoma aberrans (Poey, 1860)[c]	0.1					0.1						B	84–108
Liopropoma eukrines (Starck & Courtenay, 1962)[c]	0.2	0.3				0.2	0.4					B	70–115
Liopropoma mowbrayi Woods & Kanazawa, 1951						X						I	76
Mycteroperca spp.	0.1					0.2	0.2					B	70–106
Mycteroperca interstitialis (Poey, 1860)	0.2					0.1					X	B	70–113
Mycteroperca microlepis (Goode & Bean, 1879)	0.1					*					X	B	57–80
Mycteroperca phenax Jordan & Swain, 1884	0.4					0.3	0.2				X	B	57–113
Paranthias furcifer (Valenciennes, 1828)	0.3					0.3					X	B	57–98
Parasphyraenops incisus (Collin, 1978)									1.6			O	79
Rypticus saponaceus (Bloch & Schneider, 1801)[c]	0.1	0.2	X			0.3	0.2				X	B	70–112
Schultzea beta (Hildebrand, 1940)									1.6			O	76
Serranus annularis (Günther, 1880)		0.2				X			1.6			B	74–113
Serranus chionaraia Robins & Starck, 1961	0.1											I	77
Serranus notospilus Longley, 1935									6.3	5.6		B	74–170
Serranus phoebe Poey, 1851	2.6	4.8	21.2			0.4	12.2		15.9		X	B	59–122
Priacanthidae													
Priacanthus arenatus Cuvier, 1829	0.1	0.5				0.4	1.0				X	B	71–118

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Pristigenys alta (Gill, 1862)	0.2	2.0	25.3			0.2	13.3		3.2		X	B	70–128
Apogonidae													
Apogon affinis (Poey, 1875)						X						I	76–88
Apogon gouldi Smith-Vaniz, 1977[c]						X						O	97
Apogon pseudomaculatus Longley, 1932						X	0.1					B	70–99
Malacanthidae													
Caulolatilus microps Goode & Bean, 1878											X	O	128
Malacanthus plumieri (Bloch, 1786)	0.3											I	75–77
Carangidae													
Caranx bartholomaei Cuvier, 1833						0.1						I	71–86
Caranx lugubris Poey, 1860						*						B	69–88
Seriola spp.	0.1			5.4		0.5		7.1				B	76–99
Seriola dumerili (Risso, 1810)	0.6			1.8		0.2	0.1	35.7			X	B	70–128
Seriola rivoliana Valenciennes, 1833	0.1		2.5	X		0.3	2.6	42.9			X	B	70–128
Lutjanidae													
Lutjanus buccanella (Cuvier, 1828)						0.1					X	B	71–101
Rhomboplites aurorubens (Cuvier, 1829)			1.6			0.8	1.7				X	B	71–108
Haemulidae													
Haemulon aurolineatum Cuvier, 1830						2.4			6.3		X	B	70–103
Haemulon plumierii (Lacepède, 1801)											X	O	59–60
Haemulon striatum (Linnaeus, 1758)						3.3			6.3			O	76–96
Sparidae													
Calamus nodosus Randall & Caldwell, 1966		0.2				*	1.1				X	B	57–108
Pagrus pagrus (Linnaeus, 1758)											X	B	59–128

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Sciaenidae													
Equetus lanceolatus (Linnaeus, 1758)			0.4				0.2					O	74–77
Pareques spp.[2]	1.7					1.2	0.2					B	70–112
Pareques iwamotoi Miller & Woods, 1988						*	X					B	75–112
Pareques umbrosus (Jordan & Eigenmann, 1889)						*			1.6			B	76–101
Mullidae													
Pseudupeneus maculatus (Bloch, 1793)						0.1						I	70–85
Chaetodontidae													
Chaetodon spp.						*	0.2					B	71–105
Chaetodon ocellatus Bloch, 1787			1.2			0.1	0.1					B	70–91
Chaetodon sedentarius Poey, 1860	1.4	2.0	14.3			0.9	7.8		1.6			B	65–110
Prognathodes spp.						*						B	72–103
Prognathodes aculeatus (Poey, 1860)						*						B	71–98
Prognathodes aya (Jordan, 1886)		3.1	1.2			0.2	0.8					B	70–122
Prognathodes guyanensis (Durand, 1960)						*						B	81–101
Pomacanthidae													
Centropyge argi Woods & Kanazawa, 1951						X						I	71–77
Holacanthus bermudensis Goode, 1876	0.2	0.5	0.4			0.1	0.1					B	59–111
Holacanthus ciliaris (Linnaeus, 1758)	0.1					*						I	71–95
Holacanthus tricolor (Bloch, 1795)	0.1					0.1						B	65–102
Pomacanthus paru (Bloch, 1787)						X						I	72
Pomacentridae													
Chromis spp.	0.2	0.2				0.1						B	70–89
Chromis enchrysura Jordan & Gilbert, 1882	0.2	0.7	2.0			0.3	1.2					B	65–89

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Chromis insolata (Cuvier, 1830)	0.1					0.1						I	70–82
Chromis scotti Emery, 1968	0.2					0.4						B	70–87
Stegastes adustus (Troschel, 1865)									1.6			O	79
Labridae													
Bodianus pulchellus (Poey, 1860)	0.3	0.3				0.4	0.5				X	B	57–90
Halichoeres bathyphilus (Beebe & Tee-Van, 1932)[c]	0.8		7.8			*	X					B	70–99
Halichoeres cf. *bathyphilus* (Beebe & Tee-Van, 1932)	1.6	1.5	7.8			0.3	2.9					B	59–117
Halichoeres bivittatus (Bloch, 1791)											X	O	57–59
Lachnolaimus maximus (Walbaum, 1792)	0.1	0.2				*	0.5					B	60–87
Xyrichtys novacula (Linnaeus, 1758)	X			0.9								I	69–78
Ammodytidae													
Ammodytes americanus DeKay, 1842										1.9		O	100–110
Uranoscopidae													
Kathetostoma albigutta (Bean, 1892)										0.1		O	100
Blenniidae							X					O	86
Callionymidae													
Foetorepus agassizii (Goode & Bean, 1888)[c]								X				O	124
Gobiidae													
Undetermined		0.3				*	X					B	70–123
Bollmannia sp.[c]									1.6			O	74
Lythrypnus elasson Böhlke & Robins, 1960[c]						X						I	81
Lythrypnus spilus Böhlke & Robins, 1960[c]						X						O	97
Ptereleotridae													
Ptereleotris spp.	X	0.3										I	70–117

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Acanthuridae													
Acanthurus chirurgus (Bloch, 1787)	0.1					0.1						I	63–78
Sphyraenidae													
Sphyraena barracuda (Edwards, 1771)						*						B	80
Scombridae													
Undetermined						X						O	81
Scomberomorus cavalla (Cuvier, 1829)											X	B	99–113
Centrolophidae													
Hyperoglyphe perciformis (Mitchill, 1818)					0.3							I	241
Bothidae													
Bothus ocellatus (Agassiz, 1831)									12.7	0.7		O	76–112
Monolene sessilicauda Goode, 1880										0.1		O	215
Paralichthyidae													
Undetermined			0.4	4.5				X				B	77–154
Ancylopsetta dilecta (Goode & Bean, 1883)										0.1		O	170
Citharichthys arctifrons Goode, 1880										0.9		B	110–192
Citharichthys cornutus (Günther, 1880)										37.2		B	124
Citharichthys gymnorhinus Gutherz & Blackman, 1970										4.9		B	100–124
Etropus microstomus (Gill, 1864)										0.1		I	124
Syacium papillosum (Linnaeus, 1758)										0.5		O	107–112
Cynoglossidae													
Symphurus minor Ginsburg, 1951										0.1		O	112
Triacanthodidae													
Parahollardia lineata (Longley, 1935)										0.5		I	124

Table 2. Continued.

	ROV					JSL			OT		HL		
	HRL	LRH	BF	NH	SW	HRL	BF	NH	HB	NH	HB	p-MPA	Depth range
Taxa	(50)	(35)	(29)	(116)	(30)	(465)	(89)	(56)	(4)	(11)	(24)		
Balistidae													
Balistes capriscus Gmelin, 1789							0.2				X	O	59–75
Monacanthidae													
Undetermined		0.2										I	84
Aluterus cf. *monoceros* (Linnaeus, 1758)	0.4											I	75
Monacanthus ciliatus (Mitchill, 1818)									6.3			O	74
Ostraciidae													
Undetermined			0.4				X					O	77–86
Acanthostracion quadricornis (Linnaeus, 1758)			0.8									O	78
Tetraodontidae													
Canthigaster spp.		0.3				0.1						B	70–111
Canthigaster rostrata (Bloch, 1786)						X			1.6			B	72–74
Sphoeroides cf. *splengeri* (Bloch, 1785)							0.2					O	74–75
Diodontidae													
Undetermined						*						I	71
Chilomycterus antillarum Jordan & Rutter, 1897						X						I	85
Chilomycterus schoepfii (Walbaum, 1792)						X						I	77
Diodon holocanthus Linnaeus, 1758	0.1								1.6			B	79–81
Molidae													
Mola mola (Linnaeus, 1758)							X					O	87

[1]Anthiinae includes at least 4 species: *Anthias tenuis, Hemanthias leptus, Hemanthias vivanus,* and *Pronotogrammus martinicensis*
[2]*Pareques* spp. includes both *P. iwamotoi* and *P. umbrosus.*

Discussion

Despite numerous studies focused on SEUSCS hardbottom reef fishes, it is still difficult to characterize reef fish community structure for the entire region. Varying methods and objectives confound explicit faunal comparisons across depth and latitude. Fairly complete reef fish species lists exist for the overall area, often with indicator species of particular depth zones (e.g., Struhsaker, 1969; Miller and Richards, 1980; Grimes et al., 1982; Chester et al., 1984; Parker and Ross, 1986). However, most studies that covered large parts of the SEUSCS (Struhsaker, 1969; Miller and Richards, 1980; Grimes et al., 1982; Chester et al., 1984; Sedberry and Van Dolah, 1984) used methods that were highly selective (hook and line, trawls, traps), and sometimes concentrated only on economically important species. Other studies that used less biased direct observation techniques were spatially and/or temporally restricted, resulting in fragmented islands of data (Barans and Henry, 1984; Parker and Ross, 1986; Gutherz et al., 1995; Koenig et al., 2000; Koenig et al., 2005). The various views of shelf-edge hardbottom communities may be as much related to methodological or conceptual differences as they are to environmental factors. Nevertheless, there seems to be a trend of increasing species richness from shallow to deep, with shelf-edge reefs (~50–125 m) harboring the most species (e.g., Struhsaker, 1969; Grimes et al., 1982; Barans and Henry, 1984; Parker and Ross, 1986). The increased fish diversity in the shelf-edge zone is likely due to a warmer and/or more stable benthic temperature regime that is influenced year round by the Gulf Stream (Blanton, 1971; Stefánsson et al., 1971; Atkinson and Menzel, 1985; Mathews and Pashuk, 1986). To better document reef fish assemblages along the SEUSCS, a broad, standardized sampling program emphasizing direct observations is needed.

Results from direct observation methods, providing the most complete community view on a per sample basis, generally agree concerning the composition of the shelf-edge fish fauna from the Carolinas through the northeastern Gulf of Mexico (excluding south Florida). This hardbottom fauna is numerically dominated by several species of anthiines, *C. enchrysura*, *P. umbrosus*, *Halichoeres* spp., chaetodontids, and gobiids, all of which are typical, small, obligate reef fishes (Barans and Henry, 1984; Parker and Ross, 1986; Koenig et al., 2000; Weaver et al., 2002; Sedberry et al., 2004; Koenig et al., 2005). Larger members of shelf-edge hardbottom communities, probably dominating the biomass, are *Haemulon* spp., *R. aurorubens*, epinepheline serranids, sparids, and *Seriola* spp. (Barans and Henry, 1984; Parker and Ross, 1986; Koenig et al., 2000; Weaver et al., 2002; Sedberry et al., 2004; Koenig et al., 2005). While these generalizations occur throughout the area, data are lacking to determine what factors (e.g., depth, turbidity, currents), especially on a small scale, structure reef communities. For example, more detailed studies on trophodynamics (e.g., Cahoon and Cooke, 1992; Weaver et al. 2002), important for determining the basis of reef productivity, are needed on deeper reefs.

The use of direct observation methods in this study resulted in a more detailed description of habitats and associated fishes. Three general hardbottom habitat types (HRL, BF, and LRH) all differed in physical characteristics, but certain species were common to abundant on all habitats. The BF fish community, however, was somewhat unique. This difference cannot be explained by differences in depth, temperature, sample times, or other attributes aside from the physical appearance of the BF habitat. The greater species richness observed on HRL was probably related to increased surface area, crevices, and caves. Parker and Ross (1986) also observed that the highest profile habitats supported the largest numbers of species and individuals, regardless of depth. In the shallower (22 m) Gray's Reef National Marine Sanctuary, Georgia, Parker et al. (1994) documented higher species richness and relative abundances of fishes on ledge habitats compared to sand and low profile live-bottom habitats. Habitat complexity, such as substratum topography, relief, and interstitial space, is important in structuring fish assemblages on coral and rocky reefs (e.g., Luckhurst and Luckhurst, 1978; García Charton and Pérez Ruzafa, 1998; Friedlander and Parrish, 1998; Öhman and Rajasuriya, 1998). Few differences were observed in fish assemblages on habitats sampled within and outside of the p-MPA, and these differences likely resulted from unequal sampling effort. This was expected, since the p-MPA boundaries were not based on unique habitats or species assemblages.

The fishes observed at the Snowy Wreck were similar to those on hardbottoms at the Charleston Lumps area (185–220 m) off South Carolina where Gutherz et al. (1995) and Sedberry et al. (2004) observed 30 and eight fish taxa, respectively. The most abundant species were *A. nicholsi*, scorpaenids, *L. barbatulum*, and *E. niveatus*, all of which were abundant at the Snowy Wreck. *Hyperoglyphe perciformis* and *U. floridana* were observed at both the Charleston Lumps (Gutherz et al., 1995) and at the Snowy Wreck. Snowy Wreck depth range (238–253 m) appears to fall within a transition zone where fishes more common to deeper slope water of this latitude overlap with some species that are more common in shallower depths. For example, *E. niveatus* and *U. floridana* can occur as deep as 525 m and 400 m, respectively; however, they are most abundant at depths < 200 and 300 m, respectively (Heemstra and Randall, 1993; Iwamoto, 2002). *Laemonema barbatulum* occurs over a broad depth range (50–1620 m), but is most common in 300–400 m (Meléndez and Markle, 1997; Iwamoto and Cohen, 2002), and at the latitude of our study has not been reported shallower than 200 m. On complex, deep (> 370 m) coral bottoms off North Carolina, a completely different ichthyofauna exists, including *L. barbatulum*, *Helicolenus dactylopterus* (Delaroche, 1809), Beryciformes, and *C. oceanicus*, the latter of which is the only species in common with shallower reefs (Ross et al., unpub. data).

Better sampling of hardbottoms has yielded reef fish species that were previously unknown off North Carolina. Nearly all new records are tropical or sub-tropical, small, and/or cryptic species. In addition to the five species added here to the North Carolina ichthyofauna, Quattrini et al. (2004) documented range extensions for 14 species collected in offshore waters; four of which were previously unreported from the SEUSCS. *Pterois volitans*, an introduced species, was also recently documented several times from hardbottoms off the Carolinas (Whitfield et al., 2002; Meister et al., 2005). In the last 10 yrs, new records of 27 fishes, including those reported in this study, have been documented on North Carolina hardbottoms (Rohde et al., 1995; Whitfield et al., 2002; Quattrini et al., 2004; Ross and Rohde, 2004). Many of these species appear to be well-established, resident members of North Carolina offshore communities.

Estimates of the distribution and area of hardbottom habitat on the SEUSCS (Miller and Richards, 1980; Parker et al., 1983; Barans and Henry, 1984; SEAMAP-SA, 2001) have not provided sufficiently detailed or accurate habitat information, such as local area, relief, and substrate types. This lack of data has hampered the design of MPAs, such as the one proposed off North Carolina, for which only anecdotal (SAFMC, 2004) or very limited data (Parker and Ross, 1986; SEAMAP-SA, 2001) were available. Although we added information on the distribution, relief, and microstructure of hardbottoms within and outside of the North Carolina p-MPA, habitat data are still lacking for a large part of this area. Our data indicate that hardbottoms are scarce or absent from the p-MPA in depths > ~125 m. Thus, we suggest that a better MPA option could enclose shelf-edge hardbottoms in ~50–150 m depth and extend a longer distance north to south. A second small MPA could enclose the Snowy Wreck. Even so, more detailed bottom data, as provided by multibeam mapping and visual observations, are still needed throughout the SEUSCS (particularly in 100–300 m) to accurately evaluate the amount and type of habitats selected for protection. Ultimately, the biota of shelf-edge hardbottoms within proposed protection areas should be thoroughly surveyed using standardized direct observation methods both before and after MPA designation. Without baseline (pre-protection) habitat and faunal structure data as well as continued monitoring of areas after protection, there is no way to evaluate the effectiveness of the management strategy.

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