Deep reef fish surveys by submersible on Alderdice, McGrail, and Sonnier Banks in the Northwestern Gulf of Mexico

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Abstract—Submersible surveys at numerous reefs and banks in the northwestern Gulf of Mexico (NWGOM) were conducted as part of the Sustainable Seas Expedition (SSE) during July/August 2002 to identify reef fish communities, characterize benthic habitats, and identify deep coral reef ecosystems. To identify the spatial extent of hard bottom reef communities, the Flower Garden Banks National Marine Sanctuary (FGBNMS) and the U.S. Geological Survey (USGS) mapped approximately 2000 km^2 of the Northwestern Gulf of Mexico (NWGOM) continental shelf during June 2002 with high-resolution multibeam bathymetry. Previous investigations conducted on the features of interest (with the exceptions of East and West Flower Garden and Sonnier Banks, accessible by SCUBA) had not been conducted since the 1970s and 1980s, and did not have the use of high-resolution maps to target survey sites. The base maps were instrumental in navigating submersibles to specific features at each study site during the Sustainable Seas Expedition (SSE)—a submersible effort culminating from a partnership between the National Atmospheric and Oceanic Administration (NOAA) and the National Geographic Society (NGS). We report the initial findings of our submersible surveys, including habitat and reef fish diversity at McGrail, Alderdice, and Sonnier Banks. A total of 120 species and 40,724 individuals were identified from video surveys at the three banks. Planktivorous fishes constituted over 87% by number for the three banks, ranging from 81.4% at Sonnier Banks to 94.3% at Alderdice Bank, indicating a direct link to pelagic prey communities, particularly in the deep reef zones. High numbers of groupers, snappers, jacks, and other fishery species were observed on all three features. These sites were nominated as Habitat Areas of Particular Concern (HAPC) by the Gulf of Mexico Fishery Council in March 2004. Data obtained during this project will contribute to benthic habitat characterization and assessment of the associated fish communities through future SCUBA, ROV, and submersible missions, and allow comparisons to other deep reef ecosystems found throughout the Gulf of Mexico and western Atlantic Ocean.

Introduction

The northwestern Gulf of Mexico (NWGOM) reefs and banks are associated with the surface expression of salt domes, and have been identified as unique biological features warranting protection by Minerals Management Service (MMS) from oil and gas activities. The most recent investigations of reef fishes on the shelf-edge features in the northwestern Gulf (with the exceptions of East and West Flower Garden, Stetson and Sonnier Banks) were conducted during the 1970s and 1980s (Rezak et al., 1985; Dennis and Bright, 1988a, 1988b), without the use of high-resolution multibeam bathymetry or high-resolution camera systems.

The Sustainable Seas Expedition (SSE) was a five-year collaborative effort between NOAA and the National Geographic Society (NGS) to explore important marine ecosystems with special emphasis on the nation's National Marine Sanctuaries. Led by Sylvia Earle, Explorer-in-Residence of the NGS, the SSE program utilized both manned and unmanned submersible technologies to explore the NWGOM in 1999, 2001, and 2002. The use of the submersibles allowed the Flower Garden Banks National Marine Sanctuary (FGBNMS) team to visit several of the reefs and banks of the NWGOM and conduct exploratory dives to investigate reef fish and benthic communities in July 2002.

The reefs and banks of the northwestern Gulf have been afforded some protection since the early 1970s. The MMS recognized early on that these sensitive areas should not be subjected to the direct impacts of offshore oil and gas development, and defined them as "no activity" zones (Fig. 1). However, these features are subject to a variety of other potential impacts unrelated to offshore development, which may not be regulated sufficiently. These impacts include those of commercial shipping (predominantly anchoring), fishing, cultural resource recovery and recreational activities. There is recent emphasis on the increased use of marine protected areas (MPA's) in many ocean regions as a method to consolidate management under a coordinated mechanism. Accurately identifying the resources in the northwestern Gulf will contribute greatly to this effort.

Background

The Department of Oceanography at Texas A&M University (TAMU) conducted studies on "topographic features"—Outer Continental Shelf (OCS) reefs and banks—during the 1970s and 1980s. Funding was provided by the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), out of which MMS later emerged through reorganization. The purpose of the TAMU study

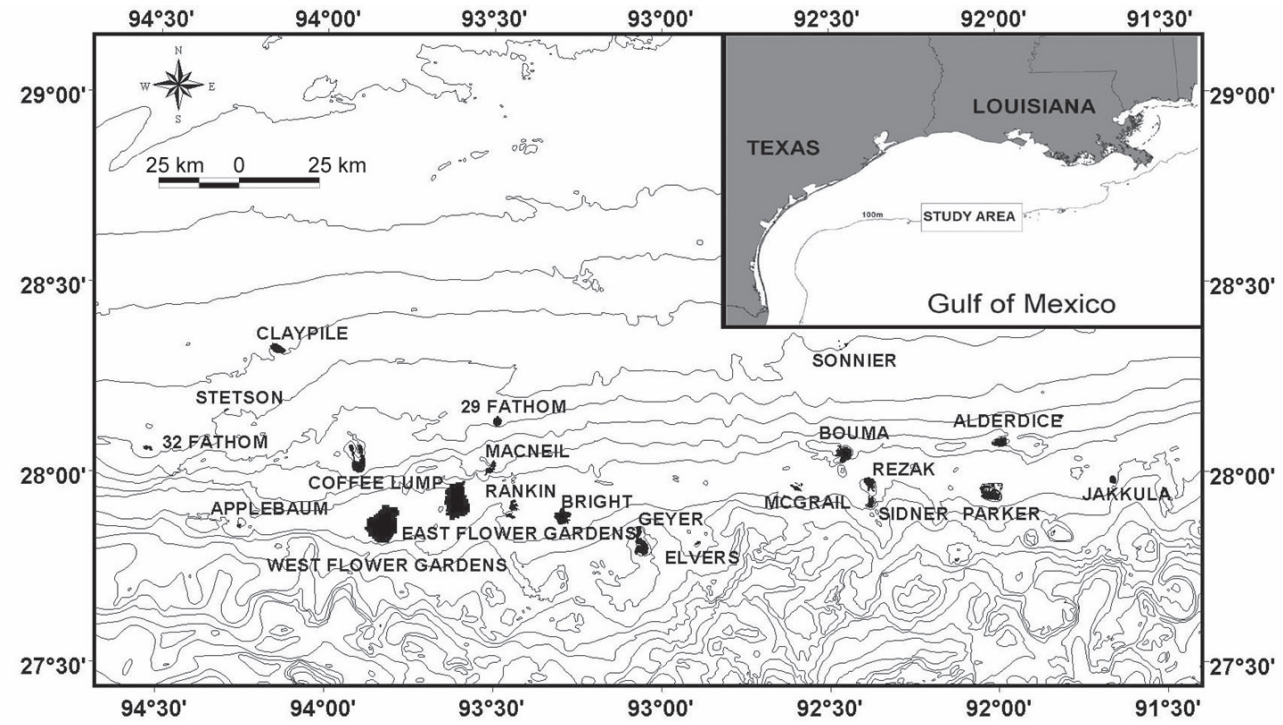


Figure 1
Location of outer shelf banks in the northwestern Gulf of Mexico.

was to provide the MMS with data on the geologic, biologic, hydrologic, and chemical characteristics of the reefs and banks, to be used as a basis for management decisions on tracts nominated for oil and gas leasing (Rezak et al., 1985).

As a comparison, the technology used for the historic surveys conducted by Rezak et al. (1985) included bathymetric mapping using a LORAN-C positioning system for navigation, a 3.5kHz subbottom profiler, EG&G Uniboom seismic system for subbottom information, and EG&G side-scan sonar systems for bottom characterization. Direct observations of the sea floor were made using the Texas A&M submersible DRV *Diaphus* (Rezak and Tieh, 1984; Dennis and Bright, 1988a).

Each of the survey sites has a distinct biological zonation associated with base depths and water turbidity, and the following zones (when present), described during the early TAMU/MMS studies (Rezak et al., 1985; 1990). The *Stephanocoenia-Millepora* Zone is inhabited by a low-diversity coral assemblage of 12 hermatypic coral species and can be found at the FGBNMS, McGrail Bank, and Bright Bank to depths of 50 m. On midshelf banks, such as Stetson and Sonnier Banks, the *Millepora*-Sponge Zone occupies depths less than 36 m. Crusts of the hydrozoan coral, *Millepora,* sponges, and other epifauna occupy the tops of siltstone, claystone, or sandstone outcrops on the crests of these features. The Algal-Sponge Zone covers the largest area among the reef-building zones on shelf-edge banks. The dominant organisms of the zone are the coralline algae, which are the most important carbonate producers through algal nodules and algal reefs (Minnery et al., 1985). The nodules range from 1 to 20 cm in size, cover up to 80 percent of the bottom, and generally occur between 55 and 85 m. Partly Drowned Reefs are also a major biotope occurring at similar depths to the Algal-Sponge Zone, and are defined as massive reefal structures covered with living crusts of coralline algae. With increased water depth, the assemblages of the zone become less diverse, characterized by antipatharians, comatulid crinoids, diminished leafy or coralline algae, and limited fish. High turbidity, sedimentation, and re-suspension occur in the Nepheloid Zone, where exposed rocks lack encrusting coralline algal crusts. Drowned Reefs occurring in this zone are often covered with a thin veneer of sediment, and epifauna are scarce. This zone occurs on all banks, but its depth differs at each bank and extends to the surrounding soft bottom.

The Sonnier Bank complex (historically referred to as Three Hickey Rock and Candy Mountain) is a mid-shelf bank, defined by Rezak et al. (1985, 1990) as salt dome structures rising from depths of 80 m or less

and having a relief of about 4 to 50 m. The banks are located 135 km south of the Louisiana border, at position 28°20′N/92°27′W. As noted by Rezak et al. (1985) the Sonnier Bank complex consists of eight separate banks or peaks associated with a single salt dome. The peaks are nearly conical features with a maximum relief of about 30 m. Observations made by SCUBA and submersible have characterized the reef habitat on the peaks as entirely encrusted with fire coral (*Millepora* sp.) and sponges (primarily *Neofibularia nolitangere* and *Ircinia* sp.) (Rezak et al., 1985). This is the basis for the zonation name of Millepora-Sponge Zone. Rezak et al. (1985) reported three species of coral from the crests at Sonnier Banks: *Stephanocoenia* sp., *Millepora* sp., and *Agaricia* sp. In 1997, SCUBA surveys conducted by MMS and FGBNMS representatives compiled coral observations on the two shallowest peaks (24 m and 18 m) of Sonnier Banks. Other hermatypic coral species added by MMS diver surveys include *Madracis decactis, M. mirabilis, M. pharensis, Siderastrea radians, Montastraea cavernosa,* and *Agaricia fragilis.*

McGrail Bank (formerly referred to as 18 Fathom Bank) is located 180 km south of the coast of Louisiana, at 27°58′N/92°36′W. As described by Rezak et al. (1985), the McGrail Bank is an arcuate pair of northeast-southwest trending ridges separated by a valley. McGrail Bank is one of the few banks in the northwestern Gulf of Mexico that has extensive growth of reef-building corals, in addition to East and West Flower Garden Banks. The original BLM OCS surveys documented four species of coral: the blushing star coral (*Stephanocoenia intersepta;* formerly *S. michilini),* fire coral (*Millepora* sp.), the great star coral (*Montastraea cavernosa*), and *Agaricia* sp.

Alderdice Bank is unique among the offshore banks in that it bears outcrops of basalt associated with the underlying salt dome (Rezak and Tieh, 1984). Alderdice Bank is located about 160 km south of Marsh Island, LA at 92°00′W/28°05′N. The bank is an oval, elongate in an east-west direction, and covers an area of approximately 9.8 km^2. Rezak and Tieh (1984) states that the bank is a classic example of the surface expression of a salt dome. A single basalt outcropping, described by Rezak and Tieh (1984), was discovered during a submersible dive during the BLM OCS studies. Potassium-argon age determination anaysis indicated an age of 76.8 ± 3.3 × 10^6 years (late Cretaceous-Campanian).

As a result of these investigations, MMS initiated regulatory zones around the majority of the hard bottom habitat in the NWGOM, regulating oil and gas activity. Regulations placed on the oil and gas industry included the mandatory shunting of discharges to within 10 m of the sea floor.

During 8–28 June 2002, a multibeam mapping cruise was conducted to survey approximately 2000 km^2 of the northwestern Gulf of Mexico continental shelf[1]. Multibeam bathymetry data sets were used as base maps to guide submersible surveys of select topographic features during the 2002 Sustainable Seas Expedition to the northern Gulf of Mexico, conducted by the FGBNMS in conjunction with the NGS.

The SSE missions initiated an ongoing multidisciplinary project led by the FGBNMS to revisit the reefs and banks of the NWGOM and build on the description and characterization effort conducted during past research programs.

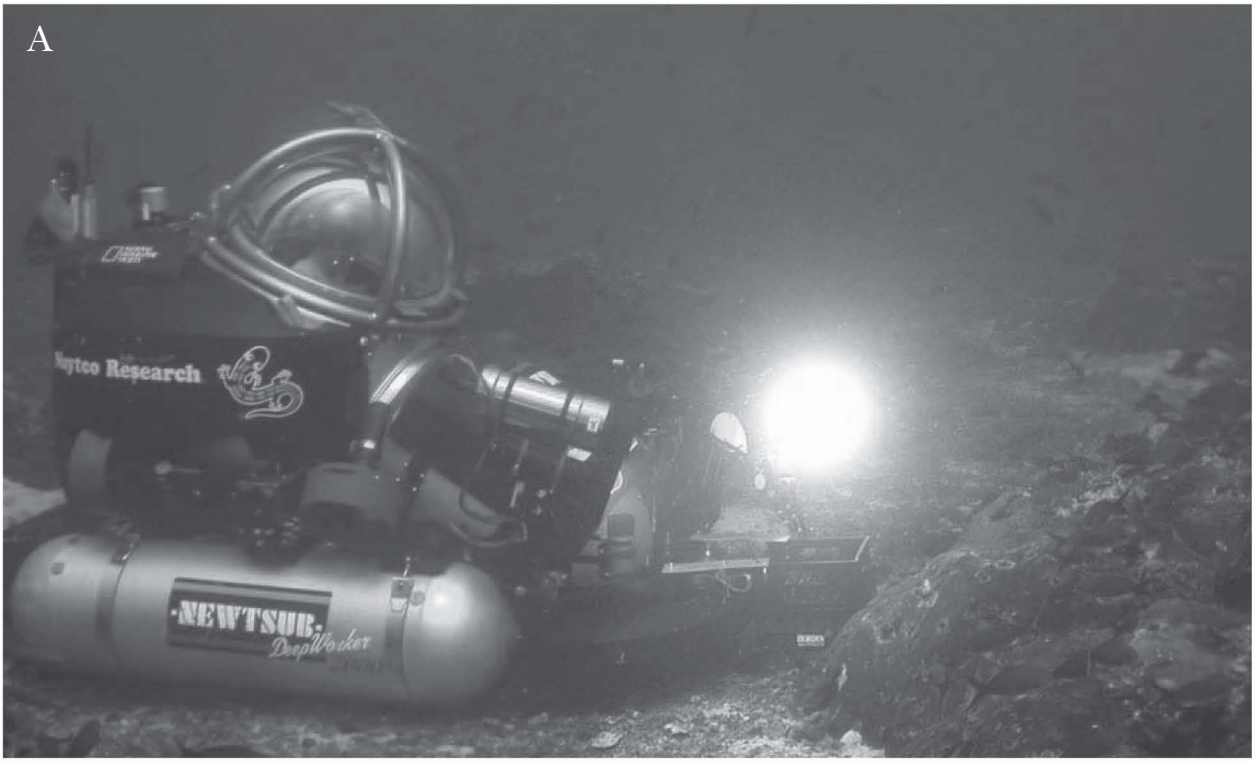
During the SSE missions, submersible dives were conducted on the East Flower Garden (EFGB), West Flower Garden (WFGB), Jakkula, Sidner, Alderdice, Bright, McGrail, and Sonnier Banks. Results from the SSE submersible surveys at Alderdice, McGrail, and Sonnier Banks are reported herein, due to the more extensive surveys conducted at these features.

Materials and methods

The SSE dives were conducted using Nuytco Research Ltd's Deepworker 2000 (DW2000) and Deep Rover (DR) submersibles (Fig. 2). Both systems are single-person submersibles—the DW2000 rated to 610 m and DR rated to 1000 m. One of the benefits of these two submersibles is the nearly 360° observation capability afforded to the pilot. Other technology that enhanced the capabilities of the submersibles during the SSE missions included accurate underwater tracking using the ORE International 4410C Track Point II with the Winfrog integrated navigation package, underwater communication, and high resolution digital video and still camera.

Submersible surveys were conducted along selected waypoints based on reef topography to survey as much hard bottom habitat as possible during each dive. Reef fishes and macroinvertebrates were only counted during segments where the field of view was illuminated and the submersible maintained close contact to the bottom. Numbers of individuals for schooling species were estimated based on paused still frames and extrapolated to the entire school. Fishes were identified to the lowest possible taxon following Humann and DeLoach (2002), based on the taxonomic nomenclature of Robins et al. (1991). Trophic categories were assigned based on dietary information from Randall (1967), Smith-Vaniz et al. (1999), or Bullock and Smith (1991) for individual species or closely related taxa.

[1] USGS (United States Geological Survey). 2002. Multibeam Bathymetry Mapping of the Northwestern Gulf of Mexico. http://walrus.wr.usgs.gov/pacmaps/wg-index.html. [Accessed 14 August 2005].



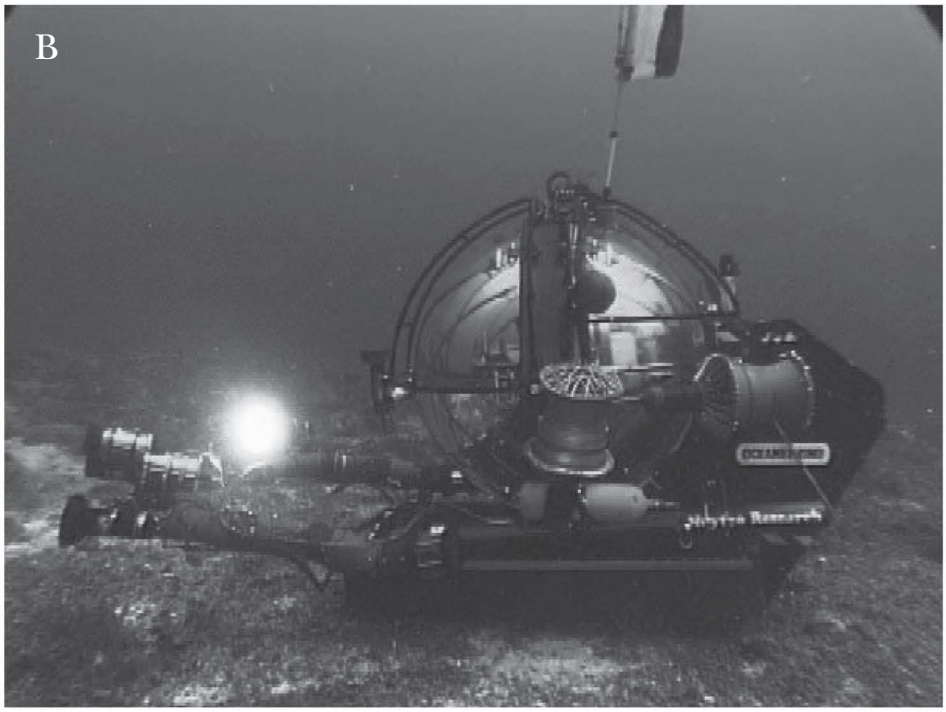


Figure 2

Submersibles used during SSE2002. A) Deepworker 2000, piloted by G.P. Schmahl during SSE Dive A20-185 at McGrail Bank. B) Deep Rover, piloted by Kip Evans, during SSE Dive A20-186 at McGrail Bank. Photograph and still image by Kip Evans, NGS, and G. P. Schmahl, FGBNMS.

Table 1
Submersible dives conducted at Sonnier, McGrail, and Alderdice Banks.

SSE dive no.	Bank	Submersible	Pilot	Depth range (m)	Survey duration	Track length (km)	Habitats observed
A20-179	Alderdice	Deep Worker	D. Weaver	62–73	5.6 hours	1.1	basalt spires, drowned reef zone
A20-180	Alderdice	Deep Worker	G. Schmahl	62–90	4.2 hours	0.9	basalt spires, algal nodule-sponge zone
A20-181	Alderdice	Deep Worker	E. Hickerson	68–85	4.3 hours	1.3	Algal nodule sponge zone
A20-184	McGrail	Deep Worker	G. Schmahl	45–78	5.2 hours	1.7	Coral cap, algal nodule-sponge zone
A20-185	McGrail	Deep Rover	K. Evans	45–85	5.5 hours	2.5	Coral cap, algal nodule-sponge zone
A20-186	Sonnier	Deep Worker	D. Weaver	19–60	3.2 hours	2.1	*Millepora*-sponge zone, drowned reef zone

The submersible dives were facilitated by the availability of detailed multibeam bathymetry collected during June 2002. A Konsberg Simrad EM1000 high resolution multibeam echosounder was used to map the seafloor at specific features, following hydrographic standards.[1] The multibeam surveys were conducted and data analyzed by James Gardner (Univ. of New Hampshire, formerly of USGS, Menlo Park). Resulting data were gridded at 5 m resolution and used to produce georeferenced images and 3D visualizations. Discussion of the earlier bathymetric surveys conducted within the FGBNMS is presented in Gardner et al. (1998), and data from those surveys are also available[1].

Base maps were used to guide submersible operations as part of the SSE mission to the northern Gulf of Mexico during 24 July–6 August 2002, co-sponsored by NGS and NOAA. Submersible dives were conducted using the Deepworker 2000 and Deep Rover submersibles aboard the Oceaneering International, Inc. M/V OCEAN PROJECT.

Bathymetry maps were geo-referenced in ArcView GIS (Version 3.2, Environmental Research Systems Institute, Redlands, CA), and used to plot waypoints for submersible transects. Submersible position was continuously logged during dives, and dive tracks were later superimposed on bathymetry to identify location of video surveys.

Results

Six submersible dives were conducted at the three study sites, focusing on hard bottom communities and high profile reef structures. Three submersible dives were made on the basalt spire features and large mound of Alderdice Bank (Table 1). Two dives were conducted around the coral cap region of McGrail Bank, while a single submersible transect was conducted at Sonnier Bank (Fig. 3). Depths surveyed at Sonnier Banks ranged from 19 to 60 m, McGrail Bank 45–85 m, and Alderdice Bank 62–90 m. Sonnier Banks were characterized by *Millepora*-sponge and drowned reef habitats, while McGrail and Alderdice transects were dominated by algal nodule-sponge communities (Table 1).

One hundred and twenty (120) fishes were observed in association with the deep reef communities of the three banks (Appendix A). McGrail Bank had the highest observed species richness (78 species), followed by Sonnier Banks (77), and Alderdice Bank (68). A total of 40,724 fishes were counted from submersible videotape from submersible dives (Table 2).

The top 25 species observed on each bank are presented in Table 3. Planktivorous fishes dominated the reef communities of all three banks, but different taxa were numerically abundant at each location. Sonnier Bank reef fish populations are dominated by the yellowtail reeffish (*Chromis enchrysura)*, creole-fish (*Paranthias furcifer)*, and brown chromis (*Chromis mulilineata)*. McGrail Bank reef fish populations are dominated by *P. furcifer*, the threadnose bass (*Anthias tenuis*), and the yellow goatfish (*Mulloidichthys martinicis*). In contrast, Alderdice Bank is dominated by the roughtongue bass (*Pronotogrammus martinicensis*), *C. enchrysura*, and *P. furcifer*.

Planktivorous fishes constituted over 81.4% by number at each bank, ranging from 81.6% at Sonnier Banks to 94.3% at Alderdice Bank. The remaining categories comprised less than 10%, with the exception of benthic carnivores at Sonnier Banks and McGrail Bank, represented by large populations of tomtate (*Haemulon aurolineatum*) and yellow goatfish, respectively. Benthic carnivores represented the second most abundant tro-

phic guild on each bank. Epibenthic browsers, including invertebrate browsers such as pomacanthids and chaetodontids, declined in number from Sonnier Banks (4.5%) to McGrail (1.6%) to Alderdice (0.5%). Herbivores also decreased in this order, and herbivores such as scarids and acanthurids made up 0.6% at Sonnier, 0.3% at McGrail, and 0.1% at Alderdice. Generalized carnivores also followed this general pattern. In contrast, piscivores exhibited a slight increase from 0.9% at Sonnier Banks to 1.6% at McGrail Bank to 1.9% at Alderdice Bank.

Sonnier Banks

High-resolution multibeam bathymetry of the Sonnier Banks reveals up to at least a dozen additional lower

Table 2

Reef fishes by trophic category at Sonnier, McGrail, and Alderdice Banks. Numbers of individuals observed during video surveys are given.

	Sonnier Banks		McGrail Bank		Alderdice Bank		Totals	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Planktivores	6284	81.4	12,465	81.6	16,717	94.3	35,466	87.1
Piscivores	68	0.9	249	1.6	335	1.9	652	1.6
General carnivores	351	4.5	218	1.4	226	1.3	795	2.0
Herbivores	49	0.6	39	0.3	11	0.1	99	0.2
Epibenthic browsers	350	4.5	237	1.6	97	0.5	783	1.9
Benthic carnivores	615	8.0	2067	13.5	346	2.0	3028	7.4
Totals	7717	100.0	15,275	100.0	17,732	100.0	40,724	100.0

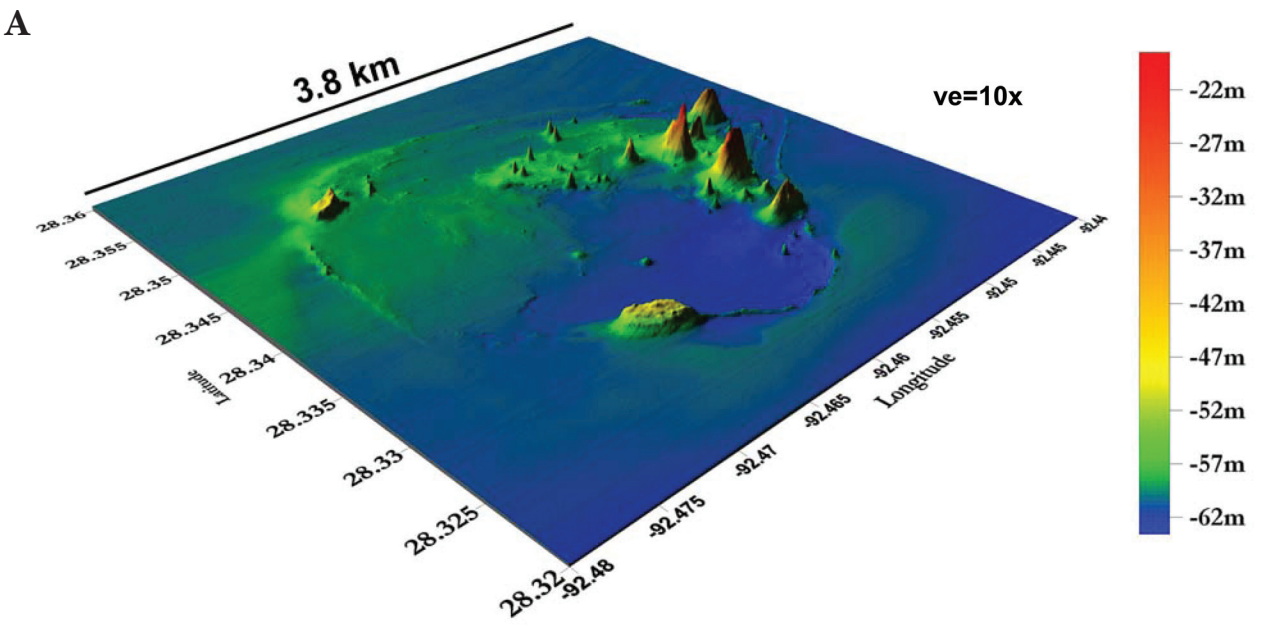
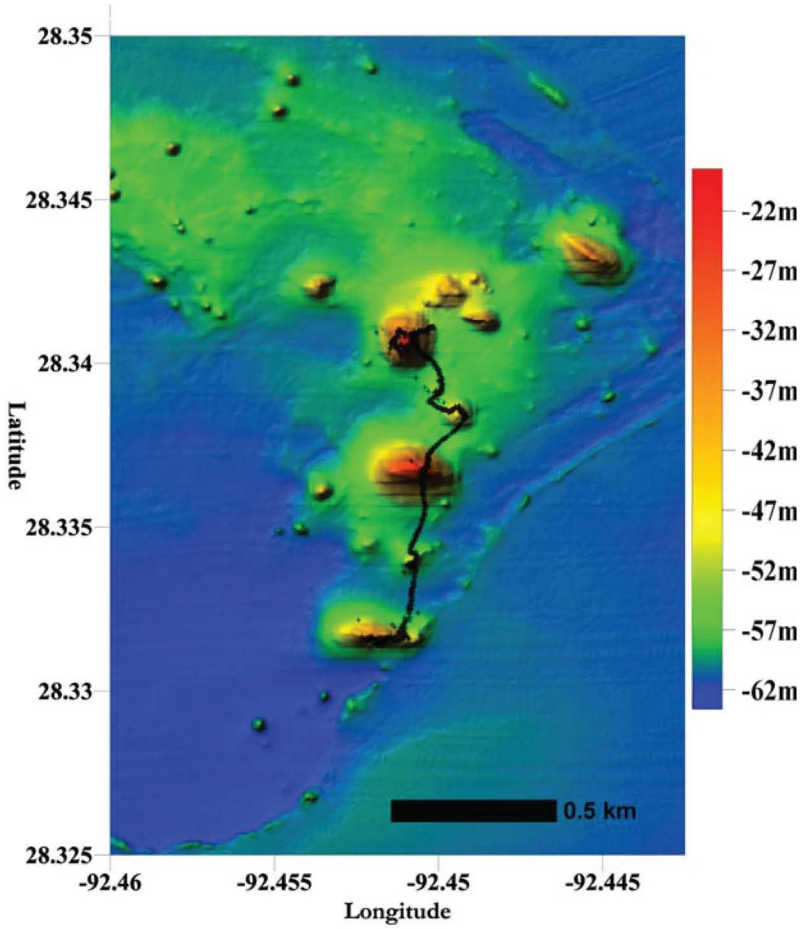


Figure 3

A) Multibeam bathymetry map of Sonnier Banks, oblique view (bathymetry data courtesy James Gardner, University of New Hampshire, Center for Coastal and Ocean Mapping, 24 Colovos Road, Durham, NH 03824). Submersible surveys were conducted on *Millepora*-sponge zones and drowned reef areas as part of the Sustainable Seas Expeditions during July–August 2002. B) Plan view (ve=vertical exaggeration) of Sonnier Banks (bathymetry data courtesy James Gardner). C) A still video frame of the Millepora-Sponge cap at Sonnier Banks, with a queen angelfish, *Holacanthus ciliaris*. Assorted sponges and *Millepora* (tan in color) are present.

B



C

Figure 3 (continued)

Table 3

Top 25 fish species observed during submersible surveys of Sonnier, McGrail, and Alderdice Banks during SSE2002. Dominance rank is based on numerical abundance from videotaped ROV surveys. Trophic categories are based on dietary studies of Randall (1967) or Bullock and Smith (1991).

			Sonnier Banks		McGrail Bank		Alderdice Bank	
Species ID	Common name	Trophic guild[1]	Rank	Percent	Rank	Percent	Rank	Percent
Chromis enchrysura	yellowtail reeffish	PL	1	23.1	5	6.19	2	24.61
Paranthias furcifer	creole-fish	PL	2	17.7	1	43.3	3	18.49
Chromis multilineatus	brown chromis	PL	3	13.6	12	0.58	—	—
Chromis insolata	sunshine fish	PL	4	6.36	4	7.64	5	5.67
Thallasoma bifasciatum	bluehead	PL	5	5.73	18	0.22	24	0.07
Haemulon aurolineatum	tomtate	GC	6	5.55	—	—	—	—
Chromis scotti	purple reeffish	PL	7	5.34	10	0.69	8	0.97
Stegastes variabilis	cocoa damselfish	H	8	2.80	—	—	—	—
Clepticus parrae	creole wrasse	PL	9	2.34	15	0.48	14	0.19
Stegastes partitus	bicolor damselfish	FL	10	2.03	7	1.04	—	—
Kyphosus sp.	Bermuda/yellow chub	PL	11	1.80	—	—	—	—
Rhomboplites aurorubens	vermilion snapper	PL	12	1.42	—	—	6	3.29
Balistes capriscus	gray triggerfish	BC	13	1.03	—	—	—	—
Lutjanus griseus	gray snapper	GC	14	1.03	9	0.73	9	0.52
Lutjanus campechanus	red snapper	GC	15	0.90	—	—	—	—
Bodianus pulchellus	spotfin hogfish	GC	16	0.66	21	0.18	10	0.42
Bodianus rufus	Spanish hogfish	GC	17	0.58	24	0.14	—	—
Lutjanus buccanella	blackfin snapper	GC	18	0.55	—	—	—	—
Abudefduf saxatalis	sergeant major	PL	19	0.53	—	—	—	—
Myripristis jacobus	blackbar soldierfish	PL	20	0.40	—	—	—	—
Chaetodon sedentarius	reef butterflyfish	EB	21	0.32	13	0.54	13	0.28
Ptereleotris calliurus	blue goby	PL	22	0.28	—	—	—	—
Epinephelus adscensionis	rock hind	GC	23	0.27	—	—	—	—
Canthigaster rostrata	sharpnose puffer	EB	24	0.25	—	—	—	—
Holacanthus tricolor	rock beauty	EB	25	0.25	—	—	22	0.08
Mulloidichthys martinicus	yellow goatfish	BC	26	0.25	3	13.0	7	1.60
Halichoeres bathyphilus	greenband wrasse	BC	28	0.24	—	—	25	0.06
Holacanthus bermudensis	blue angelfish	EB	29	0.23	—	—	23	0.07
Mycteroperca interstitialis	yellowmouth grouper	PI	33	0.18	20	0.19	15	0.17
Caranx latus	horse-eye jack	PI	34	0.16	14	0.53	—	—
Pareques umbrosus	cubbyu	BC	36	0.16	—	—	18	0.10
Chromis cyanea	blue chromis	PL	38	0.15	8	0.93	—	—
Pseudupeneus maculates	spotted goatfish	BC	39	0.15	—	—	20	0.09
Sparisoma atomarium	greenblotch parrotfish	H	42	0.14	23	0.15	—	—
Seriola dumerili	greater amberjack	PI	44	0.12	—	—	11	0.30
Holocentrus rufus	longfin squirrelfish	PL	45	0.11	22	0.18	—	—
Anthias tenuis	threadnose bass	PL	—	—	2	17.9	4	13.13
Apogon affinis	bigtooth cardinalfish	PL	—	—	—	—	12	0.29
Aulostomus maculates	trumpetfish	PI	—	—	—	—	16	0.14
Caranx bartholomaei	yellow jack	PI	—	—	17	0.24	—	—
Caranx hippos	crevalle jack	PI	—	—	19	0.19	—	—
Centropyge argi	pygmy angelfish	EB	—	—	11	0.62	—	—
Chaetodon aya	bank butterflyfish	PL	—	—	—	—	17	0.10
Gonioplectrus hispanus	Spanish flag	PI	—	—	—	—	19	0.09
Pronotogrammus martinicensis	roughtongue bass	PL	—	—	16	0.48	1	28.45
Schultzea beta	school bass	PL	—	—	6	1.43	—	—
Seriola rivoliana	almaco jack	PI	—	—	—	—	21	0.09

[1] BC-Benthic carnivores (benthic crustaceans and infauma), EB-Epibenthic browsers (sessile invertebrates), GC-General carnivore (mobile invertebrates and fishes), H-Herbivore, PL-Planktivore, PI-Piscivore (fishes and cephalopods).

relief peaks associated with the feature, ranging in depth from 18 to 55 m (Fig. 3). Deeper peaks surveyed during the SSE mission had reduced coverage of fire coral and a more extensive and diverse community of encrusting and massive sponges.

The 2002 SSE submersible dive covered three of the major peaks and two of the lower relief peaks. No additional species of hermatypic coral were observed during these surveys. *Astropyga magnifica*, a deep water echinoid, was observed in crevices along the rocky reef slopes in 2002. Submersible investigations revealed a diverse assemblage of fishes and invertebrates, from the species-rich reef fish assemblages on the *Millepora* sponge zones associated with the two shallowest banks, to species-depauperate drowned reef assemblages on the smaller features within the region (Fig. 3). Results of our surveys indicate unique biological assemblages associated with each bank within the region, related to the depth of the bank crest and the extent of the turbid Nepheloid Zone, which was encountered over surrounding soft bottom areas at each peak during submersible surveys.

Reef fishes observed at Sonnier were numerically dominated by planktivores, representing the top five species, eight of the top ten numerically abundant species. In addition to *C. enchrysura*, *P. furcifer*, and *C. multilineatus*, the sunshinefish (*Chromis insolata*) and bluehead (*Thallasoma bifasciata*) were next most abundant. Dense schools of planktivores, including *P. furcifer*, *C. multilineata*, *T. bifasciata*, and creole wrasse (*Clepticus parrae*), characterize the shallow crest areas of the larger peaks. Deeper reef communities were characterized by an assemblage of *H. aurolineatum*, red snapper (*L. campechanus*), greater amberjack (*Seriola dumerili*), and gray triggerfish (*Balistes capriscus*). Soft bottom regions surrounding the main peaks had few fishes, with the exception of the blue goby (*Ptereleotris calliurus*), living in burrows in the circum-reef talus zones, and tattler (*Serranus phoebe*), associated with talus zones and carbonate debris surrounding hard bottom features.

McGrail Bank

Submersible surveys conducted during SSE on McGrail Bank revealed extensive growth of a hard coral community dominated by *S. intersepta*, large brain corals (*Diploria strigosa*), *M. cavernosa*, and a species of *Agaricia*. Estimated coral coverage reached 30% in some areas, at a depth range of 45 m–60 m, while the base of the bank is approximately 85 m (Fig. 4A). Two SSE 2002 submersible dives targeted the crest of the southernmost ridge to identify the extent of the deep coral reef community. In addition to these four previously documented species of hermatypic corals, a 2 m tall colony of *Diploria strigosa* was noted, as was a more extensive *S. intersepta* reef than previously described. One reef site (45–60 m depth range)—a crest approximately 0.07 km^2 (0.40 km × 0.28 km), was documented to be populated by up to 30% coverage of *S. intersepta* coral heads, averaging 1m width × 0.75 m tall (Fig. 4B). Numerous heads reached upwards of 2 m in height. In addition to the *S. intersepta* colonies, numerous 1–2 m tall *M. cavernosa* colonies were encountered.

Reef fishes observed at McGrail Bank were overwhelmingly dominated by *P. furcifer*, which made up almost half of the individuals observed (43%). Threadnose bass comprised 18% of fishes observed, followed by the yellow goatfish. The occurrence of a large school of goatfish has not been previously reported in the literature. While this species was observed on all three banks, they were in much lower abundance at Alderdice and Sonnier Banks. Sunshinefish (*C. insolata*), school bass (*Schultzea beta*), bicolor damselfish (*Stegastes partitus*), and the blue chromis (*Chromis cyanea*), were the next most dominant reef fish taxa, and all are planktivorous. McGrail Bank lacked many of the species associated with the turbid drowned reef areas of Sonnier Bank, including *H. aurolineatum* and *L. campechanus*.

A notable observation made during the submersible surveys is that up to five aggregations of longspine urchins (*Astropyga magnifica*) were encountered in the sandy valley between the ridges of McGrail Bank. These aggregations were made up of at least 100 individuals. Associated with each aggregation were upwards of six juvenile marbled grouper (*Dermatolepis inermis*) individuals to each *A. magnifica* aggregation (Fig. 4A).

Alderdice Bank

While previous bathymetric surveys of the area identified a single "spire" at Alderdice Bank, the multibeam data set resolved two distinct spires with associated talus fields (Fig. 5). The second basalt spire is located approximately 220 m NNE of the outcropping described by Rezak and Tieh (1984). Both spires provide high profile structure that attracts large schools of creole-fish, vermilion snapper (*Rhomboplites aurorubens*), and several species of grouper, snapper, and jacks. In 2002, the original basalt feature was surveyed and characterized by a similar biota as originally described by Rezak et al. (1985). Through direction from a topside navigation technician, the submersible pilot was able to navigate both of the spires, confirming that the second feature was indeed an additional basalt outcrop (Figs. 5A, B).

Reef fishes observed at Alderdice Bank were overwhelmingly dominated by roughtongue bass, with yellowtail reeffish and creole-fish also dominating the reef fish community. These three species made up over 71% of the individual fishes observed. A notable observation during the SSE mission is the occurrence of the rare marbled grouper (*Dermatolepis inermis*), both at

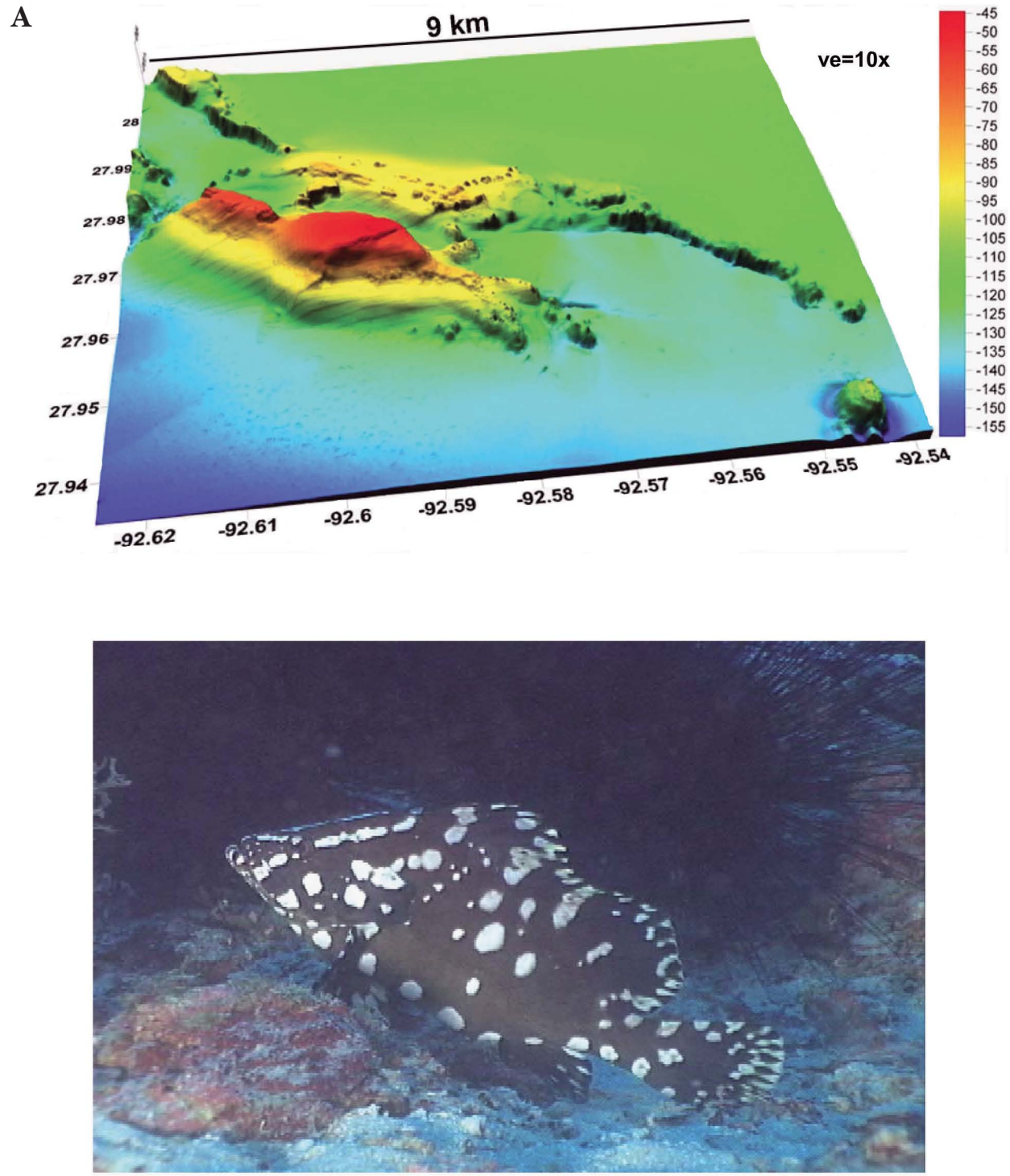


Figure 4

A) Top: Multibeam bathymetry map of McGrail Banks, oblique view (bathymetry data courtesy James Gardner; see Fig. 3 for contact info.). Bottom: Marble grouper, *Dermatolepis inermis*, resting at the base of sea urchin aggregation. B) Extensive growth of hard corals, including *Stephanocoenia, Montastraea,* and *Diploria* spp., on the summits of the bank were documented during submersible surveys during the Sustainable Seas Expedition during summer 2002. Video still courtesy SSE.

B

Figure 4 (continued)

the basalt outcroppings and the eastern algal/sponge mound.

Discussion

Reef fishes of the northwestern Gulf of Mexico, as previous authors have noted, are represented by a tropical assemblage on mid to outer shelf banks where suitable habitat occurs (Rezak et al., 1985, 1990; Dennis and Bright, 1988a). Results of this survey provide the first detailed look at reef fish communities associated with the chosen features using modern submersibles, and identify differences among the fish communities associated with their unique benthic assemblages. The number of reef-associated species at each bank was very similar, ranging from 68 at Sonnier Banks to 78 at McGrail Bank. While total species richness was similar, the numerically dominant taxa vary between sites and reflect the distribution of habitat at each of the chosen study sites. Sonnier Banks are comprised of steep sided, relatively flat-topped features that have limited talus aprons and shallow peaks. The predominance of *Millepora*-sponge zones on the shallow peaks of the main features is reflected in the abundance of creole-fish, creole wrasse, brown chromis, and other planktivores that typically associate with the shallow crests of other reefs and banks in the Gulf of Mexico, such at East Flower Garden Bank, West Flower Garden Bank, and Stetson Bank (Rezak et al., 1985; Pattengill-Semmens et al., 1997). Sonnier Banks also have limited deep reef habitat, due to the dominance of a nepheloid layer at the deeper areas surrounding the main peaks (Rezak et al., 1990). This results in extensive soft bottom communities around the banks, a lack of algal nodule-sponge zones, and limited distribution of partly drowned and drowned reef structures and associated reef fish communities.

In addition to general comments on the reef fish community at McGrail Bank, Rezak et al. (1985) noted significant populations of common black sea urchins (*Diadema* sp.) and spiny lobsters (*Panulirus* sp.) occurring on the ledges and along the slopes of many of the shelf edge banks. These observations are inconsistent with the 2002 observations. This can be accounted in part by the well-documented Caribbean-wide mass die-

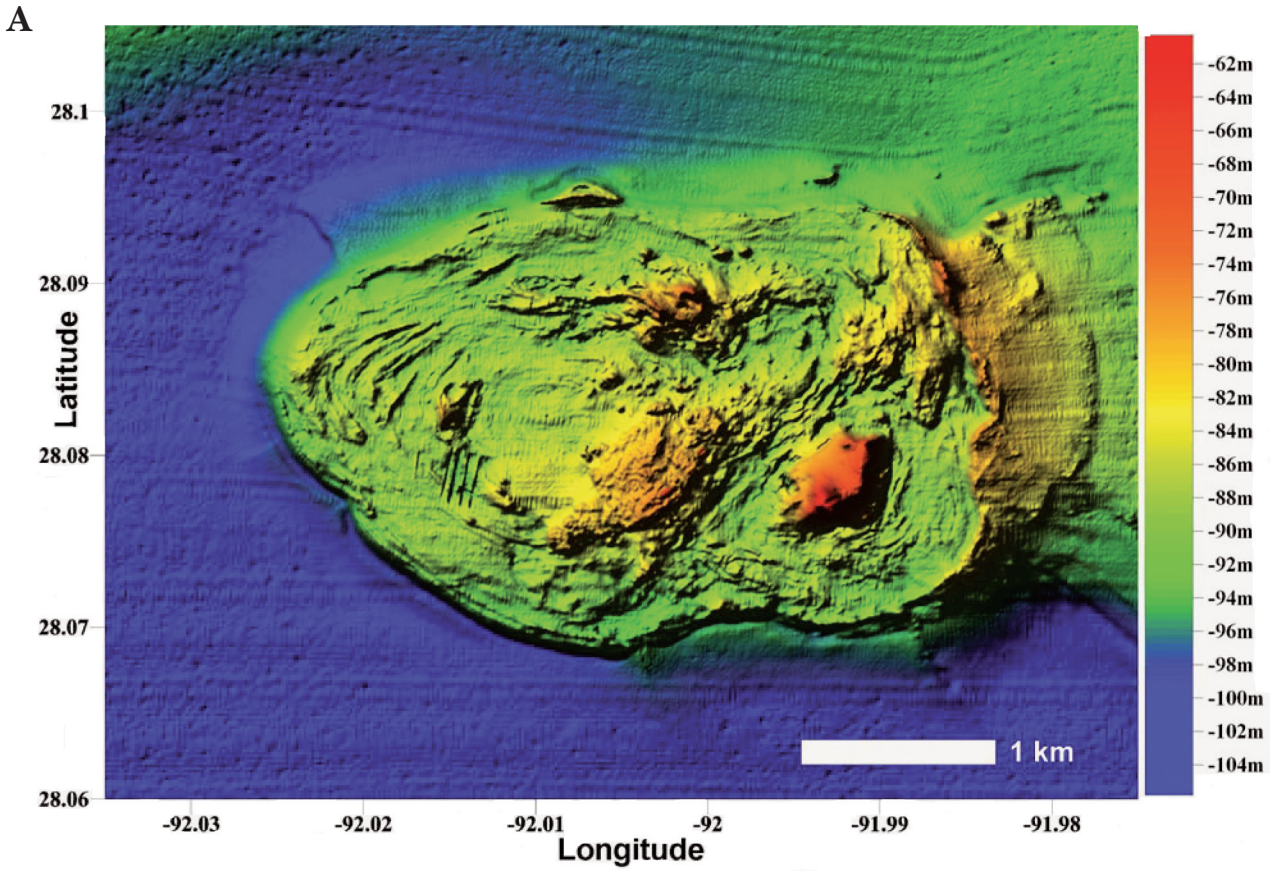


Figure 5

A) Multibeam bathymetry map of Alderdice Bank, plan view. B) Multibeam bathymetry, oblique view (ve=vertical exaggeration) of basalt spires and isolated mound (bathymetry data courtesy James Gardner, see Fig. 3 for contact info.). C) A school of roughtongue bass, *Pronotogrammus martinicensis*, the most abundant species observed at Alderdice Bank. This small, planktivorous sea bass is one of the most common members of the deep reef fish community, and a common prey species of groupers and snappers. Photograph courtesy FGBNMS/NURC-UNCW.

off of *D. antillarum* in the early 1980s (Lessios et al., 1984). This die-off was reported at the Flower Garden Banks NMS in 1984 (Gittings and Hickerson, 1998). Spiny lobster observations were rare in 2002, with a total of three individuals observed on all three banks during submersible dives.

Observations of biological communities at Alderdice Bank were very similar to those reported in the earlier studies. Both basalt spires appear abruptly out of the soft bottom sediments, and the rock surfaces are clearly visible. Rezak and Tieh (1984) speculated that the uplifting of the basalt is a geologically recent occurrence, based on the lack of growth on the basalt blocks. The 2002 observations of the basalt spires gave no indication that growth on the blocks had increased significantly in the 25 years since the last observations. Additional dives on the eastern algal/sponge mound revealed comparable biological assemblages as reported by Rezak et al. (1985). Rezak et al. (1985) report encountering an exceptionally large number of yellowtail reeffish (*Chromis enchrysura*) on the basalt peak—this is consistent with observations made on the eastern algal/sponge mound in 2002

The domination of planktivores in the deep reef fish community is both a regional and worldwide pattern (Thresher and Colin, 1986; Hamner et al., 1988). Pattengill-Semmens et al. (1997) reported planktivores to be the dominant trophic guild on Stetson Bank and the East and West Flower Garden Banks. Percentages of planktivores were lower in their study (36 to 73%), reflecting the shallower depths surveyed by SCUBA, limited to the shallow crests of each bank. Deep-water reef fishes at Enewetak, Marshall Islands (Thresher and Colin, 1986), became dominated by planktivores and piscivores

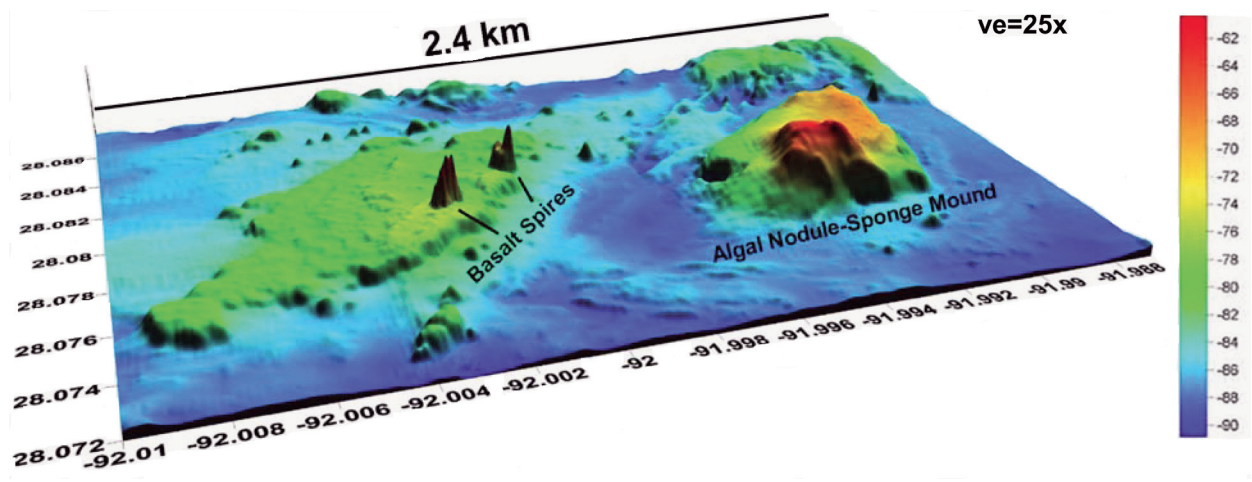


Figure 5 (continued)

with increasing depths between 90 and 120 m, and were numerically dominated by anthiine serranids (streamer basses), and the pomacentrids (*Chromis* spp.). The results of our study directly parallel this pattern, as planktivores became increasingly abundant on the deeper reef site (Alderdice), and were also numerically dominated by anthiine serranids (*A. tenuis* and *P. martinicensis*) and planktivorous damselfishes (*Chromis* spp.). Planktivores abundant on the shallower peaks of Sonnier Bank, T. *bifasciata*, *C. multilineata*, and *S. partitus*, decreased in abundance at Alderdice Bank, and were replaced by *P. martinicensis* and *A. tenuis*, two species that dominate other deepwater areas of the Flower Garden Banks National Marine Sanctuary (Dennis and Bright, 1988a).

Dennis and Bright (1988a) reported three distinct reef fish assemblages based on cluster analysis, a *Millepora*-sponge community associated with the crest of mid-shelf banks, an algal nodule-sponge fish assemblage, and a drowned reef fish assemblage. These categories are the dominant habitats characterizing Sonnier, McGrail, and Alderdice Banks, respectively, and results of this study parallel those observed by these authors on previous submersible dives. While Dennis and Bright (1988a) did not provide an extensive species list for each of the banks surveyed, their observations of reef fish/habitat associations remain valid. Increased resolution of video cameras, including zoom capabilities and clarity of digital videotape, allows for identification of a larger component of the reef fish fauna, including smaller cryptic species such as juvenile anthiines, blennies, and gobies. Many of the species observed here, including the roughtongue bass (*P. martinicensis*), have only recently been reported to occur in the NWGOM, and the threadnose bass (*A. tenuis*) has not previously been reported to occur in our area (Dennis and Bright, 1988a, b). Recent deepwater surveys at the Flower Garden Banks NMS have indicated that it is one of the most abundant species in the deep reef community between 50 and 100 m.

Rezak et al. (1990) comment on the similarity of geology and biological communities of Sonnier and Stetson Banks. Submersible observations conducted during 2002 SSE surveys support this observation, and provides data on habitat distribution and fish community structure to compare to ongoing surveys being conducted by FGBNMS staff at Stetson Bank. Dennis and Bright (1988a) reported the unique reef fish assemblage associated with the bank crests of the *Millepora* sponge zone. On the Pacific Coast, Yoklavich et al. (2000) found higher numbers of rockfishes associated with abrupt, steep sided rock features surrounded by mud and sand habitats. Both Sonnier Banks and Alderdice Bank are characterized by steep sided rocky features surrounded by relatively flat soft bottom communities. Bohnsack (1989) commented on the behavioral attraction that many fishes have for high profile rocky structure, and that as a result they aggregate in large numbers. High numbers of reef fishes, both small and large species, were observed at the crests of all three banks.

In general, the observations made between the historical surveys and the 2002 SSE mission are similar. The fish assemblages in 2002 appear to be similar to those observed in earlier surveys, although large schools of yellow goatfish that were documented in the 2002 surveys were not listed as representative assemblages in the earlier surveys at any of the shelf edge features. Variations are noted, but do not indicate deterioration of habitat or major shift in associated biological communities. The three banks under discussion were identified as areas warranting regulatory action through MMS, in regards to oil and gas development. These areas are potential ecological and biological significance, harboring juvenile populations of grouper, recovering populations of the long-spine urchins, and hermatypic deep coral reefs. These reefs and banks have also been adopted by the Gulf of Mexico Fisheries Management Council as Habitat Areas of Particular Concern (HAPC). No regulations are currently in place to protect Sonnier and Alderice from over-fishing, anchoring, or excavation. Designation of McGrail Bank as a Coral HAPC zone prohibits trawling, bottom longlines, deployment of fish traps, and bottom anchoring.

The availability of accurate, high-resolution bathymetric base maps has allowed the development of comprehensive datasets that can be integrated via a GIS database. The FGBNMS multidisciplinary effort to characterize the reefs and banks of the NWGOM continues to benefit through partnerships such as SSE, and through the advancement of the available technology. While our studies were exploratory in nature, the basic patterns of habitat distribution and reef fish assemblages will allow more rigorous, quantitative surveys of reef fish densities and habitat association during future studies. Information on habitat distribution and associated biological assemblages is also being used to revise the current benthic habitat scheme for the reefs and banks of the NWGOM, including the Flower Garden Banks National Marine Sanctuary. The data acquired will be used to make well-informed management decisions regarding the diverse biological resources of the Northwestern Gulf of Mexico.

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Appendix A

Fishes observed during SSE2002 Submersible Dives at Sonnier, McGrail, and Alderdice Banks.

Family / Species	Common name	Trophic guild[1]	Sonnier Banks			McGrail Bank			Alderdice Bank		
			Rank	No.	Percent	Rank	No.	Percent	Rank	No.	Percent
Acanthuridae											
Acanthurus chirurgus	doctorfish	EB	27	19	0.25	36	9	0.06	31	8	0.05
Acanthurus coeruleus	blue tang	EB	52	5	0.06	—	2	—	—	—	—
Apogonidae											
Apogon affinis	bigtooth cardinalfish	PL	—	—	—	—	—	—	13	50	0.29
Apogon maculatus	flamefish	PL	57	3	0.04	54	3	0.02	—	—	—
Apogon psuedomaculatus	twospot cardinalfish	PL	60	2	0.03	—	—	—	—	—	—
Aulostomidae											
Aulostomus maculatus	trumpetfish	PI	—	—	—	—	—	—	17	25	0.14
Balistidae											
Balistes capriscus	gray triggerfish	BC	13	80	1.04	27	19	0.12	28	10	0.06
Balistes vetula	queen triggerfish	BC	—	—	—	44	6	0.04			
Cantherhines macrocerus	whitespotted filefish	EB	—	—	—	38	8	0.05	56	1	0.01
Cantherhines pullus	orangespotted filefish	EB	—	—	—	—	—	—	55	1	0.01
Canthidermis sufflamen	ocean triggerfish	PL	—	—	—	29	18	0.12	—	—	—
Xanthichtys ringens	sargassum triggerfish	PL	42	7	0.05	—	—	—	—	—	—
Blenniidae											
Parablennius marmoreus	seaweed blenny	EB	59	3	0.04	—	—	—	—	—	—
Carangidae											
Alectis ciliaris	African pompano	PI	53	5	0.06	—	—	—	—	—	—
Caranx bartholomaei	yellow jack	PI	—	—	—	17	38	0.25	39	4	0.02
Caranx chrysos	blue runner	PL	54	4	0.05	—	—	—	—	—	—
Caranx hippos	crevalle jack	PI	—	—	—	19	30	0.20	—	—	—
Caranx latus	horse-eye jack	PI	34	13	0.17	14	81	0.53	—	—	—
Caranx lugubris	black jack	PI	—	—	—	39	8	0.05	—	—	—
Caranx ruber	bar jack	PI	40	11	0.14	30	17	0.11	—	—	—
Selene vomer	lookdown	GC	56	4	0.05	—	—	—	—	—	—
Seriola dumerili	greater amberjack	PI	44	10	0.13	35	10	0.07	12	53	0.30
Seriola rivoliana	almaco jack	PI	—	—	—	34	11	0.07	22	16	0.09
Carcharhinidae											
Carcharhinus plumbeus	sandbar shark	PI	50	6	0.08	59	2	0.01	58	1	0.01
Carcharhinus sp.		PI	—	—	—	64	1	0.01	—	—	—
Chaetodontidae											
Chaetodon aculeatus	longsnout butterflyfish	EB	—	—	—	45	6	0.04	59	1	0.10
Chaetodon aya	bank butterflyfish	PL	—	—	—	—	—	—	18	18	0.10
Chaetodon ocellatus	spotfin butterflyfish	EB	61	2	0.03	66	1	0.01	60	1	0.01
Chaetodon sedentarius	reef butterflyfish	EB	21	25	0.32	13	84	0.55	14	49	0.28
Clinidae											
Starksia sp.	unidentified blenny	BC	77	1	0.01	—	—	—	—	—	—

continued

Appendix A (continued)

Family Species	Common name	Trophic guild[1]	Sonnier Banks			McGrail Bank			Alderdice Bank		
			Rank	No.	Percent	Rank	No.	Percent	Rank	No.	Percent
Congridae											
Conger oceanicus	conger eel	GC	—	—	—	—	—	—	61	1	0.01
Dasyatidae											
Dasyatis americana	southern stingray	GC	—	—	—	—	—	—	62	1	0.01
Echeneidae											
Echeneis naucrates	sharksucker	GC	69	1	0.01	—	—	—	—	—	—
Gobiidae											
Gnatholepis thompsoni	goldspot goby	BC	63	2	0.03	49	5	0.03	—	—	—
Gobiidae	unidentified gobies	BC	32	16	0.21	—	—	—	—	—	—
Gobiosoma xanthiprora	prownose goby	BC	47	7	0.09	68	1	0.01	—	—	—
Ptereleotris calliurus	blue goby	PL	22	22	0.29	—	—	—	—	—	—
Haemulidae											
Haemulon aurolineatum	tomtate	GC	6	428	5.55	—	—	—	—	—	—
Holocentridae											
Corniger spinosus	spinycheek soldierfish	GC	—	—	—	—	—	—	44	2	0.01
Holocentrus adscensionis	squirrelfish	PL	43	10	0.13	46	6	0.04	49	2	0.01
Holocentrus rufus	longfin squirrelfish	PL	45	9	0.12	22	28	0.18	65	1	0.01
Myripristis jacobus	blackbar soldierfish	PL	20	31	0.40	28	19	0.12	33	8	0.05
Sargocentron bullisi	deepwater squirrelfish	PL	66	2	0.03	75	1	0.01	38	5	0.03
Kyphosidae											
Kyphosus sp.	Bermuda/yellow chub	PL	11	139	1.80	—	—	—	—	—	—
Labridae											
Bodianus pulchellus	spotfin hogfish	GC	16	51	0.66	21	28	0.18	11	73	0.42
Bodianus rufus	Spanish hogfish	GC	17	45	0.58	24	22	0.14	54	1	0.01
Clepticus parrae	creole wrasse	PL	9	181	2.35	15	74	0.48	15	34	0.19
Decodon puellaris	red hogfish	BC	—	—	—	—	—	—	45	2	0.01
Halichoeres bathyphilus	greenband wrasse	BC	28	19	0.25	—	—	—	26	11	0.06
Halichoeres bivitattus	slippery dick	BC	41	11	0.14	—	—	—	—	—	—
Halichoeres garnoti	yellowhead wrasse	BC	—	—	—	37	9	0.06	47	2	0.01
Halichoeres maculipinna	clown wrasse	BC	—	—	—	56	3	0.02	—	—	—
Thallasoma bifasciatum	bluehead	PL	5	442	5.73	18	35	0.23	25	12	0.07
Lutjanidae											
Lutjanus buccanella	blackfin snapper	GC	18	43	0.56	—	—	—	41	3	0.02
Lutjanus campechanus	red snapper	GC	15	70	0.91	—	—	—	29	10	0.06
Lutjanus cyanopterus	cubera snapper	PI	—	—	—	71	1	0.01	—	—	—
Lutjanus griseus	gray snapper	GC	14	80	1.04	9	112	0.73	10	91	0.52
Lutjanus jocu	dog snapper	GC	48	7	0.09	26	20	0.13	30	10	0.06
Lutjanus synagris	lane snapper	GC	55	4	0.05	—	—	—	—	—	—
Ocyurus chrysurus	yellowtail snapper	PL	72	1	0.01	73	1	0.01	—	—	—
Rhomboplites aurorubens	vermilion snapper	PL	12	110	1.43	—	—	—	6	576	3.29

continued

Appendix A (continued)

Family Species	Common name	Trophic guild[1]	Sonnier Banks			McGrail Bank			Alderdice Bank		
			Rank	No.	Percent	Rank	No.	Percent	Rank	No.	Percent
Malacanthidae											
Malacanthus plumieri	sand tilefish	BC	—	—	—	57	3	0.02	66	1	0.01
Mullidae											
Mulloidichthys martinicus	yellow goatfish	BC	26	20	0.26	3	2000	13.09	7	280	1.60
Pseudupeneus maculatus	spotted goatfish	BC	39	12	0.16	31	15	0.10	21	16	0.09
Muraenidae											
Gymnothorax moringa	spotted moray	GC	64	2	0.03	69	1	0.01	—	—	—
Ophichthidae											
Myrichthys breviceps	sharptail eel	GC	—	—	—	—	1	—	—	—	—
Opistognathidae											
Opistognathus aurifrons	yellowhead jawfish	PL	—	—	—	62	2	0.01	—	—	—
Ostraciidae											
Lactophrys triqueter	smooth trunkfish	BC	58	3	0.04	70	1	0.01	—	—	—
Pomacanthidae											
Centropyge argi	pygmy angelfish	EB	—	—	—	11	96	0.63	34	6	0.03
Holacanthus bermudensis	blue angelfish	EB	29	18	0.23	40	8	0.05	24	13	0.07
Holacanthus ciliaris	queen angelfish	EB	35	13	0.17	52	4	0.03	48	2	0.01
Holacanthus tricolor	rock beauty	EB	25	20	0.26	25	22	0.14	23	14	0.08
Pomacanthus paru	French angelfish	EB	30	18	0.23	53	4	0.03	—	—	—
Pomacentridae											
Abudefduf saxatalis	sargeant major	PL	19	41	0.53	—	—	—	—	—	—
Chromis cyanea	blue chromis	PL	38	12	0.16	8	143	0.94	40	3	0.02
Chromis enchrysura	yellowtail reeffish	PL	1	1782	23.11	5	947	6.20	2	4311	24.61
Chromis insolata	sunshinefish	PL	4	491	6.37	4	1168	7.64	5	993	5.67
Chromis multilineatus	brown chromis	PL	3	1055	13.68	12	90	0.59	—	—	—
Chromis scotti	purple reeffish	PL	7	412	5.34	10	106	0.69	9	170	0.97
Stegastes partitus	bicolor damselfish	PL	10	157	2.04	7	159	1.04	—	—	—
Stegastes planifrons	threespot damselfish	EB	31	18	0.23	—	—	—	—	—	—
Stegastes variabilis	cocoa damselfish	EB	8	216	2.80	62	2	0.01	—	—	—
Priacanthidae											
Priacanthus arenatus	bigeye	PL	74	1	0.01	—	—	—	27	11	0.06
Rachycentridae											
Rachycentron canadum	cobia	GC	65	2	0.03	—	—	—	—	—	—
Rhincodontidae											
Ginglymostoma cirratum	nurse shark	GC	70	1	0.01	—	—	—	64	1	0.01
Scaridae											
Cryptotomus roseus	bluelip parrotfish	EB	68	1	0.01	—	—	—	—	—	—
Scaridae	unidentified parrotfish	EB	75	1	0.01	—	—	—	—	—	—
Scarus taeniopterus	princess parrotfish	EB	67	2	0.03	—	—	—	—	—	—
Sparisoma atomarium	greenblotch parrotfish	EB	42	11	0.14	23	23	0.15	42	3	0.02
Sparisoma aurofrenatum	redband parrotfish	EB	49	7	0.09	51	5	0.03	—	—	—

continued

Appendix A (continued)

Family / Species	Common name	Trophic guild[1]	Sonnier Banks			McGrail Bank			Alderdice Bank		
			Rank	No.	Percent	Rank	No.	Percent	Rank	No.	Percent
Sciaenidae											
Equetus punctatus	spotted drum	BC	62	2	0.03	—	—	—	—	—	—
Pareques iwamotoi	blackbar drum	BC	—	—	—	—	—	—	37	5	0.03
Pareques umbrosus	cubbyu	BC	36	13	0.17	—	—	—	19	17	0.10
Scombridae											
Scomberomorus cavalla	king mackerel	PI	—	—	—	—	—	—	8	200	1.14
Serranidae											
Anthias tenuis	threadnose bass	PL	—	—	—	2	2745	17.96	4	2300	13.13
Cephalopholis cruentata	graysby	GC	37	12	0.16	48	5	0.03	—	—	—
Cephalopholis fulva	coney	GC	—	—	—	65	1	0.01	—	—	—
Dermatolepis inermis	Marble grouper	GC	—	—	—	41	7	0.05	46	2	0.01
Epinephelus adscensionis	rock hind	GC	23	21	0.27	67	1	0.01	—	1	0.01
Epinephelus guttatus	red hind	GC	—	—	—	55	3	0.02	—	—	—
Gonioplectrus hispanus	Spanish flag	GC	—	—	—	—	—	—	20	16	0.09
Liopropoma eukrines	wrasse bass	GC	71	1	0.01	—	—	—	36	5	0.03
Mycteroperca bonaci	black grouper	PI	—	—	—	33	11	0.07	50	2	0.01
Mycteroperca interstitialis	yellowmouth grouper	PI	33	14	0.18	20	30	0.20	16	29	0.17
Mycteroperca microlepis	gag	PI	—	—	—	—	—	—	51	2	0.01
Mycteroperca phenax	scamp	PI	46	9	0.12	61	2	0.01	52	2	0.01
Mycteroperca venenosa	yellowfin grouper	PI	—	—	—	50	5	0.03	—	—	—
Paranthias furcifer	creole-fish	PL	2	1370	17.77	1	6625	43.35	3	3239	18.49
Pronotogrammus martinicensis	roughtongue bass	PL	—	—	—	16	74	0.48	1	4984	28.45
Schultzea beta	school bass	PL	—	—	—	6	220	1.44	—	—	—
Serranus annularis	orangeback bass	GC	—	—	—	32	15	0.10	34	6	0.03
Serranus notospilus	saddle bass	GC	76	1	0.01	76	1	0.01	68	1	0.01
Serranus phoebe	tattler	GC	51	6	0.08	77	1	0.01	53	2	0.01
Sparidae											
Calamus sp.		BC	—	—	—	47	5	0.03	43	2	0.01
Pagrus pagrus	red porgy	BC	73	1	0.01	—	—	—	—	—	—
Sphyraenidae											
Sphyraena barracuda	great barracuda	PI	—	—	—	78	1	0.01	—	—	—
Synodontidae											
Synodus intermedius	sand diver	PI	—	—	—	—	—	—	69	1	0.01
Synodus synodus	red lizardfish	PI	—	—	—	79	1	0.01	—	—	—
Tetraodontidae											
Canthigaster jamestyleri	goldface toby	EB	—	—	—	—	—	—	57	1	0.01
Canthigaster rostrata	sharpnose puffer	EB	24	20	0.26	59	2	0.01	32	8	0.05
			No. Sp. 77	Total N 7,717		No. Sp. 79	Total N 15,288		No. Sp. 69	Total N 17,519	

[1] PL-Planktivore, PI-Piscivore, GC-General carnivore (mobile invertebrates and fishes), H-Herbivore, EB-Epibenthic browsers (sessile invertebrates), BC-Benthic carnivores (benthic crustaceans and infauna).