ASSESSMENT OF MID AND OUTER SHELF BANKS IN THE NW GULF OF MEXICO AS ESSENTIAL HABITAT OF REEF FISHES AND CORALS

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Summary:

Compared to low-relief soft-sediment environments that dominate the continental shelf of the northwestern Gulf of Mexico, hard banks support diverse fish and coral communities that represent important naturally occurring aggregation areas for exploited populations. Most of these banks are unmonitored and their importance to critical life stages of fish resources has not been quantified. This project is the second year of a multi-year project to evaluate the importance of these banks as habitat for corals and fish populations. Previously, we studied Sonnier Bank (approximate location: 28°20'N, 92°27'W) in 2004, and the aim of the 2005 survey was to expanded efforts on Sonnier as well as initiate research on McGrail Bank (approximate location: 28°20'N, 92°27'W). As part of this, we have completed an extensive side scan sonar survey of McGrail Bank in order to characterize and map habitats. We were also able to re-survey key areas at Sonnier Bank to enhance existing sonar data and facilitate habitat characterization. In addition, SCUBA and ROV surveys of the benthos and fish communities at Sonnier Bank were expanded in 2005. The fish community in the areas observed in the previous year was relatively stable in composition and abundance, but that there were prominent differences among bank locations. Similar to Sonnier Bank, the presence and abundance of important fishery resources of snappers and groupers were unique at different locations within McGrail Bank. A broad size range and diversity of groupers were observed, and our observations suggest that Sonnier Bank may function as a nursery for scamp, yellowmouth, and Warsaw grouper, and specific areas of the bank may represent spawning sites for scamp and yellowmouth groupers. Sonnier Bank was clearly a more important habitat for snappers than McGrail Bank. In addition, previous analysis of otolith microstructure on a limited number of samples, suggested that age-structure for snappers and groupers at Sonnier Bank is more diverse than what has been reported for other areas in the Gulf and northwestern Atlantic, and samples collected in 2005 have helped to better define the age structure of snapper at Sonnier Bank. Finally, we employed photographic methods to characterize benthic habitats with SCUBA, and computerized image analysis was used to quantify coverage of benthic organisms. This has allowed us to non-destructively quantify and characterize the benthic habitats at the two main peaks of Sonnier Bank. This baseline information has become immediately important due to the

potentially catastrophic effects of Hurricane Rita, which passed almost directly across Sonnier Bank as a category-4 hurricane. In response, we will be able to replicate this survey in 2006 and quantify the disturbances caused by this event in terms of the composition, diversity and abundances in both the benthic and fish communities. Finally, in this effort we have confirmed the presence of a non-native coral species at Sonnier Bank. This species is the orange-cup coral (*Tubastrea coccinea*), which has recently invaded the Gulf of Mexico and presents a conservation concern because it may displace native species.

Project Goals:

1) Characterize and quantify economically important fish populations at Sonnier Bank to support evaluation of this area as essential fish habitat (EFH)

2) Map benthic habitat characteristics on a finer scale than what is currently available for Sonnier Bank and characterize benthic coral communities

3) Develop approaches with ROV that can be used to study deep structurally complex areas that are inaccessible to SCUBA and that can be applied at other banks in the Gulf of Mexico

Accomplishments:

1) Side scan sonar cruise

In June of 2005, we conducted a four day cruise to survey all of McGrail bank and focal areas of Sonnier Bank with side scan sonar. This work was conducted from the *R/V Marie Hall* (University of Texas Medical Branch in Galveston). Two of these days were travel days to and from the site. We surveyed an area of 35.5 km^2 at McGrail and ~100,000 m^2 at Sonnier, and data have processed to develop habitat maps for each bank. These data has been provided to the Flower Garden Banks National Marine Sanctuary office and are also available upon request through our research program at TAMUG.

2) Identification of habitat features from side scan sonar data

An important part of our approach to characterize habitats at these banks is the comparison of side scan sonar data with direct observation using ROV. Better sea conditions this year allowed us to capture sonar images that exhibit much of the rugosity and finer detail of the main peak – characteristics that were not visible from the 2004 data (Figure 1). We invariably observed high reflectivity on the tall peaks consistent with uplifted caprock and coral (Figure 3). These were surrounded by either aprons of coarse-grained debris, sand patches, and/or fine-grained mud with low sonar reflectivity. Interspersed between the tall peaks were large patches of rubble and coral heads of varying densities. The presence of boulders and rubble encrusted with various corals, sponges and algae was confirmed with ROV surveys. The more gradually sloping peaks were usually characterized by an apron of coarse grained debris, which most likely represents coral debris. Small isolated patches of coral heads in deep water were also observed.

Whereas Sonnier Bank is characterized by isolated pinnacles that were capped with a millepora-sponge community and surrounded by drowned reef habitat with apron of coarse-grained debris, McGrail Bank exhibited expansive coral caps (Figure 3). These caps of hard substrate were dominated by algal fields, including algal nodules, leafy macro algae, *Lobophora*, and *Padina*, and this habitat was punctuated by outcroppings of drowned Pleistocene reef that was characterized by a “pot-hole” or “honey-comb” appearance (Figure 2).

3) SCUBA visual surveys

We conducted SCUBA visual surveys of snappers, groupers and grunts of the two main peaks during our August research cruise in 2005. We attempted a second cruise in September; however, forecasted fair weather deteriorated into unsafe diving conditions, and we were not able to conduct additional surveys. The SCUBA visual survey approach followed Bohnsack and Bannerot’s (1986) method where target fish species observed in an imaginary cylinder of radius 5m were counted. Cylinder size was visualized by the divers by setting out 5m lengths of line on the bottom. All fish species observed were quantified by the divers in order to provide a characterization of the fish community. In 2005, we conducted a total of 63 fish counts between the two peaks and these samples were distributed among three depth zones which stratified our survey design (20 to 24m, 24 to 28m, and 28 to 32m).

In 2005 we observed a total of 10 species in the snapper-grouper-grunt complex. In order of abundance these were: Atlantic creolefish (*Paranthias furcifer*), tomtate (*Haemulon* *aurolineatum*), rock hind (*Epinephelus adscensionis*), gray snapper (*Lutjanus griseus*), vermilion snapper (*Rhomboplites aurorubens*), yellowtail snapper (*Ocyurus chrysurus*), red snapper (*Lutjanus campechanus*), yellowmouth grouper (*Mycteroperca interstitialis*), graysby (*Cephalopholis cruentata*), and dog snapper (*Lutjanus jocu*). Half of these were observed in sufficient abundances to allow statistical tests of variability in density with depth and between years and peaks. The other five were only observed in low numbers (yellowtail snapper, n=15; graysby, n=4; red snapper, n=3; dog snapper, n=1; and yellowmouth grouper, n=1), and these were excluded from our analysis. Similar to 2004, the five most abundant species were the same, and the species observed in low numbers include graysby (n=6), dog snapper (n=2), yellowtail snapper (n=2), and red snapper (n=1). Other species in the target groups that were observed in 2004, but not in 2005, were: lane snapper (*Lutjanus synagris*, n=9), cottonwick (*Haemulon melanurum*, n=8), and caesar grunt (*Haemulon carbonarium*, n=2).

For the analysis, we normalized the count data to number per 100 m^2, and modeled these as a Poisson distribution with peak (either primary or secondary, see Figure 3), year (2004 and 2005), and depth (continuous covariate) as explanatory variables. Since different peaks were only surveyed in 2005, we conducted a separate analysis of 2005 data. In addition, the secondary peak lacked the 20 to 24m depth zone; therefore, the analysis was limited to depths >24m. For all five species, there were no detectable differences in density between peaks, and data from both peaks were pooled for subsequent analysis of year and depth effects. The two most abundant species, Atlantic creolefish (mean= 40.0 per 100 m^2) and tomtate (mean= 4.0 per 100 m^2), showed no detectable changes in density between years, with depth, or with depth*year interaction (Table 1). Rock hind showed a significant decline in density with depth, and the rate of the decline was 1.0 individual per 100 m^2 with each meter increase in depth (Table 1, Figure 4). There was also a consistent difference in rock hind density between years (mean difference = 1.8 per 100 m^2, *df*=1, chi-square=15.0, $p<0.001$) that was not influenced by a year*depth interaction (Table 1). Using the bathymetry data for Sonnier Bank, we applied the hypsographic function to the depth and annual trends observed with rock hind (Figure 5) and calculated that the difference in density between years indicated that approximately 200 fewer individuals were present during our survey in 2005. This represents a decline of about 50% over one year, which is within the limits of detection that we predicted using bootstrap simulations from our 2004 data (Kraus et al. *forthcoming* in volume 57 of the Proceedings of the Gulf and Caribbean Fisheries Institute). Finally, gray snapper and vermilion snapper densities were the most variable with means ranging between 0.5 and 5.0 individuals per 100 m^2 (see Figure 4). No year or depth*year interaction effect was detected for vermilion snapper, but there were significant year and depth*year interaction effects for gray snapper (Table 1). For gray snapper, increasing densities with depth were observed in 2004 with the opposite situation in 2005 (Figure 4).

4) ROV surveys

To date we have conducted two days of ROV surveys at Sonnier Bank and McGrail Bank in 2005, and an additional planned survey was cancelled on-site due to unsafe and deteriorating weather conditions. Our approach was to drive transects across each area of interest covering deep habitats and crest environments, spending approximately 20 minutes at each site (Table 2). This plan was a compromise between spending sufficient time at each site and covering multiple sites during daylight hours. A summary of the counts is given in Table 2, and these data emphasize that the presence and abundance of snappers and groupers is highly site specific. The location of the different sites is presented in Figure 3. Note that for species that were observed in lower abundances during our SCUBA surveys, such as red snapper and vermilion snapper, there were much greater numbers observed by the ROV. This emphasizes that deeper areas inaccessible to SCUBA were important habitats for certain commercially valuable species. In addition, we observed far more grouper with the ROV than during SCUBA surveys, and for yellowmouth grouper and scamp, there was some unavoidable difficulty in distinguishing certain individuals on the video. Therefore, these two species are grouped into a single category. One of the most important qualitative results from the ROV work was the identification of areas that harbored species of conservation concern, such as Warsaw grouper, for which there is scant knowledge of life history. We are planning more intensive surveys of these same sites in 2006, in order to better define the composition and relative abundances of these target species.

5) Benthic surveys with quadrats

In 2005, we employed scientific divers from TAMUG to conduct the benthic quadrat surveys using photography. This approach allowed us to collect a large amount of photographic data with minimal training, and the photographs could be shared with experts to aid in species identifications. In addition, the photographs were made with size references placed on the bottom, so that areal-coverage could be estimated using our image analysis system at TAMUG.

We analyzed a total of 161 photographs encompassing a total area of 26.8 m^2, and conducted ANOVA's to test for differences between depth strata. Due to camera problems on our initial dives to the deepest strata of the primary peak, we were not able to identify benthic species; therefore, the image analysis includes the shallow and intermediate depth zones from the primary peak and the intermediate and deepest depth zone from the secondary peak (note that the shallowest depth zone was not present at the secondary peak). We quantified % coverage of each species and the area of each patch or fragment. This process was straight forward for most of the species, but we also observed patches that were covered by a variable mix of algae species: predominately red filamentous algae, *Lobophora* sp., and crustose coralline algae. Rather than separate these areas into numerous small fragments of each algae species, we grouped these into a category called mixed algae, which we treated as continuous. This mixed algae category constituted the majority of our photographs with an overall coverage of 45.1%. The second most abundant species was fire coral (*Millepora alcicornis*) with an overall coverage of 20.6%. Various sponges made up almost all of the rest of the benthos, and the primary species were: touch-me-not sponge (*Neofibularia nolitangere*, 15.9%), black ball sponge (*Ircinia strobilina*, 3.4%), and orange elephant ear sponge (*Agelas clathrodes*, 3.0%). Various other benthic species comprised 7.1% of the area photographed (2.2% were not identified to species), and 4.9% of the area photographed was unclassifiable. The other benthic species that we have identified to-date include: *Placospongia melobesioides* (1.0%) and the hermatypic star coral *Stephanocoenia intersepta* (0.4%). Coral rubble made up 2.7% of the area we surveyed. We also identified one colony of the non-native orange cup coral (*Tubastrea coccinea*), which is a concern for conservation as this species is abundant on oil rigs in the Gulf and may displace native species. In 2006, we plan to take small samples of algae and sponges for positive identification of remaining unknowns.

We observed significant variability for mean fragment size with depth/peak for all five main benthic groups (Table 3; Figure 6). In the ANOVAs of fragement size, significant ($p<0.05$) Tukey-Kramer adjusted pair-wise differences were observed between peaks/strata for all benthic groups. In the mixed algae group, only depth zones on the secondary peak were found to be similar (Figure 6). For fire coral, fragment sizes were significantly larger at the primary peak in the 24 to 28m depth zone than at the same depth zone on the secondary peak or the 20 to 24m depth zone of the primary peak (Figure 6). For touch-me-not sponge, the shallow depth zone at the primary peak had significantly smaller fragments than the 24 to 28m depth zones at the primary peak or the 28 to 32m zone at the secondary peak (Figure 6). For black ball sponge, fragments were significantly larger at the primary peak in the 24 to 28m depth zone than at the same depth zone at the secondary peak. For orange elephant ear sponge, significant pair-wise differences were evident with larger fragments at the primary peak, and no differences were detected between depth zones at the primary peak or between peaks at their shallowest depths (Figure 6). In the ANOVA of percent coverage, Tukey-Kramer adjusted pair-wise differences were only observed for fire coral between the deepest (28 to 32m) and shallowest (20 to 24m) depth zones with the highest coverage at in the deeper zone (Figure 6).

6) Biodiversity Assessment

From SCUBA and ROV video surveys we have been compiling and inventory of fish species at Sonnier and McGrail banks that will aid in conservation of these habitats. To date, we identified a number of species that were both of tropical origin and representing economically valuable resources (Table 4). At Sonnier Bank we have identified 81 fish species with SCUBA and ROV surveys (2004, 2005), and at McGrail Bank we have identified 24 with ROV surveys (2005). Many of the fish species that were added to the list from last year are species that inhabit deeper areas that were surveyed with ROV.

7) Otolith microstructure analysis

We opportunistically sampled with hook-and-line to collect otoliths and determine size distributions of species observed during SCUBA and ROV operations. These collections were made to provide information on the demographic structure of the major species at the banks. Each fish was measured and otoliths were extracted and stored in plastic vials. In the laboratory, we cleaned each otolith with dilute hydrogen peroxide and then rinsed with deionized water. For each fish, right or left sagittae were chosen at random, and then embedded in epoxy resin. Using a low-speed diamond saw, we cut a thin transverse section and mounted this on a glass slide with thermoplastic glue. Sections were polished to expose the core area and transmitted light microscopy was used to count opaque annuli. Samples collected in 2005 were from red snapper, vermilion snapper, tomtate, striped grunt, and marbled grouper (McGrail Bank only) and the results were combined with 2004 data (Figure 7). As we noted in 2004, age distributions were similar to those reported in the literature for heavily exploited species such as vermilion snapper, red snapper, and rock hind, with most of the samples ranging in age between 4 and 11 years. We also noted previously that our 2004 samples had some unusually old individuals of Atlantic creolefish, tomtate and rock hind. These were unusual because they were older than anything to our knowledge in the peer-reviewed literature. In our 2005 collections, we again observed some unusually old (>17 years) individuals of tomtate (age = 23) and rock hind (age = 24). Additionally, we collected a striped grunt (age = 20), vermilion snapper (age = 18), and marbled grouper (age ~39, from McGrail Bank). These ages should be treated with caution because they have not been verified independently, and otolith ageing has not been validated for all of these species (e.g., this appears to be the first age estimate for marbled grouper). Still, the possibility that a number of species may have more diverse age distributions at Sonnier Bank than elsewhere has implications that highlight future research topics and information needs: 1) the presence of older/larger fish suggests that fishing mortality may be lower at Sonnier Bank than in other areas, 2) these species may have long residence times at Sonnier Bank and therefore connectivity with neighboring habitats may be limited, 3) as an alternative to long residence times, Sonnier Bank may represent an area where older fish migrate on a seasonal basis. Studies of movement/migration patterns and continued population monitoring of species in the snapper/grouper/grunt complex at this bank are needed to test these hypotheses and to direct management decisions concerning this Habitat Area of Particular Concern (HAPC).

8) Comparison SCUBA-ROV surveys

To compare these banks with other areas, indices of fish abundance measured with our ROV must be calibrated to density. As with surveys in 2004, densities estimated with ROV were typically lower than those made by SCUBA surveys (Figure 8). These differences were due, at least in part, to a smaller search area and limited field of view with the ROV. Our approach to refine this relationship was to record the navigation of the vessel from which we deployed the ROV. The distance traveled by the boat should be related to the distance traveled by the ROV (with some random variance), when the boat is close to the ROV and the tether is kept at a fixed length. In practice, this approach was problematic, and analysis of the navigation data revealed erratic movement paths. Despite our efforts to keep the vessel close to the ROV and obtain a reasonable measure of the distance traveled by the ROV, these paths were determined to have little relationship to the ROV's path. This was due to zig-zag motion of the boat that was necessary for keeping position near the ROV in the face of shifting currents, thus the tracks were unrealistically long (10s of km). Underwater positioning systems are clearly a better alternative, but these were prohibitively costly for this project. During upcoming surveys, we will instead use a combination of straight paths and start/end coordinates determined more precisely from range and bearing (by measuring tether length and compass heading) to generate a standardized index of abundance from ROV video.

9) *Presentation at International, National, and Regional Scientific Conferences*

We have presented this work at a number of meetings which have provided timely venues for sharing our results with a group of researchers and managers that are interested in related issues. The citations are listed below.

Friess, C., R. T. Kraus, J. R. Rooker, and R. L. Hill. 2006. Biotic diversity of a mid-shelf bank in the northwestern Gulf of Mexico. Oral presentation at the 109^{h} annual meeting of the Texas Academy of Science, Lamar University, Beaumont, Texas, 2 – 4 March.

Friess, C., R. T. Kraus, J. R. Rooker, and R. L. Hill. 2006. Biotic diversity of a mid-shelf bank in the northwestern Gulf of Mexico. Poster presentation at the 14th annual meeting of the Southern Division of the American Fisheries Society, San Antonio, Texas, 8 – 12 February.

Kraus, R. T., Ronald L. Hill, and J. R. Rooker. 2005. Comparison of ROV and SCUBA approaches to quantify reef fish abundances in the NW Gulf of Mexico. Poster

presentation at the 135th annual meeting of the American Fisheries Society, Anchorage, Alaska, 11 – 16 September.

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Beaudoin, J.D., Gardner, J.V., and Hughes Clarke, J.E. 2002. Cruise Report; R.V. Ocean Surveyor Cruise O1–02–GM; bathymetry and acoustic backscatter of selected areas of the outer continental shelf, northwestern Gulf of Mexico: U.S. Geological Survey Open-File Report 02-410 [URL http://geopubs.wr.usgs.gov/open-file/of02-410].

Bohnsack, J. A., and S. P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report, NMFS 41. 15 p.

Kraus, R. T., R. L. Hill, J. R. Rooker, and T. Dellapenna. *forthcoming in 2006*. Preliminary characterization of a mid-shelf bank in the northwestern Gulf of Mexico as essential habitat of reef fishes. Proceedings of the Gulf and Caribbean Fisheries Institute. v.57.

Rezak, R., T. J. Bright, and D. W. McGrail. 1985. Reefs and Banks of the Northwestern Gulf of Mexico. John Wiley & Sons, Inc., New York. 259 p.

Table 1. Analysis of variance of fish counts from SCUBA surveys for the 5 most abundant species in the snapper-grouper-grunt complex. A Poisson distribution of counts was modeled using a log-link function. Depth was modeled as a covariate (continuous). F-statistics ($F_{ndf,ddf}$) were used for type-3 tests of parameters, and these statistics were adjusted for over-dispersion by scaling the parameter covariance matrix by the deviance (D_{df}; see Little et al. 1996). Significance at α=0.05 is indicated by asterisk (*).

	D_{95}	$F_{1,95}$	p-value
Atlantic creolefish	3510.0		
Depth		0.83	0.366
Year		1.10	0.297
Interaction		0.92	0.641
Rock hind	144.9		
Depth		8.17	0.005*
Year		0.05	0.826
Interaction		0.13	0.720
Tomtate	1735.5		
Depth		2.11	0.150
Year		0.59	0.444
Interaction		0.23	0.633
Gray snapper	746.2		
Depth		0.16	0.687
Year		4.61	0.034*
Interaction		4.56	0.035*
Vermilion snapper	790.0		
Depth		0.13	0.716
Year		0.84	0.362
Interaction		0.65	0.423

Table 2. Totals counts of selected species from ROV surveys at Sonnier Bank (A through F) and McGrail Bank (G & H). Sites are indicated in Figure 3.

Groupers Site→	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Rock Hind	14	8	0	0	0	7	0	0
Graysby	2	1	2	0	1	0	1	3
Yellowmouth & Scamp	0	0	1	13	2	20	30	6
Yellowfin	0	0	0	0	0	0	0	2
Marbled	0	0	0	0	0	0	2	0
Warsaw	0	0	0	2	0	0	0	0
Creolefish	203	549	416	261	246	111	19	537
Snappers								
Gray	103	1	34	57	5	72	0	0
Red	0	0	47	81	0	6	0	0
Dog	1	2	0	0	0	0	0	2
Vermilion	0	220	0	157	0	170	0	0
Grunts								
Tomtate	182	6	0	72	3	249	0	0
Depth Range (m)	25 - 47	25 - 32	37 - 43	53 - 60	38 - 45	48 - 51	67 - 80	54 - 60
Duration (min.)	26	27	20	30	18	18	26	17

Table 3. Analysis of variance tables for the major benthic species quantified by image analysis from photographic surveys with SCUBA. The main effect was depth*peak with 4 categories: depth zones 20 to 24m and 24 to 28m at the primary peak and depth zones 24 to 28m and 28 to 32m at the secondary peak (see Figure 3). Separate ANOVAs were conducted for fragment size and % coverage. Significance was assessed at alpha=0.05 (*).

Fragment sizes				
Taxa	numerator	denominator	F-value	p-value
Orange elephant ear sponge	3	220	5.71	0.0009*
Black ball sponge	3	34	3.83	0.0182*
Fire coral	3	305	4.88	0.0025*
Touch-me-not sponge	3	255	4.26	0.0059*
Mixed algae	3	278	17.61	<.0001*
% Coverage				
Orange elephant ear sponge	3	73	1.39	0.2530
Black ball sponge	3	27	1.26	0.3092
Fire coral	3	101	3.24	0.0252*
Touch-me-not sponge	3	74	0.23	0.8774
Mixed algae	3	132	0.38	0.7697

Table 4. List of fishes observed from SCUBA and ROV surveys at Sonnier Bank and McGrail Bank.

common name	scientific name
Target Groups:	
Serranidae	
Atlantic creolefish	*Paranthias furcifer*
Graysby	*Cephalopholis cruentata*
Rock hind	*Epinephelus adscensionis*
Yellowmouth grouper	*Mycteroperca interstitialis*
Scamp	*Mycteroperca phenax*
Yellowfin	*Mycteroperca venenosa*
Marbled	*Dermatolepis inermis*
Warsaw	*Epinephelus nigritus*
Threadnose bass	*Anthias tenuous*
Orangeback bass	*Serranus annularis*
Lutjanidae	
Dog snapper	*Lutjanus jocu*
Gray snapper	*Lutjanus griseus*
Lane snapper	*Lutjanus synagris*
Red snapper	*Lutjanus campechanus*
Vermilion snapper	*Rhomboplites aurorubens*
Yellowtail snapper	*Ocyurus chrysurus*
Haemulidae	
Ceasar grunt	*Haemulon carbonarium*
Cottonwick	*Haemulon melanurum*
Tomtate	*Haemulon aurolineatum*
Striped grunt	*Haemulon striatum*
Black Margate	*Anisotremus surinamensis*
Carangidae	
Almaco jack	*Seriola rivoliana*
Bar jack	*Caranx ruber*
Blue runner	*Caranx crysos*
Crevalle jack	*Caranx hippos*
Greater amberjack	*Seriola dumerili*
Horse-eye jack	*Caranx latus*
Rainbow runner	*Elagatis bipinnulata*
African pompano	*Alectis ciliaris*
Other Species:	
Balistidae	
Gray triggerfish	*Balistes capriscus*
Black durgon	*Melichthys niger*
Scombridae	
King mackerel	*Scomberomorus cavalla*
Kyphosidae	
Bermuda chub	*Kyphosus sectatrix*
Mullidae	
Spotted goatfish	*Pseudopeneus maculates*
Pomacentridae	
Yellowtail reeffish	*Chromis enchrysura*
Bicolor damselfish	*Stegastes partitus*
Blue chromis	*Chromis cyanea*
Brown chromis	*Chromis multilineata*
Sunshinefish	*Chromis insolata*
Cocoa damselfish	*Pomacentrus variabilis*
Sergeant major	*Abudefduf saxatilis*
Purple reeffish	*Chromis scotti*
Triakidae	
Smooth dogfish	*Mustelus canis*
Carchinidae	
Sandbar shark	*Carcharhinus plumbeus*
Silky shark	*Carcharhinus falciformis*
Pomacanthidae	
French angelfish	*Pomacanthus paru*
Gray angelfish	*Pomacanthus arcuatus*
Queen angelfish	*Holacanthus ciliaris*
Blue angelfish	*Holacanthus bermudensis*
Rock beauty	*Holacanthus tricolor*
Cherubfish	*Centropyge argi*
Acanthuridae	
Doctorfish	*Acanthurus chirurgus*
Ocean Surgeon	*Acanthurus bahianus*
Scaridae	
Redband parrotfish	*Sparisoma aurofrenatum*
Princess parrotfish	*Scarus taeniopterus*
Labridae	
Spanish hogfish	*Bodianus rufus*
Spotfin hogfish	*Bodianus pulchellus*
Puddingwife	*Halichoeres radiatus*
Bluehead	*Thalassoma bifasciatum*
Yellowhead	*Halichoeres garnoti*
Creole wrasse	*Clepticus parrae*
Holocentridae	
Longspine squirrelfish	*Holocentrus rufus*
Squirrelfish	*Holocentrus adscensionis*
Monacanthidae	
Unicorn filefish	*Aluterus monoceros*
Orangespotted filefish	*Cantherhines pullus*
Whitespotted filefish	*Cantherhines macrocerus*
Ostraciidae	
Scrawled cowfish	*Lactophrys quadricornis*
Smooth trunkfish	*Lactophrys triqueter*
Tetraodontidae	
Sharpnose puffer	*Canthigaster rostrata*
Chaetodontidae	
Reef butterfly	*Chaetodon sedentarius*
Spotfin butterfly	*Chaetodon ocellatus*
Banded butterflyfish	*Chaetodon striatus*
Longsnout butterflyfish	*Chaetodon aculeatus*
Albulidae	
Bonefish	*Albula vulpes*
Priacanthidae	
Big-eye	*Priacanthus arenatus*
Malacanthidae	
Sand tilefish	*Malacanthus plumieri*
Rachycentridae	
Cobia	*Rachycentron canadum*
Blenniidae	
Seaweed blenny	*Parablennius marmoreus*
Redlip blenny	*Ophioblennius atlanticus*
Gobiidae	
Neon goby	*Gobiosoma oceanops*
Scorpaenidae	
Spotted Scorpionfish	*Scorpaena plumieri*
Muranidae	
Spotted moray	*Gymnothorax moringa*
Scianidae	
Cubbyu	*Equetus umbrosus*
Spotted drum	*Equetus punctatus*
Cirrhitidae	
Redspotted hawkfish	*Amblycirrhitus pinos*

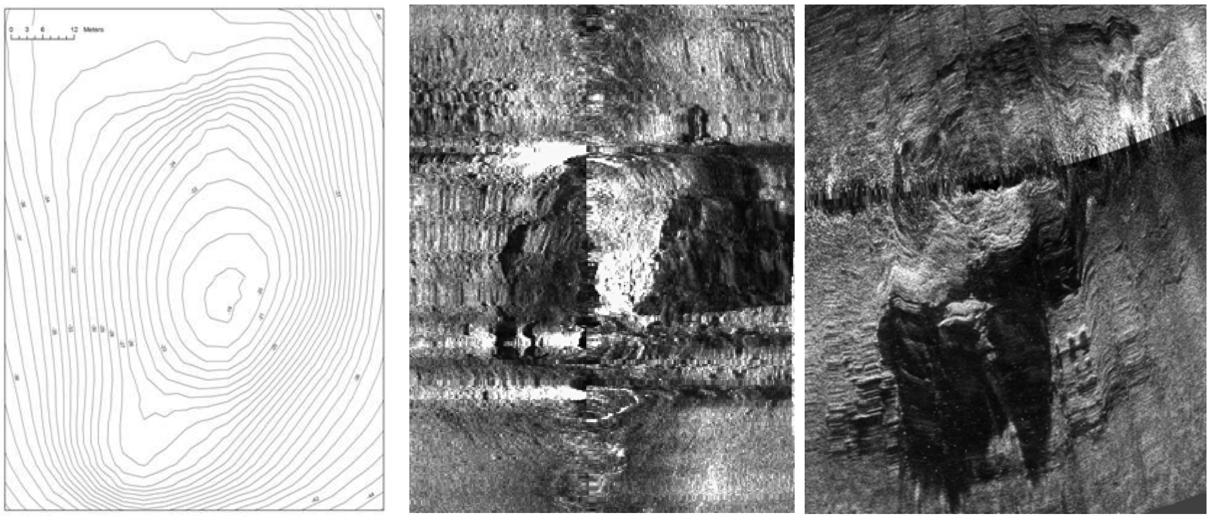

Figure 1. Side scan and multi-beam sonar data from the main peak at Sonnier Bank. The panel on the left shows the bathymetry data from the multi-beam sonar survey (Beaudoin et al. 2002). The middle panel shows the main peak imaged with sides can sonar during the 2004 cruise, and the right panel shows the same peak imaged from the 2005 cruise. This illustrates how the multi-beam sonar obscures much of the important detail that is relevant to reef-fish habitat, and how sea conditions can degrade side scan sonar images. For example, 8 to 12 foot seas in 2004 were clearly problematic (middle panel), but the 2005 cruise had better sea conditions and the data revealed much of the steeply dipping ridges that typified the main peak.

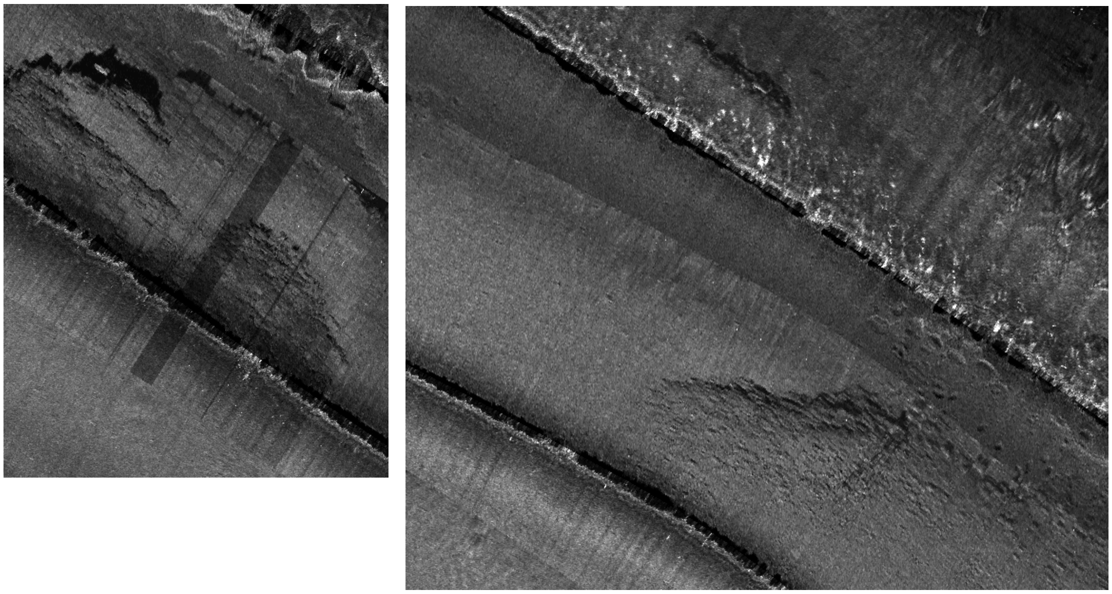

Figure 2. Side scan sonar data from the western (left panel) and eastern (right panel) coral caps at McGrail Bank. Images are from the two areas that were surveys with ROV. Note the ledges are associated with pock-marks that represent “pot-holes” or “honey-comb” networks of spaces in the outcroppings of drowned Pleistocene reefs, and these habitats were associated with aggregations of groupers.

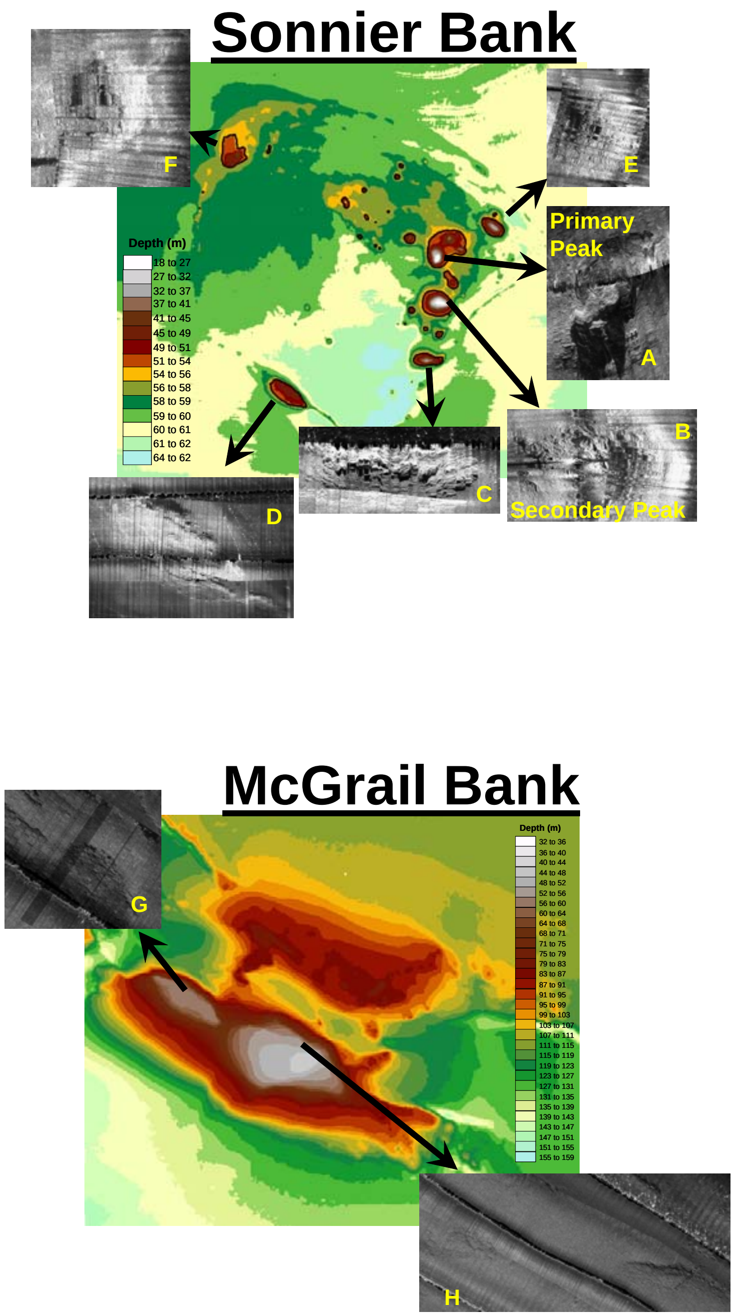

Figure 3. Bathymetry of Sonnier Bank and McGrail Bank. Detail of areas that were surveyed with SCUBA and ROV are presented as inset side scan sonar images that are labeled alphabetically. The labels correspond to table 1.

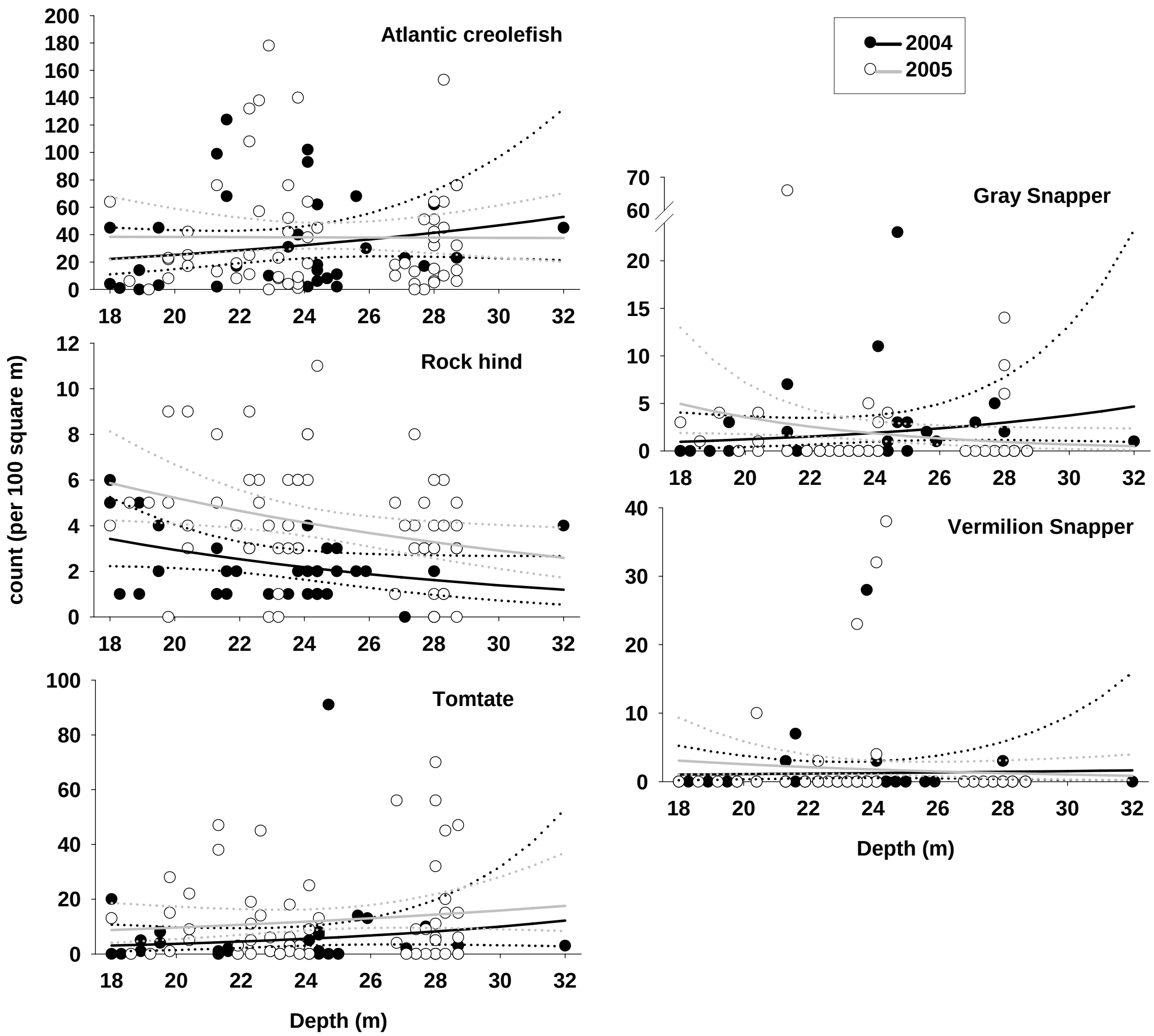

Figure 4. SCUBA point count data from surveys of Sonnier Bank in summers of 2004 and 2005. The mean depth trends (and 95% confidence intervals, dotted lines) were estimated with analysis of covariance modeling a Poisson response distribution.

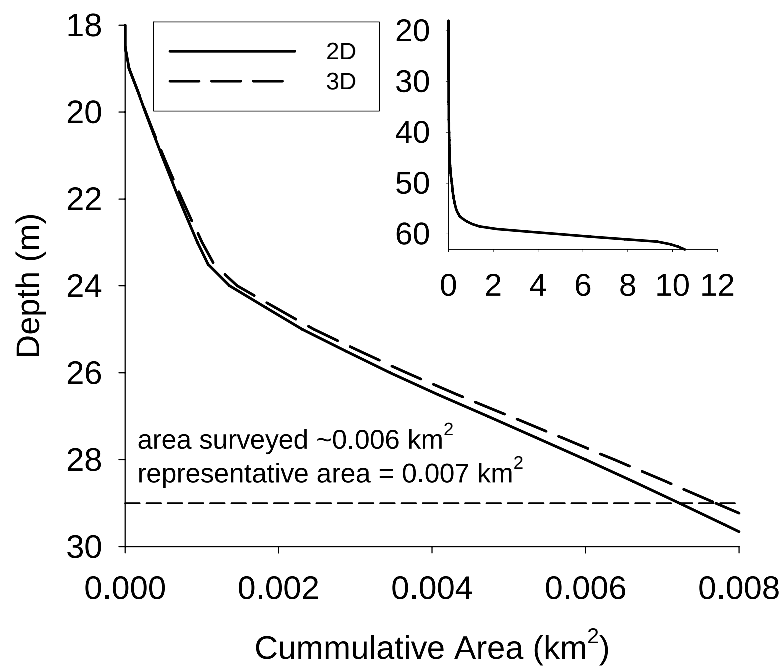

Figure 5. Hypsographic plot of depth on cumulative area (both 2-dimensional and 3-dimensional area, as denoted in the key). Horizontal dashed line represents maximum depth of SCUBA visual surveys, and inset plot shows hypsographic function for the entire bank. Plots were calculated from the bathymetry data of Beaudoin et al. (2002). The steepness of the highest peaks is emphasized by the divergence of the 2-dimensional and 3-dimensional cumulative areas. In the inset plot, these two functions are essentially the same, demonstrating that the high-relief peaks represent a very small fraction of the entire bank.

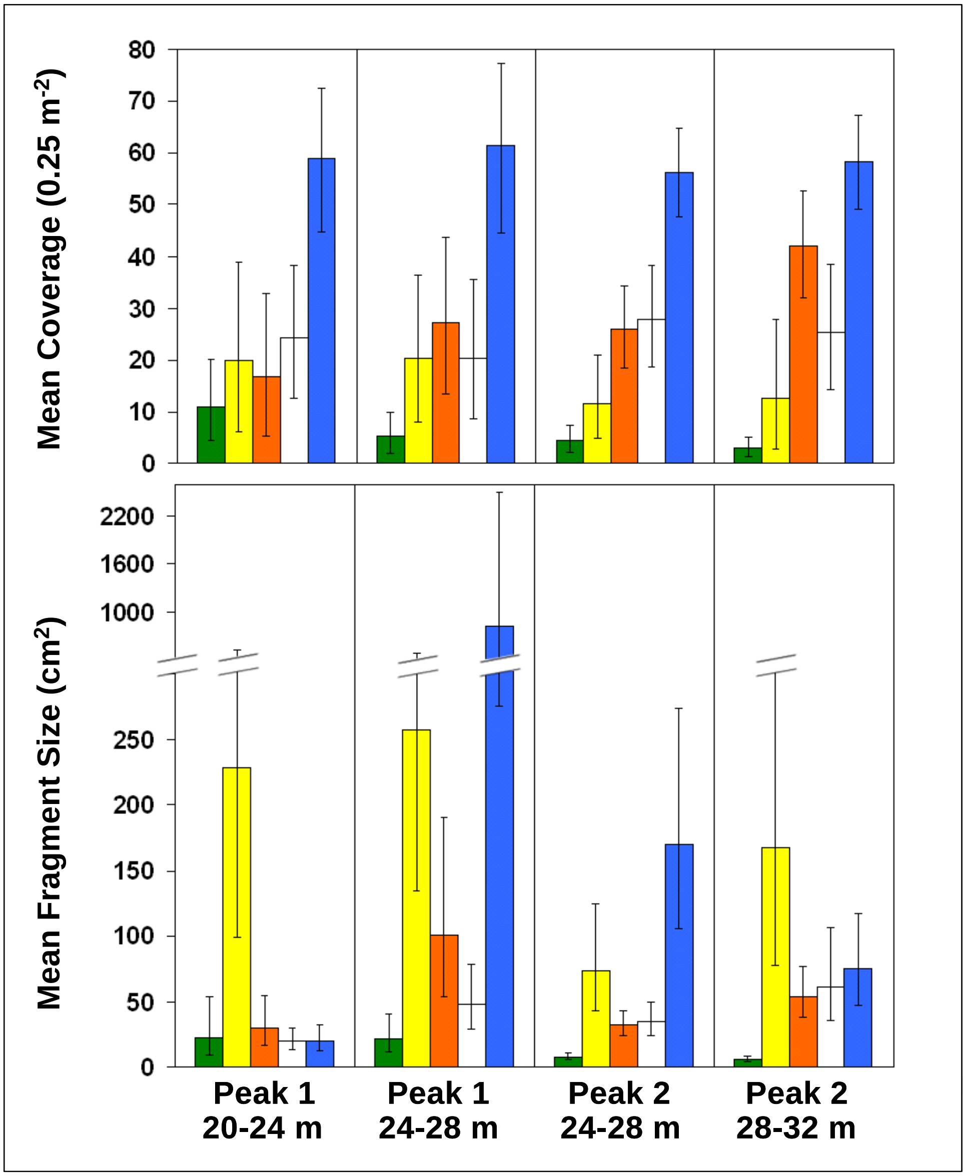

Figure 6. Dominant benthic species at Sonnier Bank: mixed algae (blue), touch-me-not sponge (white), fire coral (orange), black ball sponge (yellow), and orange elephant ear sponge (green). Mean % coverage is shown in the upper panel and mean fragment size in the lower panel. The % coverage is based upon our quadrat size of 0.25 m^2.

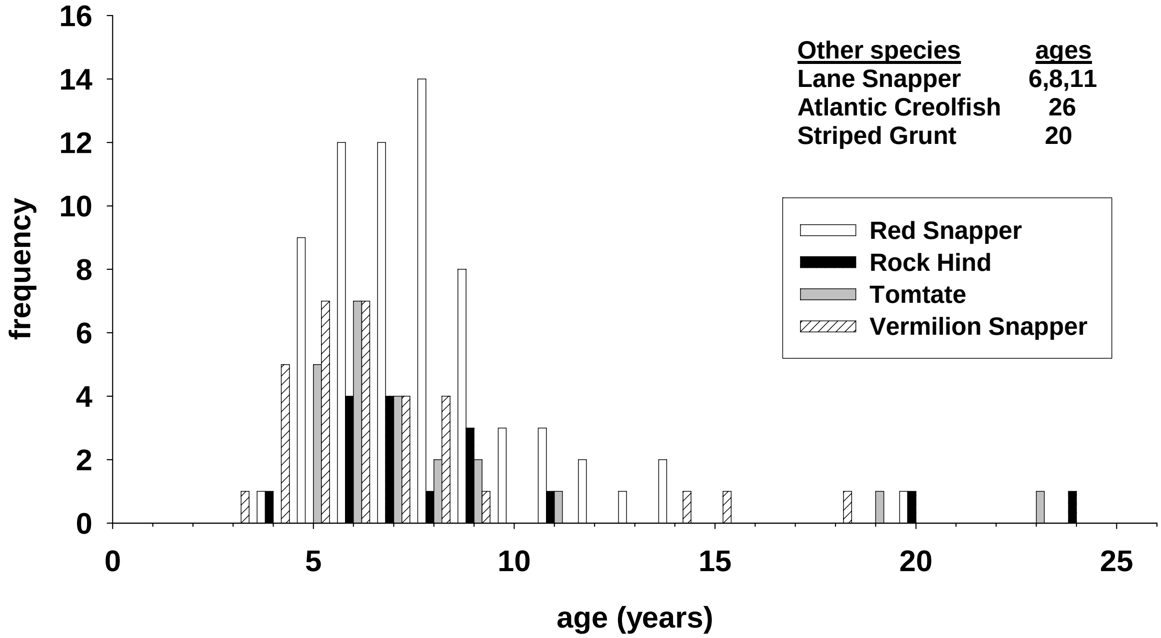

Figure 7. Age distribution of species collected from Sonnier Bank. Ages were determined from thin-sections of otoliths. Species with low sample sizes are not plotted and listed in the upper right of the panel.

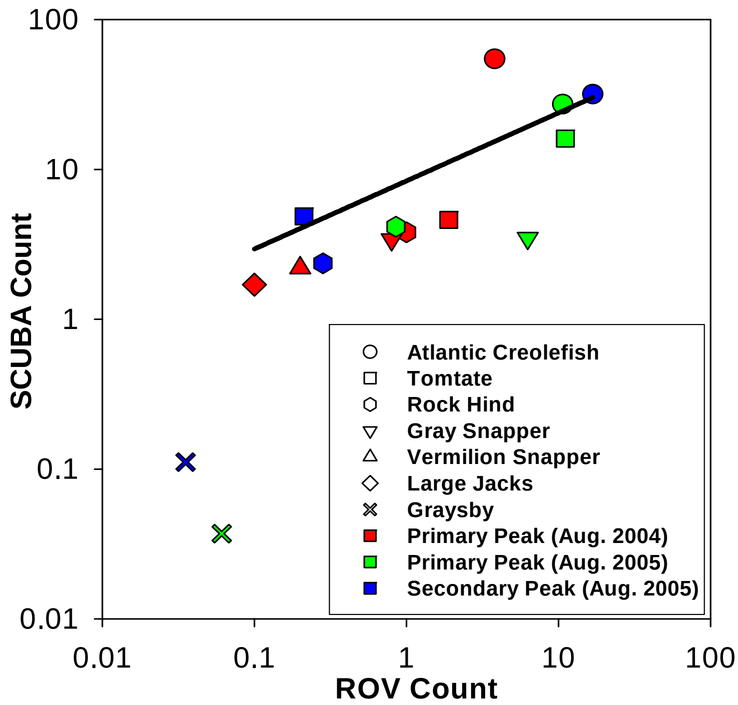

Figure 8. Comparison of SCUBA and ROV counts for selected species from sites at Sonnier Bank. The fitted line suggests that the relationship follows a power function (low density graysby not included). Mean time for the ROV to search areas surveyed with SCUBA was used as a basis for the comparison. To do this we estimated the mean time to search marked areas where SCUBA point counts were made (in 2004 surveys), and then we normalized the ROV count data in 2005 by the number of equivalent point counts based upon time.