Fish Monitoring in the Gray's Reef National Marine Sanctuary – 2002-2006
Reef Environmental Education Foundation (REEF)

Summary Report – DRAFT August 17, 2007

Background

The Gray's Reef National Marine Sanctuary (GRNMS), designated in 1981, is a live-bottom reef located 32 km off the Georgia coast. The area features large expanses of sand flats interspersed with rocky ledges that are richly colonized by colorful sponges and algae (Figure 1). The extensive but discontinuous rock ledges support a unique assemblage of temperate and tropical marine species, including many species of resident and pelagic fish species. The Sanctuary is relatively small at 17.5 nm^2, but many important species of commercial fishes reside around the rocky outcroppings, including black sea bass, red snapper, gag, scamp, and a variety of porgy. In response to increasing threats from harvest and habitat-altering gear types and anchoring, new regulations were implemented in February 2007. These regulations allow fishing only by rod and reel, handline or spearfishing gear without powerheads, and anchoring is now prohibited.

Fish presence and abundances reflect the overall condition of an area. Understanding the current inventory and state of natural systems, including the fishes that inhabit those systems, is critical to effective management. Monitoring size structure and density in key harvested species provides information needed to evaluate certain management actions. While information on commercially harvested species is critical, without data on the entire community assemblage, complex ecosystem relationships cannot be adequately assessed. Due to the variety of spatial patterns and frequency of occurrences among species, a suite of survey methods may be appropriate (Pattengill-Semmens and Semmens 2003; Schmitt et al 2002).

The Reef Environmental Education Foundation (REEF), through the enlistment and education of volunteer divers, has developed the Fish Survey Project to assist scientists and resource agencies in the collection of fish assemblage data. The Project started in Key Largo, FL, in 1993, and has since created the largest database of tropical western Atlantic fishes in the world. This program has been successful in engaging the public in an activity that increases awareness and understanding of the marine environment, while providing valid and usable data (Pattengill-Semmens and Semmens, 1998; Schmitt and Sullivan, 1996).

In 2002, REEF initiated a coordinated fish monitoring program within GRNMS. Members of the REEF Advanced Assessment Team (AAT) annually conducted visual fish surveys within the Sanctuary using the Roving Diver Technique (RDT; Schmitt and Sullivan 1996) to measure species composition and estimate abundances. Beginning in 2004, REEF added a quantitative size-monitoring component for targeted species (black sea bass, Lutjanids and Serranids). Divers conducted Rapid Visual Count (RVC; Bohnsack and Bannerot 1986) surveys along rocky ridge habitats. These efforts greatly expanded early RDT surveys conducted by REEF staff at Station 20, a historical GRNMS monitoring site, between 1998 and 2001.

The primary goals of this project were to 1) to provide GRNMS with a taxonomic inventory of fish species found within the Sanctuary as well as a dataset that can be used through time to

measure spatial and temporal trends, 2) to assess the size structure and density of key targeted fish species within the GRNMS, 3) to complement the current RVC surveys that have been conducted at GRNMS since 1995, and 4) to increase local and national awareness on the Sanctuary resources and give constituents a comparative fish data resource that can be used for the better management of GRNMS.

This report provides an overview of fish assemblage data collected by REEF staff and volunteers in the GRNMS between 1998 and 2006. During this time, a total of 58 sites inside the Sanctuary as well as at representative sites outside the GRNMS boundary were surveyed. A total of 349 RDT surveys were conducted at 55 sites; 704 RVC surveys were conducted at 39 sites between 2004 and 2006 (Figure 2).

Method

Between 2002 and 2006, in collaboration with GRNMS staff, REEF coordinated annual fish assessments within and around the Sanctuary. A team of REEF Staff and AAT members (typically between 6 and 8 surveyors) conducted the data collection. The AAT is comprised of REEF's most experienced and knowledgeable surveyors. The REEF AAT was formed in direct response to a fish monitoring contract with the Florida Keys NMS and has been in place since 1997.

REEF volunteers conducted RDT surveys and, beginning in 2004, size-assessment RVC surveys. The RDT is a non-point visual survey method specifically designed to generate a comprehensive species list along with frequency and abundance estimates. During RDT surveys, divers swim freely throughout a dive site and record every observed fish species. Only those species positively identified are recorded. At the conclusion of each survey, divers assign recorded species one of four $\log_{10}$ abundance categories [single (1); few (2-10), many (11-100), and abundant (>100)]. Following the dive, each surveyor transfers the species data along with survey time, depth, temperature, and other environmental information to a REEF scansheet. The scansheets are returned to REEF. The data are optically scanned, checked for errors, and then are loaded into the REEF SQL database. Summary reports from this database are publicly accessible on the Internet at http://www.reef.org. The paper scanforms are electronically archived through NOAA's Climate Data Modernization Program.

The size-assessment surveys were conducted using a modified RVC of targeted species (black sea bass, grouper, snapper, jack, mackerel, barracuda, triggerfish, porgy, and grunt). Divers conducted 3-5 RVC surveys during a given dive, and buddy-teams "leap-frogged" over each other along a particular ridge. The diver delineated a cylinder with a 5m radius and then completed one rotation to count and measure (to the nearest 5cm) each individual black sea bass present within the cylinder at that moment. A second rotation was then conducted to count and measure any of the other targeted species. Size data was entered into an Excel spreadsheet. At the beginning of each year's monitoring effort, the survey team conducted RVC field training to standardize size and distance estimates.

RDT survey data provide species presence and sighting frequency. The basic statistic generated from REEF data is the Density Score (DEN), which is a weighted average of the abundance categories reported for each species. This score can then be combined with non-sighting

information (Sighting Frequency) to generate an Abundance Score. It is calculated as: abundance score = $[(n_S x1)+(n_F x2)+(n_M x3)+(n_A x4)] / (n_S + n_F + n_M + n_A)$ * percent sighting frequency, where n is the number of times each abundance category was assigned.

RVC survey data provide density and size distribution data for targeted species. All RVC surveys from a given site from a given year were maintained as separate worksheets in an Excel workbook. The total number of individuals in each size class was combined and the proportion of individuals in each class was calculated to estimate size distribution. Average size was calculated using the average of the mid-point in each size class (e.g. 5cm for the 0-10cm size class) multiplied by the total number of individuals in that class. Average density was calculated per 100 m^2, based on a calculated RVC survey area of 78.5m.

Results

Between 1998 and 2006, a total of 58 sites inside the GRNMS and at representative sites outside the Sanctuary boundary were surveyed by REEF volunteers and staff. A total of 349 RDT surveys were conducted at 55 sites; 704 RVC Surveys were conducted at 39 sites between 2004 and 2006 (Figure 2; Table 1). There was not a coordinated REEF monitoring effort in 2007; however one member of the AAT participated in a GRNMS cruise aboard the NOAA vessel *Nancy Foster* in June 2007 and conducted 21 RDT surveys at 7 sites (3 of which were new sites not previously surveyed by REEF; see his mission log posting at http://sanctuaries.noaa.gov/missions/2007grnms/log_061207.html).

Using all RDT data collected between 1998 and 2007, a comprehensive fish species list was generated for the GRNMS (Table 2). A total of 370 RDT surveys were conducted during this time, reporting 185 fish species. The top 5 most frequently sighted species (all of which were seen in at least 75% of all surveys) were: belted sandfish, black sea bass, slippery dick, bank sea bass, and cubbyu. REEF surveyors documented several new fish species records for GRNMS, including:

spotted goby, emerald parrotfish, and painted wrasse (first documented in 2002);

leopard searobin, clearnose skate, Carolina hake, blackbar soldierfish, rainbow runner, and spotted spoonnose eel (first documented in 2003);

24 species were added to the REEF database in 2004 (over a 20% increase) due to the expanded survey effort. Notably - shortfin pipefish, banded jawfish, and pygmy filefish; and,

ocellated frogfish and orangespotted blenny (first documented in 2005).

RVC data were consistently collected on 15 species (Table 3). An additional 21 species were documented infrequently and in low numbers and will not be presented in this report. The RVC cylinders were dominated by juvenile tomtate (0-20cm) and a total of 188,145 individuals (0-50 cm) were recorded in the 704 RVC surveys conducted (average density was 361 per 100m^2). Five other species were present in relatively high numbers in the RVC surveys, black sea bass, spottail pinfish, Atlantic spadefish, blue runner and amber jack, and all had average densities greater than 2 per 100m^2. However, two of these species, blue runner and amberjack, are highly

mobile species and their average density values were strongly influence by abundance spikes in only one of the three years. In 2004, blue runner were documented with a density of 12.3 per $100m^2$, whereas their density in subsequent years was less than 0.5 per $100m^2$. In 2005, amber jack were documented with a density of 6.85 per $100m^2$, versus a density of 1.59 in 2004 and 0.72 in 2006. In both events, large numbers were recorded at multiple sites in the given year of the spike. These spikes likely do not represent actual shifts in abundance of these species but rather chance events that schools of these species moved through the Sanctuary during the time of the survey. Size distribution for the 15 species recorded in the RVC surveys are shown in Figures 3a-3e.

Results presented thus far have represented an overall summary of the status of GRNMS fish assemblages. These data will be useful as a baseline to compare with future data. This information will also complement the larger suite of information and data being collected on the living marine resources of the Sanctuary in order to conduct a more complete site characterization. Because REEF only collected RVC data for 3 years and has consistently collected RDT data for 5 years, this report does not include a quantitative analysis of trends through time. However, in order to provide a coarse look at changes through time in size structure and density of four key species, black sea bass, gag, scamp, and red snapper, these species were evaluated using RVC data from 2004 through 2006 (Figures 4a-d) and using RDT data from 2002 through 2006 (Figures 5a-c).

Black sea bass exhibited little change in size structure and density between 2004 and 2006, with the exception of a large pulse of juveniles (0-10cm) in 2006 (Figure 4a). Both gag and scamp grouper exhibited a trend toward fewer, larger individuals over the three year period (Figures 4b and 4c). Red snapper numbers and size changed very little between 2004 and 2005, but in 2006, only a small handful (4 individuals, versus 48 in 2004 and 122 in 2005) of larger individuals were reported (Figure 4d).

These trends are also reflected in the RDT data (Figures 5a and 5b). Black sea bass exhibited very little change in Abundance Score between 2002 and 2006, ranging from 2.6 to 3.0 (Figure 5b). Sighting Frequency during this time was consistently between 90-100%, except in 2004 when Sighting Frequency dropped to 78%. Abundance Score in the two grouper species, gag and scamp, decreased from 0.9 to 0.45 and from 1.4 to 1.0, respectively, between 2004 and 2006 (Figure 5a). Both of these species actually exhibited an increase from 2003 Abundance Score values, however, scamp appear to have significantly decreased over the five year time period. Sighting frequency of scamp in 2002 was over 90% with an Abundance Score of 1.8 versus 39% with an Abundance Score of 1.0 in 2006. The RDT data on red snapper suggests that the apparent decline of this species over the three years in RVC data more likely reflects variability in this stock rather than a straight forward decline. In the two years prior to 2004 when the RVC surveys started, red snapper were typically seen in 5% of surveys with an Abundance Score of 0.1 (Figure 5b). In 2004, these values jumped to 29% with an Abundance Score of 0.5. Similar to what the RVC data showed, red snapper declined in the subsequent two years, returning to a Sighting Frequency of 8% and an Abundance Score of 0.1 in 2006.

The trends in Abundance Score for two additional species, cocoa damselfish and seaweed blenny, are shown in Figure 5c. Neither of these species is commercially important but both are

likely ecologically important players on the reefs and sand flats of GRNMS. Both species have exhibited declines over the 5-year period between 2002 and 2006. Cocoa damselfish, once a very common and frequently sighted species (seen in 93% of surveys in 2002 with an Abundance Score of 2.5) plummeted to a Sighting Frequency of 9% and an Abundance Score of 0.1 in 2006. Seaweed blenny have shown a similar, but less dramatic, pattern.

In addition to the fish monitoring activities, REEF staff on the annual projects conducted outreach and public training opportunities during several years. In 2003, Lad Akins, conducted a REEF training workshop for 17 local divers. A second public training session was held in 2005. Also in 2003, Georgia Public Television conducted filming and interviews during the REEF survey week for an episode of Georgia Outdoors. The episode, "Eco-Tourism", originally aired on February 14, 2004, and more information can be found at http://www.gpb.org/public/tv/georgiaoutdoors/shows.jsp?episid=1280&catid=1085. In 2005, a Savanna-based television crew participated in the REEF project.

Summary

Through coordinated efforts of the REEF Volunteer Survey Program between 2002 and 2006, a valuable set of data on the fish assemblages of GRNMS has been generated. Volunteer-collected data plays an important role in the management and understanding of natural resources. National, regional and local government strategies often include education and awareness as critical components. Citizen science programs meet the mandate for education and constituency building by training and involving volunteers. Such programs are also an ideal approach for managers needing to collect data with limited funds. Marine resource managers are consistently challenged to make decisions despite limited knowledge of the system they are charged to protect. Without complete inventories, management efforts themselves become incomplete.

Data collected by REEF provides a baseline of fish composition in GRNMS. By periodically supplementing the standardized REEF survey method (RDT) with more quantitative and size-specific data (RVC) on a selected group of targeted species, the REEF monitoring program can provide additional information useful in the evaluation of the efficacy of management actions such as zones and harvest restrictions. The focus on total fish diversity in the RDT surveys provide critical data needed to better understand the effects of management strategies using an assemblage-wide approach, rather than traditional single species or single family analysis. These data also contribute to the larger REEF database, which is accessible to researchers and managers and can provide the basis for a variety of regional analyses.

Literature Cited

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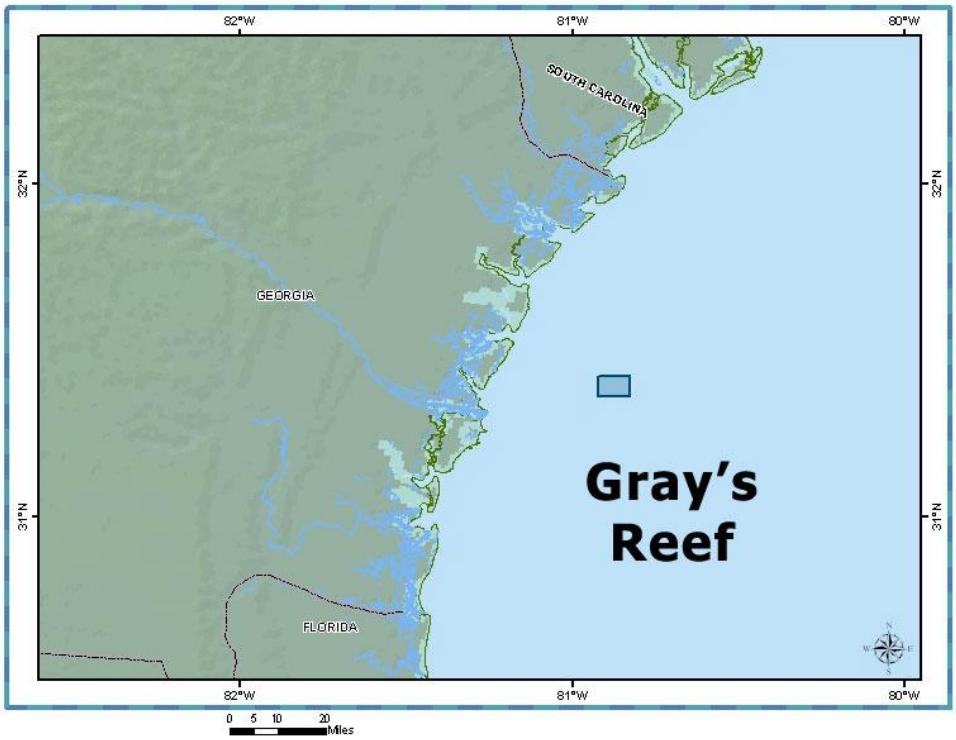

Figure 1a. Location of Gray's Reef National Marine Sanctuary (GRNMS). The site is located 32 km off the coast of Georgia and is 17.5 square nautical miles in size.

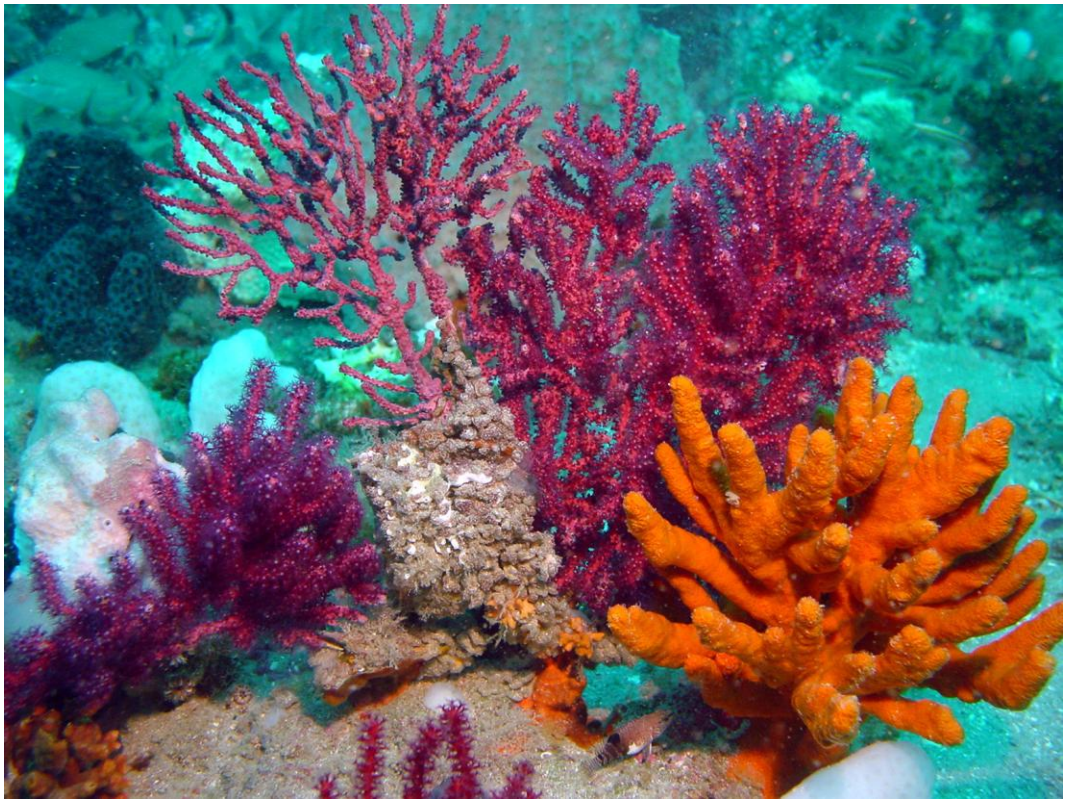

Figure 1b. Live-bottom habitat at GRNMS that is rich with sponges and gorgonians. Photo by Greg McFall.

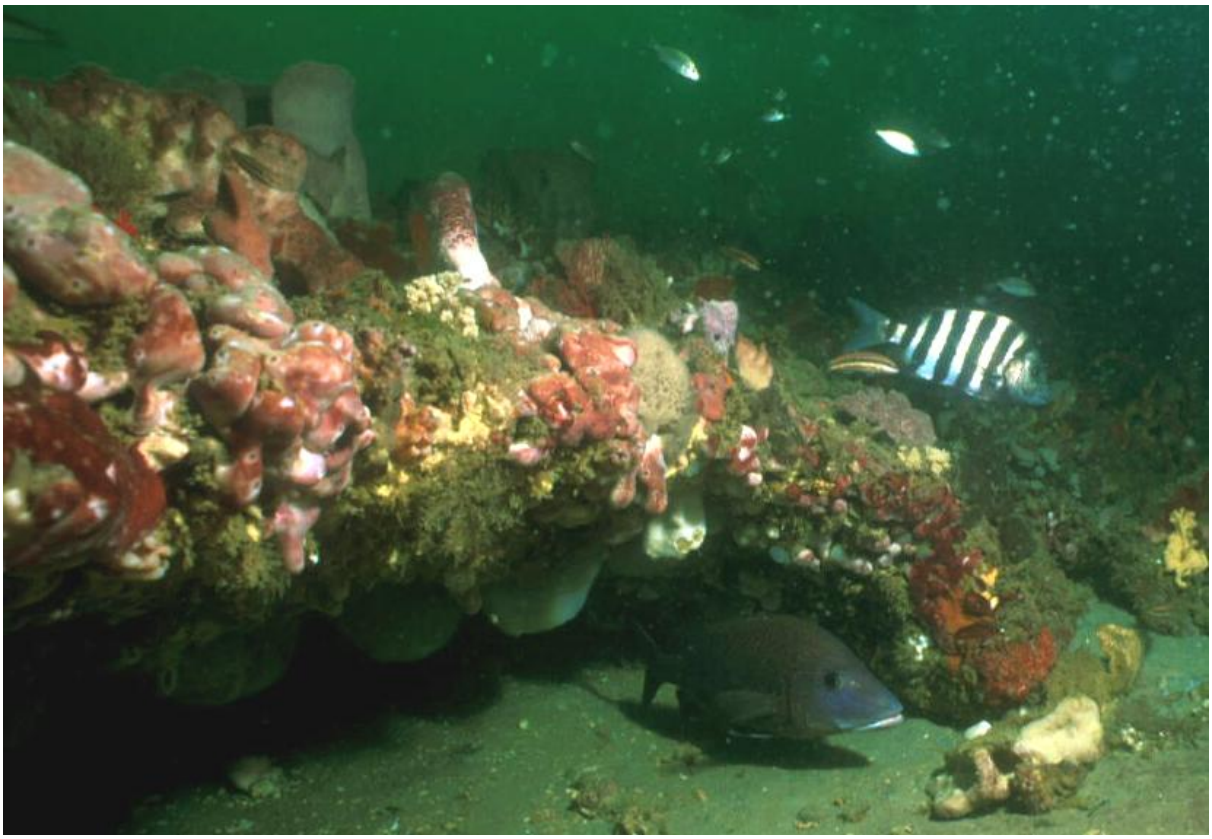

Figure 1c. A typical ledge at GRNMS, which serves as critical habitat for a variety of fish and benthic invertebrate species. Photo by Lad Akins.

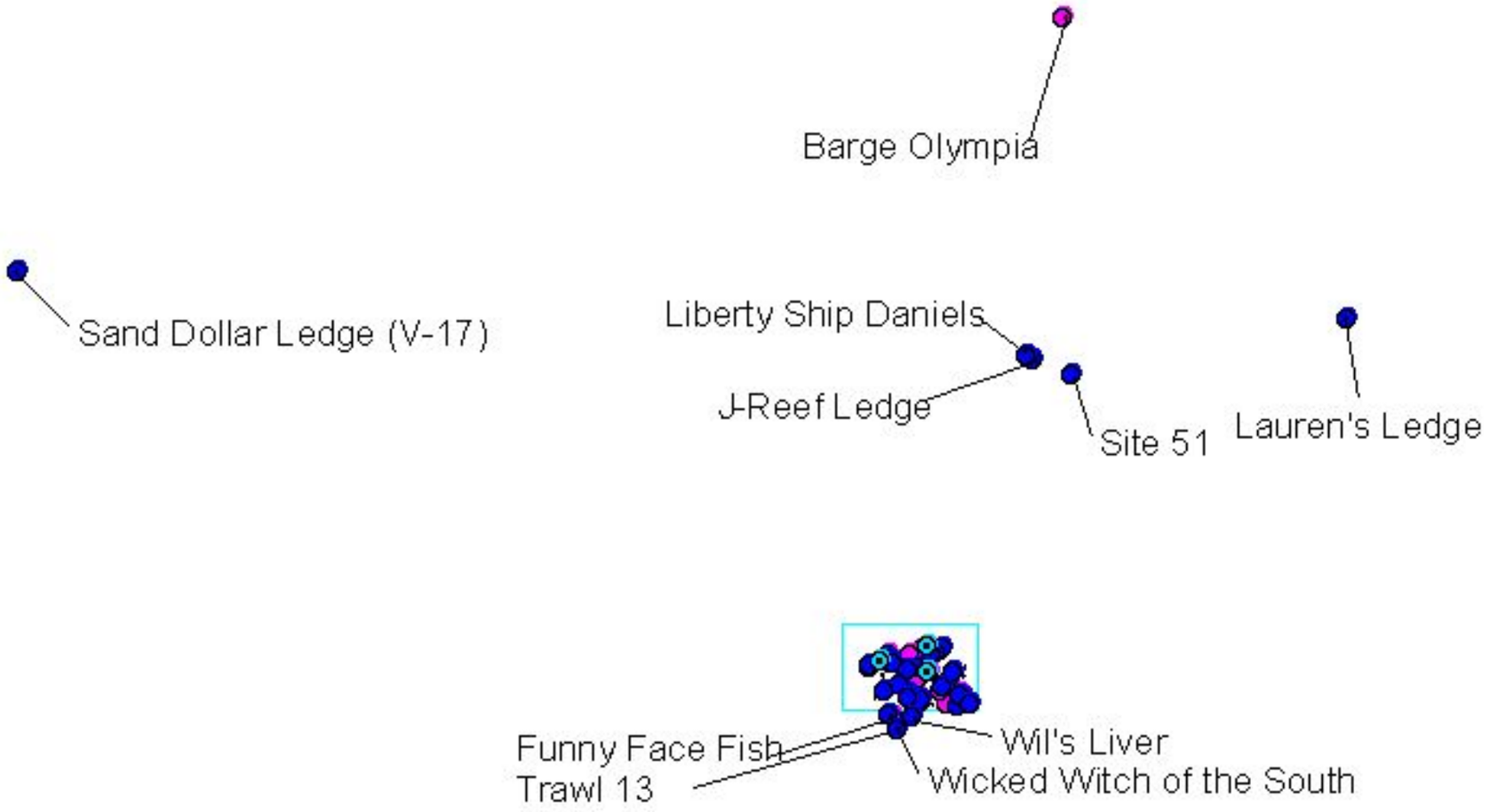

Figure 2a

Locations of Sites In and Around the GRNMS Surveyed by the Reef Environmental Education Foundation. The GRNMS boundary is shown by the green box surrounding the majority of the sites visited. A total of 58 sites were surveyed. 335 Roving Diver Technique (RDT) Surveys were conducted at 55 sites between 1998 and 2006; 704 Rapid Visual Count (RVC) Surveys were conducted at 39 sites between 2004-2006.
Legend: Blue Dots- RDT and RVC Survey Locations
Purple Dots- RDT-only Survey Locations
Turquoise Dots- RVC-only Survey Locations

REEF Survey Sites Within the GRNMS Boundary. Benthic Habitat data provided by the NOAA Biogeography Office (white - rippled sand; yellow- flat sand; tan- sparsely colonized hard bottom; red- densely colonized hard bottom).

Legend: Blue Dots- RDT and RVC Survey Locations
Purple Dots- RDT-only Survey Locations
Turquoise Dots- RVC-only Survey Locations

Figure 2b

REEF Survey Sites Within the GRNMS Boundary. Benthic Habitat data provided by the NOAA Biogeography Office, representing ledge height (maroon - high; red-medium; tan-low).

Legend: Blue Dots- RDT and RVC Survey Locations
Purple Dots- RDT-only Survey Locations
Turquoise Dots- RVC-only Survey Locations

Figure 2c

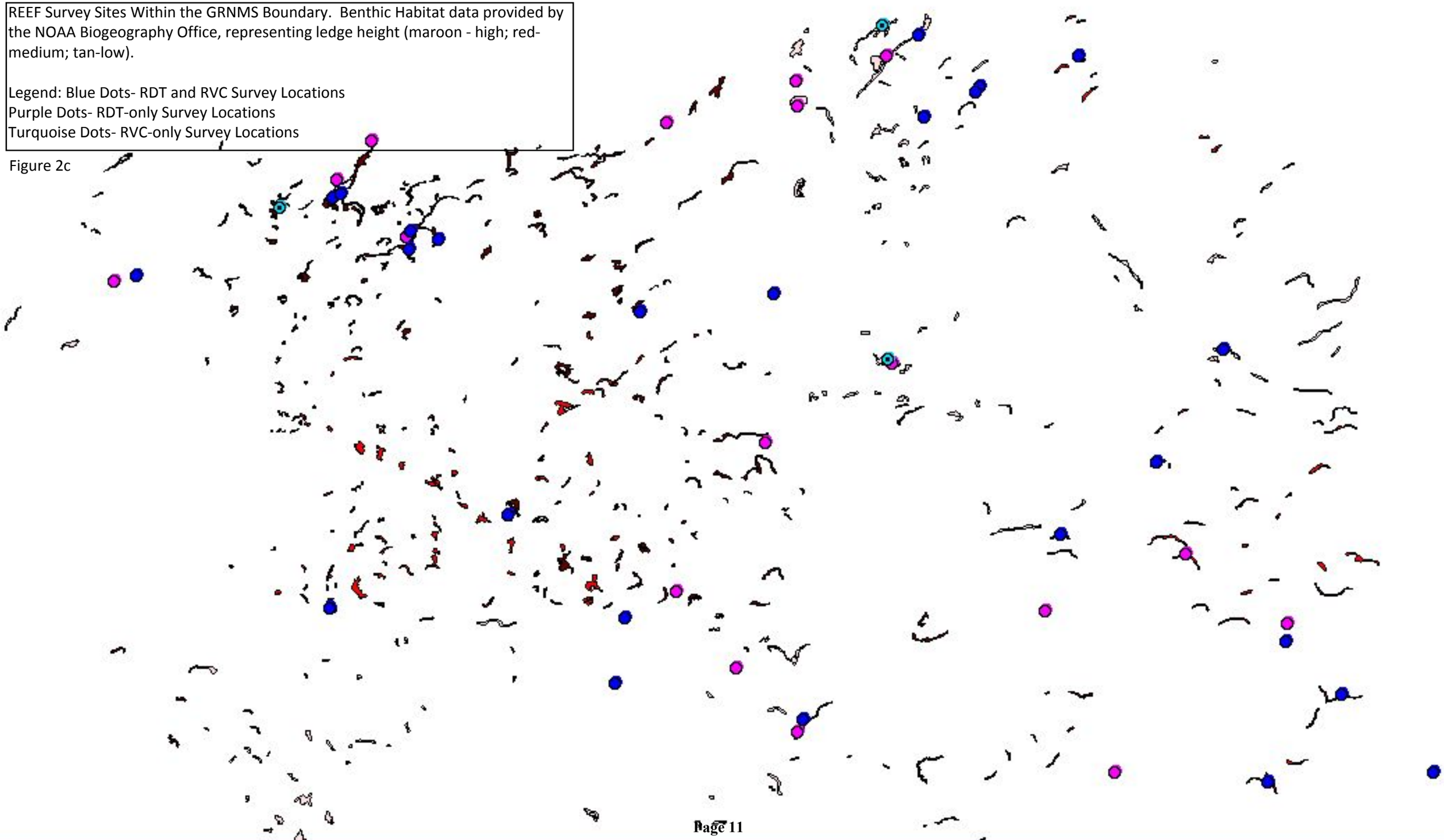

Table 1. Reef Environmental Education Foundation Monitoring Effort in Gray's Reef National Marine Sanctuary

Zone Code	Site	Latitude	Longitude	98RDT	99RDT	00RDT	01RDT	02RDT	03RDT	04RDT	04RVC	05RDT	05RVC	06RDT	06RVC	GRNMS
93020001	GRNMS - unspecified location				5		4		5	1		2				yes
93020003	Station 20	31.396833	-80.891	6	16	15		44	23	7	42	4		1	12	yes
93020004	GRNMS Southwest Ledge 1	31.394167	-80.887					5	6	7	42					yes
93020005	GRNMS Southwest Ledge 2	31.394833	-80.887167					14	6							yes
93020006	GRNMS Southwest Ledge 3	31.397833	-80.890833					5		7						yes
93020007	GRNMS Site R9	31.368833	-80.866667						3							yes
93020008	GRNMS Site F3	31.399833	-80.889						1							yes
93020011	May05_LAM9 - Tigershark Ledge	31.404333	-80.862						7			2	25			yes
93020012	May05_LAM6 - Hake Ledge	31.38837	-80.86191						6			2	12			yes
93020013	Spoonnose	31.378167	-80.846333						6							yes
93020014	Skate City	31.401667	-80.866667						6							yes
93020015	Goliath Ledge	31.39705	-80.890567							3	33					yes
93020016	J-Reef Ledge	31.600933	-80.790517							8	21			1	8	no
93020017	Liberty Ship Daniels	31.60345	-80.795833							7				3	15	no
93020018	Lauren's Ledge	31.628133	-80.5777							9	10					no
93020019	Site 51	31.589833	-80.765							6	30					no
93020020	Site 64									2						unk
93020021	Barge Olympia	31.831733	-80.771							4						no
93020022	Scamp Ledge (V-8)	31.395117	-80.886933							6	18					yes
93020023	Housing Site	31.369467	-80.866333							3	9					yes
93020024	Sand Dollar Ledge (V-17)	31.660883	-81.479833							5	12					no
93020025	V-10 (sand)									2						unk
93020026	May05_LAM1	31.3748	-80.8757									1	27			yes
93020027	May05_LAM2	31.4054	-80.8603									2	15			yes
93020028	May05_LAM3	31.3802	-80.8818									3	20			yes
93020029	May05_LAM4	31.396317	-80.893833									3	15			yes
93020030	May05_LAM7	31.3662	-80.842									4	12			yes
93020031	May05_LAM8	31.382967	-80.847833									3	15			yes
93020032	May05_LAM10	31.375367	-80.8912									2	15			yes
93020033	May05_LAM11	31.3947	-80.8855									4	14			yes
93020034	May05_LAM12	31.3928	-80.9013									4	21	3	12	yes
93020035	May05_LAM13	31.3708	-80.8381									4	12			yes
93020036	May05_LAM14	31.4027	-80.8571									4	34	1	6	yes
93020037	May05_LAM15	31.3889	-80.8443									2	18			yes
93020038	May05_LAM16	31.379183	-80.852867									2	12			yes
93020039	May05_LAM17	31.4043	-80.8519									2	16			yes
93020040	Sarah's Ledge	31.3918	-80.8679											1	12	yes
93020041	East of Africa	31.4024	-80.8573											1	10	yes
93020042	Funny Face Fish	31.3592	-80.889											1	10	no
93020043	Wicked Witch of the South	31.35	-80.8833											1	12	no
93020044	Donut Hole	31.3909	-80.8749											1	12	yes

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Zone Code	Site	Latitude	Longitude	98RDT	99RDT	00RDT	01RDT	02RDT	03RDT	04RDT	04RVC	05RDT	05RVC	06RDT	06RVC	GRNMS
93020045	Paul's Pancreatic Reef	31.4011	-80.86											1	11	yes
93020046	Handlebar Mustache	31.3714	-80.8762											1	10	yes
93020047	Tatonka	31.3667	-80.85											2		yes
93020048	Panther	31.3722	-80.8699											2		yes
93020049	The Claw	31.37355	-80.841017											1	10	yes
93020050	Seagull Ledge	31.3667	-80.8333											1	12	yes
93020051	Pop-a-Top	31	-80.8908											1	12	no
93020052	Trawl 13	31.3576	-80.8856											3		no
93020053	Wil's Liver	31.3588	-80.8732											1	6	no
93020054	Jigsaw Reef	31.403	-80.8667											3		yes
93020056	May05_SP12	31.3752	-80.8537									1				yes
93020057	May05_FS2	31.3925	-80.9025									1				yes
93020058	May05_R1	31.4008	-80.8735									1				yes
93020059	May05_LBM12	31.3745	-80.841									1				yes
93020060	May05_SP8	31.3762	-80.873									1				yes
93020061	May05_LAM18	31.384	-80.8683									1				yes
93020067	May05_LAM9	31.40592	-80.86221										25			yes
93020068	GR4	31.39632	-80.89383												9	yes
TOTAL EFFORT				**6**	**21**	**15**	**4**	**69**	**71**	**77**	**217**	**56**	**308**	**30**	**179**	

RDT - Roving Diver Technique; RVC - Rapid Visual Count

GRNMS field denotes whether site is within GRNMS boundary.

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Belted Sandfish	91.5%	3.2	100.0%	3.1	98.3%	3.3	90.9%	3.4	81.8%	3	86.6%	2.8
Black Sea Bass	89.0%	3.1	97.0%	3.1	100.0%	3	76.6%	3.5	94.5%	3.2	93.3%	2.8
Slippery Dick	86.8%	3.2	86.7%	3.6	93.4%	3.1	84.4%	3.1	80.0%	2.9	90.0%	2.7
Bank Sea Bass	79.2%	2.6	95.5%	2.5	91.8%	2.7	72.7%	3	52.7%	1.9	86.6%	2.3
Cubbyu	78.4%	2.8	91.1%	2.5	60.6%	2.5	89.6%	3.4	69.0%	3	73.3%	2.7
Tomtate	68.0%	3.5	92.6%	3.7	54.0%	2.8	81.8%	3.9	29.0%	3.4	43.3%	2.7
Longspine Porgy	67.2%	3.1	83.8%	2.9	72.1%	3.1	72.7%	2.9	78.1%	3.3	90.0%	3.5
Twospot Cardinalfish	67.2%	2.2	79.4%	1.9	60.6%	2.2	74.0%	2.3	60.0%	2.6	56.6%	2.2
Spottail Pinfish	65.8%	3	94.1%	3.3	39.3%	2.5	74.0%	3.1	58.1%	2.7	40.0%	2.8
Sheepshead	62.1%	2	58.8%	1.7	36.0%	1.8	71.4%	2.2	56.3%	2.2	70.0%	2.2
Blue Angelfish	61.0%	1.8	94.1%	2.1	29.5%	1.3	61.0%	1.7	40.0%	1.8	43.3%	1.5
Oyster Toadfish	58.8%	1.6	51.4%	1.4	67.2%	1.5	76.6%	1.7	69.0%	1.7	43.3%	1.4
Whitespotted Soapfish	57.7%	1.9	72.0%	2	27.8%	1.2	76.6%	2.2	56.3%	2	53.3%	2
Cocoa Damselfish	57.4%	2.2	92.6%	2.5	42.6%	1.9	75.3%	2.1	1.8%	1	6.6%	1.5
Sand Perch	55.1%	2.2	60.2%	2.1	63.9%	2.3	74.0%	2.6	40.0%	1.8	56.6%	1.9
Scamp	53.2%	2.1	91.1%	2	31.1%	2	58.4%	2.4	43.6%	2.3	36.6%	2.2
Great Barracuda	52.6%	2.3	79.4%	2.3	27.8%	2.5	71.4%	2.2	10.9%	1.5	23.3%	1.4
Painted Wrasse	48.4%	2.2	51.4%	2.1	62.2%	2.3	80.5%	2.5	36.3%	1.7	46.6%	2
Seaweed Blenny	47.6%	1.7	58.8%	1.5	21.3%	1.6	66.2%	1.8	47.2%	2	26.6%	1.5
Round Scad	47.0%	3.7	86.7%	3.7	31.1%	3.6	66.2%	3.7	10.9%	3.8	20.0%	3.6
Atlantic Spadefish	38.6%	2.7	44.1%	2.6	27.8%	2.2	46.7%	2.7	21.8%	2.9	33.3%	2.5
Planehead Filefish	38.0%	1.5	80.8%	1.7	32.7%	1.4	37.6%	1.4	29.0%	1.5	13.3%	1
Gag	37.2%	1.9	42.6%	1.8	19.6%	1.8	48.0%	1.9	34.5%	2	26.6%	1.7
Gray Triggerfish	34.1%	1.6	38.2%	1.5	18.0%	1.2	48.0%	1.9	30.9%	1.5	30.0%	1.7
Blue Runner	33.0%	2.9	70.5%	2.9	18.0%	2.7	45.4%	3.2	9.0%	1.8	13.3%	3.2
Crested Blenny	31.3%	1.5	33.8%	1.4	13.1%	1.1	42.8%	1.8	49.0%	1.7	16.6%	1.6
Greater Amberjack	29.9%	2.3	23.5%	2	24.5%	2.3	53.2%	2	20.0%	3	20.0%	2.3
Dwarf Goatfish	29.6%	2.5	77.9%	2.6	3.2%	2	3.8%	2	29.0%	2.3	36.6%	2.7
Spanish Mackerel	28.8%	2	50.0%	1.5	9.8%	1.8	41.5%	2.5	30.9%	2.1	10.0%	2
Bar Jack	28.0%	2.5	60.2%	2.5	9.8%	2.5	44.1%	2.4				
Blue Goby	28.0%	2	36.7%	1.8	11.4%	2	36.3%	2.5	7.2%	1.2	43.3%	2.3
White Grunt	25.4%	1.7	26.4%	1.4	14.7%	2.1	44.1%	1.8	21.8%	1.6	20.0%	1.5
Mackerel Scad	23.5%	3.5	33.8%	3.4	13.1%	3.1	20.7%	4	7.2%	2.7	40.0%	3.1

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Spotfin Butterflyfish	21.2%	1.7	58.8%	1.9	4.9%	1					26.6%	1.3
Nurse Shark	21.0%	1.4	17.6%	1.1	6.5%	1	50.6%	1.5	7.2%	1.7	16.6%	1.2
Carolina Hake	20.7%	1.7			19.6%	1	28.5%	1.8	60.0%	1.9	6.6%	2
Red Porgy	17.0%	2.3	42.6%	2.7	-- SO --	0	27.2%	1.9	12.7%	2.1		
Highhat	16.8%	2	67.6%	2	11.4%	1.8			3.6%	2	10.0%	2
Scrawled Cowfish	16.5%	1.3	30.8%	1.2	11.4%	1.1	5.1%	1.2	9.0%	1.4	13.3%	1.5
Gulf Flounder	16.5%	1.2	19.1%	1.1	21.3%	1	20.7%	1	20.0%	1.9	10.0%	1.3
Reticulate Moray	16.5%	1.1	14.7%	1	9.8%	1	27.2%	1.2	27.2%	1.4	6.6%	1
Whitebone Porgy	15.4%	1.6	7.3%	1.6	14.7%	2	19.4%	1.6	18.1%	2	3.3%	1
Red Snapper	14.8%	1.9	5.8%	1.7	6.5%	1.7	27.2%	2	18.1%	2.1	6.6%	1.5
Almaco Jack	14.2%	1.7	51.4%	1.8	6.5%	1.5	9.0%	1.4	1.8%	2		
Jackknife-Fish	12.8%	1.3	4.4%	1.6	9.8%	1.3	22.0%	1.2	29.0%	1.5	10.0%	1
Scup	12.0%	3.2	1.4%	3	21.3%	3.1			12.7%	2.5		
Bridled Goby	11.7%	1.7	23.5%	2	6.5%	1	20.7%	1.5				
Sheepshead Porgy	11.7%	1.1	22.0%	1.1	6.5%	1	7.7%	1.1	9.0%	1.6	16.6%	1
Beaugregory	11.2%	1.5	33.8%	1.5	9.8%	1.5					20.0%	1
Southern Stingray	10.9%	1.2	25.0%	1	3.2%	1	12.9%	1.2			10.0%	1.3
Emerald Parrotfish	10.6%	2	38.2%	2.1	8.1%	2	9.0%	1.2				
Silversides, Herrings, Anchovies	9.2%	3.9					10.3%	4	7.2%	3.7	20.0%	3.6
Loggerhead Sea Turtle	8.9%	1	7.3%	1	8.1%	1.2	16.8%	1			20.0%	1.1
Spotted Goby	8.6%	1.5	17.6%	1.5	6.5%	1.2	12.9%	1.7	3.6%	1		
Doctorfish	8.6%	1.4	30.8%	1.5	1.6%	2	7.7%	1.3			3.3%	1
Saucereye Porgy	8.6%	1.4	29.4%	1.5	4.9%	1.6	2.5%	1.5	3.6%	1.5	10.0%	1.3
Pearly Razorfish	8.1%	2	5.8%	1.5	3.2%	2	12.9%	2.2	7.2%	2	20.0%	2
Pygmy Sea Bass	8.1%	1.3			14.7%	1.3	3.8%	1			30.0%	1.5
Sergeant Major	7.8%	1.4	41.1%	1.4								
Sharksucker	7.5%	1.5	11.7%	1.6	3.2%	3	7.7%	1.1	3.6%	1	3.3%	1
Guaguanche	6.7%	2.9					10.3%	3.5	12.7%	3	26.6%	2.2
Seminole Goby	6.1%	1.8			14.7%	2	1.2%	1	5.4%	1.3	26.6%	2
Pinfish	6.1%	1.7			4.9%	1.3	10.3%	1.6	7.2%	1.7	6.6%	2
Porcupinefish	6.1%	1	13.2%	1	9.8%	1	3.8%	1				
Sand Diver	5.3%	1.1	2.9%	1			18.1%	1	3.6%	1		
Blue Tang	5.0%	1	14.7%	1			9.0%	1.1			3.3%	1

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Cobia	4.7%	1.7	1.4%	2	6.5%	1.5	2.5%	1.5	1.8%	3	13.3%	1.2
Inshore Lizardfish	4.7%	1.4	10.2%	1.2	6.5%	1	5.1%	2.5				
Bandtail Puffer	4.7%	1.1	8.8%	1.1	3.2%	1	2.5%	1	1.8%	1	3.3%	1
Leopard Toadfish	3.9%	1.3			1.6%	1	5.1%	1.5	3.6%	1.5	20.0%	1.3
Vermillion Snapper	3.6%	2.3			6.5%	2.2	7.7%	2.5			3.3%	3
Pilot Fish	3.6%	2	1.4%	2	3.2%	2			1.8%	1		
Yellow Jack	3.6%	2	10.2%	1.8	3.2%	2.5					3.3%	1
Red Grouper	3.6%	1.3							18.1%	1.4	6.6%	1
Bicolor Damselfish	3.6%	1.3	5.8%	1.2							20.0%	1.1
Little Tunny	3.3%	3					10.3%	3	3.6%	4	6.6%	2.5
Hovering Goby	2.8%	1.4	1.4%	1	4.9%	1.3						
Manta	2.8%	1.2			3.2%	2						
Spotted Scorpionfish	2.8%	1.2			9.8%	1.3	2.5%	1	3.6%	1		
Squirrelfish	2.8%	1.1	13.2%	1.1								
Honeycomb Moray	2.8%	1	4.4%	1			5.1%	1	5.4%	1		
Southern Guitarfish	2.5%	3.8					11.6%	3.8				
Goliath Grouper	2.5%	1.3			4.9%	1	5.1%	1.7				
Leopard Searobin	2.5%	1			8.1%	1			5.4%	1		
Pigfish	2.2%	3					9.0%	3.1			3.3%	2
Yellowtail Snapper	2.2%	1.8			1.6%	2	3.8%	1				
Townsend Angelfish	2.2%	1.3	7.3%	1.4					1.8%	2	6.6%	1
Remora	2.2%	1.2	4.4%	1							10.0%	1
Polka-dot Batfish	2.2%	1.1					6.4%	1.2	3.6%	1		
Barbfish	2.2%	1			8.1%	1	3.8%	1				
Atlantic Guitarfish	2.2%	1			1.6%	1			9.0%	1	3.3%	1
Southern Sennet	1.9%	2							5.4%	2.3		
Gray Snapper	1.9%	1.5	7.3%	1.8								
Whitenose Pipefish	1.9%	1.2					9.0%	1.2				
Striped Burrfish	1.9%	1.1	5.8%	1					1.8%	1	3.3%	2
Ocean Surgeonfish	1.9%	1.1	8.8%	1.1								
Bigeye Scad	1.6%	3.6					6.4%	3.8			3.3%	3
Red Drum	1.6%	1.8					3.8%	1			10.0%	2.6
Black Grouper	1.6%	1.8	7.3%	1.8								

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Lane Snapper	1.6%	1.6	7.3%	1.6								
Black Margate	1.6%	1.3	1.4%	1	6.5%	1.5					3.3%	1
Yellow Goatfish	1.6%	1.3	1.4%	1			6.4%	1.4				
Bandtail Searobin	1.6%	1			3.2%	1	2.5%	1	1.8%	1		
Clearnose Skate	1.6%	1			6.5%	1			1.8%	1	3.3%	1
Eyed Flounder	1.6%	1					2.5%	1			13.3%	1
Conger Eel	1.4%	1.8					3.8%	1.6	3.6%	2		
Spotted Moray	1.4%	1.2	2.9%	1			3.8%	1.3				
Web Burrfish	1.4%	1	2.9%	1					1.8%	1		
Juvenile Grunt	1.1%	3.5							5.4%	3.6	3.3%	3
Atlantic Bumper	1.1%	3					2.5%	3			6.6%	3
Saddled Blenny	1.1%	1.7									10.0%	1.3
Bighead Searobin	1.1%	1.5									13.3%	1.5
Rainbow Runner	1.1%	1.2			1.6%	1	3.8%	1.3				
Cottonwick	1.1%	1					5.1%	1				
Orangespotted Filefish	1.1%	1	2.9%	1					1.8%	1		
French Angelfish	1.1%	1										
King Mackerel	0.8%	2.3	1.4%	1					3.6%	3		
Spotted Goatfish	0.8%	2	2.9%	1.5								
Lancer Dragonet	0.8%	1.6							5.4%	1.6		
Cubera Snapper	0.8%	1.6	4.4%	1.6								
Roughtail Stingray	0.8%	1.3									6.6%	1
Jolthead Porgy	0.8%	1.3	2.9%	1								
Tautog	0.8%	1			4.9%	1						
Shortnose Batfish	0.8%	1					2.5%	1			3.3%	1
Blackbar Soldierfish	0.8%	1			3.2%	1	1.2%	1				
Flamefish	0.8%	1			1.6%	1			1.8%	1	3.3%	1
Balao	0.5%	3	2.9%	3								
Sea Bream	0.5%	2.5	1.4%	3	1.6%	2						
Lookdown	0.5%	2.5										
Cero	0.5%	2.5	1.4%	3							3.3%	2
Crevalle Jack	0.5%	2.5			1.6%	3	1.2%	2				
Lipstick Surgeonfish (exotic)	0.5%	2									6.6%	2

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Queen Angelfish	0.5%	2										
Bluespotted Searobin	0.5%	1					2.5%	1				
Orangespotted Blenny	0.5%	1							3.6%	1		
Rock Sea Bass	0.5%	1					1.2%	0				
Redfin Needlefish	0.5%	1									6.6%	1
Pygmy Filefish	0.5%	1					2.5%	1				
Checkered Blenny	0.5%	1							1.8%	1		
Green Razorfish	0.5%	1										
Spotted Eagle Ray	0.5%	1					2.5%	1				
Redband Parrotfish	0.5%	1										
Banded Butterflyfish	0.5%	1			3.2%	1						
Trunkfish	0.5%	1										
Gray Angelfish	0.5%	1					2.5%	1				
Scaled Sardine	0.2%	4					1.2%	4				
Blackfin Snapper	0.2%	4			1.6%	4						
Spotcheek Blenny	0.2%	4										
Horse-Eye Jack	0.2%	3										
Black Hamlet	0.2%	3										
Florida Pompano	0.2%	2			1.6%	2						
Crested Goby	0.2%	2										
Channel Flounder	0.2%	2							1.8%	2		
Tesselated Blenny	0.2%	2	1.4%	2								
Rainbow Wrasse	0.2%	2										
Balloonfish	0.2%	2									3.3%	2
Coney	0.2%	2									3.3%	2
Atlantic midshipman	0.2%	1					1.2%	1				
Atlantic stingray	0.2%	1										
Red Lionfish (exotic)	0.2%	1										
Sea Turtle sp. (unidentified)	0.2%	1										
Atlantic Sharpnose Shark	0.2%	1							1.8%	1		
Sandbar Shark	0.2%	1										
Shortfin Pipefish	0.2%	1					1.2%	1				
Lined Seahorse	0.2%	1							1.8%	1		

Table 2. Summary of Fish Sightings in the GRNMS from RDT data collected by REEF Surveyors -- 184 Species

	Total		2002		2003		2004		2005		2006	
	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score	%SF	Den Score
Keeltail Needlefish	0.2%	1										
Banded Jawfish	0.2%	1										
Spotted Spoon-nose Eel	0.2%	1			1.6%	1						
Flameback Angelfish	0.2%	1									3.3%	1
Greater Soapfish	0.2%	1										
Longlure Frogfish	0.2%	1										
Ocean Triggerfish	0.2%	1			1.6%	1						
Mutton Snapper	0.2%	1			1.6%	1						
Peppermint Basslet	0.2%	1										
Rosy Razorfish	0.2%	1										
Hogfish	0.2%	1	1.4%	1								
Tiger Grouper	0.2%	1										
Colon Goby	0.2%	1					1.2%	1				
Whitespotted Filefish	0.2%	1	1.4%	1								
Scrawled Filefish	0.2%	1										
Reef Butterflyfish	0.2%	1									3.3%	1
Honeycomb Cowfish	0.2%	1							1.8%	1		
Bigeye	0.2%	1										
Northern Searobin	-- SO --								-- SO --	0		
Ocellated Frogfish	-- SO --								-- SO --	0		

Values in the Total column represent all data collected between 1998-2007. A total of 370 REEF surveys have been conducted during this time.

"--SO--" indicates a species that was reported during a Species Only REEF Survey.

%SF - Percent Sighting Frequency; Den Score - Density Score, average log-scale abundance cateogry when seen

Table 3. Number of Individuals in Each Size Cateogry (cm) and Average Density Reported From 704 RVC Surveys Collected From 39 Sites In and Around GRNMS Between 2004-2006

	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total	Avg. Size (cm)	Avg. Density (/100m2)
Tomtate	141,352	43,009	3,193	582	9	0	0	0	0	0	188,145	7.72	360.65
Black Sea Bass	480	2,740	4,087	925	57	1	0	0	0	0	8,290	21.79	15.73
Spottail Pinfish	52	1,600	2,308	279	7	0	0	0	0	0	4,246	21.68	7.51
Atlantic Spadefish	0	290	1,867	1,530	356	13	1	0	0	0	4,057	29.92	6.68
Blue Runner	0	0	297	936	227	391	0	0	0	0	1,851	38.85	4.56
Amber Jack	0	0	0	546	601	513	76	51	17	2	1,806	46.94	3.05
Scamp	0	13	103	351	300	81	47	17	9	0	921	41.37	1.92
Sheepshead	0	11	337	356	62	4	1	0	0	0	771	31.29	1.37
Spanish Mackerel	0	0	29	137	139	270	2	0	0	0	577	46.37	1.08
Barracuda	0	0	1	7	11	25	71	49	52	115	331	77.87	0.58
Bar Jack	2	90	164	29	5	0	0	0	0	0	290	23.10	0.42
Gray Trigger	0	11	94	116	12	3	0	0	10	0	246	33.05	0.58
Gag	0	0	27	29	58	29	28	21	16	1	209	51.41	0.41
Red Snapper	0	0	31	76	47	15	1	3	1	0	174	38.79	0.28
White Grunt	0	4	35	42	7	0	0	0	0	0	88	30.91	0.20

Size Distribution of Selected Species In GRNMS Based on 704 RVC Surveys Collected Between 2004-2006

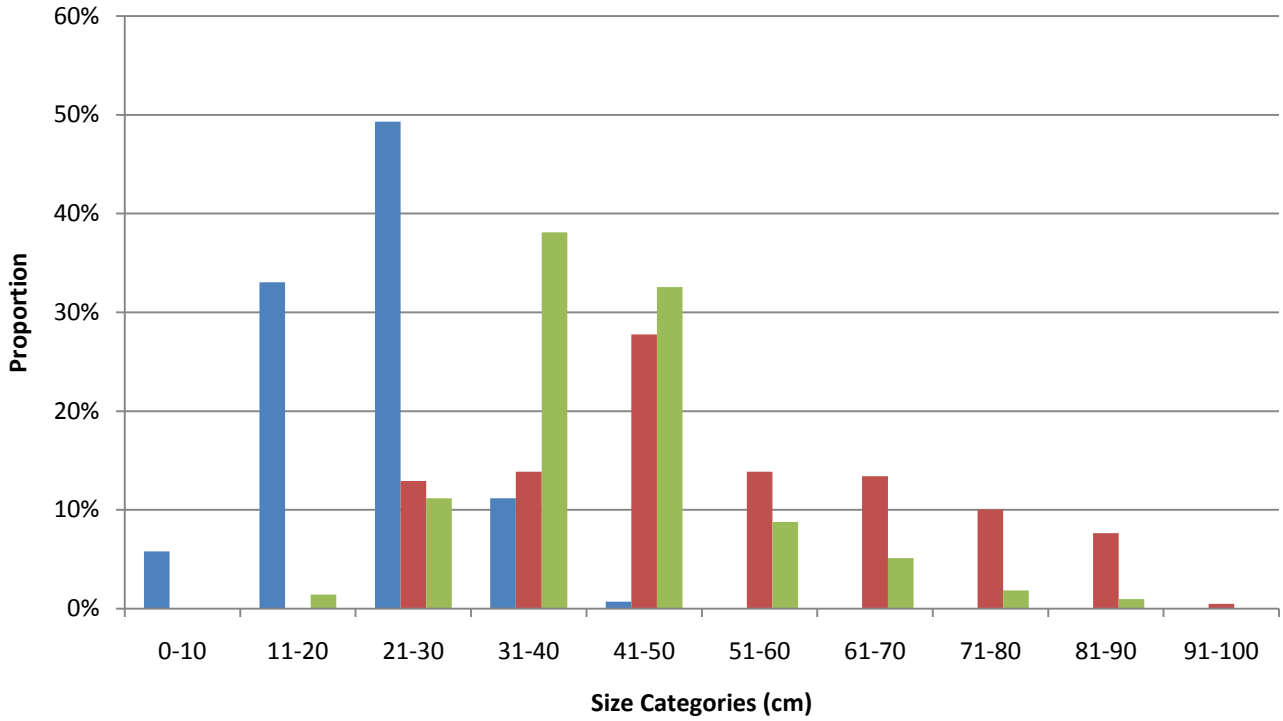

Figure 3a

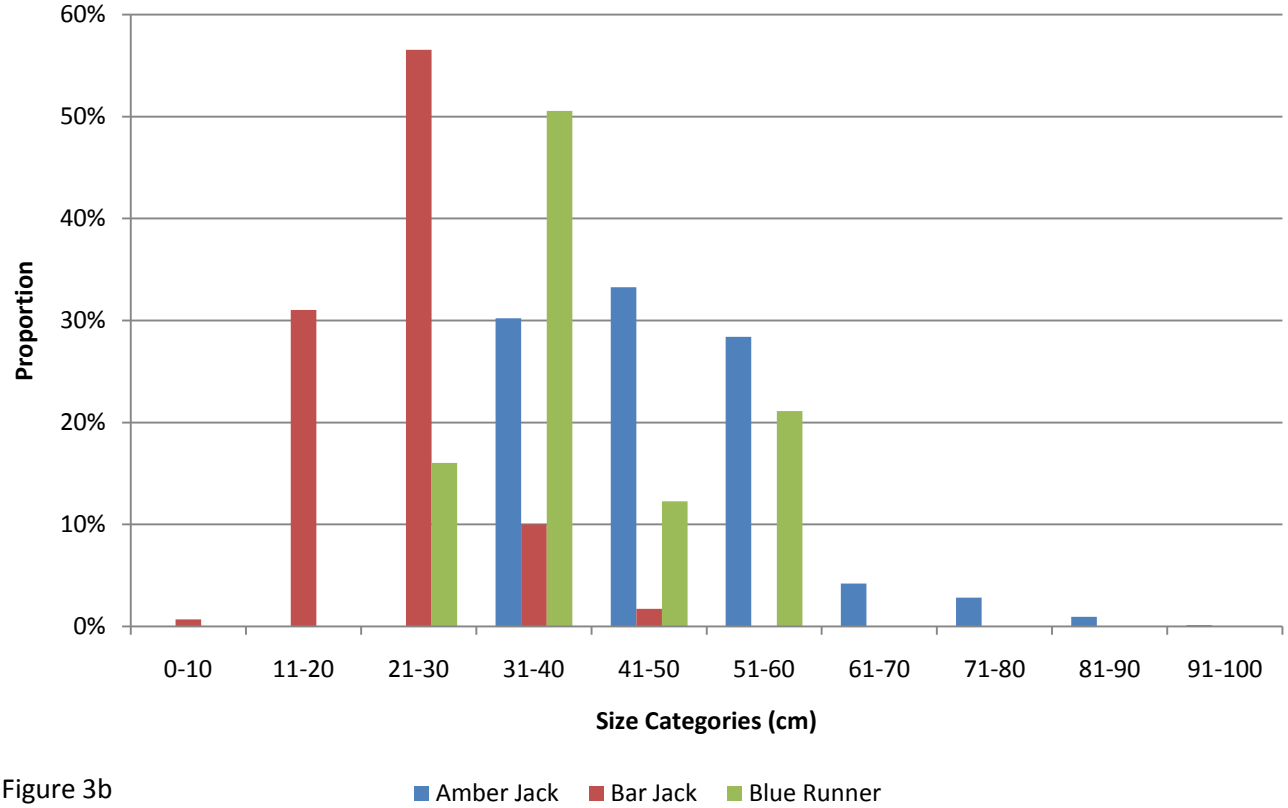

Figure 3b

Size Distribution of Selected Species In GRNMS Based on 704 RVC Surveys Collected Between 2004-2006, cont.

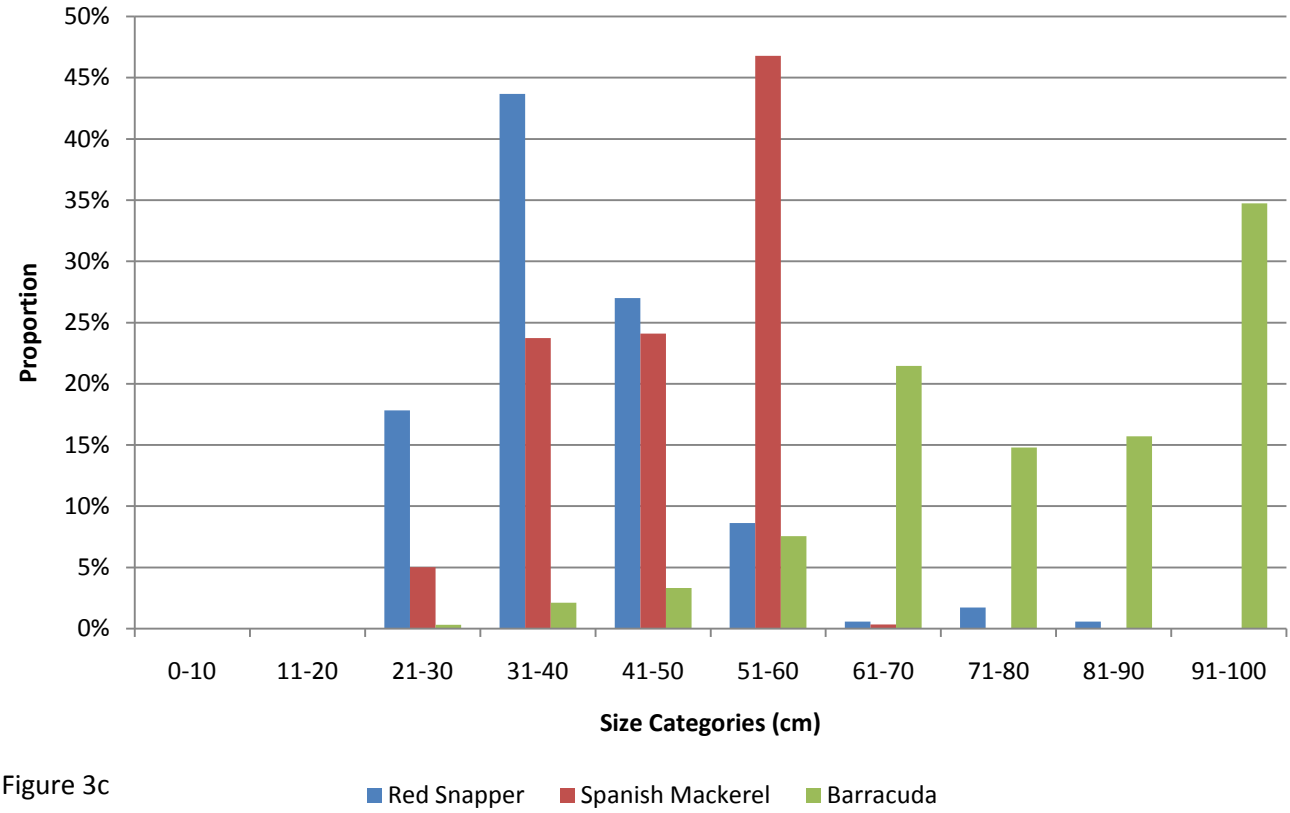

Figure 3c

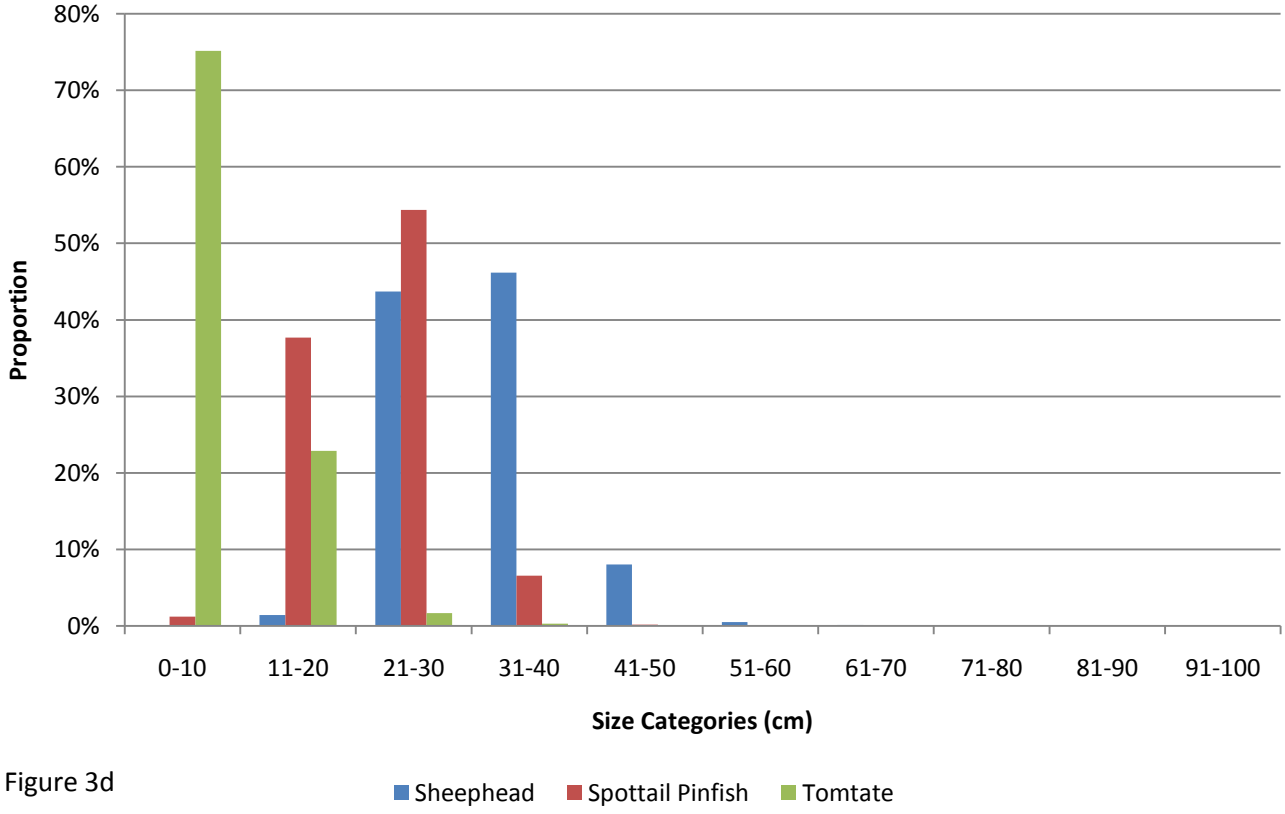

Figure 3d

Size Distribution of Selected Species In GRNMS Based on 704 RVC Surveys Collected Between 2004-2006, cont.

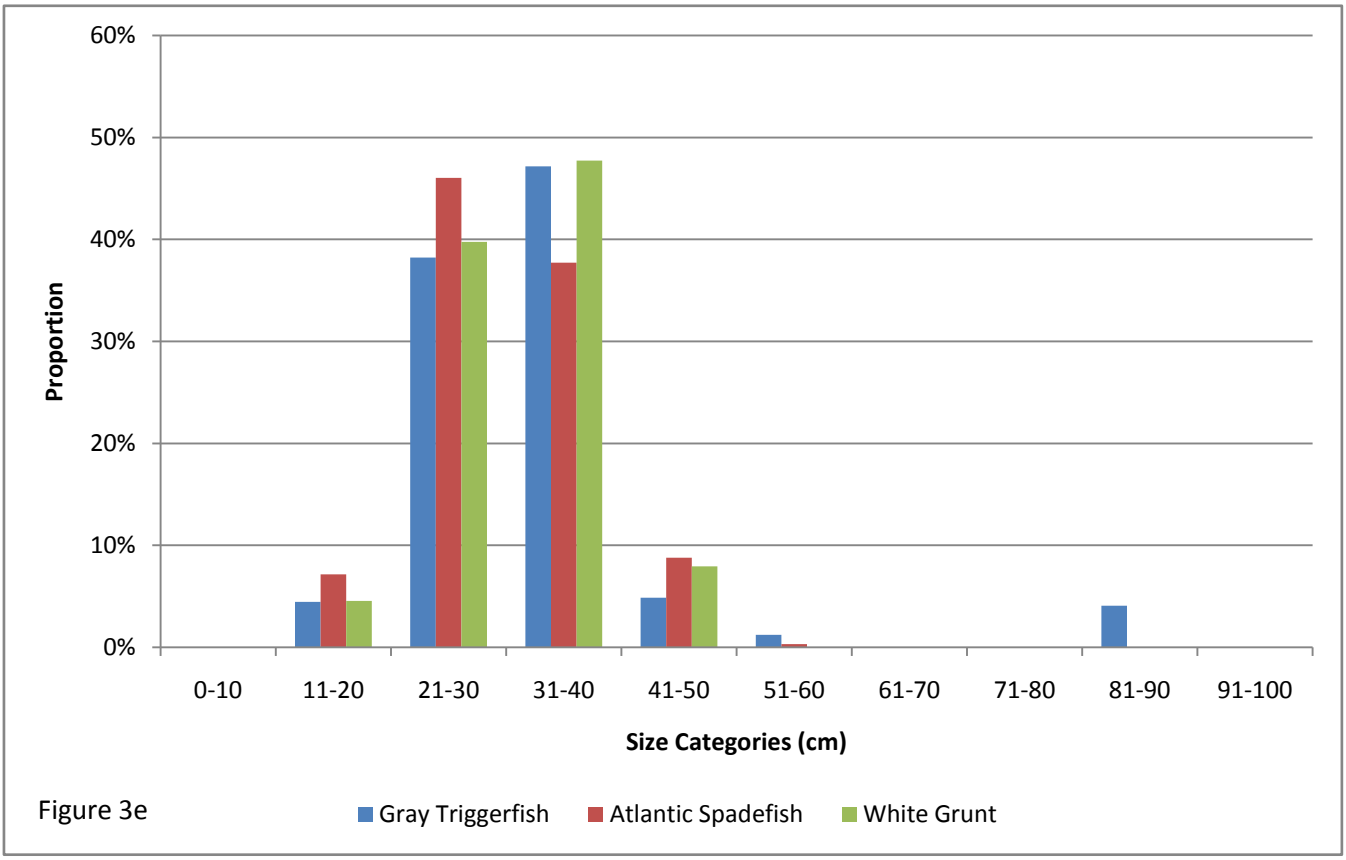

Figure 3e

Size Distribution of Four Key Species During Three Years In GRNMS Based on RVC Data

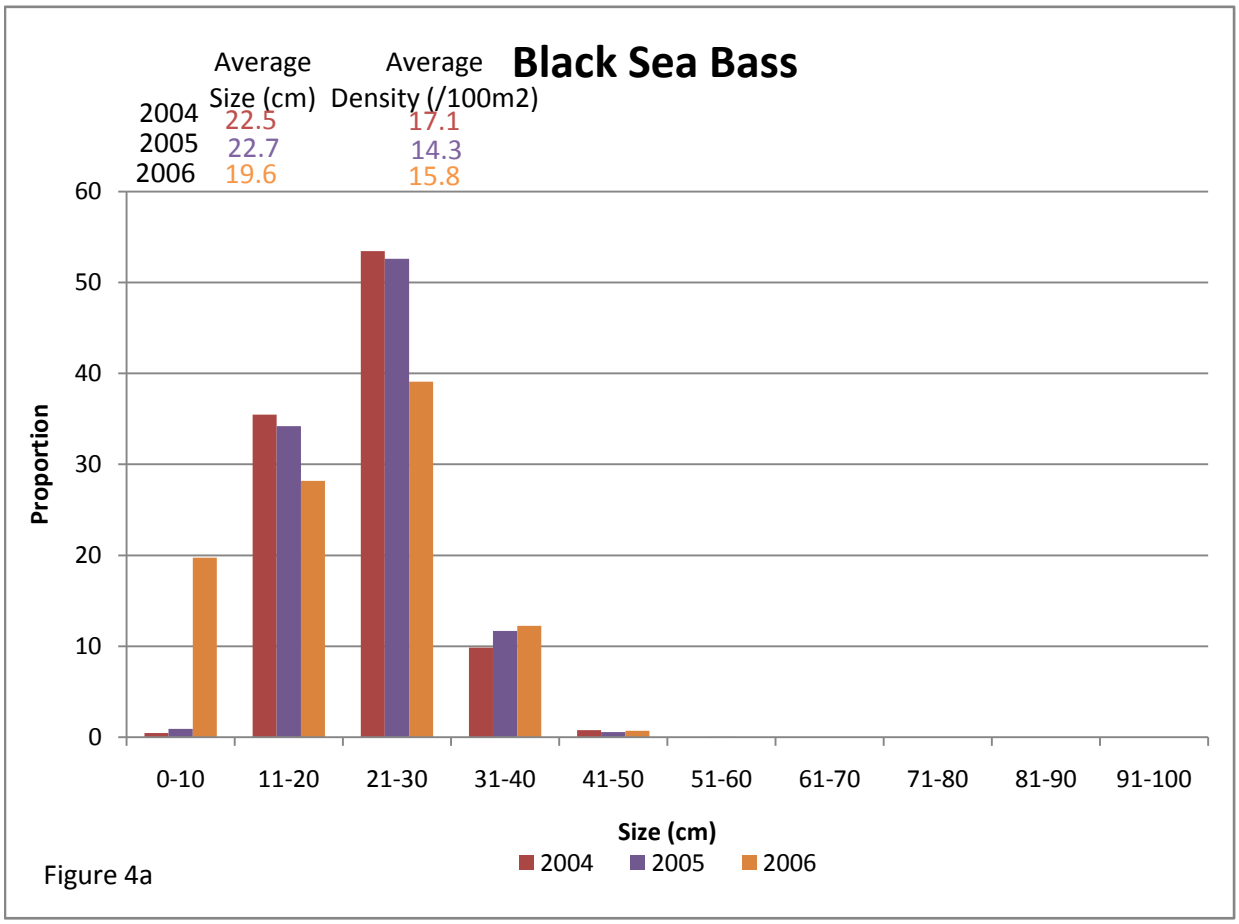

Figure 4a

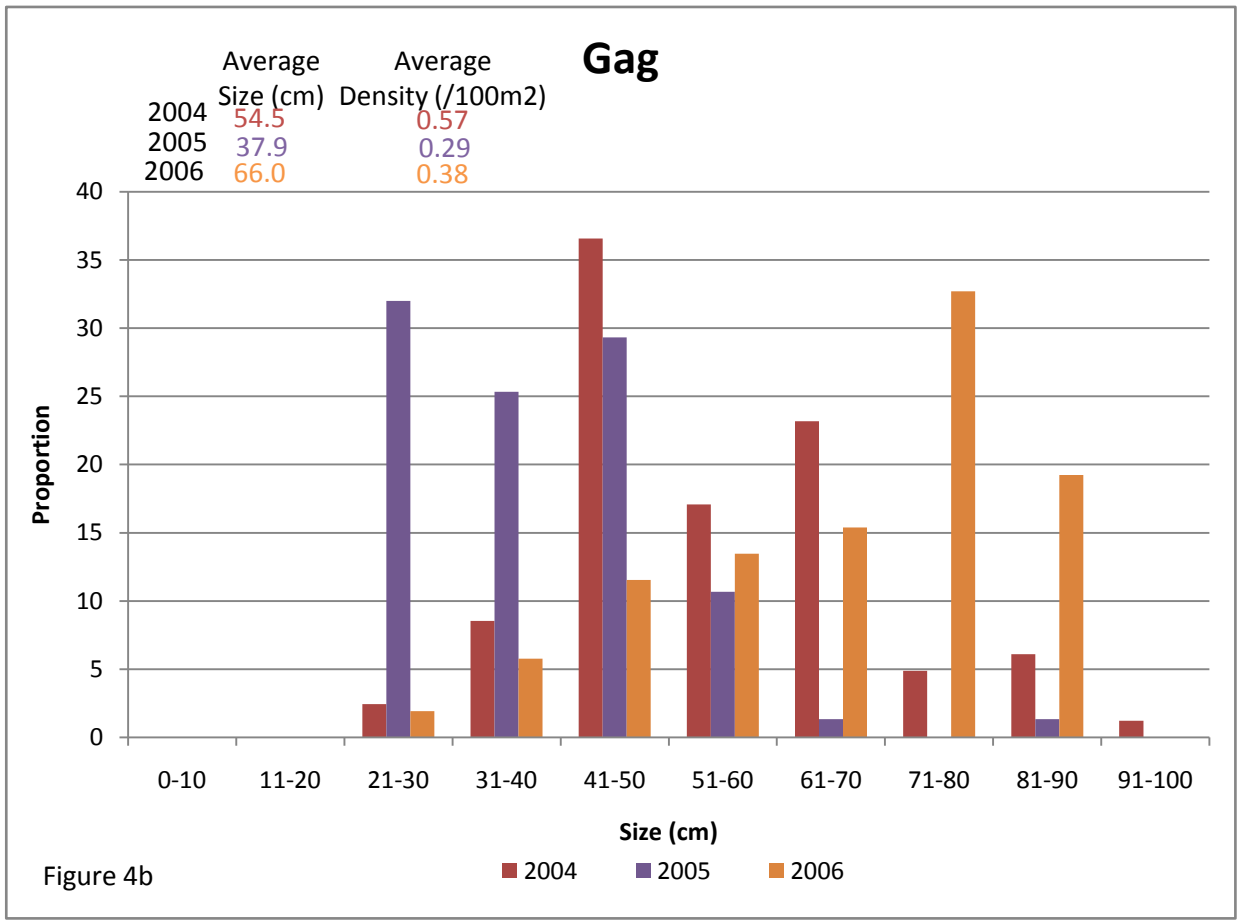

Figure 4b

Size Distribution of Four Key Species During Three Years In GRNMS Based on RVC Data, cont.

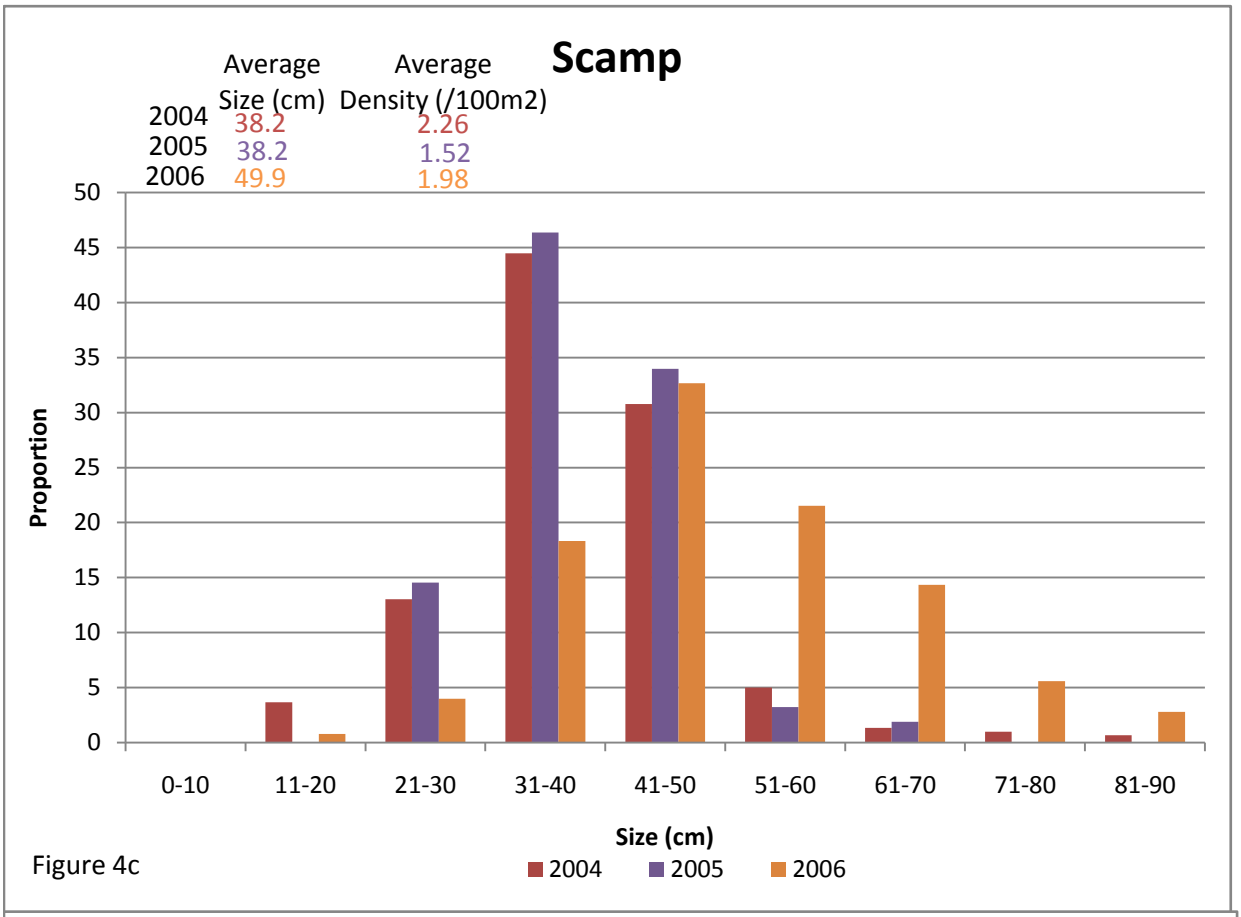

Figure 4c

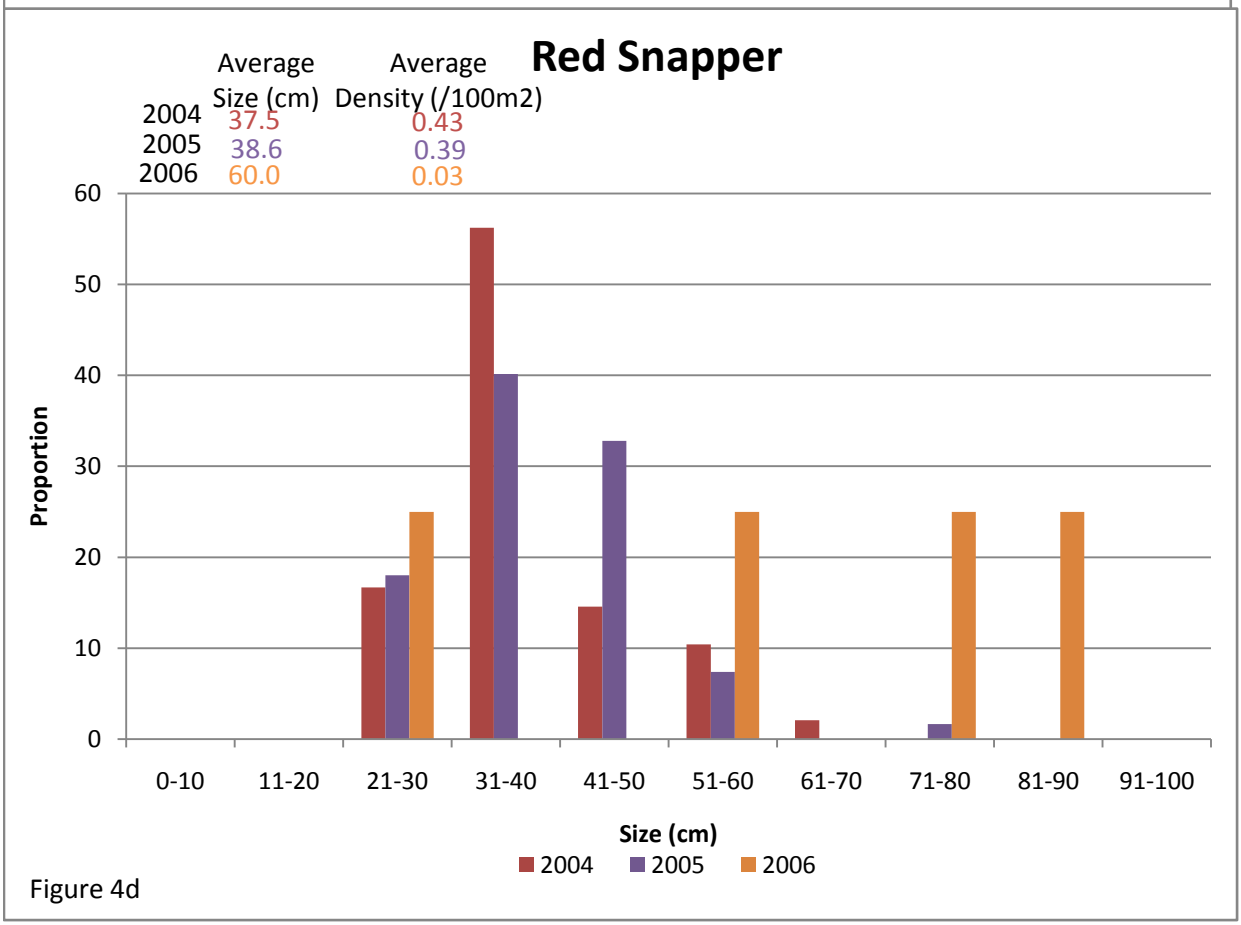

Figure 4d

Patterns in Abundance Score During Five Years Based on REEF RDT Surveys

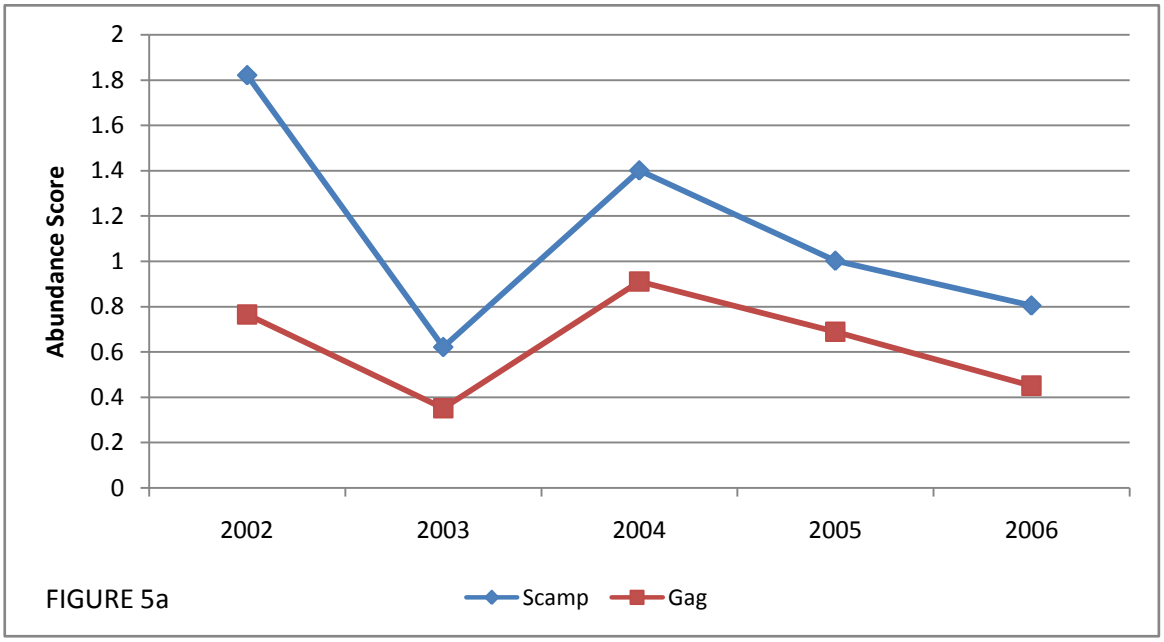

FIGURE 5a

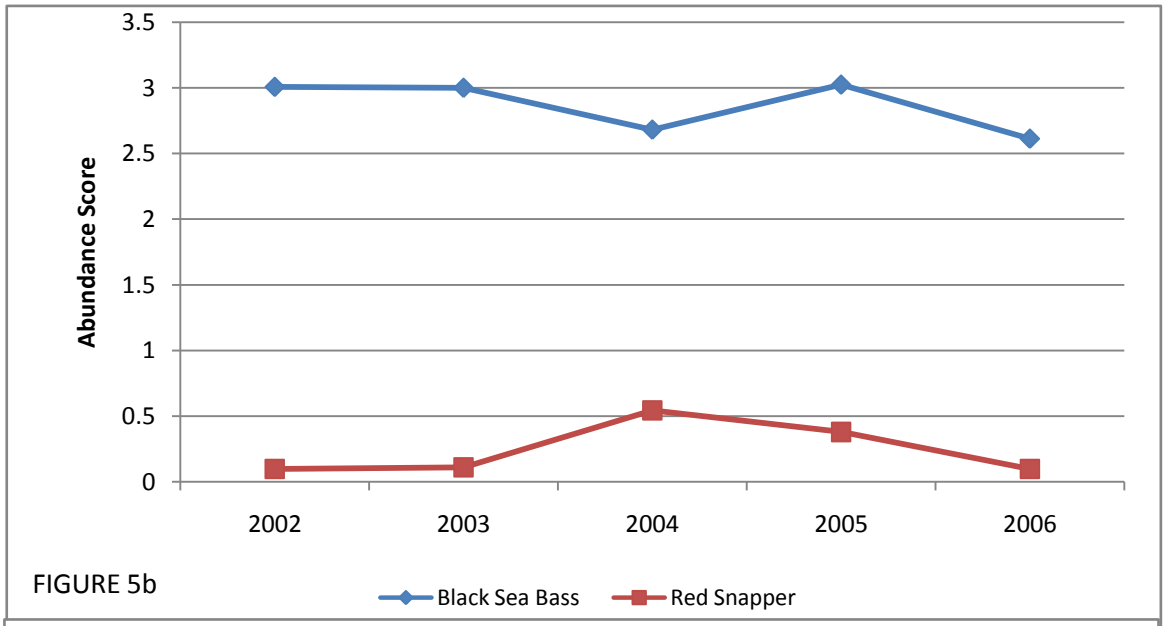

FIGURE 5b

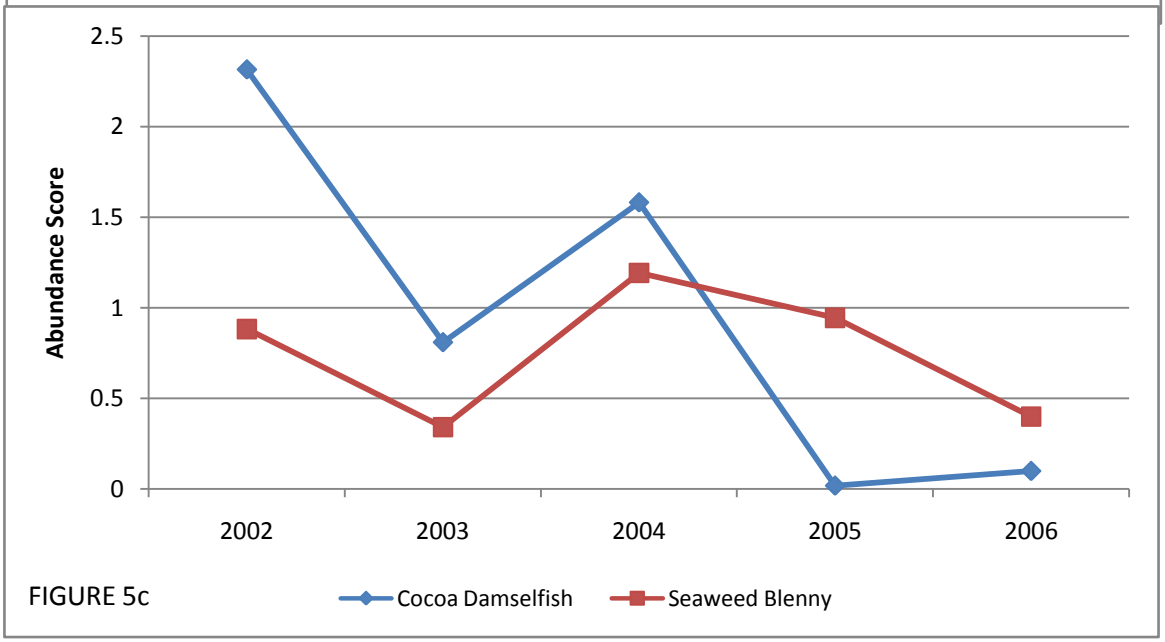

FIGURE 5c