South Atlantic marine protected areas: pre-closure evaluation of habitat and fish assemblages in five proposed reserves.

A report to the South Atlantic Fishery Management Council
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Abstract

The South Atlantic Fisheries Management Council (SAFMC) has proposed implementation of nine marine protected areas (MPAs) between Cape Hatteras, NC and the Florida Keys to protect seven species of grouper and tilefish, all members of the deepwater snapper-grouper complex. Based on recent stock assessments, four of these are considered to be overfished including snowy grouper (*Epinephelus niveatus*), warsaw grouper (*E. nigritus*), speckled hind (*E. drummondhayi*), and tilefish (*Lopholatilus chamaeleonticeps*). Yellowedge grouper (*E. flavolimbatus*) are not considered overfished, and the status of misty grouper (*E. mystacinus*) and blueline tilefish (*Caulolatilus microps*) is unknown at this time. Life history characteristics of several of the targeted species make them more vulnerable to overfishing. Many are protogynous hermaphrodites with highly female-skewed ratios, even in unfished populations. Aggregate spawning with strong interannual site fidelity is also common, offering knowledgeable fishermen the possibility to harvest large numbers of reproductively active fish in a short period of time. Dominant males aggressively defend these spawning aggregation sites and are more easily caught than during non-spawning periods, leading to further skewing of the sex ratios. The National Marine Fisheries Service has volunteered to conduct preliminary investigations of the proposed MPAs and then to evaluate the efficacy of the closures once they have been made. A project was designed to examine five of the proposed MPAs with three main objectives: 1) establish baseline estimates of species composition and fish abundance, especially for species of grouper and tilefish; 2) describe habitat features; and 3) document the relationship between habitat and species assemblages. Four of the nine proposed MPA sites were not included for this project, two artificial reef sites in the South Atlantic Bight and two sites off extreme southern Florida. The artificial reef sites were excluded because the project focused on fish-habitat relationships in natural areas. The south Florida sites were excluded for logistical reasons related to their remoteness from the remaining five natural habitat sites in the South Atlantic Bight. Gear employed during the surveys included a remotely operating vehicle (ROV), a stationary video camera array, and chevron fish traps. Three of the seven targeted reef fish (snowy grouper, speckled hind, and blueline tilefish) were observed in the first year of the survey (2004). Species composition varied between proposed MPAs, but all were dominated by small reef fish of limited commercial or economical importance. Fish densities differed among the habitats observed. Grouper were most abundant on rock outcrops, especially those of higher relief, while tilefish were most abundant on flat pavement habitat and low relief outcrops. One

surprising result was the abundance of lionfish (*Pterois volitans*), an invasive species native to the Indo-Pacific. Like groupers, lionfish are structure-oriented and were most abundant on high relief outcrops. Grouper, lionfish, and tilefish displayed a latitudinal decrease in density from north to south. A cruise similar to the one presented in this report has been funded for 2005 and subsequent annual cruises are planned through 2012. This study presents a unique opportunity to examine proposed MPA sites before implementation of fishing restrictions, thus providing fishery managers with robust baseline data upon which efficacy evaluations of closures can be made.

Introduction

The South Atlantic Fishery Management Council (SAFMC) is considering the implementation of nine MPAs between Cape Hatteras, NC and the Florida Keys to protect seven species of the deepwater snapper-grouper complex. These consist of five species of grouper including snowy grouper (*Epinephelus niveatus*), yellowedge grouper (*E. flavolimbatus*), warsaw grouper (*E. nigritus*), speckled hind (*E. drummondhayi*), and misty grouper (*E. mystacinus*) and two species of tilefish including tilefish (*Lopholatilus chamaeleonticeps*) and blueline tilefish (*Caulolatilus microps*). These species are considered to be at risk due to currently low stocks and life history characteristics which subject them to substantial fishing mortality. All of them are slow growing, long-lived species, most of which are considered to be overfished based on recent stock assessments. In addition, most of the grouper species are protogynous hermaphrodites attracted to high-relief sites where they aggregate to spawn and are thus susceptible to targeted fishing operations which may selectively remove males (Gilmore and Jones, 1992; Coleman et al., 1996). The proposed areas are known to contain habitat which supports populations of economically valuable reef fish including the seven target species and other reef-associated fishes. Our goal was to conduct preliminary examinations of five of the proposed MPAs including Snowy Wreck, NC (hereafter denoted as NC), South Carolina 'A' (SCA), South Carolina 'B' (SCB), Georgia (GA), and N. Florida (FL), each containing two or more options (Figure 1). Within each proposed MPA, we characterized habitat and documented fish species composition and densities of all fish encountered with emphasis on economically important species. Our specific objectives were to: 1) establish baseline estimates of reef fish density and species composition associated with bottom features within and outside proposed MPAs; 2) describe habitat features within and outside proposed MPAs; and 3) document the relationship between habitat and species assemblages.

Methods

High resolution bathymetric maps do not exist for the majority of the five, natural hardbottom, proposed MPAs which were examined. Therefore, site selection was based upon local knowledge acquired during previous scientific cruises and upon split beam acoustic bathymetry acquired during the present cruise which took place in April – May 2004. As the proposed MPAs were designed to protect deep reef grouper and tilefish, which are structure-oriented fish, suspected hardbottom and reef sites were the primary targets.

The primary gear used to characterize habitat and estimate fish densities was a Phantom S-2 remotely operated vehicle (ROV) owned and operated by the National Undersea Research Center at Wilmington, NC. High currents required the use of a downweight to keep the ROV near the bottom throughout the dive. This downweight (~145 kg) was tethered to the ROV umbilical 25m behind the vehicle and provided sufficient freedom of movement to investigate habitat features within visual range of the transect line. The downweight configuration allowed the ROV to drift just above the bottom at approximately one knot (range 0.5 to 1.5 knots). The geographic position of the ROV was constantly recorded throughout each dive with a tracking system linked to the ship's GPS system. The ROV provided continuous video data as well as high-resolution digital still images of fish and habitat within the study areas. These dives resulted in approximately thirty hours of underwater video documentation. The video footage was used to delineate and quantify habitat type as well as fish species presence and density

within each habitat type. All fish within a 5m radius on the video tapes were identified to the lowest discernable taxonomic level and counted. Fish densities (#/hectare) were determined by estimating the area of view of the video camera during transects. The area of each transect was determined from transect length (L) and width (W). Length was calculated from latitude and longitude recorded by the ROV tracking system. Width of each transect was calculated using the following equation: $W=2(\tan(\frac{1}{2}A))(D)$ where A is the horizontal angle of view (78º, a constant property of the camera) and D is the distance from the camera at which fish could always be identified. The distance (D) was usually 5m except for two dives where visibility was reduced to 3m. Transect area (TA) was then calculated as: $TA= (LxW) - \frac{1}{2} (WxD)$. Density of each fish species was calculated by dividing the number of each species by the TA. Average densities were calculated for all observed fish species for each proposed MPA. Density differences among habitats within each MPA were determined for grouper, tilefish, and lionfish. A Seabird SBE25 sealogger CTD was mounted on the ROV to provide in situ measurements of temperature and corroborate depth determinations produced by the ROV.

We also used a stationary video camera array to determine relative abundance of fish and percent cover of habitat within each proposed MPA. The array was comprised of four Sony VX-2000 digital camcorders in Gates Diego underwater housings mounted at 90º angles to each other in the horizontal plane at a height of 30cm above the bottom of the array. The camera array was allowed to soak on the bottom for at least thirty minutes during each deployment. This allowed sufficient time for sediment stirred up during camera deployment to dissipate and ensured tapes with an unoccluded view of at least twenty minutes duration. All fish captured on videotape were identified to the lowest discernable taxonomic level. Abundance values were calculated from the maximum number of fish of a given species in the field of view at any time during the twenty minute videotape. This is a more conservative abundance estimate than one derived from the total number of individuals observed, but it avoids multiple counts of the same individual and produces more reproducible estimates. The average maximum number of each species was calculated for each proposed MPA. Percent coverage of substrate types were calculated for each camera drop as well and percent occurrence of each habitat type was determined for each proposed MPA.

A chevron fish trap (1.83m x 1.83m x 0.75m with 3.81cm mesh), baited with mackerel and soaked for ninety minutes, was employed at most proposed MPA sites. Standard length, fork length, and total length (mm) were taken for all fish caught in the traps. Otoliths and gonads were removed and a weight recorded from grouper and other targeted reef fish species caught. Samples were brought back to the lab for subsequent age, growth, and reproductive studies.

Results

A total of thirty-one dives were made between April 17 and May 6, 2004; eight in NC, seven in SCA, four in SCB, five in GA, and seven in FL. Six major habitats were identified from the dives: 1) sand (sometimes with a shell hash), 2) flat pavement (flat limestone rock with no relief usually covered with a thin layer of sand, but a definite presence of hardbottom underneath, i.e. presence of sea whips or cracks and crevices), 3) knoll pavement (undulating areas of limestone pavement, rising and falling 1-2m with peak to peak distances often exceeding the range of visibility and sometimes covered with a thin layer of sand), 4) small rock outcrops (0.3-1m.), 5) medium rock outcrops (1.3-3m), and 6) large rock outcrops (>3m relief). All of these habitats

were observed in every proposed MPA with the exception of medium outcrops in GA and large outcrops in GA and SCB.

A total of ninety-three fish species were identified, including three of the seven targeted reef fish; snowy grouper, speckled hind, and blueline tilefish. The most abundant taxa differed between proposed MPAs, however none of the target species were among those most frequently observed in any proposed MPA (Table 1). At NC, the most abundant taxa were anthiids (small sea basses consisting of roughtongue bass (*Holanthias martinicensis*) and red barbiers (*Hemanthias vivanus*)), tattlers (*Serranus phoebe*), amberjack (*Seriola* sp.), and greenband wrasses (*Halichoeres bathyphilus*). In SCA, the dominant fish were anthiids, yellowtail reeffish (*Chromis enchrysurus*), scorpionfish (Scorpaenidae), short bigeyes (*Pristigenys alta*), and boarfish (*Antigonia* sp.). The most frequently observed fish in SCB were damselfish (consisting of yellowtail reeffish, purple reeffish (*Chromis scotti*), and sunshinefish (*Chromis insolatus*)), tattlers, reef butterflyfish, short bigeyes, and spotfin hogfish (*Bodianus pulchellus*). Scad (*Decapterus* sp.), tattlers, short bigeyes, bank sea basses (*Centropristis ocyurus*), and porgies (Sparidae) were the most common fish in GA. Finally, in FL, the most abundant species were grunts (especially tomtates (*Haemulon aurolineatum*) and striped grunts (*Haemulon striatum*)), yellowtail reeffish, vermilion snapper (*Rhomboplites aurorubens*), tattlers, and purple reeffish. Groupers were most abundant on rock outcrops particularly the higher relief habitats (Figure 2). Grouper densities ranged from 0.0/hectare on sand and knoll pavement to 154.1/hectare on large outcrops. Tilefish were most associated with flat pavement and low relief outcrops (Figure 3). Their densities ranged from 0.0/hectare on sand and knoll pavement to 1.6/hectare on flat pavement. A surprising result of the ROV dives was the abundance of the invasive lionfish (*Pterois volitans*). Lionfish are also structure-oriented fish and were most abundant on rock outcrops, especially those of higher relief (Figure 4). Densities ranged from 0.0/hectare on sand and knoll pavement to 21.5/hectare on large outcrops. Grouper, tilefish, and lionfish all displayed a latitudinal decrease in density from north to south. This could be due to higher fishing pressure in the south although the exact cause is unknown.

Eleven camera array drops were made; one in NC, two in SCA, two in SCB, three in GA, and three in FL. Six substrate types were identified on the tapes; sand, rock, sponge, sea whips, coral, and other sessile and attached epifauna. Sand was the dominant substrate in NC (100%) and FL (63.3%) while rock was the most prominent in SCA (62%), SCB (35%), and GA (50%) (Figure 5). A total of forty-seven fish species were observed. Only one of seven targeted species, speckled hind, was observed on the camera array videotapes. No tilefish were seen and grouper were most abundant at SCA and GA. Scamp was the most frequently observed grouper being present in three of the five proposed MPAs. Only amberjack (*Seriola* sp.) were observed at NC, but this was probably due to the single habitat seen there (sand). Creole-fish (*Paranthias furcifer*), porgies (both red porgies (*Pagrus pagrus*) and *Calamus* sp.) and scamp (*Mycteroperca phenax*) were most abundant at SCA (Figure 6). SCB was dominated by yellowtail reeffish. Other commonly occurring species included spotfin hogfish, butterflyfish (*Chaetodon* sp.), and blue angelfish (*Holacanthus bermudensis*) (Figure 7). In GA, grunts, scad, amberjack (bother greater (*Seriola dumerili*) and almaco(*Seriola rivoliana*)), red porgies, and scamp were observed most frequently (Figure 8). FL was dominated by vermilion snapper. Other common taxa were yellowtail reeffish, wrasses (*Halichoeres* sp.), and reef butterflyfish (Figure 9).

Nine fish traps were made; two in NC, two in SCA, three in GA, and two in FL. Fish were captured in five of these and consisted of (in decreasing order of abundance) red porgy, scamp,

gray triggerfish (*Balistes capriscus*), vermilion snapper, and knobbed porgy (*Calamus nodosus*) (Figure 10). Most of the fish caught in traps (96%) were from GA.

Discussion

Ideally, assessment of the efficacy of MPAs for increasing populations of economically valuable reef fish would require a sequential approach of mapping, habitat delineation, and fishery surveys. High resolution maps are extremely crucial in site selection for this type of study. However, since no maps were available for the proposed areas, site selection was based on local knowledge and split beam acoustic bathymetry collected during the cruise.

Three of the target species (speckled hind, snowy grouper, and blueline tilefish) were observed during this study. Yellowedge grouper, misty grouper, warsaw grouper, and tilefish, however, were not seen. Of the targeted deepwater grouper and tilefish, the three species that were observed occur in the shallowest depths (starting at 30m). The remaining species are all found in the depth range of around 65-500m and over half of the ROV dives were done in depths of <61m. Therefore, depth may explain why several of the targeted species were not found.

Usually, examination of marine reserves does not begin until after the closure has already been implemented. This study, however, presented a unique opportunity to examine these areas before fishing restrictions have been implemented allowing baseline estimates to be made. These MPAs may be put into effect as early as 2006, thus at least two years of data can be acquired and used to examine the population levels of these sites under fishing pressure. Location of the reserves is critical if enhancement of fishery yields is to occur (Stockhausen et al., 2000). It is hoped that results from this initial study and our second cruise scheduled for September 2005 will aid the SAFMC in placement of the MPAs. Since grouper and tilefish occupy slightly different habitat types, separate sites may have to be chosen for each group of species.

An on-going problem for marine reserves is enforcement of fishing restrictions. In order to effectively evaluate the efficacy of MPAs, fishing should cease in those designated areas. In lieu of cessation of fishing, the level of fishing effort should be determined. Any fishing activity will make it difficult to evaluate the impact of closure on fishery productivity. Even relatively moderate levels of poaching can quickly deplete gains achieved by closure (Roberts and Polunin, 1991).

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Table 1. Average densities and standard errors (SE) of all fish observed with the ROV at each of the five proposed MPAs (Snowy Wreck NC, South Carolina A, South Carolina B, Georgia, and Florida).

Snowy Wreck, NC

Species	Common Name	Average Density	SE
Anthiinae	anthiids	144.65	144.57
Holanthias martinicensis	roughtongue bass	64.49	52.02
Serranus phoebe	tattler	15.52	5.95
Seriola sp.	amberjack sp.	12.61	11.44
Halichoeres bathyphilus	greenband wrasse	10.74	7.82
Chaetodon sedentarius	reef butterflyfish	8.40	3.30
Pristigenys alta	short bigeye	7.98	4.56
Equetus umbrosus	cubbyu	5.46	5.46
Chromis enchrysurus	yellowtail reeffish	3.29	1.64
Holocentrus sp.	squirrelfish sp.	2.92	2.92
Mycteroperca phenax	scamp	2.89	2.51
Prionotus sp.	searobin sp.	2.68	2.39
Chaetodon aya	bank butterflyfish	2.64	2.42
Holocentridae	soldierfish sp.	2.14	2.14
Synodus sp.	lizardfish sp.	1.82	0.68
Seriola dumerili	greater amberjack	1.74	1.40
Paranthias furcifer	creole-fish	1.69	1.55
Halichoeres sp.	wrasse sp.	1.62	1.08
Paralichthys sp.	flounder sp.	1.54	0.72
Priacanthus arenatus	bigeye	1.13	0.81
Aluterus monoceros	unicorn filefish	0.94	0.94
Serranidae	sea bass sp.	0.82	0.60
Liopropoma eukrines	wrasse bass	0.82	0.60
Laemonema barbatulum	cod	0.77	0.77
Bodianus pulchellus	spotfin hogfish	0.74	0.42
Holocentrus rufus	longspine squirrelfish	0.71	0.71
Chromis sp.	damselfish sp.	0.70	0.58
Holacanthus bermudensis	blue angelfish	0.68	0.28
Serranidae	grouper sp.	0.62	0.39
Malacanthus plumieri	sand tilefish	0.59	0.59
Apogon sp.	cardinalfish sp.	0.59	0.59
Chaetodon sp.	butterflyfish sp.	0.57	0.38
	eel sp.	0.55	0.38
Epinephelus niveatus	snowy grouper	0.50	0.33
Holacanthus sp.	angelfish sp.	0.47	0.47
Muraenidae	moray eel	0.46	0.30
Chaetodon ocellatus	spotfin butterflyfish	0.46	0.30
Acanthurus chirurgus	doctorfish	0.43	0.28
Hemipteronotus novacula	pearly razorfish	0.43	0.28
Pterois volitans	lionfish	0.39	0.39
Hippocampus sp.	seahorse sp.	0.38	0.21
Helicolenus dactylopterus	blackbelly rosefish	0.38	0.21
Sparidae	porgy sp.	0.38	0.21

Table 1. Continued.
Snowy Wreck, NC

Species	Common Name	Average Density	SE
Lachnolaimus maximus	hogfish	0.31	0.21
Rypticus sp.	soapfish sp.	0.31	0.21
Bellator militaris	horned searobin	0.27	0.27
Dactylopterus volitans	flying gurnard	0.26	0.20
Mycteroperca microlepis	gag	0.24	0.24
Canthigaster rostrata	sharpnose puffer	0.23	0.23
Ogcocephalus corniger	longnose batfish	0.20	0.20
Diodon holocanthus	balloonfish	0.20	0.20
Centropristis ocyurus	bank sea bass	0.20	0.20
Liopropoma mowbrayi	cave bass	0.20	0.20
Epinephelus cruentatus	graysby	0.20	0.20
Holacanthus tricolor	rock beauty	0.20	0.20
Gonioplectrus hispanus	spanish flag	0.20	0.20
Bodianus rufus	spanish hogfish	0.20	0.20
Chromis insolatus	sunshinefish	0.20	0.20
Holacanthus ciliaris	queen angelfish	0.12	0.12
Serranus chionaraia	snow bass	0.12	0.12
Priacanthidae	bigeye sp.	0.12	0.12
Tetraodontidae	puffer sp.	0.12	0.12
Balistidae	triggerfish sp.	0.12	0.12
Gymnothorax saxicola	ocellated moray	0.10	0.10
Rypticus saponaceus	greater soapfish	0.07	0.07
Lactophrys polygonia	honeycomb cowfish	0.07	0.07
Equetus lanceolatus	jackknife-fish	0.07	0.07
Lactophrys quadricornis	scrawled cowfish	0.07	0.07

Table 1. Continued.

South Carolina A

Species	Common Name	Average Density	SE
Anthiinae	anthiids	99.44	62.84
Chromis enchrysurus	yellowtail reeffish	41.94	41.94
Scorpaenidae	scorpionfish sp.	26.91	15.91
Pristigenys alta	short bigeye	24.61	17.41
Antigonia sp.	boarfish	24.01	19.19
Synodus sp.	lizardfish sp.	18.99	18.04
Serranus phoebe	tattler	14.99	12.55
Hemipteronotus novacula	pearly razorfish	8.70	5.85
Holocentrus sp.	squirrelfish sp.	8.59	5.47
Decodon puellaris	red hogfish	7.11	3.57
Sparidae	porgy sp.	7.09	3.68
Chaetodon sedentarius	reef butterflyfish	5.55	3.60
Laemonema barbatulum	cod	5.52	4.87
Halichoeres bathyphilus	greenband wrasse	4.98	4.98
Lachnolaimus maximus	hogfish	4.36	3.83
Serranus notospilus	saddle bass	3.57	1.98
Priacanthus arenatus	bigeye	3.06	2.34
Paranthias furcifer	creole-fish	2.57	2.57
Gephyroberyx darwini	slimehead	2.45	1.63
Mycteroperca phenax	scamp	2.09	2.09
Holacanthus sp.	angelfish sp.	1.77	1.77
Chromis scotti	purple reeffish	1.61	1.61
Serranidae	sea bass sp.	1.52	1.18
Chaetodon ocellatus	spotfin butterflyfish	1.51	1.18
Chaetodon aya	bank butterflyfish	1.48	1.27
Caulolatilus microps	blueline tilefish	1.23	0.79
Lactophrys quadricornis	scrawled cowfish	1.19	1.19
Balistes capriscus	gray triggerfish	1.19	1.19
Halichoeres sp.	wrasse sp.	1.12	1.12
Bodianus pulchellus	spotfin hogfish	0.96	0.96
Synodus intermedius	sand diver	0.92	0.64
Holacanthus bermudensis	blue angelfish	0.92	0.63
Canthigaster rostrata	sharpnose puffer	0.80	0.80
Pterois volitans	lionfish	0.78	0.52
Holacanthus tricolor	rock beauty	0.78	0.52
Serranidae	grouper sp.	0.76	0.59
Paralichthys sp.	flounder sp.	0.75	0.43
Haemulon plumieri	white grunt	0.60	0.60
Acanthurus chirurgus	doctorfish	0.60	0.60
Priacanthidae	bigeye sp.	0.57	0.40
Gymnothorax moringa	spotted moray eel	0.46	0.31
Prionotus sp.	searobin sp.	0.39	0.39
Centropristis ocyurus	bank sea bass	0.39	0.39
Pareques iwamotoi	blackbar drum	0.38	0.24

Table 1. Continued.
South Carolina A

Species	Common Name	Average Density	SE
Holocentridae	soldierfish sp.	0.38	0.24
Ostichthys trachypoma	bigeye soldierfish	0.37	0.37
Liopropoma eukrines	wrasse bass	0.32	0.32
Holocentrus rufus	longspine squirrelfish	0.32	0.32
Haemulon sp.	grunt sp.	0.30	0.30
Diplectrum bivittatum	dwarf sand perch	0.26	0.26
Ogcocephalus corniger	longnose batfish	0.21	0.21
Mola mola	ocean sunfish	0.19	0.19
Macrorhamphosus scolopax	longspine snipefish	0.19	0.19
Epinephelus drummondhayi	speckled hind	0.19	0.19
Epinephelus niveatus	snowy grouper	0.18	0.18
	cod/hake	0.18	0.18
Sphoeroides spengleri	bandtail puffer	0.16	0.16
Seriola sp.	amberjack sp.	0.16	0.16
Epinephelus guttatus	red hind	0.16	0.16
Chaetodon sp.	butterflyfish sp.	0.16	0.16
Balistes vetula	queen triggerfish	0.16	0.16
Apogon pseudomaculatus	twospot cardinalfish	0.16	0.16
Gymnothorax saxicola	ocellated moray	0.13	0.13
Prognathodes marcellae	french butterflyfish	0.09	0.09
Plectrypops retrospinis	cardinal soldierfish	0.09	0.09

Table 1. Continued.

South Carolina B

Species	Common Name	Average Density	SE
Chromis enchrysurus	yellowtail reeffish	232.18	135.82
Chromis sp.	damselfish sp.	80.21	30.36
Chromis scotti	purple reeffish	69.80	41.07
Serranus phoebe	tattler	61.05	33.04
Chaetodon sedentarius	reef butterflyfish	52.76	25.12
Pristigenys alta	short bigeye	35.11	24.00
Bodianus pulchellus	spotfin hogfish	34.15	15.97
Chromis insolatus	sunshinefish	29.19	13.52
Haemulon sp.	grunt sp.	25.04	25.04
Chaetodon aya	bank butterflyfish	23.30	16.33
Haemulon aurolineatum	tomtate	21.70	21.70
Seriola dumerili	greater amberjack	20.94	6.97
Hemipteronotus novacula	pearly razorfish	14.46	3.10
Sparidae	porgy sp.	12.74	7.25
Halichoeres bathyphilus	greenband wrasse	10.01	6.64
Mycteroperca phenax	scamp	9.99	4.95
Holacanthus bermudensis	blue angelfish	6.96	2.67
Canthigaster rostrata	sharpnose puffer	6.24	3.82
Halichoeres sp.	wrasse sp.	6.01	6.01
Liopropoma eukrines	wrasse bass	5.91	4.33
Seriola rivoliana	almaco jack	4.80	3.70
Priacanthus arenatus	bigeye	4.72	2.71
Lactophrys sp.	trunkfish sp.	3.64	2.08
Chaetodon ocellatus	spotfin butterflyfish	3.61	2.86
Centropristis ocyurus	bank sea bass	3.45	1.37
Holacanthus sp.	angelfish sp.	3.34	2.22
Chaetodon sp.	butterflyfish sp.	3.23	1.87
Epinephelus drummondhayi	speckled hind	3.01	2.21
Acanthurus chirurgus	doctorfish	2.45	1.59
Lachnolaimus maximus	hogfish	2.23	1.48
Pterois volitans	lionfish	2.23	1.48
Holacanthus ciliaris	queen angelfish	2.23	1.48
Holocentrus sp.	squirrelfish sp.	2.00	2.00
Sphoeroides spengleri	bandtail puffer	1.90	1.48
Holacanthus tricolor	rock beauty	1.67	1.67
Seriola sp.	amberjack sp.	1.42	0.64
Balistes vetula	queen triggerfish	1.34	1.34
Equetus lanceolatus	jackknife-fish	1.00	1.00
Serranus annularis	orangeback bass	1.00	1.00
Balistidae	triggerfish sp.	1.00	1.00
Apogon pseudomaculatus	twospot cardinalfish	1.00	1.00
Diodon holocanthus	balloonfish	0.78	0.78
	eel sp.	0.78	0.78
Monacanthus sp.	filefish sp.	0.78	0.78

Table 1. Continued.
South Carolina B

Species	Common Name	Average Density	SE
Epinephelus cruentatus	graysby	0.78	0.78
Serranidae	grouper sp.	0.78	0.78
Gymnothorax moringa	spotted moray eel	0.78	0.78
Priacanthidae	bigeye sp.	0.67	0.67
Pomacanthus paru	french angelfish	0.67	0.67
Mycteroperca microlepis	gag	0.67	0.67
Lactophrys quadricornis	scrawled cowfish	0.67	0.67
Rypticus sp.	soapfish sp.	0.67	0.67
Paralichthys sp.	flounder sp.	0.60	0.60
Monacanthus setifer	pygmy filefish	0.34	0.34
Bodianus rufus	spanish hogfish	0.34	0.34
Opsanus sp.	toadfish sp.	0.34	0.34
Muraenidae	moray eel	0.30	0.30

Table 1. Continued.

Georgia

Species	Common Name	Average Density	SE
Decapterus sp.	scad	251.00	169.15
Serranus phoebe	tattler	40.57	11.47
Pristigenys alta	short bigeye	37.47	11.51
Centropristis ocyurus	bank sea bass	23.10	6.83
Sparidae	porgy sp.	19.54	5.54
Paralichthys sp.	flounder sp.	11.80	3.01
Chromis enchrysurus	yellowtail reeffish	8.12	6.55
Mycteroperca phenax	scamp	7.19	4.04
Seriola sp.	amberjack sp.	6.76	6.27
Chaetodon aya	bank butterflyfish	4.97	4.29
Halichoeres bathyphilus	greenband wrasse	4.56	3.33
Priacanthus arenatus	bigeye	4.10	2.00
Synodus sp.	lizardfish sp.	4.04	2.01
Chaetodon sedentarius	reef butterflyfish	3.77	1.08
Haemulon sp.	grunt sp.	3.22	3.22
Seriola dumerili	greater amberjack	2.93	2.93
Synodus intermedius	sand diver	2.64	1.62
Halichoeres sp.	wrasse sp.	2.45	1.20
	eel sp.	1.89	0.92
Hippocampus sp.	seahorse sp.	1.78	1.05
Prionotus sp.	searobin sp.	1.61	1.61
Hemipteronotus novacula	pearly razorfish	1.59	0.70
Pterois volitans	lionfish	1.50	0.67
Sphoeroides spengleri	bandtail puffer	1.38	0.60
Chaetodon ocellatus	spotfin butterflyfish	1.32	0.95
Liopropoma eukrines	wrasse bass	1.29	0.83
Balistes capriscus	gray triggerfish	1.01	0.52
Lutjanus campechanus	red snapper	0.98	0.98
Anthiinae	anthiids	0.91	0.58
Serranidae	sea bass sp.	0.81	0.56
Bellator militaris	horned searobin	0.80	0.80
Seriola rivoliana	almaco jack	0.73	0.73
Equetus umbrosus	cubbyu	0.73	0.73
Priacanthus cruentatus	glasseye snapper	0.65	0.65
Ogcocephalus corniger	longnose batfish	0.60	0.60
Holacanthus bermudensis	blue angelfish	0.57	0.36
Epinephelus niveatus	snowy grouper	0.57	0.57
Apogon pseudomaculatus	twospot cardinalfish	0.57	0.57
Holacanthus sp.	angelfish sp.	0.49	0.49
Pareques iwamotoi	blackbar drum	0.49	0.49
Priacanthidae	bigeye sp.	0.34	0.34
Muraenidae	moray eel	0.34	0.34
Dactylopterus volitans	flying gurnard	0.33	0.33

Table 1. Continued.
Georgia

Species	Common Name	Average Density	SE
Gymnothorax moringa	spotted moray eel	0.33	0.33
Caulolatilus microps	blueline tilefish	0.24	0.24
Epinephelus morio	red grouper	0.24	0.24
Holocentridae	soldierfish sp.	0.24	0.24
Opsanus sp.	toadfish sp.	0.24	0.24
Lactophrys sp.	trunkfish sp.	0.24	0.24
Apogon sp.	cardinalfish sp.	0.20	0.20
Scorpaenidae	scorpionfish sp.	0.20	0.20
Bodianus pulchellus	spotfin hogfish	0.20	0.20

Table 1. Continued.

Florida

Species	Common Name	Average Density	SE
Haemulon aurolineatum	tomtate	260.76	126.38
Haemulon sp.	grunt sp.	103.11	95.68
Chromis enchrysurus	yellowtail reeffish	66.83	24.60
Rhomboplites aurorubens	vermilion snapper	62.36	41.53
Haemulon striatum	striped grunt	31.27	31.27
Serranus phoebe	tattler	19.17	5.95
Chromis scotti	purple reeffish	17.76	9.15
Halichoeres sp.	wrasse sp.	11.40	5.18
Chaetodon sedentarius	reef butterflyfish	11.07	5.18
Centropristis ocyurus	bank sea bass	8.67	6.65
Bodianus pulchellus	spotfin hogfish	8.57	4.08
Holocentrus sp.	squirrelfish sp.	8.15	2.31
Chromis sp.	damselfish sp.	7.41	4.64
Priacanthus arenatus	bigeye	7.32	5.22
Anthiinae	anthiids	7.03	7.03
Hemipteronotus novacula	pearly razorfish	4.60	1.21
Holacanthus bermudensis	blue angelfish	3.76	1.66
Halichoeres bathyphilus	greenband wrasse	3.19	2.10
Chaetodon aya	bank butterflyfish	2.86	1.63
Paranthias furcifer	creole-fish	2.05	2.05
Chaetodon ocellatus	spotfin butterflyfish	1.82	1.22
Sparidae	porgy sp.	1.54	0.74
Seriola rivoliana	almaco jack	1.49	0.78
Pristigenys alta	short bigeye	1.37	0.99
Holanthias martinicensis	roughtongue bass	1.33	1.15
Mycteroperca phenax	scamp	1.23	0.78
Seriola dumerili	greater amberjack	1.06	0.52
Holacanthus ciliaris	queen angelfish	1.05	0.68
Chaetodon sp.	butterflyfish sp.	1.03	0.70
Liopropoma eukrines	wrasse bass	0.98	0.72
Lachnolaimus maximus	hogfish	0.86	0.45
Paralichthys sp.	flounder sp.	0.85	0.37
Holacanthus sp.	angelfish sp.	0.79	0.39
Equetus umbrosus	cubbyu	0.74	0.56
Lactophrys quadricornis	scrawled cowfish	0.63	0.63
Serranus annularis	orangeback bass	0.60	0.39
Acanthurus chirurgus	doctorfish	0.56	0.56
Synodus sp.	lizardfish sp.	0.55	0.55
Chromis insolatus	sunshinefish	0.50	0.44
Balistidae	triggerfish sp.	0.45	0.30
Lutjanus synagris	lane snapper	0.45	0.45
Serranidae	grouper sp.	0.39	0.28
Lactophrys sp.	trunkfish sp.	0.39	0.28
Ogcocephalus corniger	longnose batfish	0.37	0.28

Table 1. Continued.
Florida

Species	Common Name	Average Density	SE
Sphoeroides spengleri	bandtail puffer	0.36	0.36
Balistes capriscus	gray triggerfish	0.29	0.19
Pterois volitans	lionfish	0.28	0.28
Balistes vetula	queen triggerfish	0.27	0.27
Hippocampus sp.	seahorse sp.	0.26	0.18
Canthigaster rostrata	sharpnose puffer	0.26	0.17
Tetraodontidae	puffer sp.	0.20	0.13
Seriola sp.	amberjack sp.	0.18	0.18
Scorpaenidae	scorpionfish sp.	0.18	0.18
Holocentridae	soldierfish sp.	0.18	0.18
Cyclopsetta fimbriata	spotfin flounder	0.15	0.15
Ocyurus chrysurus	yellowtail snapper	0.15	0.10
Priacanthidae	bigeye sp.	0.14	0.14
Lactophrys polygonia	honeycomb cowfish	0.14	0.14
Muraenidae	moray eel	0.14	0.14
Lutjanus analis	mutton snapper	0.14	0.14
Synodus intermedius	sand diver	0.14	0.14
Lactophrys sp.	cowfish sp.	0.09	0.09
Bellator militaris	horned searobin	0.09	0.09
Epinephelus morio	red grouper	0.09	0.09
Prionotus sp.	searobin sp.	0.09	0.09
Acanthurus sp.	surgeonfish	0.09	0.09
Opsanus sp.	toadfish sp.	0.09	0.09
Helicolenus dactylopterus	blackbelly rosefish	0.06	0.06
Apogon sp.	cardinalfish sp.	0.06	0.06
Mycteroperca microlepis	gag	0.06	0.06
Epinephelus cruentatus	graysby	0.06	0.06
Diodontidae	spiny puffer	0.06	0.06

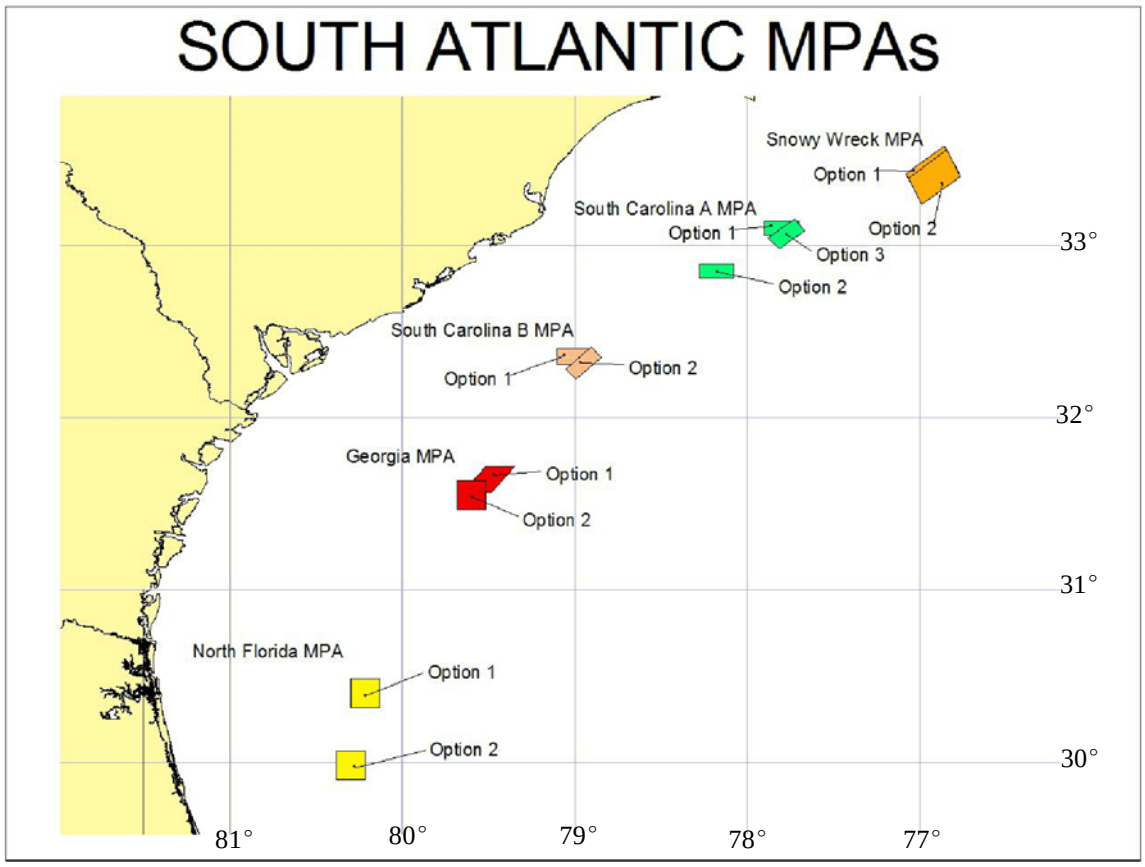

Figure 1. Locations of five proposed, natural bottom, MPA sites in the South Atlantic Bight.

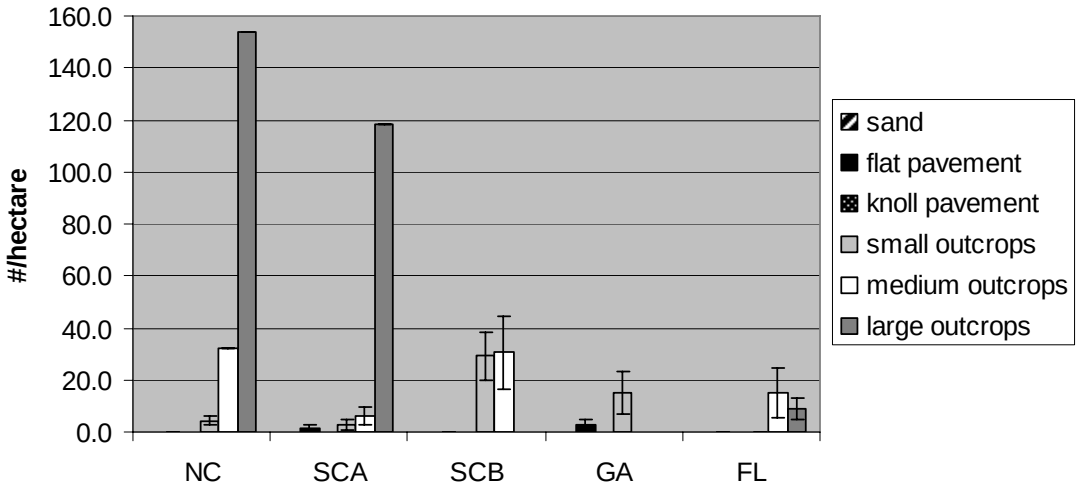

Figure 2. Mean grouper densities (± standard error) by habitat for each proposed MPA from the ROV.

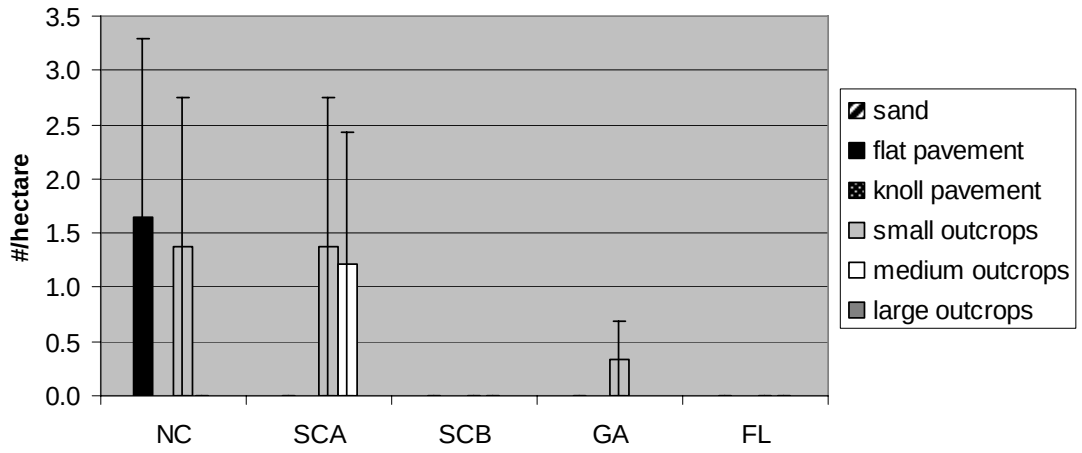

Figure 3. Mean tilefish densities (± standard error) by habitat for each proposed MPA from the ROV.

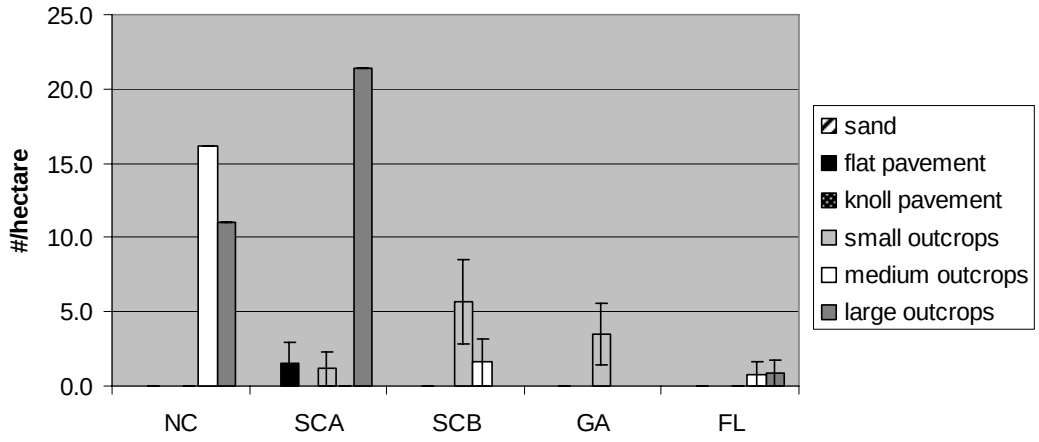

Figure 4. Mean lionfish densities (± standard error) by habitat for each proposed MPA from the ROV.

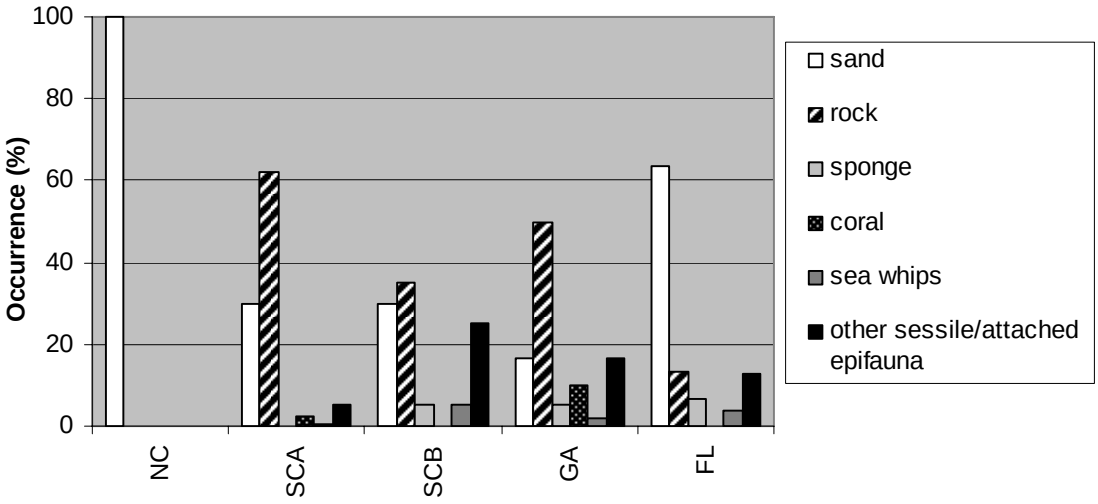

Figure 5. Occurrence (%) of habitat types observed at each proposed MPA with the camera array.

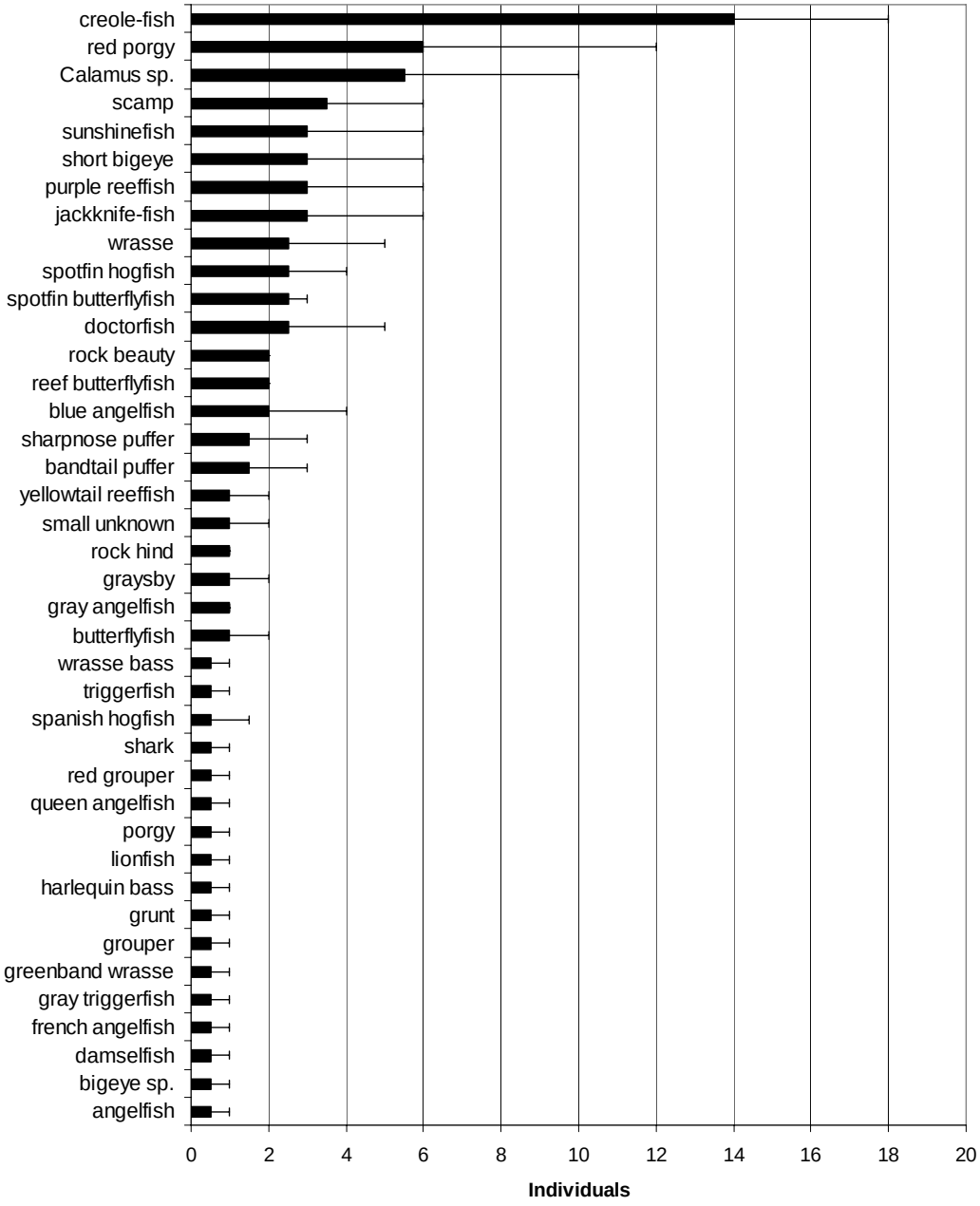

Figure 6. Mean maximum number of individuals by each species (± standard error) observed at SCA by the camera array.

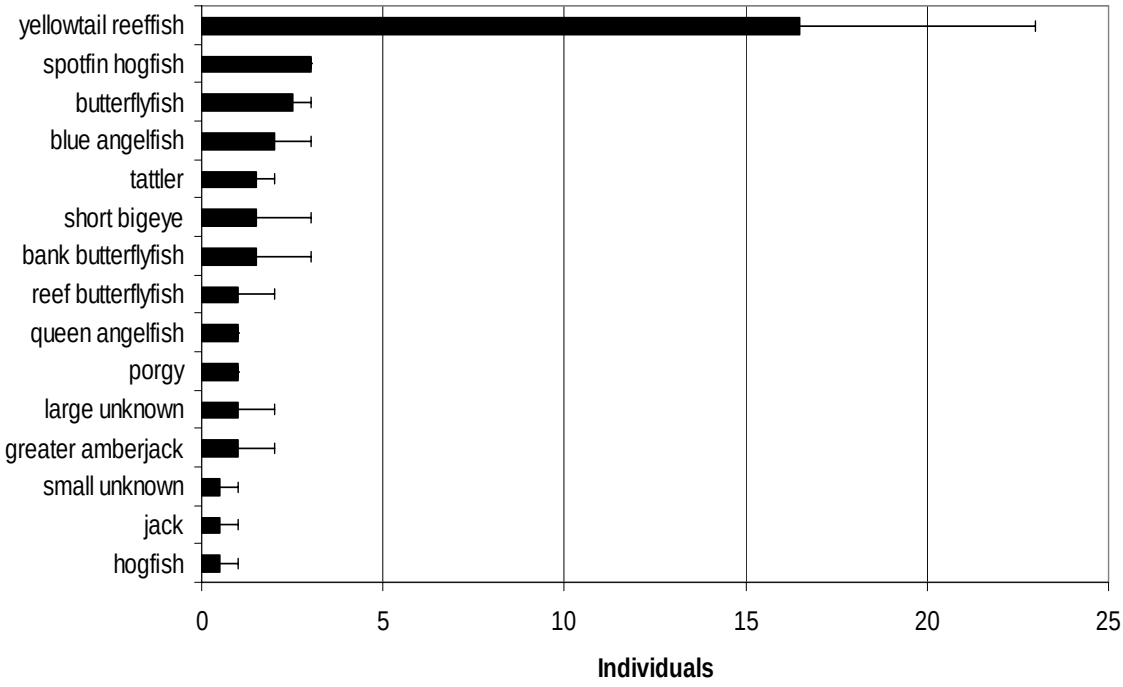

Figure 7. Mean maximum number of individuals by each species (± standard error) observed at SCB by the camera array.

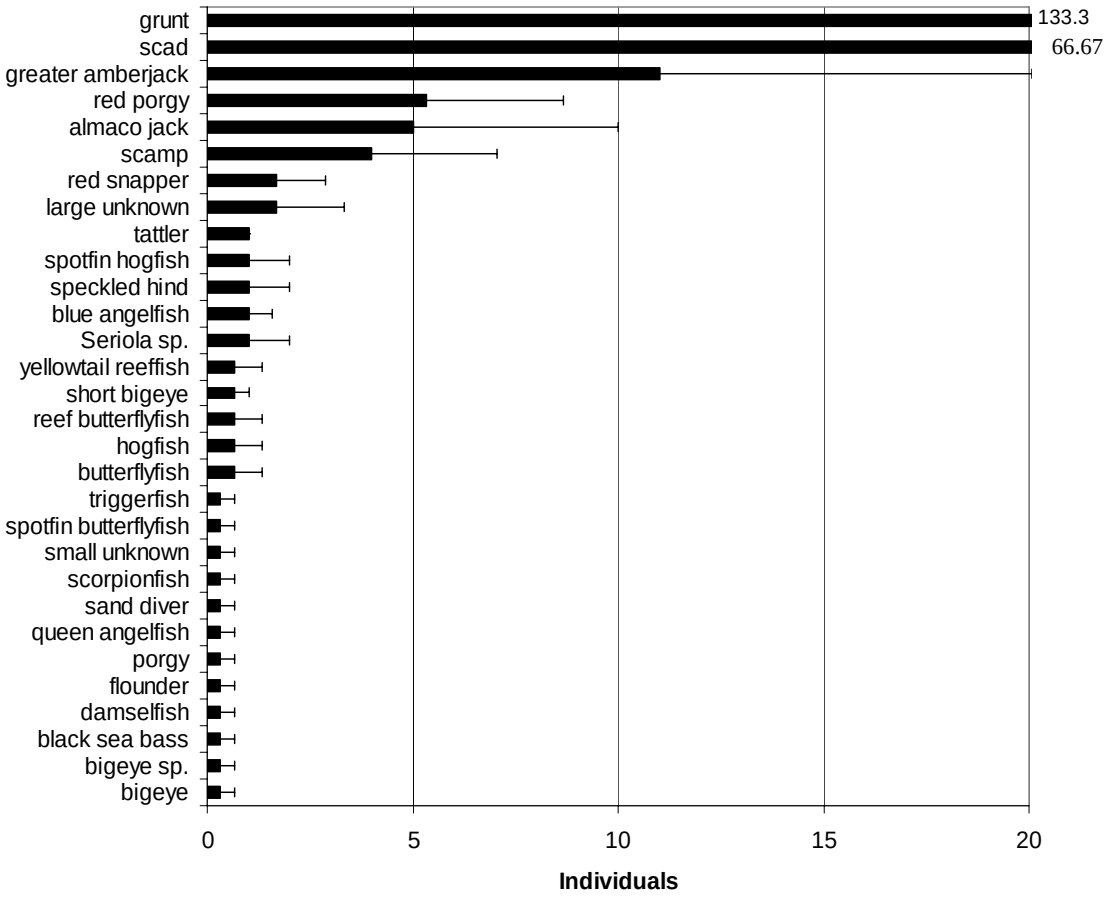

Figure 8. Mean maximum number of individuals by each species (± standard error) observed at GA by the camera array.

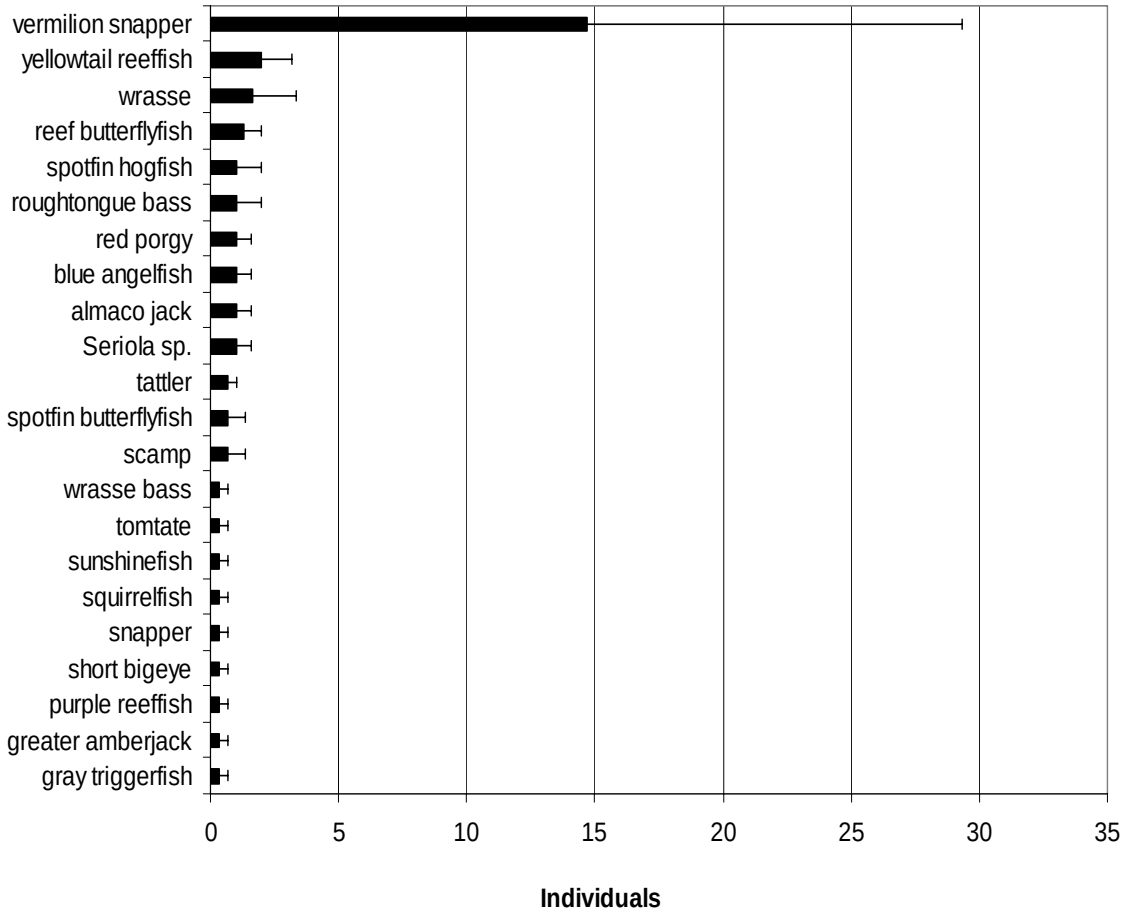

Figure 9. Mean maximum number of individuals by each species (± standard error) observed at FL by the camera array.

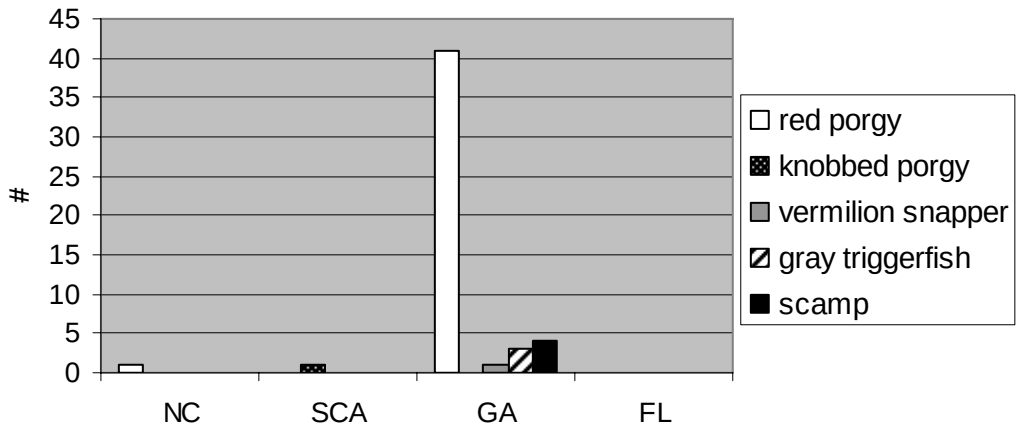

Figure 10. Total number of each species caught in the fish trap for each proposed MPA.