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

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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 sex 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. NOAA Fisheries has conducted preliminary investigations of the proposed MPAs and intends to evaluate the efficacy of the closures once they have been implemented. This is year two (the first survey was in 2004) of a project 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 operated vehicle (ROV), a stationary video camera array, and chevron fish traps. Two of the seven targeted reef fish (snowy grouper and warsaw grouper) were observed in the second year of the survey (2006). Relative fish abundances varied between proposed MPAs. Neither of the target species had the highest abundance of fishes observed; however other species of the snapper/grouper complex were among those most frequently observed. Fish densities were

correlated with habitat complexity. Total fish, grouper, and lionfish densities were highest on habitats which contained the most structure. As seen in 2004, the abundance of lionfish (*Pterois volitans*), an invasive species native to the Indo-Pacific, was surprisingly high and comparable to that of groupers. Like groupers, lionfish are structure-oriented and, therefore, occupy similar niches. 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. Subsequent annual cruises are planned for this project and are scheduled for funding through the Coral Reef Conservation Program through at least FY-09. Results from the 2004 and 2006 cruises will provide baseline data on fish communities and habitat in the proposed MPA areas. Area closures are expected to be implemented later this year after which subsequent survey results will be compared to pre-closure data to evaluate any closure effects. Areas examined in 2004 and 2006 which are not selected for closure will serve as control sites for the time series analyses.

Introduction

The South Atlantic Fishery Management Council (SAFMC) is considering the implementation of nine Type II 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; 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; 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 are slow growing, long-lived species, most of which are considered to be overfished based on recent stock assessments. In addition, the grouper species are protogynous hermaphrodites and most are 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 MPAs 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. This project supplements similar work conducted in 2004 which also provided preliminary information on fish communities and habitats in the proposed MPAs.

Methods

High resolution bathymetric maps exist only for a portion of the GA and SCA proposed MPA sites. Site selection for this cruise was based on these multibeam maps as well as results from the 2004 cruise. The proposed MPAs were designed to protect deep reef grouper and tilefish, which are structure-oriented fish, thus suspected hardbottom and reef sites were the primary targets.

The principle gear used to characterize habitat and estimate fish densities was a remotely operated vehicle (ROV) owned and operated by the National Undersea Research Center at the University of Connecticut. High currents required the use of a downweight to keep the ROV near the bottom throughout the dives. This downweight (~182 kg) was tethered to the ROV umbilical 30m 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 0.75 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 was equipped with a forward-looking 3 CCD digital video camera and a down-looking high-resolution digital camera used to capture images used for habitat quantification. These dives resulted in approximately twelve 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. Each dive was divided into 150m transects within a single 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 (½A)) (D) where A is the horizontal angle of view (60º, 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 the Georgia dives where visibility was reduced to 3 or 4 m. Transect area (TA) was then calculated as: TA= (LxW) - ½ (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 option. Total fish as well as grouper and lionfish densities were compared among habitats within each MPA option. A Seabird SBE-39 sealogger CTD was mounted on the ROV to provide *in situ* measurements of temperature and corroborate depth determinations recorded 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 option. 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 maximum number of each species as well as the percent coverage of substrate types was determined for each camera drop.

A chevron fish trap (1.83m x 1.83m x 0.75m with 3.81cm mesh), baited with mackerel and soaked for a minimum of ninety minutes (maximum time was 201 minutes), was employed at four of the proposed MPA options. 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. CPUE (# fish/hr.) was calculated for each species caught at every proposed MPA option.

Results

The cruise took place between 8 and 12 June 2006. Originally, this cruise was expected to be ten days, however a steep increase in cost for ship time due to increased fuel prices reduced it to seven days. Another two days were lost due to Tropical Storm Alberto, not permitting enough time to survey the North Carolina MPA. The sites which were examined included Florida MPA Option 1 (hereafter denoted as FL-1), Florida MPA Option 2 (FL-2), Georgia MPA Option 2 (GA-2), Georgia MPA Options 1&2 (GA-1&2), outside the Georgia MPA (GA-out), South Carolina ‘A’ Option 1 (SCA-1), South Carolina ‘A’ Options 1&3 (SCA-1&3), outside the South

Carolina 'A' MPA (SCA-out), and South Carolina 'B' MPA (SCB-1). Some of the proposed MPA options are coincident with each other and those sites listing more than one option (i.e. GA-1&2) were places which were in both options. Maps displaying locations and types of gear deployed at each proposed MPA option are shown in Figure 2

A total of nine ROV dives were made; three in SCA (two within the proposed MPA and one outside), one in SCB, three in GA (two within the proposed MPA and one outside), and two in FL. Five major habitats were identified from the dives: 1) soft substrate [no hardbottom (hereafter denoted as NH)], 2) pavement (PAV), 3) low relief outcrops (LRO), 4) moderate relief outcrops (MRO), and 5) high relief ledge (HRL). NH habitats exhibited no relief and were composed of fine to coarse sand, sometimes with a shell hash. PAV habitats were composed of hardbottom with no relief and usually had some degree of coverage with sessile and encrusting invertebrates and a presence of cracks/crevices up to 2m deep. LRO consisted of rock outcrops with < 1m relief. MRO habitat was made up of rock outcrops with 1-2m relief and HRL exhibited >2m relief often with large boulders and overhangs. Not all habitats were observed in each proposed MPA option; however some quantity of hardbottom was seen on each dive. The percentages of habitat types surveyed in each option are shown in Figure 3. NH and PAV were present on most dives. LRO were only present in FL-1, GA-1&2, and GA-2. MRO were observed in SCA-out and SCB-1 and HRL was only seen in FL-2.

A total of sixty-four fish species were identified from the ROV dives, including two of the seven targeted reef fish; snowy grouper and warsaw grouper. To compare fish community structure among the different proposed MPA options, relative abundances (%) of fishes were calculated (# individuals/total # individuals * 100) (Table 1). The most abundant taxa differed between proposed MPA options, however none of the target species were among the three most frequently observed. Nonetheless, other members of the snapper/grouper complex were often among the top three most abundant species. In FL-2, tomtates (*Haemulon aurolineatum*) and vermilion snapper (*Rhomboplites aurorubens*) were dominant species. In GA-2, bank sea bass (*Centropristis ocyurus*), scamp (*Mycteroperca phenax*), and red porgy *(Pagrus pagrus*) were most frequently observed. Bank sea bass were one of the most abundant species at GA-out. They were also prolific at SCB-1 along with red porgies. Greater amberjack (*Seriola dumerili*) were a dominant fish at SCA-1 and banded rudderfish (*Seriola zonata*) were abundant at SCA-out. No differences in fish species composition were apparent between dives inside and outside the proposed MPAs. Lionfish were observed in five of the dive sites.

As expected, total fish, grouper, and lionfish densities were highest on hardbottom habitats (PAV, LRO, MRO, and HRL) (Table 2). Total fish densities ranged from 3.9/hectare on NH to 8,834.8/hectare on HRL. Grouper were present only on hardbottom habitats (PAV, MRO, and HRL) and were not observed on NH. Grouper densities ranged from 0.0/hectare on NH to 227.5/hectare on PAV. Scamp was the most abundant grouper species, being observed on every dive where hardbottom was present. As in 2004, the abundance of the invasive lionfish (*Pterois volitans*) in 2006 was surprisingly high displaying comparable densities to grouper species. Like grouper, lionfish are structure-oriented fish and were observed on PAV and MRO habitats. Densities ranged from 0.0/hectare on NH to 23.6/hectare on PAV.

Four camera array drops were made; one in SCA, one in SCB, and two in FL. Six substrate types were identified on the tapes; sand, rock, sponge, sea whips, algae, and other sessiles and attached epifauna. Sand was the dominant substrate in FL-1 (50%), rock was most prominent in FL-2 (68%), and sessiles and attached epifauna were dominant in SCB-1 (58%) and SCA-1 (45%) (Figure 4). A total of twenty-five fish species were observed on the tapes, none of which were the targeted species. Only a single porgy was observed at FL-1, but this can be explained by the habitat which consisted of sand and no relief. Anthiids, greenband wrasse (*Halichoeres bathyphilus*), and spotfin hogfish (*Bodianus pulchellus*) were the most abundant fish observed at FL-2 (Figure 5). In SCB-1, blue angelfish (*Holacanthus bermudensis*) and red porgies were observed most frequently (Figure 6). SCA-1 was dominated by wrasses (*Halichoeres* sp.), spotfin hogfish, lionfish, and scamp (Figure 7).

Five fish traps were deployed; one in SCA, two in GA, one in SCB, and one in FL. Fish were captured in four of these and consisted of (in decreasing order of abundance) red porgy, scamp, and gray triggerfish (*Balistes capriscus*) (Figure 8).

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 a limited amount of mapping has been done in the proposed areas, site selection was primarily based on results from the 2004 cruise.

Two of the target species (snowy grouper and warsaw grouper) were observed during this study. Yellowedge grouper, misty grouper, speckled hind, blueline tilefish, and tilefish, however, were not seen. Tilefish prefer muddy habitat offshore from the shelf/slope break and as we targeted reef habitat, it is not surprising tilefish were not observed. The two grouper that were observed occur in the shallowest depths (starting at 30m). With the exception of speckled hind and blueline tilefish, the remaining species are all found in the depth range of around 65-500m and about half of the ROV dives were done in depths of <63m. Therefore, depth may explain why several of the targeted species were not found. The small sample size due to the weather shortened cruise may also explain why some of the shallower species were not seen. Landings data from the South Atlantic region demonstrate that yellowedge grouper, tilefish, and blueline tilefish are caught all year round with the highest landings between April and September (during the time of the cruise). Therefore, seasonality does not explain why these species were not observed.

Usually, examination of marine reserves does not begin until after the closure has 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 later this year, thus two years of data (2004 & 2006) have been acquired and will be used to compare the population levels of these sites under reduced 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 these two years of research 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. A monitoring program written into the FMP amendment incorporating an effort survey and annual fish assessments would be beneficial to future evaluations. 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. Relative abundances (%) of all fish species observed with the ROV in each of the proposed MPA options.

Species	Common Name	FL-1	FL-2	GA-2	GA-1&2	GA-out	SCB-1	SCA-1	SCA-1&3	SCA-out
Acanthurus chirurgus	doctorfish							2.2	1.3	1.1
Anthiinae	anthiid	37.6		5.5		3.3				
Apogon pseudomaculatus	twospot cardinalfish	3.0								
Balistes capriscus	gray triggerfish	1.5					1.9	0.6	2.0	0.2
Balistidae	triggerfish							0.6		
Bodianus pulchellus	spotfin hogfish		1.1				1.1			4.5
Bothidae	flounder			1.7	20.6	0.5	0.6			
Calamus sp.	porgy						0.8	3.3	0.7	0.4
Canthigaster rostrata	sharpnose puffer									1.7
Centropristis ocyurus	bank sea bass	6.8		19.3		5.8	6.7			0.6
Centropristis sp.	sea bass					5.6				
Chaetodon aya	bank butterflyfish	0.8	0.2			0.2	2.5		1.3	0.4
Chaetodon ocellatus	spotfin butterflyfish		0.6				0.8	4.4	1.3	
Chaetodon sedentarius	reef butterflyfish	2.3	2.3	1.1		0.2	4.0	3.3	2.0	1.7
Chaetodon sp.	butterflyfish		0.2					0.6	0.7	0.4
Chilomycterus schoepfi	striped burrfish									0.4
Chromis enchrysurus	yellowtail reeffish	9.0	8.0			0.6	1.7	2.2	10.5	2.4
Chromis scotti	purple reeffish	1.5	5.1				0.6			
Chromis sp.	damselfish		3.3				0.2			
Corniger spinosus	spinycheek soldierfish						0.2			
Dasyatidae	stingray							0.6		
Epinephelus adscensionis	rock hind									0.4
Epinephelus cruentatus	graysby							0.6		
Epinephelus nigritus	warsaw grouper			2.2						
Epinephelus niveatus	snowy grouper			0.6	1.6		0.8			
Equetus acuminatus	high-hat							0.6		
Equetus lanceolatus	jack-knife fish						1.5			
Equetus sp.	drum					0.2		0.6		

Table 1. Continued.

Species	Common Name	FL-1	FL-2	GA-2	GA-1&2	GA-out	SCB-1	SCA-1	SCA-1&3	SCA-out
Equetus umbrosus	cubbyu		0.6	1.1		1.6				0.6
Gymnothorax moringa	spotted moray eel								0.7	0.4
Gymnothorax saxicola	ocellated moray								0.7	
Haemulon aurolineatum	tomtate		38.2			14.8				
Haemulon plumieri	white grunt							3.3		0.2
Halichoeres sp.	wrasse	21.8	1.6	1.7		4.7	6.5	18.2	41.2	2.4
Hemipteronotus sp.	razorfish						5.2	3.3	1.3	1.1
Holacanthus bermudensis	blue angelfish	0.8	1.5			0.2	1.0	0.6		0.9
Holacanthus ciliaris	queen angelfish		0.1							
Holacanthus sp.	angelfish		0.1							
Holacanthus tricolor	rock beauty		0.1							0.6
Holocentrus sp.	squirrelfish	0.8	0.5							5.6
Lachnolaimus maximus	hogfish		0.1				0.4	3.9	1.3	0.4
Lactophrys quadricornis	scrawled cowfish		0.1							0.2
Lactophrys sp.	trunkfish		0.3						0.7	
Liopropoma eukrines	wrasse bass			0.6		0.2			0.7	0.2
Lutjanus campechanus	red snapper			8.8						
Mycteroperca microlepis	gag			0.6						0.2
Mycteroperca phenax	scamp		0.3	12.7		1.6	2.9	0.6	2.0	1.1
Mycteroperca sp.	grouper			0.6						
Ogcocephalus sp.	batfish				0.8					
Opsanus tau	oyster toadfish					0.2				
Pagrus pagrus	red porgy			17.1		0.3	13.2			0.4
Paranthias furcifer	creole-fish									0.6
Pareques iwamotoi	blackbar drum				1.6					
Pomacanthus sp.	angelfish							0.6		
Priacanthus arenatus	bigeye							1.1	0.7	0.2
Pristigenys alta	short bigeye		0.1	1.7	1.6	4.4	5.9	18.2	13.7	5.4
Pterois sp.	lionfish					0.2	0.4	1.7	1.3	1.1
Rachycentron canadum	cobia							0.6		

Table 1. Continued.

Species	Common Name	FL-1	FL-2	GA-2	GA-1&2	GA-out	SCB-1	SCA-1	SCA-1&3	SCA-out
Rhomboplites aurorubens	vermilion snapper		32.1				5.9			
Rypticus maculatus	whitespotted soapfish									0.2
Scorpaenidae	scorpionfish	0.8		0.6	3.2					
Seriola dumerili	greater amberjack	1.5				3.0	2.1	4.4		1.3
Seriola rivoliana	almaco jack						0.6			
Seriola sp.	amberjack		0.1				4.4		1.3	0.6
Seriola zonata	banded rudderfish						2.7			45.4
Serranidae	grouper						0.4			0.2
Serranidae	sea bass	4.5		3.9		1.9	4.4			
Serranus annularis	orangeback bass		0.1				0.4			
Serranus notospilus	saddle bass			7.7	6.3	4.1	1.7	2.2	0.7	
Serranus phoebe	tattler	5.3	1.4	4.4		3.4	3.4	3.9	9.8	7.6
Sparidae	porgy		0.1				1.3	4.4	2.6	0.6
Sphoeroides spengleri	bandtail puffer		0.3				0.2	0.6	1.3	
Sphyraena barracuda	great barracuda					0.2				
Synodus intermedius	sand diver			2.8	14.3	1.7	0.2			
Synodus sp.	lizardfish			2.2	4.8	1.9				0.2
Tetraodontidae	puffer								0.7	
Triglidae	sea robin			1.1	16.7	0.2				
	eel				0.8	0.5	0.6			
	unidentifiable	2.3	1.6	2.2	27.8	39.1	12.8	13.3		7.6

Table 2. Total fish, grouper, and lionfish densities (#/hectare) by habitat type in each proposed MPA option from ROV dives. NH= no hardbottom, PAV= pavement, MRO= moderate relief outcrops, and HRL= high relief ledge. Numbers in () represent standard errors. A dash denotes that particular habitat was not present in that MPA option.

	Total Fish					**Grouper**					**Lionfish**				
MPA	NH	PAV	LRO	MRO	HRL	NH	PAV	LRO	MRO	HRL	NH	PAV	LRO	MRO	HRL
FL-1	3.9 (2.5)	-	-	-	-	0.0 (0.0)	-	-	-	-	0.0 (0.0)	-	-	-	-
FL-2	-	-	2037.9 (1044.4)	-	8834.8 (0.0)	-	-	0.0 (0.0)	-	56.3 (0.0)	-	-	0.0 (0.0)	-	0.0 (0.0)
GA-2	160.0 (66.5)	1175.6 (0.0)	-	-	-	0.0 (0.0)	227.5 (0.0)	-	-	-	0.0 (0.0)	0.0 (0.0)	-	-	-
GA-1&2	383.2 (87.1)	-	-	-	-	0.0 (0.0)	-	-	-	-	0.0 (0.0)	-	-	-	-
GA-out	130.2 (58.5)	1038.6 (341.6)	-	-	-	0.0 (0.0)	0.0 (0.0)	-	-	-	0.0 (0.0	5.1 (5.1)	-	-	-
SCA-1	68.4 (17.0)	1369.9 (0.0)	-	-	-	0.0 (0.0)	23.6 (0.0)	-	-	-	0.0 (0.0)	23.6 (0.0)	-	-	-
SCA-1&3	90.0 (0.0)	-	-	-	-	0.0 (0.0)	-	-	-	-	0.0 (0.0)	-	-	-	-
SCA-out	317.1 (0.0)	1436.8 (0.0)	-	-	-	0.0 (0.0)	12.0 (0.0)	-	-	-	0.0 (0.0)	12.0 (0.0)	-	-	-
SCB-1	132.7 (47.6)	1826.6 (580.6)	-	759.8 (0.0)	-	0.0 (0.0)	87.0 (19.7)	-	24.5 (0.0)	-	0.0 (0.0)	5.9 (5.9)	-	12.3 (0.0)	-

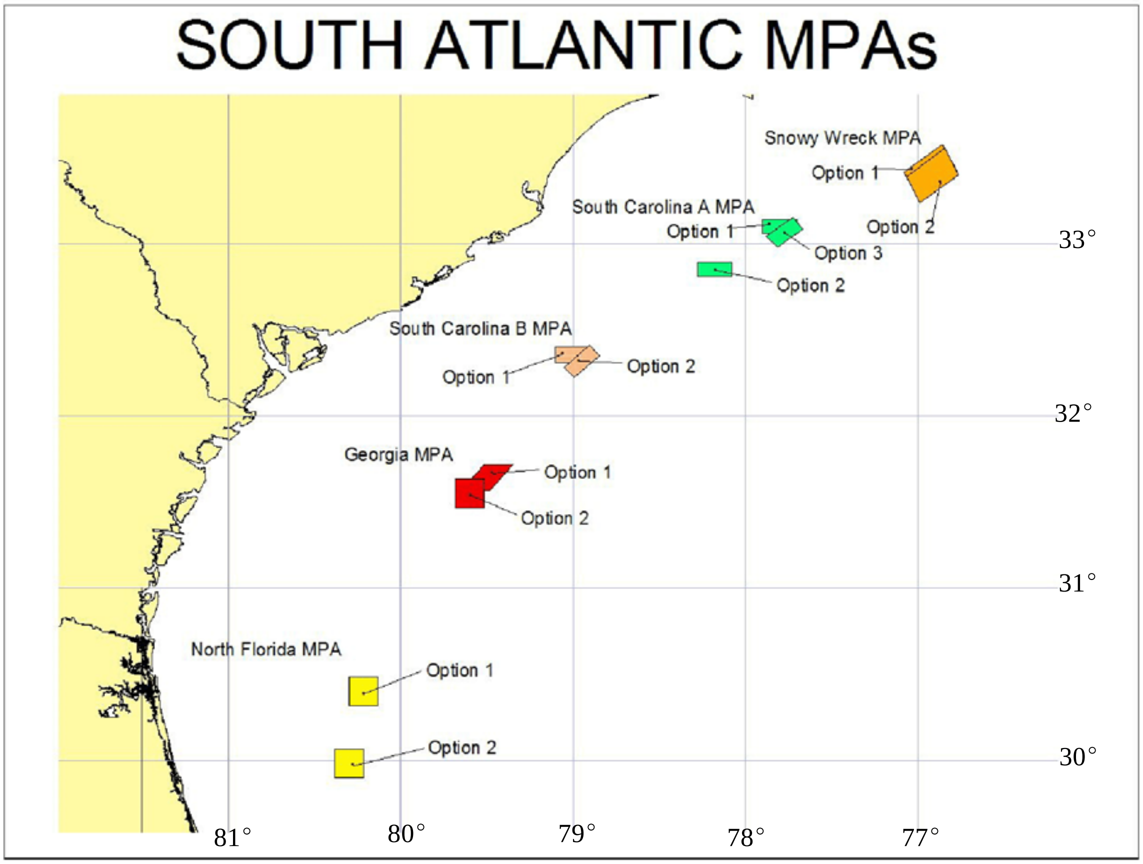

Figure 1. Locations of five proposed, natural bottom, MPA sites in the South Atlantic Bight.

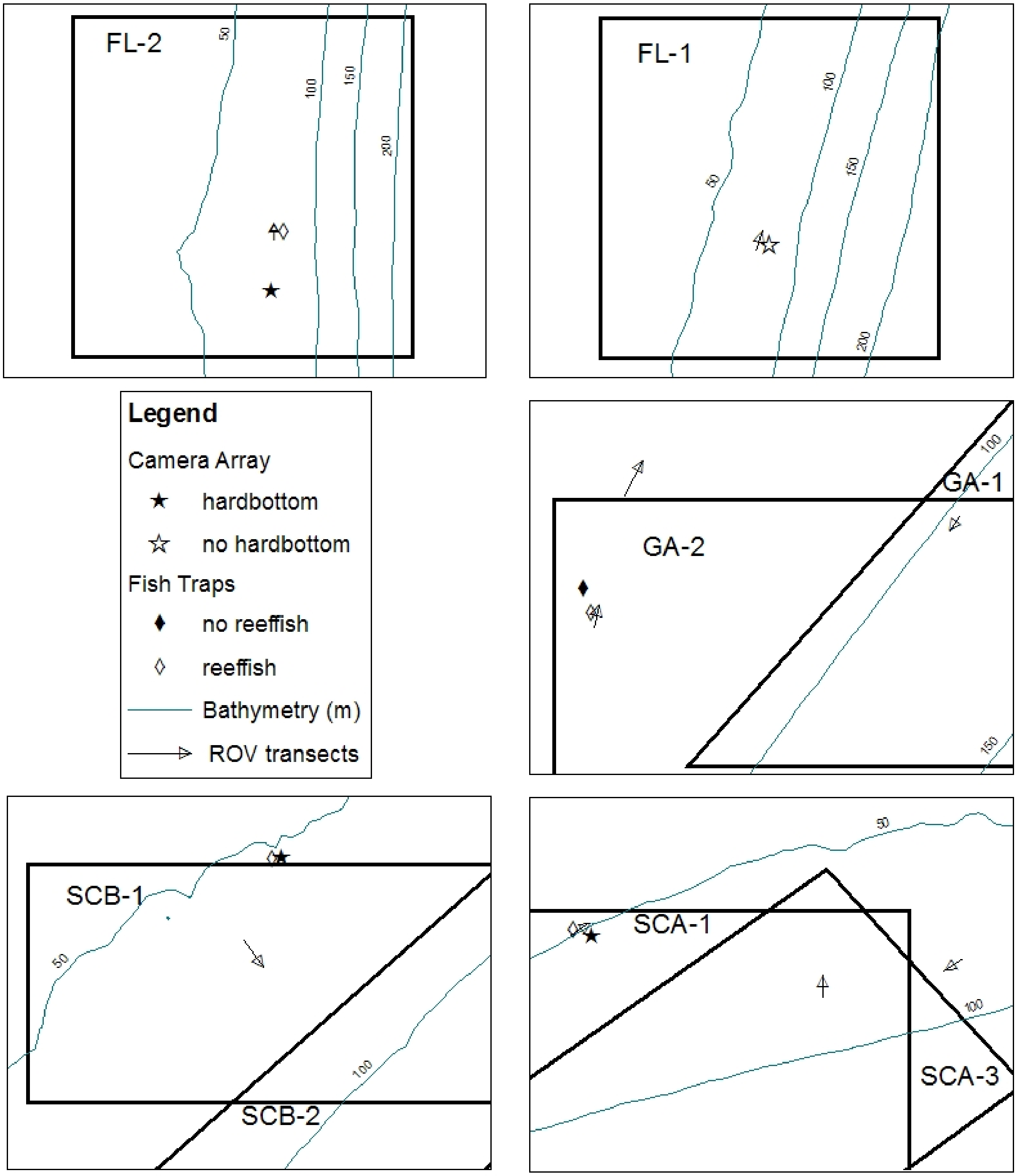

Figure 2. Maps of each proposed MPA examined and the locations and types of gear that were deployed in each. Stars represent locations where camera drops were made; black stars indicate that hardbottom was found and open stars where no hardbottom was observed. Diamonds display locations of fish traps; black diamonds indicate reeffish were caught and open diamonds where no reeffish were caught. Arrows show the direction and length of ROV transects. Hardbottom was observed on all dives to some degree.

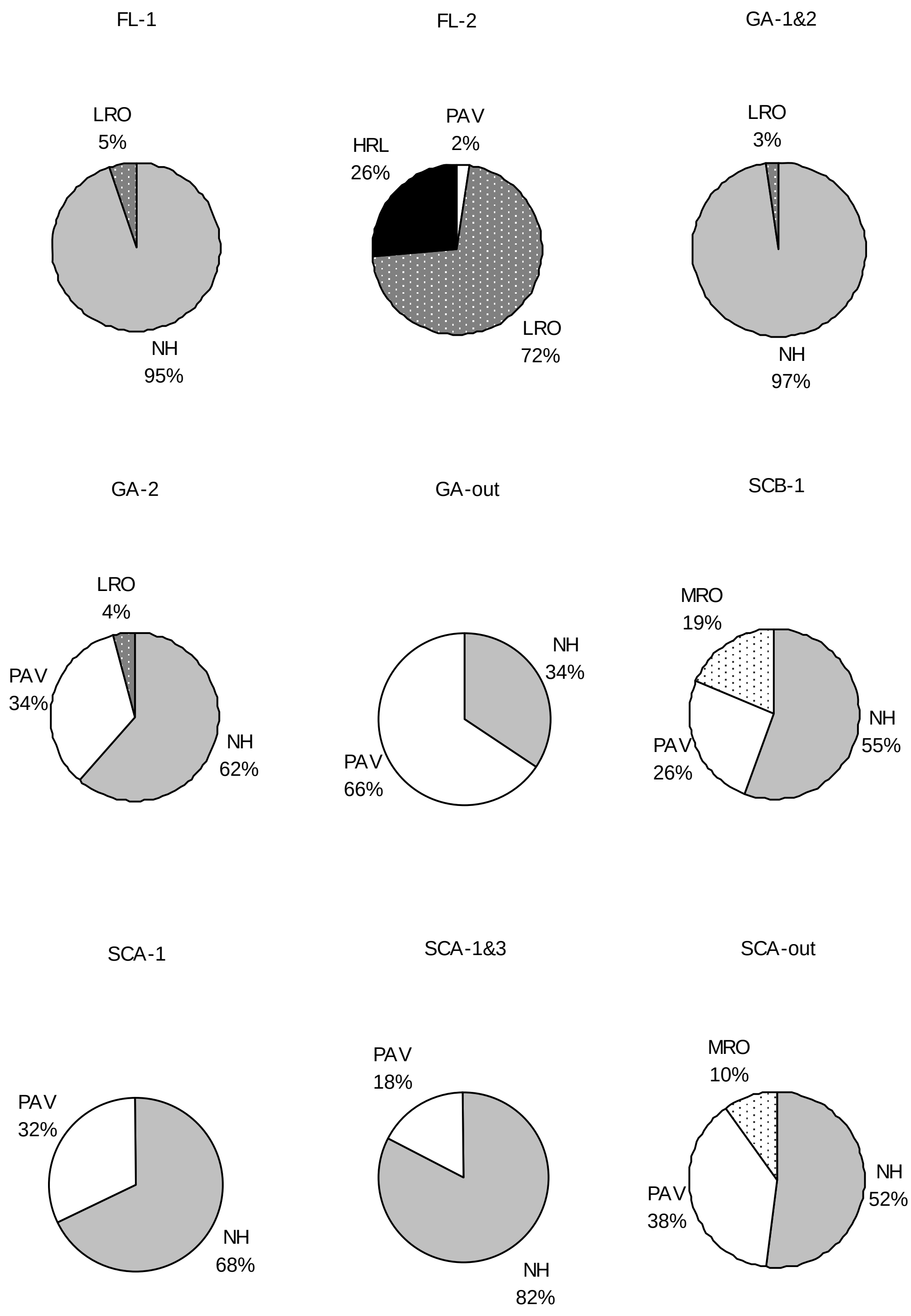

Figure 3. Occurrence (%) of habitat types observed in each proposed MPA option from ROV dives. NH= no hardbottom, PAV= pavement, MRO= moderate relief outcrops, and HRL= high relief ledge.

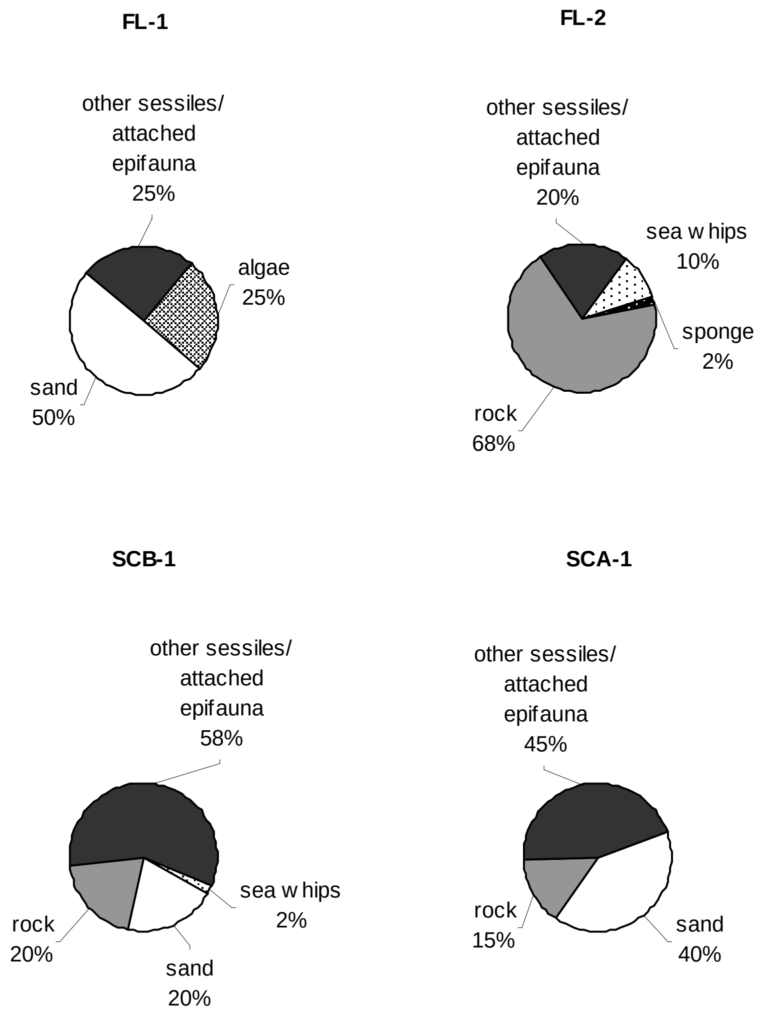

Figure 4. Occurrence (%) of habitat types observed on each camera array drop.

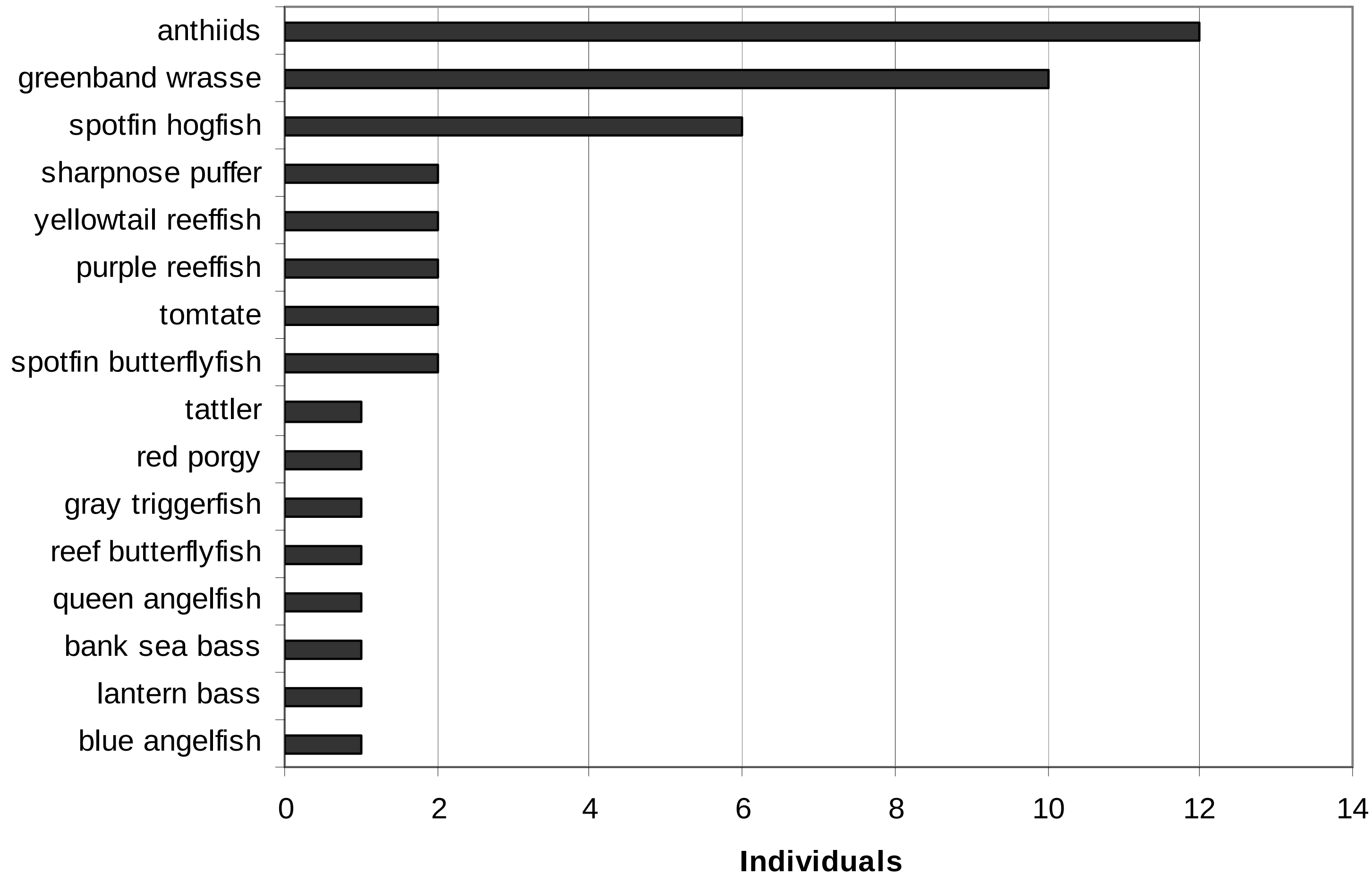

Figure 5. Maximum number of individuals by species observed at FL-2 by the camera array.

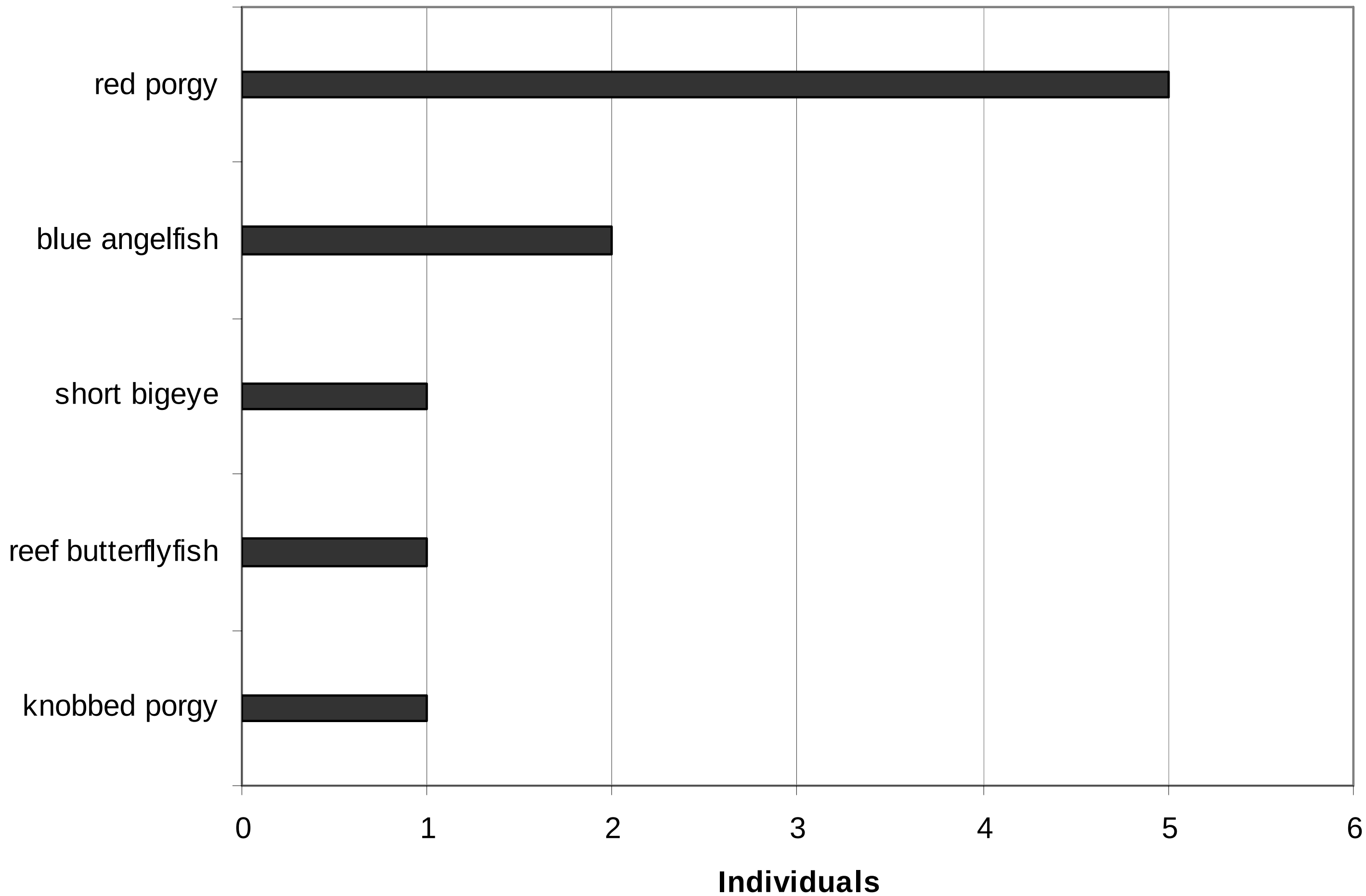

Figure 6. Maximum number of individuals by species observed at SCB-1 by the camera array.

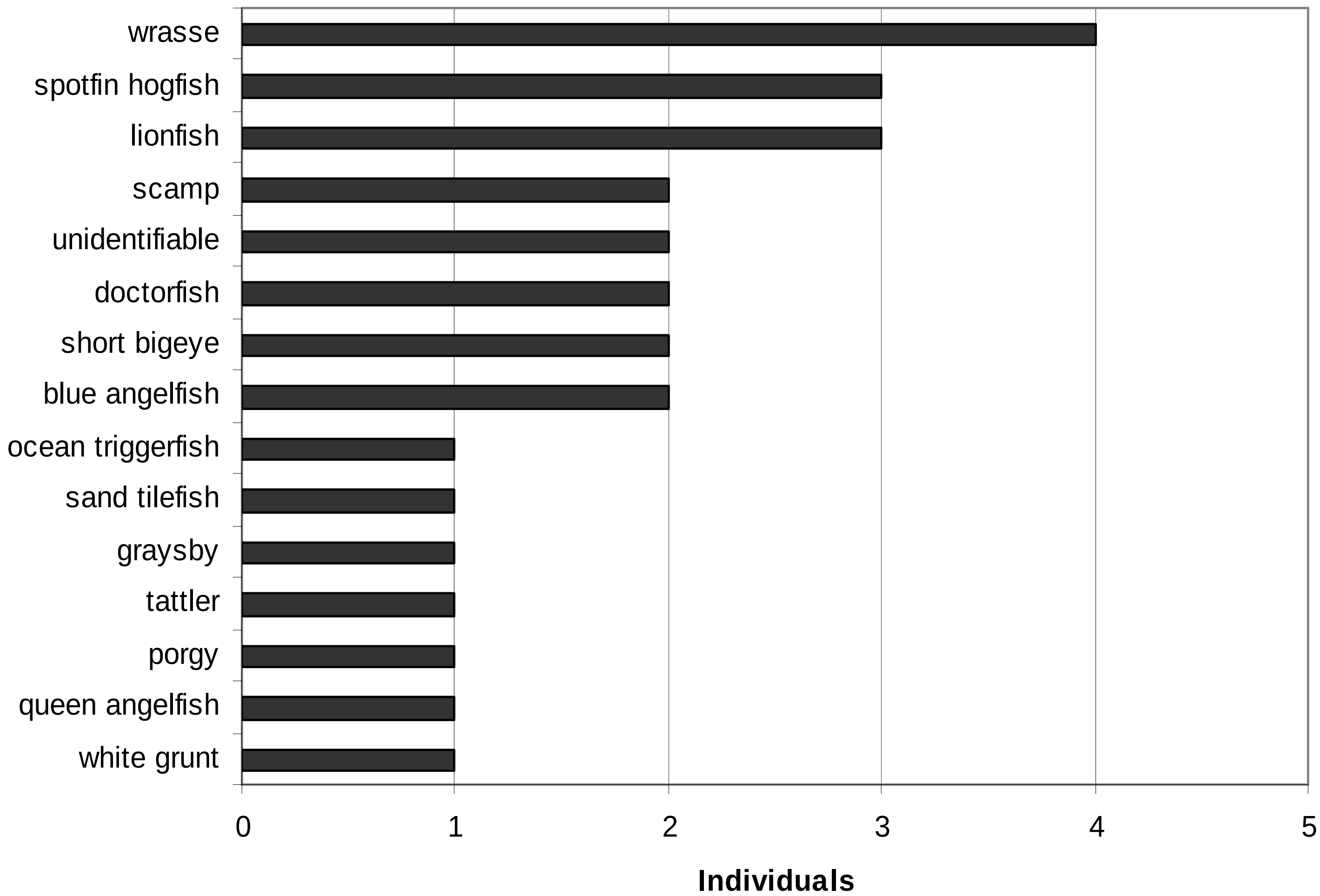

Figure 7. Maximum number of individuals by species observed at SCA-1 by the camera array.

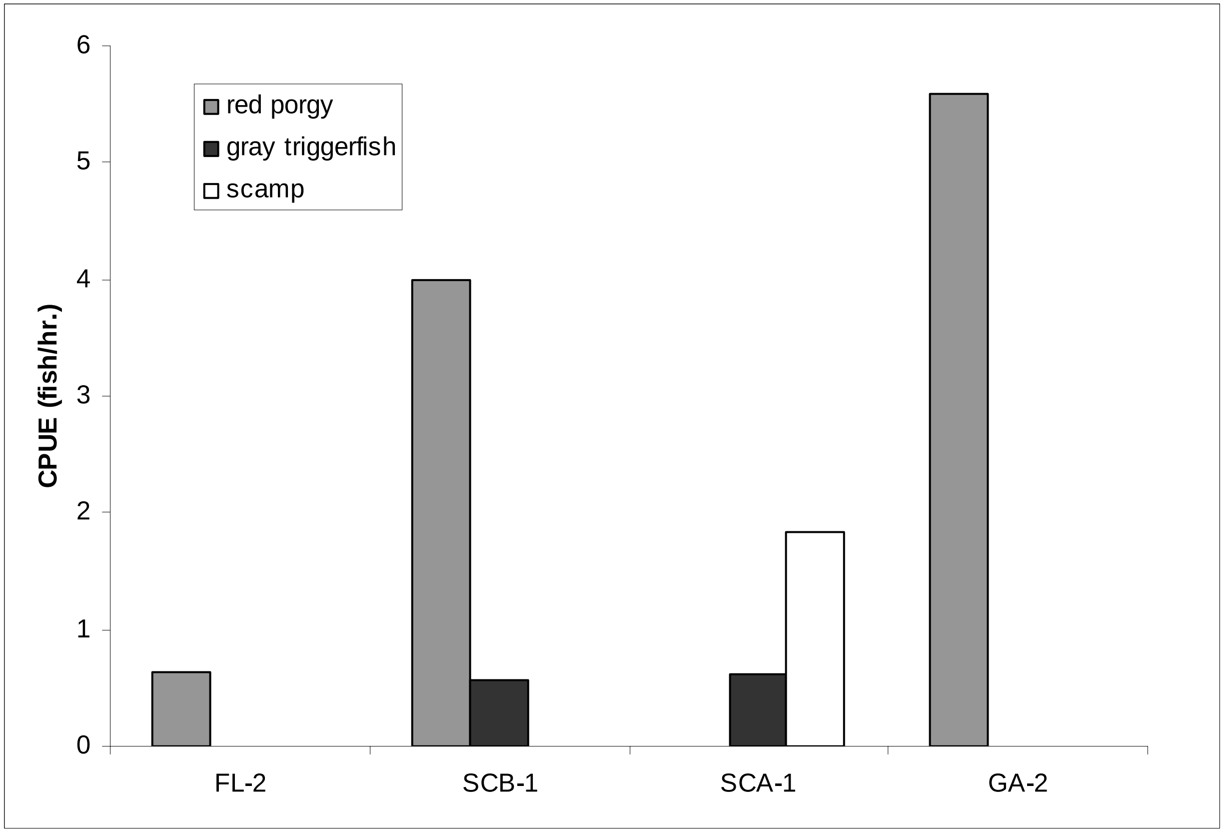

Figure 8. CPUE (# fish/hr.) of each species caught in the fish trap for each proposed MPA option.