South Atlantic marine protected areas: year four of a 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 Fishery Management Council (SAFMC) and the National Oceanic and Atmospheric Administration (NOAA) has proposed implementation of eight 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. During 2008, the NOAA Fisheries Laboratory in Panama City, FL completed the fourth annual survey of five of the proposed MPA sites with three main objectives: 1) establish pre-closure 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. Gear employed during the surveys included a Remotely Operated Vehicle (ROV) and a stationary video camera array. Four of the seven targeted reef fish including snowy grouper (*Epinephelus niveatus*), speckled hind (*E. drummundhayi*), warsaw grouper (*E. nigritus*), and blueline tilefish (*Caulolatilus microps*) were observed in 2008. Relative fish abundances varied between proposed MPAs. None of the target species had the highest abundance of fishes observed; however other species of the snapper/grouper complex such as vermilion snapper (*Rhomboplites aurorubens*), tomtates (*Haemulon aurolineatum*), striped grunts (*Haemulon striatum*), and amberjack (*Seriola* spp.) were among those most frequently observed. Lionfish (*Pterois volitans*) densities were exponentially higher in the 2007 and 2008 surveys compared to the 2004 and 2006 surveys. Lionfish also showed comparable densities to the most abundant grouper, scamp (*Mycteroperca phenax*). As expected, lionfish and grouper densities increased with increasing habitat complexity. This study presents a unique opportunity to examine proposed MPA sites before implementation of fishing restrictions, thus providing fishery managers with robust pre-closure data upon which efficacy evaluations of closures can be made.

Introduction

The South Atlantic Fishery Management Council (SAFMC) is considering the implementation of eight 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, yellowedge grouper (*E. flavolimbatus*), warsaw grouper, speckled hind, and misty grouper (*E. mystacinus*) and two species of tilefish; tilefish (*Lopholatilus chamaeleonticeps*) and blueline tilefish. These species are considered to be at risk due to currently low stock densities and to life history characteristics which subject them to substantial fishing mortality. Based on recent stock assessments (SEDAR, 2004), four of these are considered to be overfished including snowy grouper, warsaw grouper, speckled hind, and tilefish. Yellowedge grouper are not considered overfished, and the status of misty grouper and blueline tilefish 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 (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 Grouper Wreck (hereafter denoted as NC), Northern South Carolina (SC), Edisto (ED), Georgia (GA), and North Florida (FL), each containing two or more alternatives (Figure 1). Three of the eight proposed MPA sites were not included in this survey, one artificial reef site off Charleston, SC and two sites off extreme southern Florida. The artificial reef site was 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. Early in 2007, the SAFMC announced the preferred alternatives for closure (Figure 1) and in January 2009, the Council presented the final rule for review with anticipated closure starting in February 2009. 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 pre-closure estimates of reef fish density and species composition associated with bottom features within and outside the preferred proposed MPAs; 2) describe habitat features within and outside the preferred proposed MPAs; and 3) document the relationship between habitat and species assemblages. This project supplements similar work conducted in 2004, 2006, and 2007 which also provided pre-closure information on fish communities and habitats in the proposed MPAs. This report is National Marine Fisheries Service Panama City Laboratory Contribution Number 09-03.

Methods

High resolution bathymetric maps exist only for a portion of the GA and SC proposed MPA sites. Sampling site selection for this cruise was based on these multibeam maps as well as results from the previous cruises. 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 (NURC) at the University of North Carolina at Wilmington (UNCW). High currents required the use of a downweight to keep the ROV umbilical cable near the bottom throughout the dives. This downweight was tethered to the ROV umbilical and the ROV operated on a 30 m leash which 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 a controlled over-the-ground speed of approximately 1.4 km/hr (range 0.9 to 2.8 km/hr). The geographic position of the ROV (± 3m) was constantly recorded throughout each dive with a tracking system linked to the ship's GPS system. The ROV was equipped with lights and a forward-looking color digital video camera which provided continuous imaging data. These dives resulted in approximately 10.5 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 50 m transects (± 5m) within each habitat type. All fish within a 5 m radius of the transect line on the video tapes were identified to the lowest discernable taxonomic level and counted (5 m was determined as the maximum distance that fish could reasonably be identified). Fish densities (# $hectare^{-1}$) 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). Transect length was calculated from latitude and longitude recorded by the ROV tracking system. The 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 2.5 m (range from 2 m to 4 m) and was determined by the clarity of the water. 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 and relative abundances were calculated for all observed fish species. Grouper and lionfish (*Pterois volitans*) densities were compared by species and among habitats inside and outside each preferred MPA alternative. The percentage of each habitat covered by the ROV inside and outside each preferred MPA alternative was also calculated.

We also used a stationary video camera array to determine relative abundance of fish and percent cover of habitat within and outside each preferred 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 30 cm 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 each habitat type inside and outside each preferred MPA alternative were determined.

A similar project examining shelf edge MPAs in the Gulf of Mexico has revealed modified fish behavior in the presence of ROVs. The lights, sounds, and motion of the vehicle attract some species and scare others whereas the stationary array has minimal impact upon fish behavior. The array, however, provides data on only a single spot with each deployment whereas the ROV can cover more than a kilometer with each dive. We have used both types of gear in an effort to maximize the area surveyed (ROV) and minimize fish behavior modification (array).

Results

The cruise took place between 18 and 24 July 2008. A map displaying locations and types of gear deployed at all sampled proposed MPA alternatives is shown in Figure 1. The plan was to conduct two ROV dives and one camera array drop inside and outside the preferred alternative for each MPA. This, however, did not happen due to ROV failures during the cruise. All planned ROV dives and camera deployments were completed in ED, as was the case in FL with the exception of one camera deployment in the control area. All camera drops and 2 ROV dives were made in SC prior to the ROV failure. Two camera drops were made in GA, however only 10 minutes of ROV footage was collected in NC before ROV failure. Sites outside the preferred alternatives were either from the other (non-preferred) MPA alternatives or outside all alternatives completely but in the immediate surrounding area.

A total of 11 ROV dives were made. Five major habitats were identified from the dives: 1) soft substrate/sand (hereafter denoted as SA), 2) pavement (PAV), 3) low relief outcrops (LRO), 4) moderate relief outcrops (MRO), and 5) high relief ledge (HRL). SA 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 2 m deep. LRO consisted of rock outcrops with < 1 m relief. MRO habitat was made up of rock outcrops with 1-3 m relief and HRL exhibited > 3 m relief often with large boulders and overhangs. Not all habitats were observed in each proposed MPA; however some quantity of hardbottom was seen on each dive. LRO was the most prominent habitat, while the higher relief areas (MRO and HRL) were only observed in FL and ED (Table 1).

A total of 61 fish species were identified from the ROV dives, including three of the seven targeted reef fish; snowy grouper, speckled hind, and warsaw grouper. To compare fish community structure inside and outside of each preferred proposed MPA alternative, relative abundances (%) of fishes were calculated (# individuals/total # individuals * 100) (Table 2). The most abundant taxa differed between the proposed MPAs, 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. Both inside and outside the preferred FL alternative, vermilion snapper (*Rhomboplites aurorubens*) and tomtates (*Haemulon aurolineatum*) were the dominant species. Yellowtail reeffish (*Chroms enchrysurus*) and short bigeyes (*Pristigenys alta*) dominated the preferred ED alternative while tomtates and vermilion snapper dominated outside the preferred alternative. Wrasses (*Halichoeres* spp.), short bigeyes, and striped grunts (*Haemulon striatum*) were the most frequently observed species outside the SC preferred alternative. Outside the preferred NC alternative, amberjacks (*Seriola* spp.) were most abundant.

As expected, grouper and lionfish were only found on hardbottom habitats (PAV, LRO, MRO, and HRL) and never on SA habitat (Table 3). Total grouper densities ranged from 0.0 hectare^{-1} to 441.4 hectare^{-1}. Lionfish densities ranged from 0.0 hectare^{-1} to 220.6 hectare^{-1}. The highest lionfish density came from a pair of dives outside the SC preferred alternative with pavement and low relief outcrops displaying 1-2 m relief. Lionfish densities in the 2007 and 2008 surveys have been higher by an order of magnitude compared to those of 2004 and 2006. The highest density from the earlier years was approximately 22 hectare^{-1}. The highest grouper densities came from a dive outside the ED preferred alternative that had moderate relief outcrops, mostly 1-1.5m relief. As seen in Table 3, lionfish and grouper densities progressively increased as habitat complexity increased, which was expected. Scamp (*Mycteroperca phenax*) was the most abundant grouper species with a maximum density of 133.8 hectare^{-1} (Figure 2). Lionfish displayed comparable densities to scamp and higher densities than all other grouper species in ED and FL and higher densities than all grouper species including scamp in SC (Figure 2).

Eight camera array drops were made. Rock was the dominant habitat with 1 m or less relief except inside and outside the preferred ED alternative where only sand was observed (Table 4). A total of 35 fish species were observed on the videotapes, including one of the target species, blueline tilefish. The dominant species for each MPA somewhat mirrored those from the ROV dives. Vermilion snapper and red porgy (*Pagrus pagrus*) dominated outside the FL preferred alternative (Figure 3). The most abundant fish observed outside the GA preferred alternative were red porgies and greenband wrasse (*Halichoeres bathyphilus*) (Figure 4). A high diversity of fish species was not seen on the ED camera drops because they were over sand, however, hardbottom was very close based on the fish species observed. Red porgies and wrasses dominated inside the preferred alternative while greater amberjack (*Seriola dumerili*), porgies, and gray angelfish (*Pomacanthus arcuatus*) were observed outside the preferred alternative (Figure 5). Inside the SC preferred alternative, vermilion snapper and tomtates were most frequently observed, while greenband wrasse, scamp, and short bigeyes dominated outside (Figure 6).

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 study areas, site selection was primarily based on results from the previous cruises. Site selection for the first cruises was based upon published data and personal communications with other researchers familiar with the areas.

Four of the target species (snowy grouper, speckled hind, warsaw grouper, and blueline tilefish) were observed during the 2008 survey. Yellowedge grouper, misty grouper, and tilefish 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. Depth probably explains why yellowedge and misty grouper were not found. Of the targeted grouper, these two are found in the deepest waters and the majority of our ROV dives targeted shallower hardbottom areas (< 100 m). Landings data from the South Atlantic region demonstrate that yellowedge grouper and tilefish are caught 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 closures have been implemented. This study presented a unique opportunity to examine these areas before fishing restrictions have been implemented allowing pre-closure data to be collected. The implementation date of these MPAs is 12 February 2009, thus four years of data (2004, 2006, 2007, and 2008) have been acquired and will be available 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). 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 must 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 undocumented 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. Percentage of each habitat covered by the ROV inside and outside all sampled preferred MPA alternatives. SA=sand, PAV=pavement, LRO=low relief outcrops, MRO=moderate relief outcrops, and HRL=high relief ledge.

MPA	% SA	% PAV	% LRO	% MRO	% HRL
FL-IN	6.8	21.8	7.0	0.0	64.4
FL-OUT	0.0	0.0	64.7	0.0	35.3
ED-IN	42.6	16.1	41.3	0.0	0.0
ED-OUT	0.0	12.5	45.9	20.3	21.3
SC-OUT	40.9	35.1	24.0	0.0	0.0
NC-OUT	0.0	0.0	100.0	0.0	0.0

Table 2. Relative abundances (%) of all fish species observed with the ROV inside and outside all sampled preferred MPA alternatives. X indicates a member of the grouper/snapper complex. * denotes a relative abundance of <0.1%.

	FL		ED		SC	NC
Taxa	IN	OUT	IN	OUT	OUT	OUT
Muraenidae						
Undetermined				*	0.1	
Gymnothorax moringa				*		
Gymnothorax spp.			0.2			
Gymnothorax vicinus	0.1					
Synodontidae						
Synodus intermedius			0.2			
Holocentridae						
Undetermined	1.1			0.1		
Holocentrus spp.	0.3	1.5	1.4	0.4	3.5	
Myripristis jacobus				0.2		
Ostichthys trachypoma				*		
Fistulariidae						
Fistularia tabacaria				*		
Scorpaenidae						
Undetermined		0.8				
Pterois volitans	0.1		2.2	1.1	4.4	
Dactylopteridae						
Dactylopterus volitans				0.1		
Serranidae						
Undetermined				*		
Centropristis ocyurus (X)	0.2	0.4				
Epinephelus adscensionis (X)				*	0.1	
Epinephelus cruentatus (X)				0.1	0.4	

Taxa	FL		ED		SC	NC
	IN	OUT	IN	OUT	OUT	OUT
Epinephelus drummondhayi (X)			0.2			2.0
Epinephelus morio (X)				*		
Epinephelus nigritus (X)	0.1					
Epinephelus niveatus (X)			0.4			
Liopropoma eukrines	0.2	1.1	0.6			
Mycteroperca phenax (X)	0.1	0.4	2.6	1.3	0.8	
Mycteroperca spp. (X)	0.1					
Rypticus saponaceus					0.5	
Rypticus spp.					0.1	
Serranus annularis		0.8	2.2	*		
Serranus notospilus			0.6			
Serranus phoebe	0.8	2.7	3.6	0.9	2.5	3.0
Serranus spp.			0.4	*	0.3	
Priacanthidae						
Priacanthus arenatus		0.4			0.5	
Pristigenys alta	0.1		9.3	0.2	11.9	17.6
Apogonidae						
Apogon pseudomaculatus				0.1		
Carangidae						
Seriola dumerili (X)	0.1	0.8		0.1	1.7	
Seriola spp. (X)	0.2	0.8	5.2	0.9	1.7	49.0
Lutjanidae						
Lutjanus campechanus (X)				*		
Rhomboplites aurorubens (X)	9.9	53.4		23.7		
Haemulidae						
Haemulon aurolineatum (X)	54.5	32.2		53.5		
Haemulon plumieri (X)				*	1.7	

Taxa	FL		ED		SC	NC
	IN	OUT	IN	OUT	OUT	OUT
Haemulon spp. (X)					0.3	
Haemulon striatum (X)				0.7	13.0	
Sparidae						
Undetermined		0.4	1.0	*		
Calamus spp. (X)	0.1		1.0	0.7	2.5	
Pagrus pagrus (X)	11.4	0.4	0.6	0.2		
Sciaenidae						
Equetus lanceolatus			0.4	*	0.3	
Equetus umbrosus	0.2			0.1	1.3	
Mullidae						
Pseudupeneus maculatus				0.1		
Ephippidae						
Chaetodipterus faber (X)				*		
Chaetodontidae						
Chaetodon aya	1.0	0.4	2.2	0.4		
Chaetodon ocellatus	0.1		0.8	0.5	0.7	
Chaetodon sedentarius	2.9	2.3	5.2	2.3	5.2	
Chaetodon spp.				0.1		
Pomacanthidae						
Centropyge argi					0.1	
Holacanthus bermudensis	1.5		4.0	1.0	0.8	
Holacanthus ciliaris	0.3	0.4	0.2			
Holacanthus spp.					0.1	
Holacanthus tricolor					0.1	
Pomacanthus paru				0.2		
Pomacanthus spp.				0.1		
Pomacentridae						

Taxa	FL		ED		SC	NC
	IN	OUT	IN	OUT	OUT	OUT
Chromis enchrysurus	1.3	0.4	26.0	2.7	8.2	3.9
Chromis insolatus				0.1	2.1	
Chromis partitus				*		
Chromis scotti	0.6			1.1	0.1	
Chromis spp.	0.1			0.2	0.4	
Labridae						
Bodianus pulchellus	2.3	0.4	2.2	0.5	2.9	
Decadon puelleris			0.2			
Halichoeres bathyphilus	1.5		3.0	0.1	4.7	17.6
Halichoeres spp.	5.0		6.0	2.1	14.6	2.0
Hemipteronotus spp.			1.8		0.5	
Lachnolaimus maximus (X)				0.1	3.1	
Acanthuridae						
Acanthurus chirurgus					3.5	
Balistidae						
Undetermined	0.1					
Balistes capriscus (X)	0.1			1.1	2.3	
Ostraciidae						
Lactophrys quadricornis			0.2	0.1		
Lactophrys spp.			0.4	0.1	0.1	
Tetraodontidae						
Canthigaster rostrata	0.4		6.0	1.2	0.3	
Sphoeroides spengleri			0.8	0.1		
Diodontidae						
Diodon spp.				0.1		
Undetermined	3.5	0.4	8.7	1.4	2.5	2.0

Table 3. Total grouper and lionfish densities (# $hectare^{-1}$) by habitat type inside and outside all sampled preferred MPA alternatives from ROV dives. SA= sand, PAV= pavement, LRO= low relief outcrops, 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 alternative.

	Grouper					Lionfish				
MPA	SA	PAV	LRO	MRO	HRL	SA	PAV	LRO	MRO	HRL
FL-IN	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-	12.4 (7.3)	0.0 (0.0)	0.0 (0.0)	32.9 (32.9)	-	3.2 (3.2)
FL-OUT	-	-	0.0 (0.0)	-	12.8 (12.8)	-	-	0.0 (0.0)	-	0.0 (0.0)
ED-IN	0.0 (0.0)	26.8 (15.5)	75.4 (49.8)	-	-	0.0 (0.0)	94.3 (58.6)	21.1 (11.6)	-	-
ED-OUT	-	0.0 (0.0)	18.7 (6.5)	208.8 (232.6)	276.0 (101.3)		0.0 (0.0)	26.9 (10.2)	146.8 (43.0)	179.2 27.7
SC-OUT	0.0 (0.0)	22.4 (16.2)	56.8 (8.7)	-	-	0.0 (0.0)	173.1 (47.5)	107.41 (26.9)	-	-
NC-OUT	-	-	21.2 (21.2)	-	-	-	-	0.0 (0.0)	-	-

Table 4. Occurrence (%) of sand and rock observed from camera array drops inside and outside all sampled preferred MPA alternatives. Relief (m) is also noted.

MPA	% sand	% rock	Relief (m)
FL-IN	30	70	<1
ED-IN	100	0	0
ED-OUT	100	0	0
SC-IN	25	75	<1
SC-OUT	60	40	<1
GA-OUT	0	100	<1

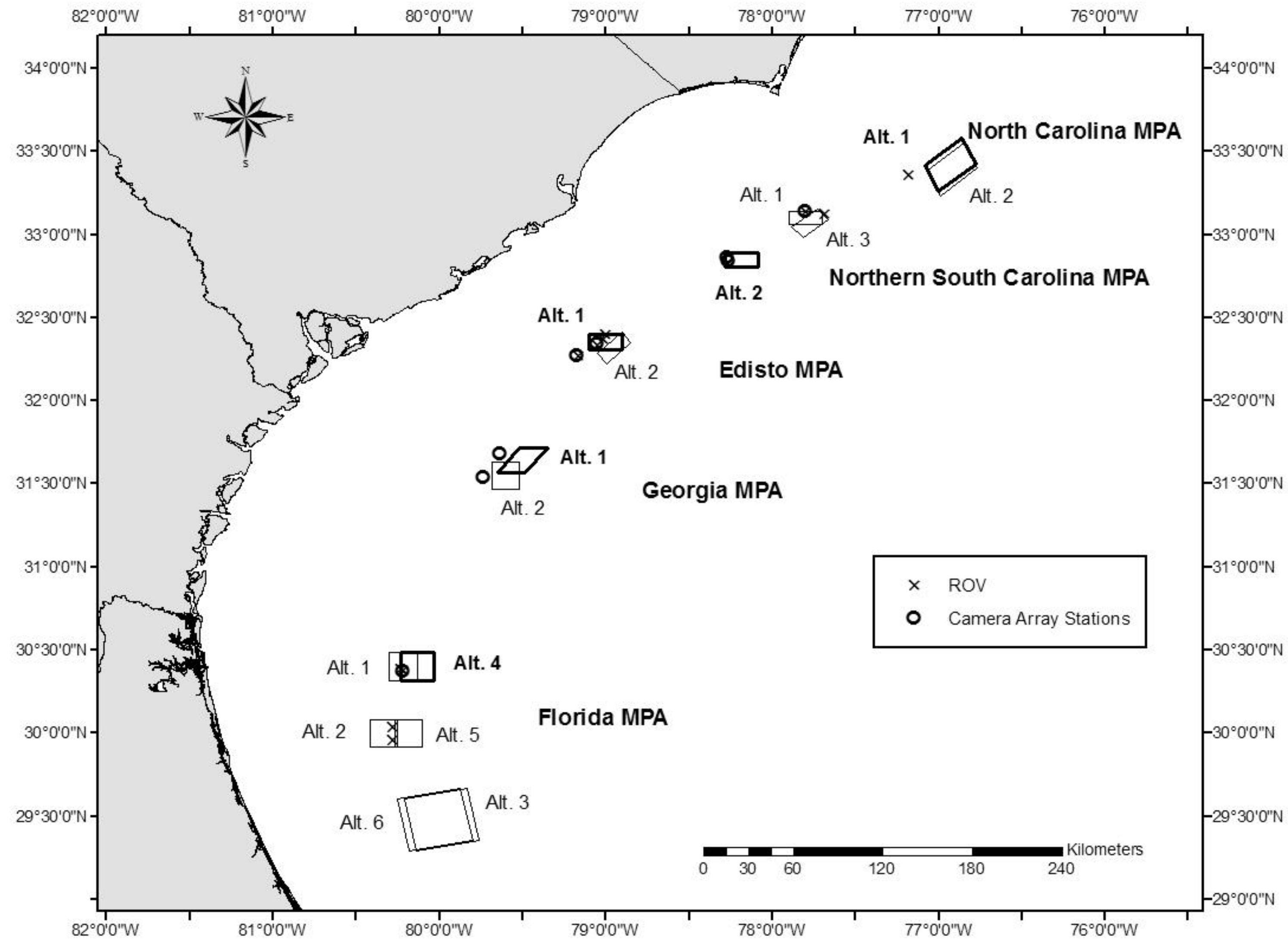


Figure 1. Locations of all alternatives for each of the five proposed, natural bottom MPA sites in the South Atlantic. An x indicates locations of ROV dives. Circles display locations of camera array drops. SAFMC preferred MPA alternatives are in bold.

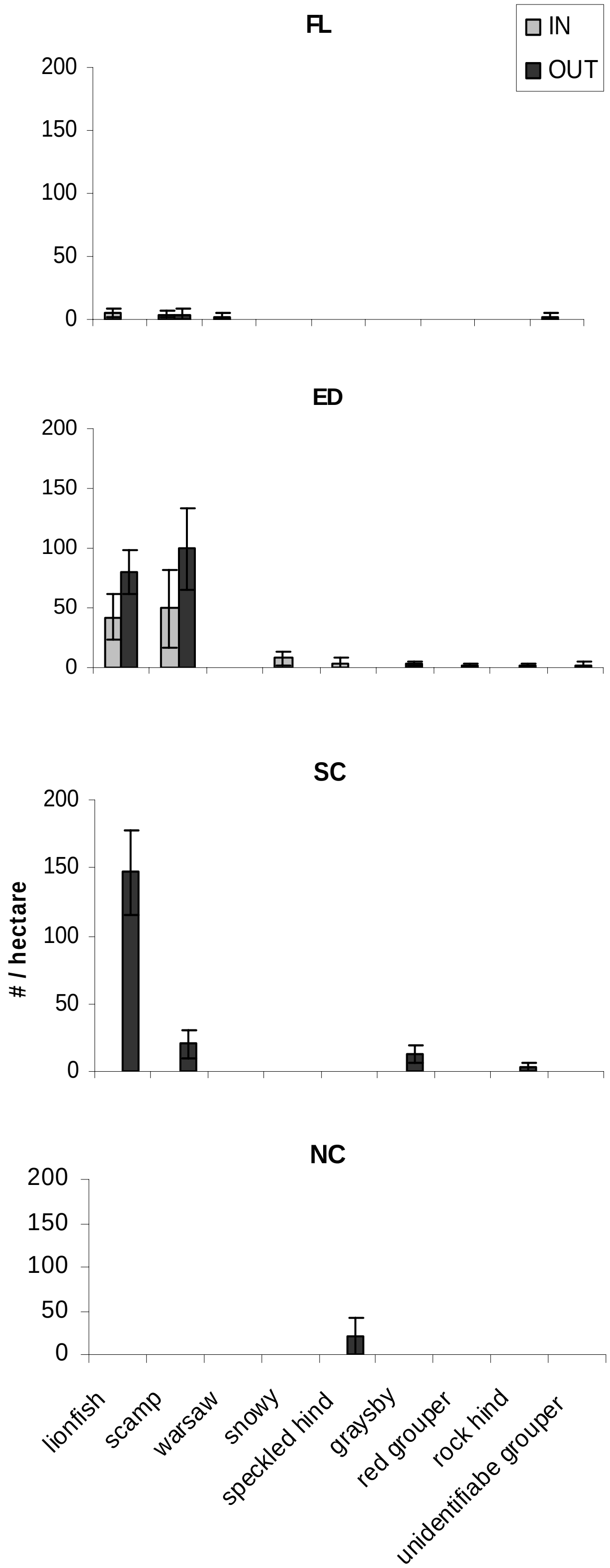


Figure 2. Average grouper and lionfish densities by species for all sampled proposed MPAs (inside and outside the preferred alternative) ± S.E from ROV dives.

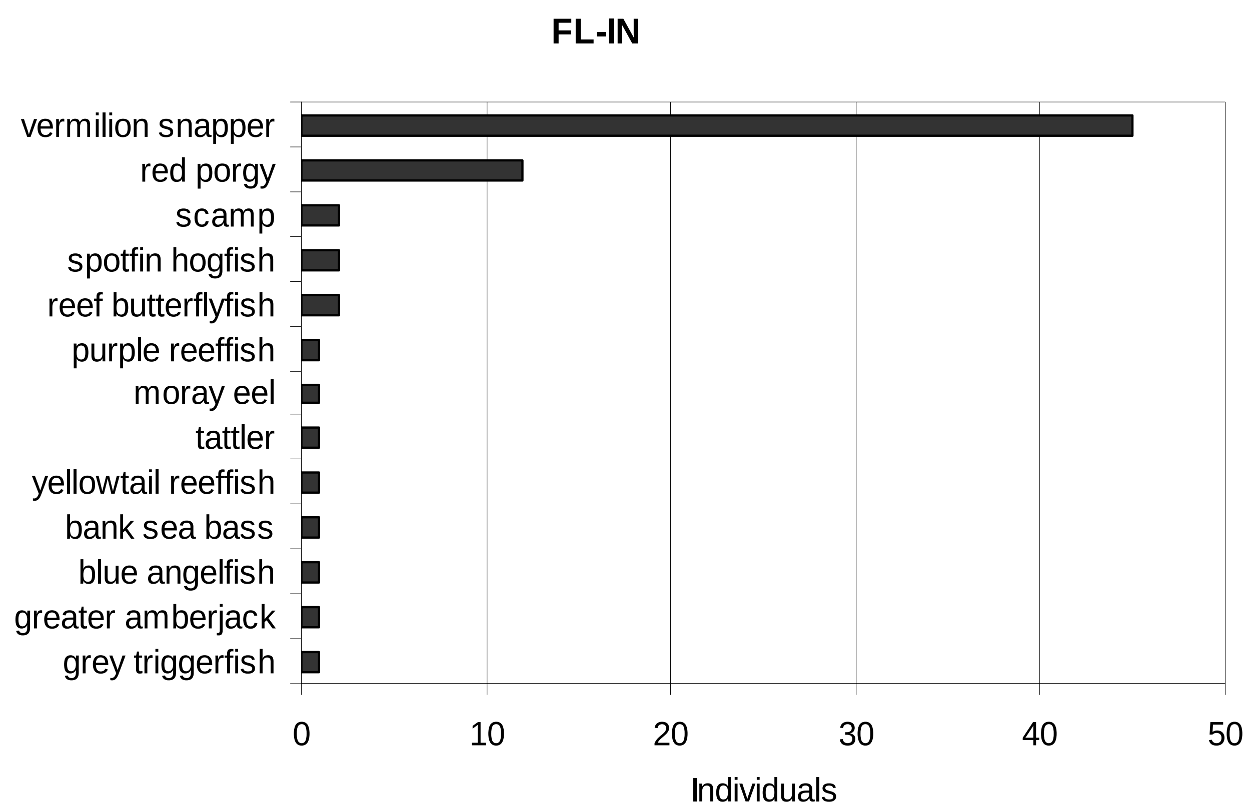


Figure 3. Maximum number of individuals by species observed inside the FL preferred alternative from the camera array.

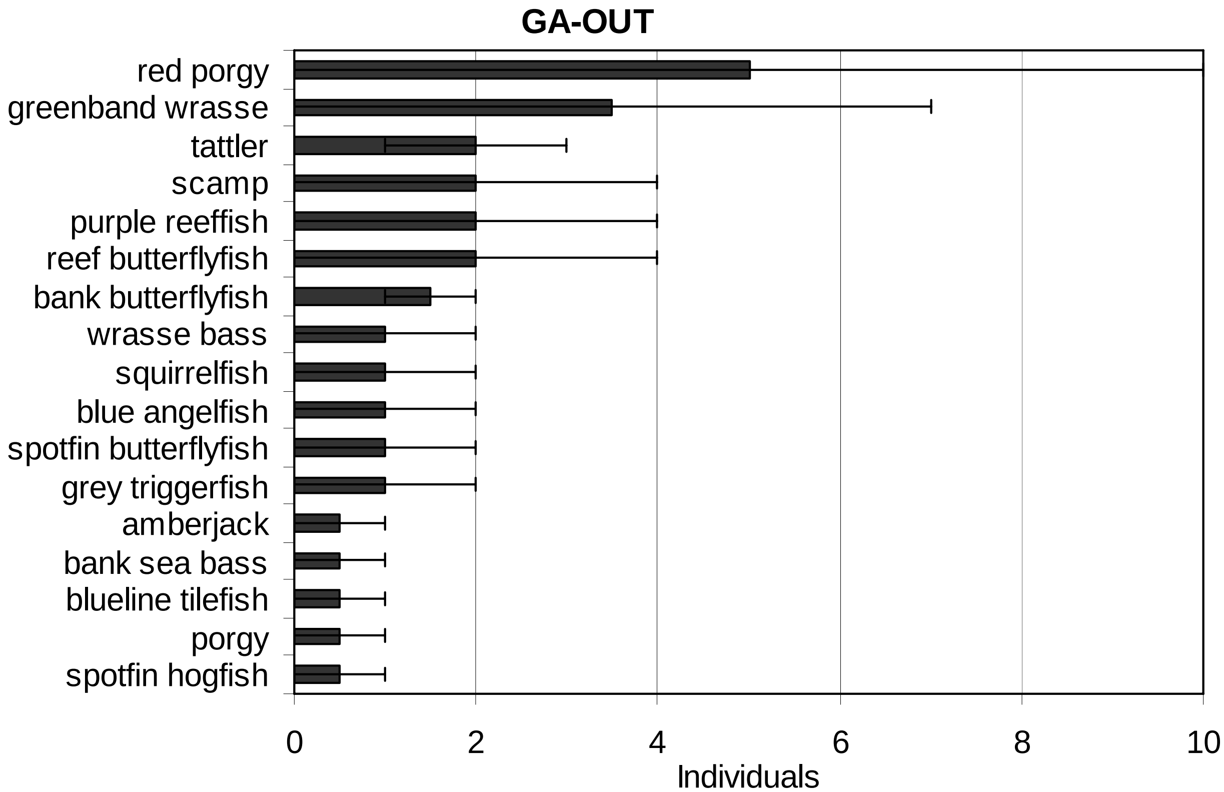


Figure 4. Maximum number of individuals by species observed inside and outside the NC preferred alternative from the camera array.

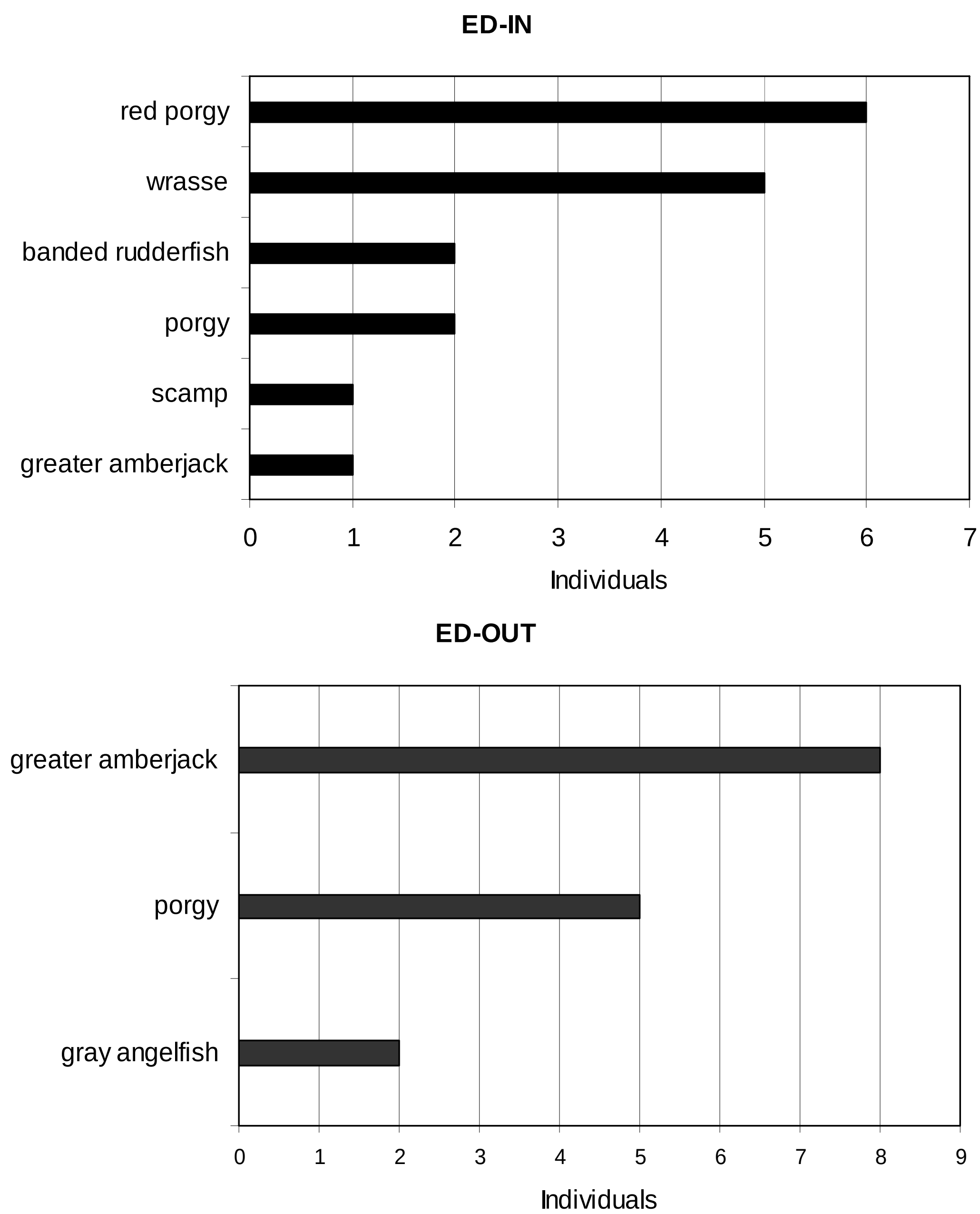
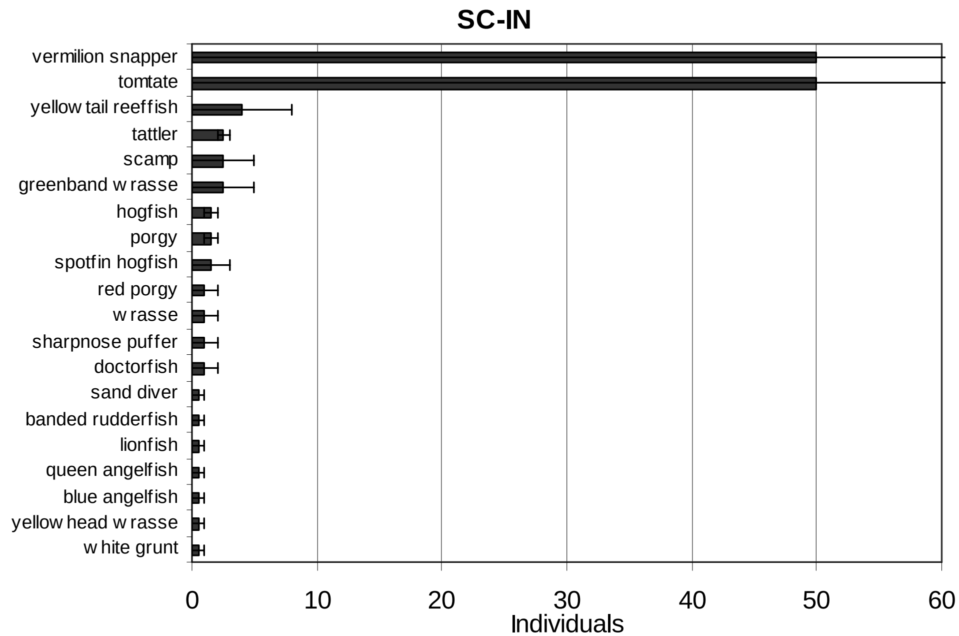


Figure 5. Maximum number of individuals by species observed inside and outside the ED preferred alternative from the camera array.



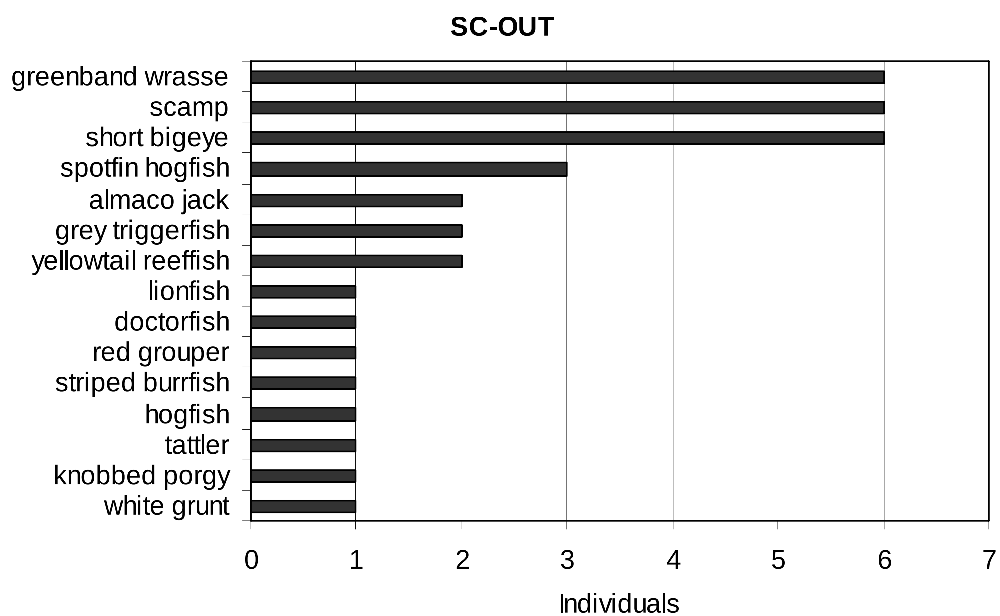


Figure 6. Maximum number of individuals (± S.E.) by species observed inside and outside the SC preferred alternative from the camera array.