South Atlantic marine protected areas: year five of an evaluation of habitat and fish assemblages in a network of 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) have implemented a network 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. In November 2009, the NOAA Fisheries Laboratory in Panama City, FL completed its fifth annual survey of the MPA sites. Previously, four pre-closure surveys were conducted and 2009 was the first year of post-closure data collected. A remotely operated vehicle (ROV) was used to examine the areas with four main objectives: 1) establish estimates of species composition and fish abundance, especially for species of grouper and tilefish; 2) describe habitat features; 3) document the relationship between habitat and species assemblages and 4) begin to investigate any changes in fish species composition and/or abundances between pre- and post-closure data as well as comparisons between areas inside and outside the MPAs. In 2009, inclement weather concatenated the survey and we were forced to limit observations to the Florida, Edisto, and northern South Carolina MPAs. Several members of the snapper-grouper complex were present both inside and outside the surveyed MPAs including nine species of grouper, one of which being a targeted species (speckled hind (*Epinephelus drummondhayi*)). Biodiversity of grouper species was higher in 2009 compared to all previous survey years. Unfortunately, lionfish (*Pterois volitans/miles*) abundances continued to increase with 2009 displaying the highest abundances of any other survey year. Lionfish showed comparable abundances to the most common grouper, scamp (*Mycteroperca phenax*), at Edisto and Florida MPAs and were significantly more prevalent than all grouper species at the northern South Carolina MPA. This study has presented a unique opportunity to examine 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) and the National Oceanic and Atmospheric Administration (NOAA) have implemented eight Type II marine protected areas (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. nigritu*)*)*, 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 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 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 examinations inside and outside 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) (Figure 1). Due to poor weather during the survey period, we were forced to narrow our 2009 efforts to three of the MPAs including SC, ED, and FL. NC was eliminated from the survey because it has the least amount of habitat for the target species and GA was not surveyed because it was established primarily to protect tilefish. The primary tilefish habitat is the muddy slope area of the MPA for which we have no multibeam bathymetric maps and minimal local knowledge. Three of the eight proposed MPA sites have never been 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. In January 2009, the Council presented the final rule for review and the closures were implemented in February 2009. Within and adjacent to each MPA, we characterized habitat and documented fish species composition and abundances of all fish encountered with emphasis on economically important species. Our specific objectives were to: 1) establish estimates of reef fish abundance and species composition associated with bottom features within and outside the MPAs; 2) describe habitat features within and outside MPAs; 3) document the relationship between habitat and species assemblages; and 4) begin to investigate any changes in fish species composition and/or abundances between pre- and post-closure data as well as inside compared to outside the MPAs. The majority of areas surveyed which were outside of the MPAs were inside one of the original alternatives which were not selected for closure. This project supplements similar work

conducted in 2004, 2006, 2007, and 2008 which 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 10-18.

Methods

Ideally, assessment of the efficacy of MPAs for increasing populations of economically valuable reef fish would entail a sequential approach of mapping, habitat delineation, and fishery surveys. High resolution maps are extremely crucial in site selection for this type of study. Multibeam maps, however, exist only for a small portion of the GA and SC MPAs. Sampling site selection for this cruise was based on these multibeam maps as well as results from previous cruises and information gathered from other researchers. The 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 gear used to characterize habitat and estimate fish abundance 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 from the surface to near the bottom and the ROV operated on a 30 m leash below the downweight 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 abundance within each habitat type both inside and outside the MPAs. Each dive was divided into 2 minute transects within individual habitat types. All fish within a 5 m radius of the transect line were identified to the lowest discernable taxonomic level and counted (5 m was determined as the maximum distance that fish could reasonably be identified). Average abundances of fish species inside versus outside each MPA were calculated by habitat type for the following: the seven target species of grouper and tilefish; other common members of the grouper-snapper complex; and lionfish (*Pterois volitans/miles*).The percentage of each habitat covered by the ROV inside and outside each MPA was also calculated.

Results and Conclusions

The cruise took place between 16 and 20 November 2009. A map displaying locations of ROV dives at all sampled MPAs is shown in Figure 1. The original cruise plan was to conduct two ROV dives inside and outside each of the five selected MPAs. This, however, did not happen due to the weather-shortened cruise time. All planned ROV dives were completed in ED, however, only one ROV dive was completed inside the FL MPA as well as outside the SC MPA.

Sites outside the MPAs were either from proposed MPA alternatives which were not chosen for closure or in the immediate surrounding area.

A total of 10 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 occasional cracks/crevices up to 2 m deep. LRO consisted of rock outcrops with < 1 m vertical 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 MPA or control site; however some quantity of hardbottom was present on each dive. The percentage of each habitat type for all MPAs and control areas can be seen in Table 1. Higher relief (MRO & HRL) were observed inside all MPAs except ED.

Approximately 85 fish species were identified from the ROV dives, including one of the seven targeted reef fish, speckled hind. Table 1 displays all the fish species present inside and outside each MPA. We have observed a larger number of the target species in previous years. The absence of a few species can be explained by our sampling design. Tilefish prefer muddy habitat offshore from the shelf/slope break and as we targeted reef habitat, it is not surprising tilefish were not observed. Survey depth probably explains the absence of yellowedge and misty grouper. 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 (after the time of the cruise). Therefore, seasonality may also explain why these species were not observed. Although several of the target species were not observed, numerous other member of the snapper-grouper complex were present including nine different species of grouper, which is more than any other survey year.

As expected, grouper and lionfish were only found on hardbottom habitats (PAV, LRO, MRO, and HRL) and never on sand. Unfortunately, lionfish were more abundant in 2009 than in any previous survey year. They were most abundant at the SC MPA site (Figure 3), even more so than all grouper species. Lionfish were most prevalent in the higher relief habitat types and were more abundant inside the FL and SC MPAs compared to outside, while the opposite was true at the ED MPA. Scamp (*Mycteropera* phenax) was the most abundant grouper species observed and displayed the same trends as lionfish (Figure 4). Graysby (*Epinephelus cruentatus*) were another common grouper species observed, but were not seen at the FL MPA site (Figure 5). They tended to be more abundant outside the ED MPA but displayed no trend at the SC MPA. The only target species observed, speckled hind, were only found inside the FL MPA on high relief habitat. Red grouper (*Epinephelus morio*) were a common grouper species, but only at the SC MPA. They were observed in relatively equal abundances both inside and outside the MPA.

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 were implemented allowing pre-closure data to be collected. The closures became effective in February 2009, thus four years of pre-closure data (2004, 2006, 2007, and 2008) have been acquired and we now have one year of post-closure data (2009). As more post-closure data is collected, we will be able to compare the population levels of these sites under reduced fishing pressure.

An on-going problem for marine reserves is enforcement of fishing restrictions. In order to effectively evaluate the efficacy of MPAs, ideally fishing must cease in those designated areas. In lieu of a cessation of fishing, the level of fishing effort should be determined. 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).

Acknowledgements

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Table 1. Fish species presence (denoted with a X) observed with the ROV inside and outside all sampled MPAs (FL, SC, and ED). IN represents inside the MPA while OUT indicates outside the MPA. * denotes a member of the snapper-grouper complex.

		FL		SC		ED	
Common Name	**Species Name**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
*almaco jack	*Seriola rivoliana*				X	X	X
*amberjack	*Seriola* sp.			X			
angelfish	*Holacanthus* sp.	X				X	
angelfish	*Pomacanthus* sp.	X	X				
anthiids	Anthiinae	X				X	
bandtail puffer	*Sphoeroides spengleri*	X	X	X	X		X
bank butterflyfish	*Chaetodon aya*	X	X	X		X	X
*bank sea bass	*Centropristis ocyurus*	X	X	X			X
barracuda	*Sphyraena barracuda*	X	X	X	X		X
bicolor damselfish	*Pomacentrus partitus*	X	X			X	X
bigeye	*Priacanthus arenatus*	X	X				X
*black grouper	*Mycteroperca bonaci*					X	
blackbar soldierfish	*Myripristis jacobus*	X	X				X
blue angelfish	*Holacanthus bermudensis*	X	X	X	X	X	X
blue goby	*Ioglossus calliurus*		X				X
bluespotted cornetfish	*Fistularia tabacaria*						X
cardinalfish	*Apogon* sp.		X			X	
cardinal soldierfish	*Plectrypops retrospinus*					X	
chalk bass	*Serranus tortugarum*				X		
*coney grouper	*Epinephelus fulvus*						X
cowfish	*Lactophrys* sp.		X	X		X	X
creole-fish	*Paranthias furcifer*	X					
cubbyu	*Equetus umbrosus*	X	X	X			X
damselfish	*Chromis* sp.	X	X	X		X	X
doctorfish	*Acanthurus chirurgus*			X	X		X
filefish	Monacanthidae		X				X
flounder	Bothidae	X				X	
flying gurnard	*Dactylopterus volitans*				X		
french angelfish	*Pomacanthus paru*	X		X			X
*gag grouper	*Mycteroperca microlepis*			X			
goby	Gobiidae					X	
*graysby	*Epinephelus cruentatus*			X	X	X	X
*greater amberjack	*Seriola dumerili*		X	X	X		X
greater soapfish	*Rypticus saponaceous*			X	X		
greenband wrasse	*Halichoeres bathyphilus*				X		X
grey angelfish	*Pomacanthus arcuatus*					X	
*grey snapper	*Lutjanus griseus*		X				

		FL		SC		ED	
Common Name	**Species Name**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
*grey triggerfish	*Balistes capriscus*		X	X	X	X	X
*grouper	Serranidae		X	X			
*grunts	*Haemulon* sp.	X				X	X
*hogfish	*Lachnolaimus maximus*		X	X	X	X	X
honeycomb cowfish	*Lactophrys polygonia*				X		X
*jack	Carangidae			X			
jack-knife fish	*Equetus lanceolatus*		X			X	X
*goliath grouper	*Epinephelus itajara*	X					
leopard toadfish	*Opsanus pardus*		X				
lionfish	*Pterois volitans*	X	X	X	X	X	X
lizardfish	*Synodus* sp.					X	X
moray eel	Moraenidae	X		X			
orangeback bass	*Serranus annularis*	X	X		X	X	X
pipefish	Syngnathidae					X	
*porgy	Sparidae		X				X
*porgy	*Calamus* sp.		X	X	X	X	X
purple reeffish	*Chromis scotti*	X	X	X	X	X	X
queen angelfish	*Holacanthus ciliaris*	X	X				X
*queen triggerfish	*Balistes vetual*					X	X
razorfish	*Hemipteronotus* sp.				X	X	
*red grouper	*Epinephelus morio*			X	X		X
*red porgy	*Pagrus pagrus*	X	X			X	
*red snapper	*Lutjanus campechanus*						X
redband parrotfish	*Sparisoma aurofrenatum*						X
reef butterflyfish	*Chaetodon sedentarius*	X	X	X	X	X	X
rosy razorfish	*Hemipteronotus martinicensis*						X
rock beauty	*Holacanthus tricolor*			X		X	
*rock hind	*Epinephelus adscensionis*			X			
roughtongue bass	*Pronotogrammus martinicensis*	X	X				
saddle bass	*Serranus notospilus*	X	X		X		X
sand diver	*Synodus intermedius*				X		X
*sand tilefish	*Malacanthus plumieri*					X	
scad	*Decapturus* sp.	X	X				
*scamp	*Mycteroperca phenax*	X	X	X		X	X
scorpionfish	Scorpaenidae	X					X
scrawled cowfish	*Lactophrys quadricornis*	X	X			X	X
sea bass	*Serranus* sp.	X					
sennet	*Sphyraena* sp.						X
sharpnose puffer	*Canthigaster rostrata*	X	X	X	X	X	X
short bigeye	*Pristigenys alta*	X	X	X	X	X	X

Common Name	Species Name	FL		SC		ED	
		IN	OUT	IN	OUT	IN	OUT
snake eel	Ophichthidae				X		
*snapper	*Lutjanus* sp.	X	X				X
soapfish	*Rypticus* sp.						X
soldierfish	*Holocentridae*		X			X	X
*speckled hind	*Epinephelus drummondhayi*	X					
spiny pufferfish	Diodontidae						X
spotfin butterflyfish	*Chaetodon ocellatus*	X	X	X	X	X	X
spotfin hogfish	*Bodianus pulchellus*	X	X	X	X	X	X
spotted goatfish	*Pseudupeneus maculatus*			X			X
spotted moray	*Gymnothorax moringa*				X		X
squirrelfish	*Holocentrus* sp.	X	X	X		X	X
squirrelfish	*Holocentrus adscensionis*	X	X	X		X	X
striped burrfish	*Chilomycterus schoepfi*						X
*striped grunt	*Haemulon striatum*						X
stout moray	*Muraena robusta*		X		X		
sunshinefish	*Chromis insolatus*	X	X	X			X
tattler	*Serranus phoebe*	X	X	X	X	X	X
toadfish	*Opsanus* sp.	X					
*tomtate	*Haemulon aurolineatum*	X	X	X			X
trumpetfish	*Aulostomus maculatus*						X
twospot cardinalfish	*Apogon pseudomaculatus*						X
*vermilion snapper	*Rhomboplites aurorubens*	X	X	X			X
*white grunt	*Haemulon plumieri*			X			
wrasse	*Halichoeres* sp.	X	X	X	X	X	X
wrasse bass	*Liopropoma eukrines*	X	X	X	X	X	X
yellowhead wrasse	*Halichoeres garnoti*		X	X		X	
yellowtail reeffish	*Chromis enchrysurus*	X	X	X	X	X	X

Figure 1. Map of ROV dives (pink circles) completed inside and outside the three surveyed MPAs in 2009.

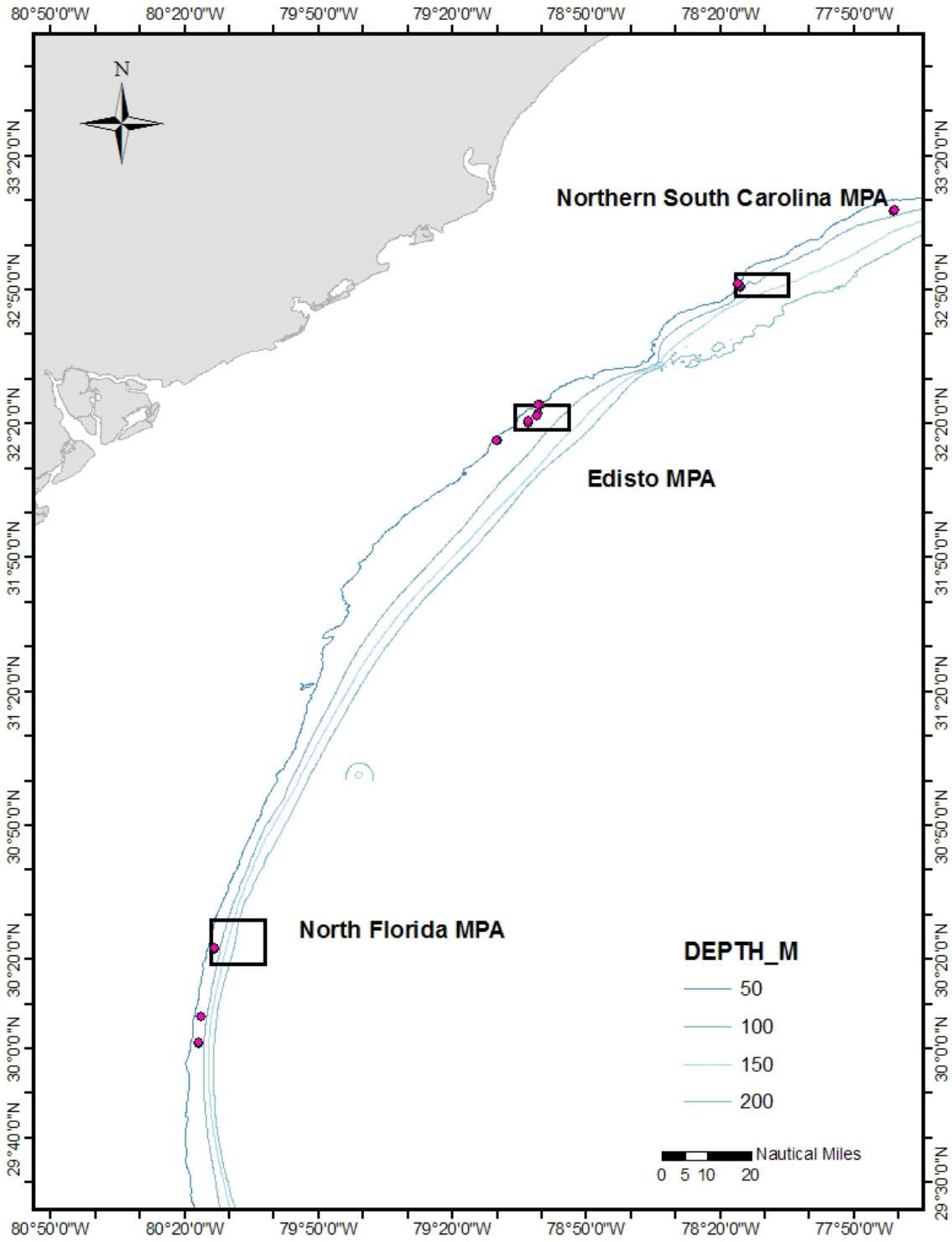
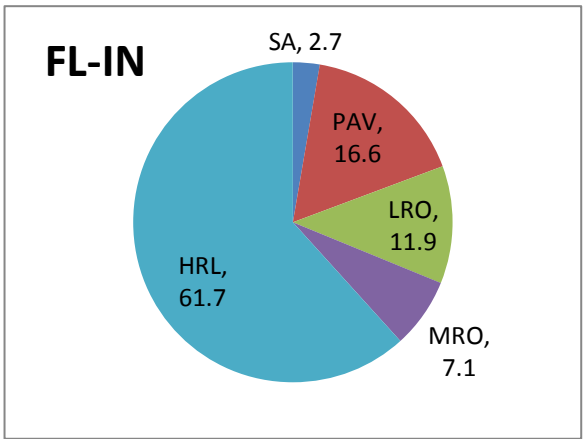
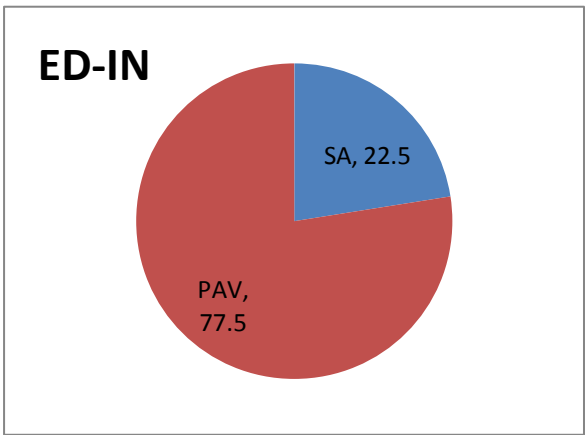
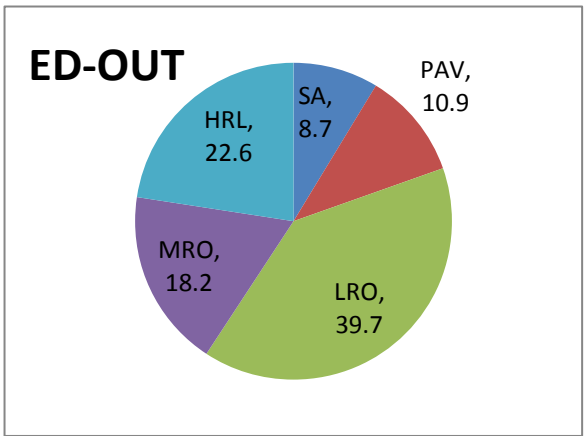
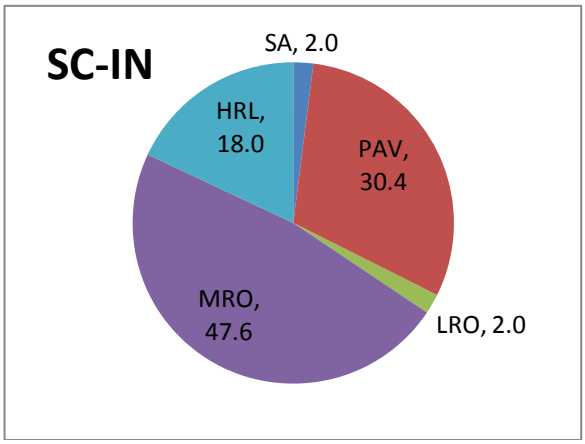


Figure 2. Percentage of each habitat covered by the ROV inside and outside all sampled MPAs (FL, ED, and SC). IN denotes inside the MPA while OUT indicates outside the MPA. SA=sand, PAV=pavement, LRO=low relief outcrops, MRO=moderate relief outcrops, and HRL=high relief ledge.









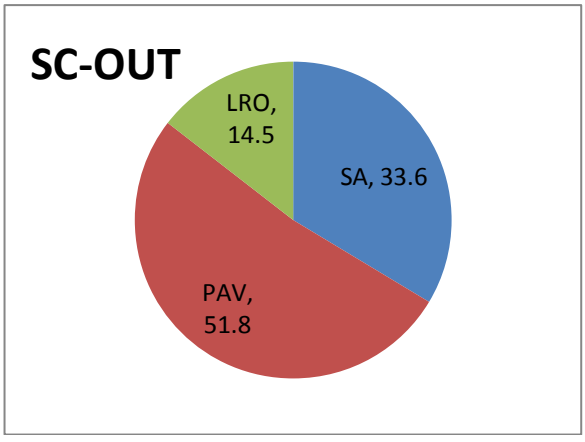


Figure 3. Average abundance (±S.E.) of lionfish inside versus outside each MPA by habitat type. PAV= pavement, LRO= low relief outcrops, MRO= moderate relief outcrops, and HRL= high relief ledge.

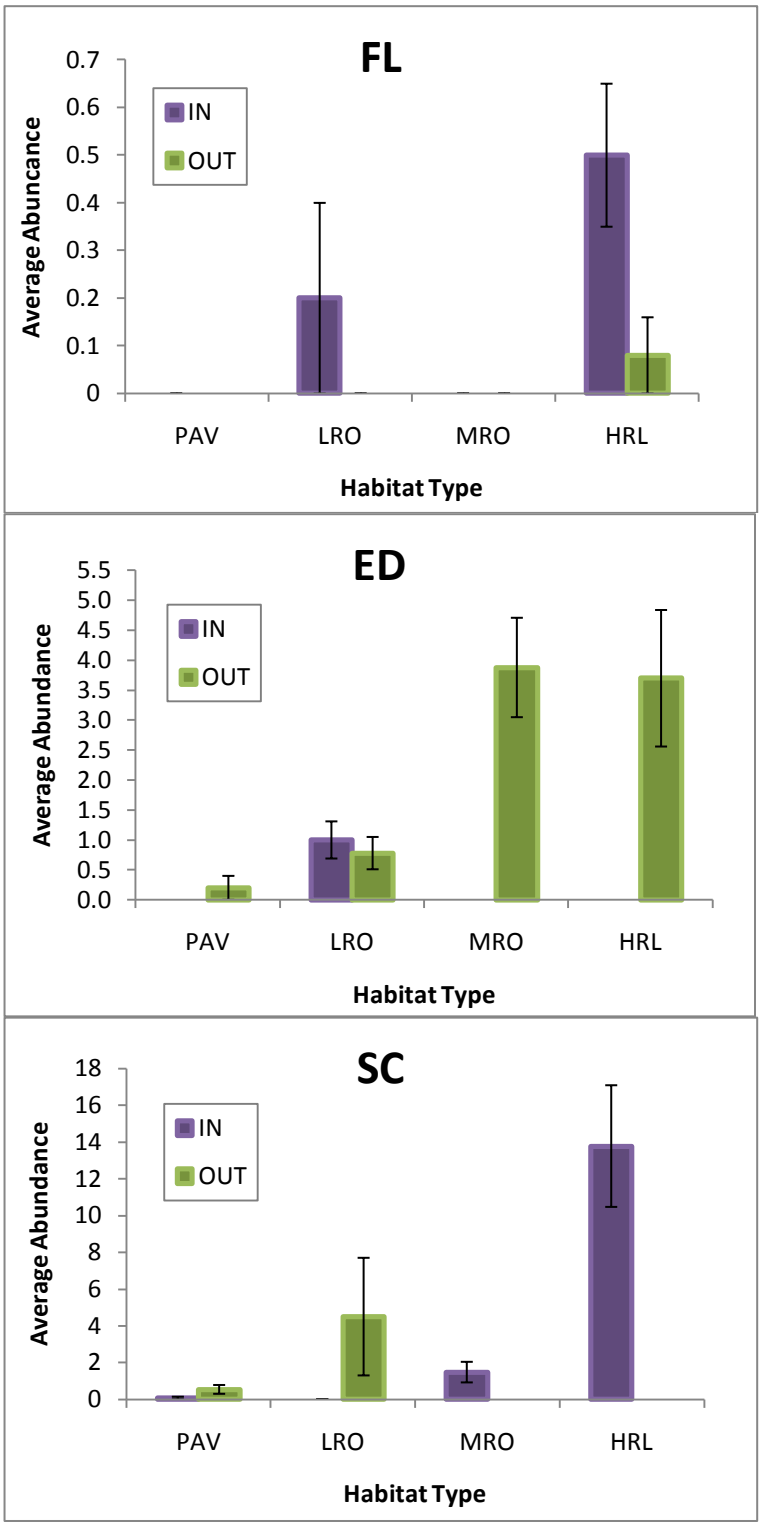


Figure 4. Average abundance (±S.E.) of scamp inside versus outside each MPA by habitat type. PAV= pavement, LRO= low relief outcrops, MRO= moderate relief outcrops, and HRL= high relief ledge.

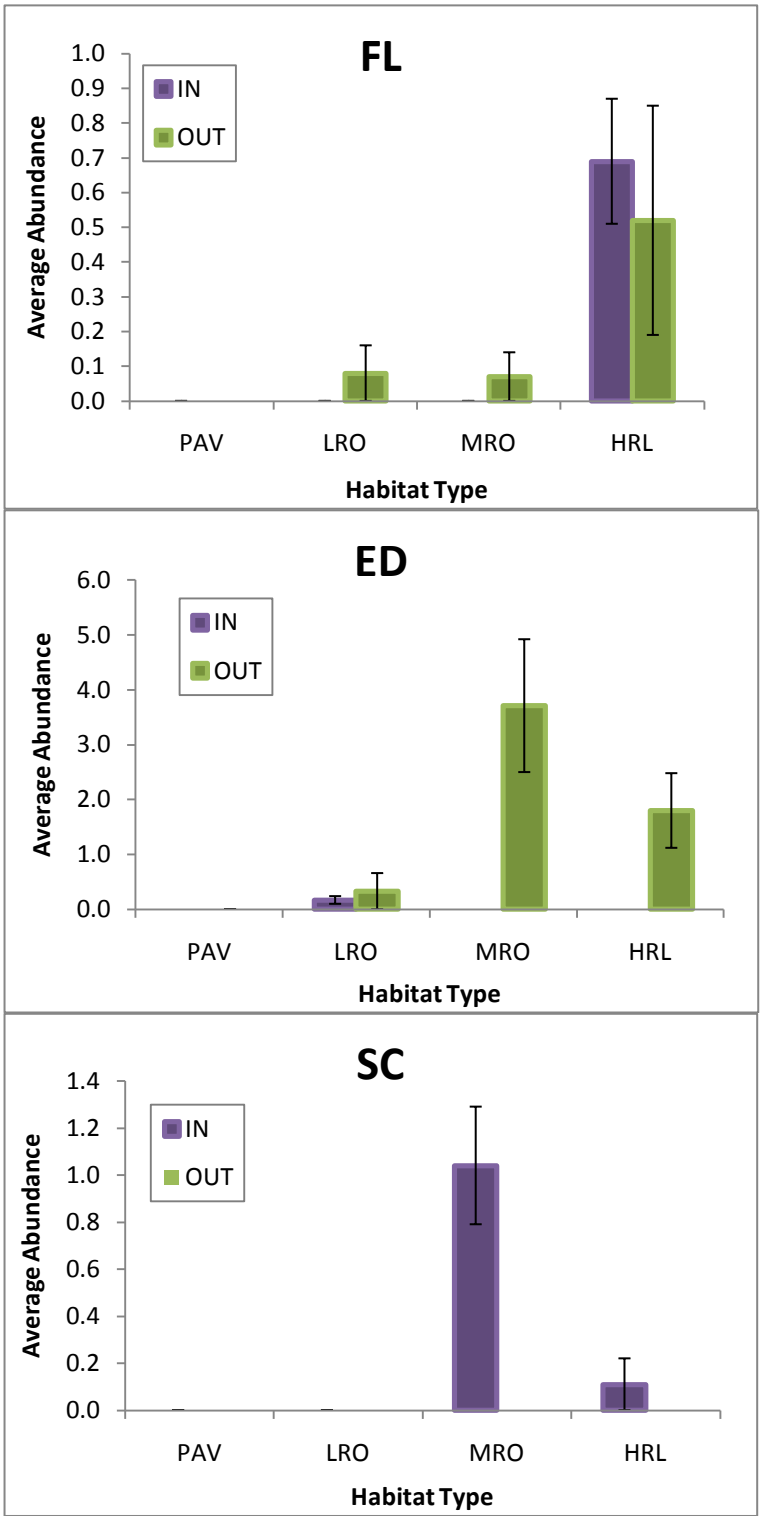


Figure 5. Average abundance (±S.E.) of graysby inside versus outside each MPA by habitat type. PAV= pavement, LRO= low relief outcrops, MRO= moderate relief outcrops, and HRL= high relief ledge. No graysby were observed in the FL MPA.

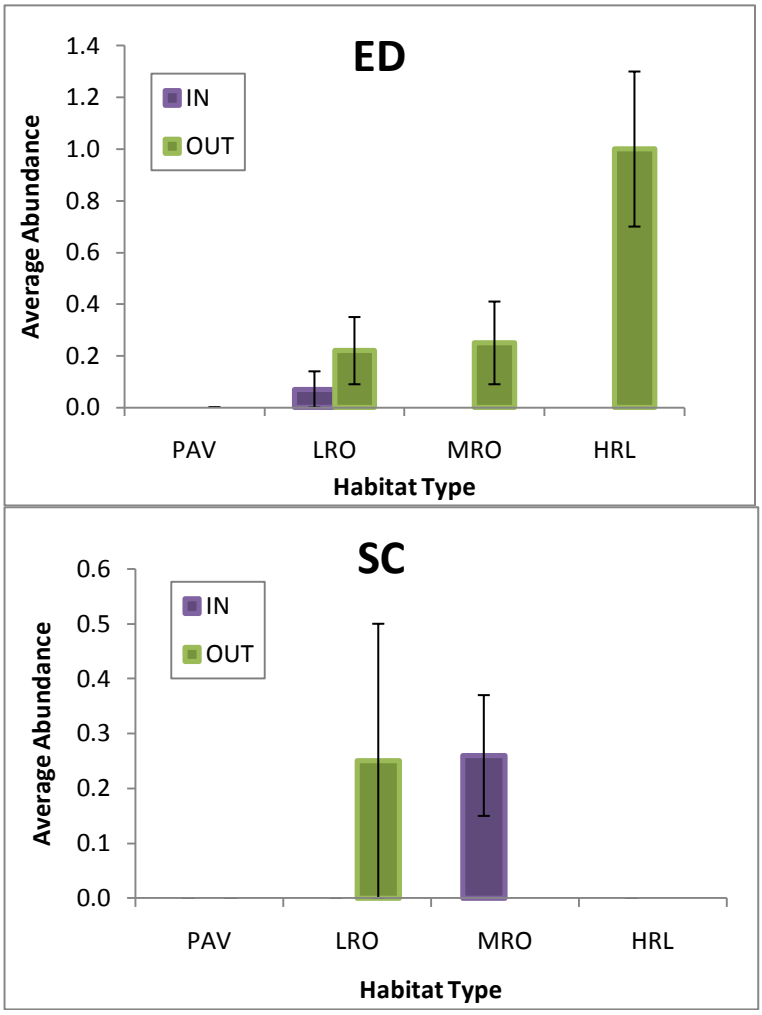


Figure 6. Average abundance (±S.E.) of speckled hind inside versus outside each MPA by habitat type. PAV= pavement, LRO= low relief outcrops, MRO= moderate relief outcrops, and HRL= high relief ledge. No speckled hind were observed in the ED and SC MPAs.

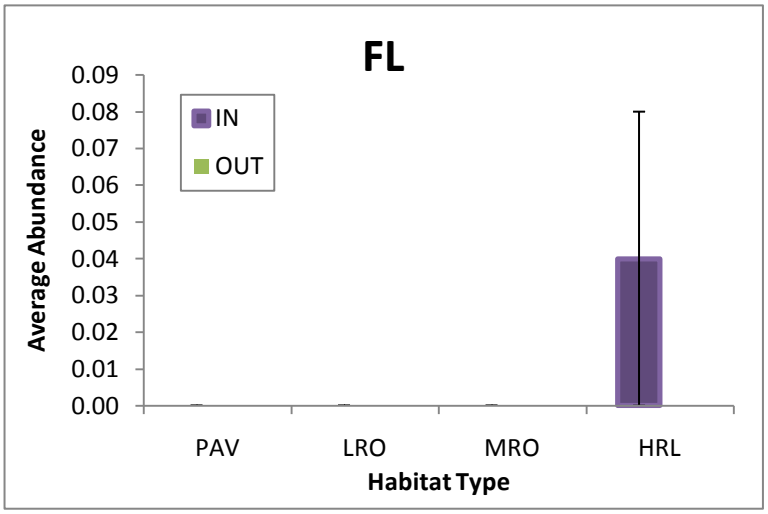


Figure 7. Average abundance (±S.E.) of red grouper inside versus outside each MPA by habitat type. PAV= pavement, LRO= low relief outcrops, MRO= moderate relief outcrops, and HRL= high relief ledge. No red grouper were observed in the FL and ED MPAs.