ANALYSIS OF MARINE PROTECTED AREAS ON THE NORTH CAROLINA SHELF

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ABSTRACT

Along the Southeastern coast of the United States, oceanic and conservation organizations have joined forces to enact Marine Protected Areas (MPAs) with varying geographic locations, sizes, and types of management in order to benefit focal species and their critical habitats. Once the sites are established their biophysical effectiveness can be evaluated. Two MPAs in North Carolina, located off the coast of Frying Pan Shoals and Cape Lookout Shoals, NC were evaluated through the analysis of their seafloor features and biology. In June 2014, NOAA geoscientists collected multibeam sonar data from aboard *NOAA Ship Nancy Foster* with a Reson 7125. This bathymetric information provided insight to the seafloor features found at each designated site. Additionally, NOAA provided underwater photographs from a remotely operated vehicle (ROV) in the areas of MPAs. Images showed evidence of biological presence or absence of the focal species near these protected and managed zones, and were used in combination with post-processed bathymetric 3D imagery created through CARIS HIPS 8.1. Seafloor features and biota present were analyzed together to assess each MPA's influence on the focal species abundances. Over time the MPA's geological and biological data can continue to be combined and studied to gauge its success.

BACKGROUND

Off the coast of the Southeast US, Marine Protected Areas (MPAs) were established through the collaborative efforts of many fishery organizations, including the Fishery Management Council, the Scientific and Statistical Committee, Snapper Grouper Committee, and National Oceanic and Atmospheric Administration Fisheries. The South Atlantic MPAs are classified as "A network of specific areas of marine environments reserved and managed for the primary purpose of aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and associated habitats" (SAFMC 2009). The MPAs off the Southeastern US coast were chosen for the protection of deep-water species within the snapper-grouper complex. MPAs would benefit the populations of these slow-growing, long-lived, focal species through the protection of critical habitats that are used during important life history stages (spawning, migration, and juvenile settlement) and through the reduction in harvest by restricting certain types of fishing pressures (Pomeroy 2004, SAFMC 2009). The specific habitat that species in the snapper-grouper complex prefer varies on both the species present and the life cycle stage of the individuals. All species of grouper and snapper spawn on offshore reefs and produce larvae in the ocean open; their larvae settle as juveniles in sea grass beds, mangroves, oyster reefs and marshes; most juveniles and adults live in deeper water, close to hard substrate on the continental shelf with moderate to high relief (Pomeroy 2000, SAFMC 2009).

The protection of these fish for both their juvenile and adult stages will ensure more stability and an even age distribution throughout the populations. The MPA zones allow some types of fishing to continue, but all deep-water fishing is prohibited, to preserve an area where these fish species can potentially thrive without human disturbances. The local increase of fish populations will also extend beyond the MPAs' boundaries due to emigration of species through seasonal and spawning migrations (Farmer 2011).

The MPAs within the South Atlantic Bight were selected to represent a diversity of geographic locations, sizes, and types of management as an apparatus for conserving the biophysical conditions of the marine ecosystems. In June 2014, geoscientists collected multibeam sonar data from aboard NOAA Ship *Nancy Foster* to gather viable bathymetric data of multiple MPAs off the Southeast US coast. The data provide detailed insight to the varying components of the benthic habitats for these areas. The seafloor's features within each protected habitat are characterized through post-processed data, and are observed for their biological influence using photographs taken from a NOAA remotely operated underwater vehicle. This information can be analyzed to evaluate the successfulness of the MPAs to restore populations of the deep-water fish species in the snapper- grouper complex.

Figure 1: Location of the two Marine Protected Areas examined in this study, along the North Carolina coast.

METHODS

- North Carolina MPA data were collected by NOAA Ship *Nancy Foster* with a Reson Seabat7125 multibeam sonar on June 22 and 23, 2014.
- CARIS HIPS & SIPS 8.1 was used to post process sonar data.
- 5m resolution CUBE BASE surfaces were created for each data collection site.
- Measurements of depth, width, and slope were examined of MPAs' features.
- Profile starting and ending points were based on contour lines for consistency.
- 3D BASE surfaces were analyzed at 3X vertical exaggeration to classify characteristics of each MPA feature.
- Photographs of biological presence or absence are compared with post processed data and measurements at these sites. Underwater photographs were taken with a NOAA remotely operated underwater vehicle.

NOAA Underwater Photographs near studied NC MPAs

Figure 10: Location 33 28.7411 N, -76 59.3322 W with *Seriola dumerili* (Greater Amberjack), *Seriola rivoliana* (Almaco Jack), and *Mycteroperca phenax* (Scamp).

Figure 11: Location 33 28.7340 N, -76 59.0214 W with *Haemulon aurolineatum* (Tomtate) present as well as fish outside the snapper-grouper complex (*Paranthias furcifer*, or Creolefish and *Equetus umbrosus*, or Cubbyu).

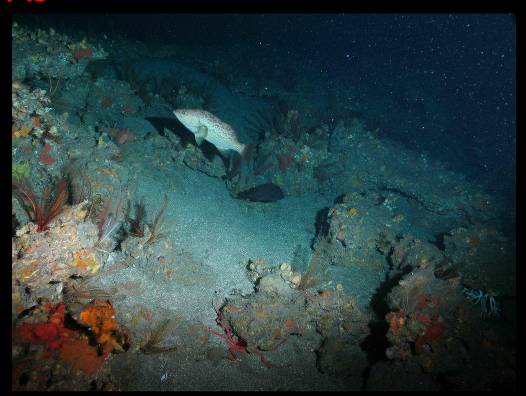

Figure 12: Location 33 28.7340 N, -76 59.0214 W with *Mycteroperca phenax* (Scamp) present as well as fish outside the snapper-grouper complex (*Equetus umbrosus*, or Cubbyu).

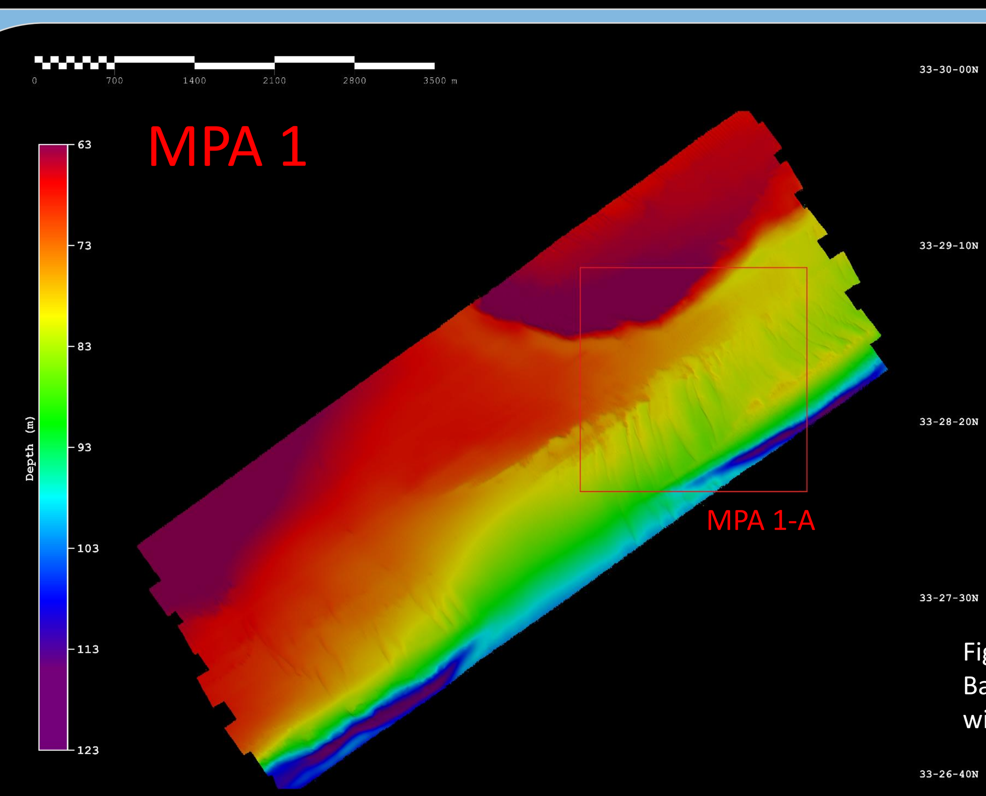

Figure 2: 2D Base Surface with MPA 1-A

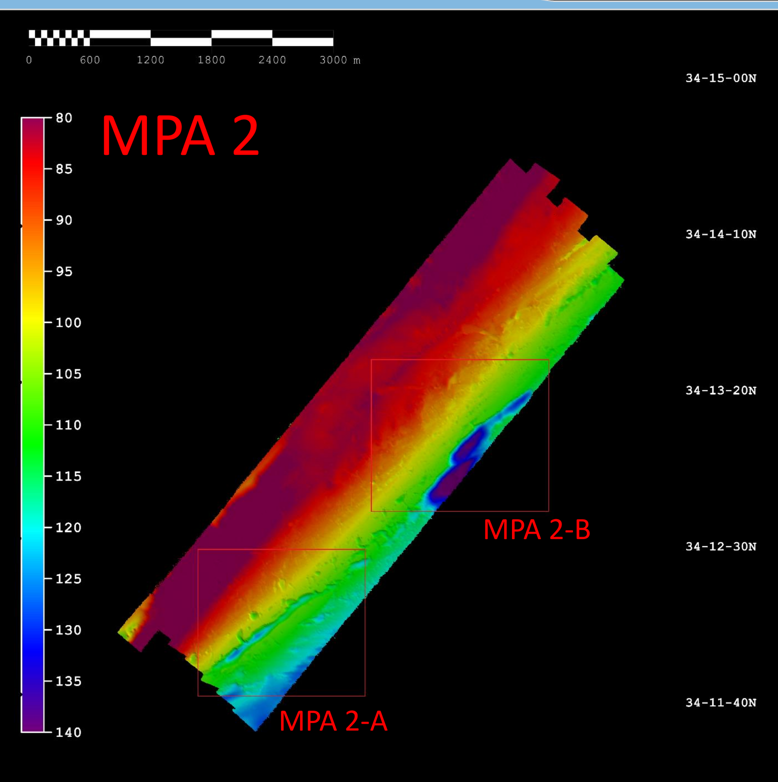

Figure 3: 2D Base Surface with MPA 2-A and MPA 2-B

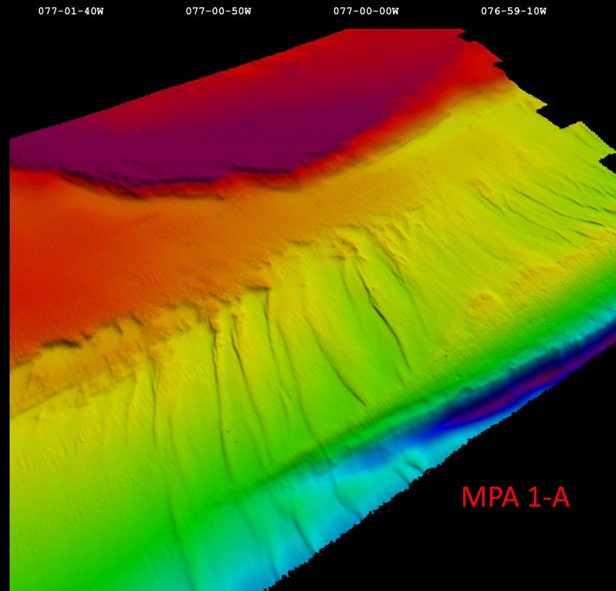

Figure 4: 3D Base Surface of MPA 1-A (VE=5).

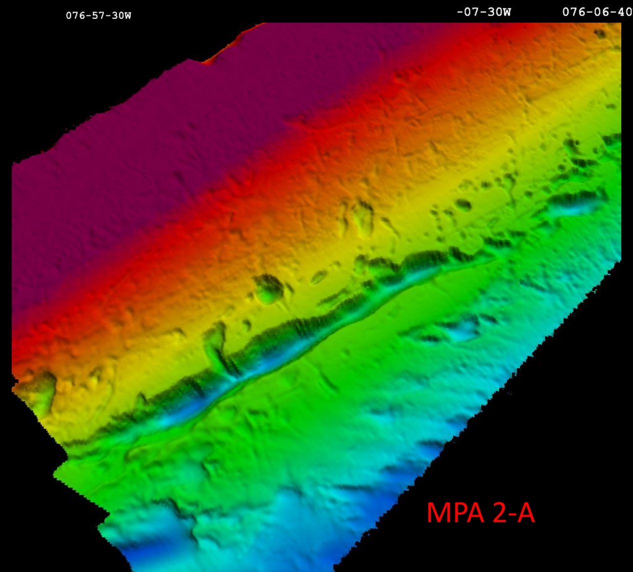

Figure 5: 3D Base Surface of MPA 2-A (VE=5).

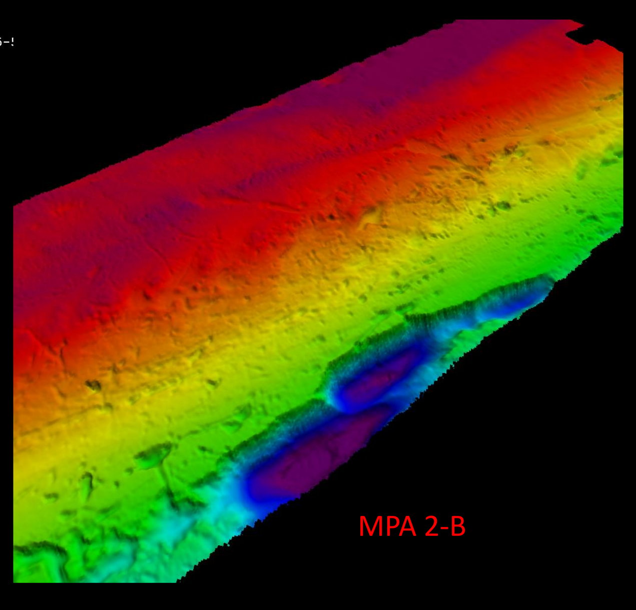

Figure 6: 3D Base Surface of MPA 2-B (VE=5).

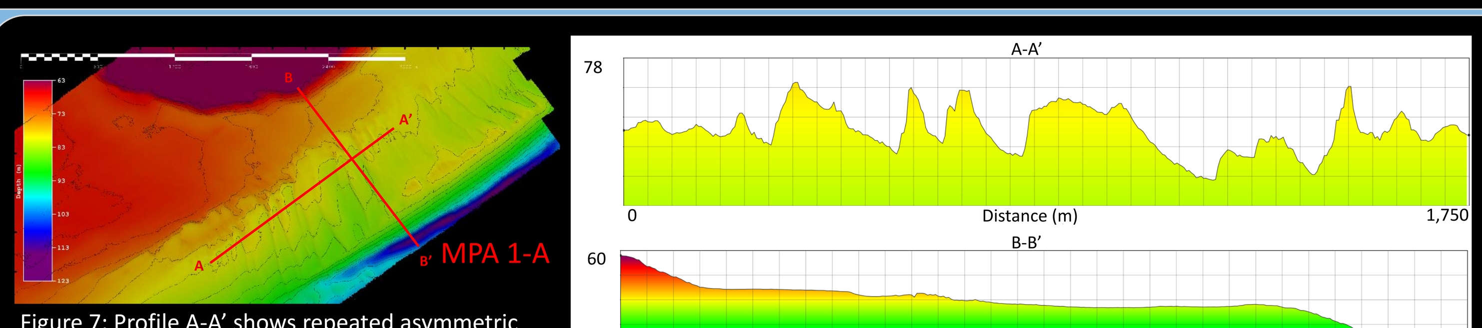

Figure 7: Profile A-A' shows repeated asymmetric sand waves from the current flowing in the direction from A' to A. Profile B-B' shows a slump with a relief of 30 meters.

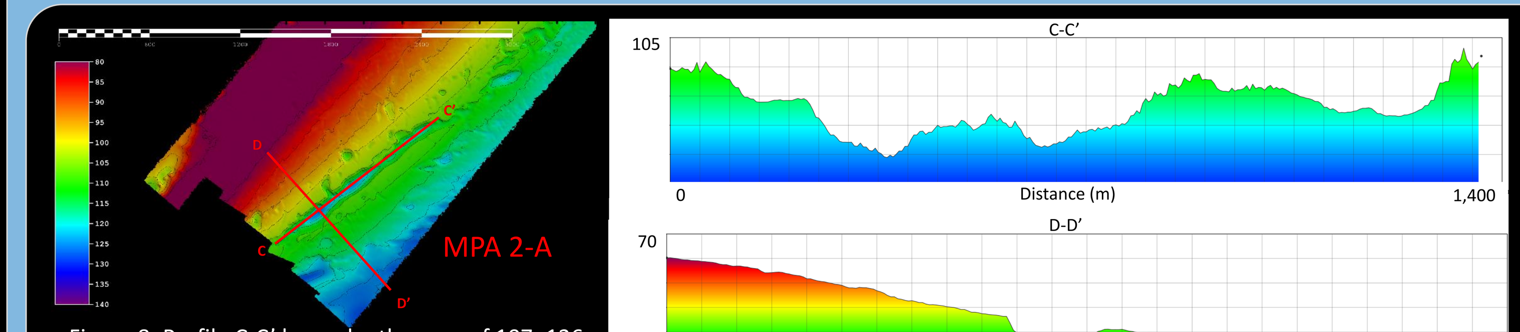

Figure 8: Profile C-C' has a depth range of 107–126 meters with multiple varying scours. Profile D-D' shows a slump with a relief of 32 meters.

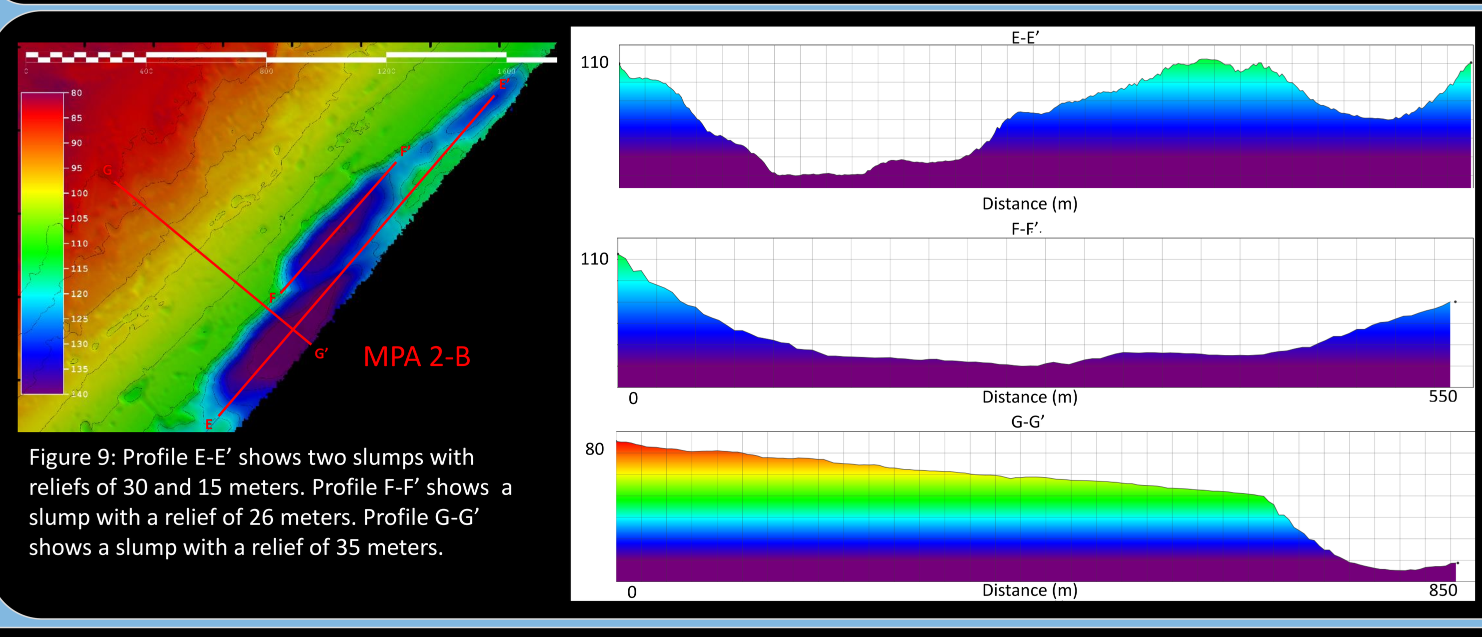

Figure 9: Profile E-E' shows two slumps with reliefs of 30 and 15 meters. Profile F-F' shows a slump with a relief of 26 meters. Profile G-G' shows a slump with a relief of 35 meters.

RESULTS

MPA 1-A (Figs. 2 and 4) has a depth range between 60 and 115 meters and shows evidence of sand waves, a rocky ledge, and a slump. Profile A-A' shows evidence of repeated asymmetric sand waves between the depths of 78.8 and 82.2 meters, with an average relief of 1.53 meters per sand wave. Profile B-B' has a relief of 52 meters with little variance. There is a high relief slump (30 m) between 1,250 to 1,500 meters (Fig. 7).

MPA 2-A (Figs. 3 and 5) has a depth range between 77 and 128 meters and shows evidence of multiple erosional scours that vary in size. Profile C-C' has two relatively smaller scours with widths of 140 and 180 meters and reliefs of 3 and 6 meters, respectively. It also shows three relatively larger scours with widths of 300, 330, and 450 meters and reliefs of 11, 11, and 12 meters, respectively. Profile D-D' has a relief of 45 with little variance between 0 to 1,200 meters, with the exception of one high relief slump (32 m) between 480 to 610 meters (Fig. 8).

MPA 2-B (Figs. 3 and 6) has a depth range between 84 and 146 meters and shows evidence of relatively larger slumps with high relief and a broad flat area. Profile E-E' has two main slumps with 1,100 and 400 meters in width, with reliefs of 30 and 15 meters, respectively. Profile F-F' has a slump measuring 525 meters in width with a relief of 26 meters. Profile G-G' has a slope of -0.04 between the distances 0 and 630 meters with a relief of 25 meters. There is a high relief slump (35 m) with a slope of -0.26 between 630 to 850 meters (Fig. 9).

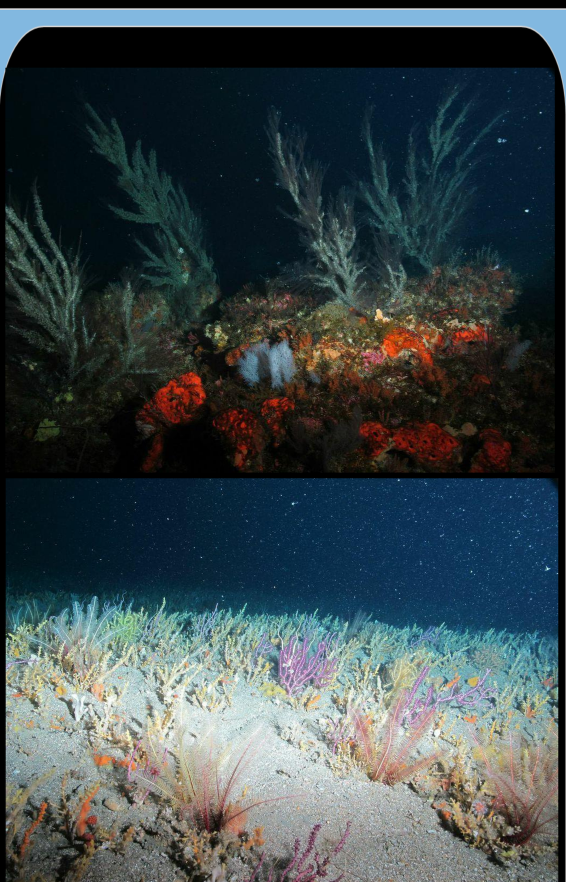

Figure 13: Examples of benthic habitat with dense populations of invertebrates at 33 28.7351 N, -76 59.3269 W (top) and 34 12.0470 N, -76 06.0290 W (bottom).

CONCLUSIONS

The MPAs off North Carolina are located on the Continental Shelf and exhibit different types of benthic habitats. MPA 1-A shows evidence of sand waves, a rocky ledge, and a slump (Fig. 4). MPA 2-A shows multiple erosional scours of various sizes (Fig. 5). MPA 2-B shows evidence of relatively larger slumps with high relief and a broad flat area surrounding the slumps (Fig. 6). MPA 1 and MPA 2 show directional seafloor features influenced by the Gulf Stream, such as the asymmetrical sand waves seen in Profile A-A' (Fig. 7) and erosional scours seen in Profile C-C' (Fig. 8). All three study sites show areas that deep-water species can potentially inhabit and thrive without the effects of directed fishing. Bathymetric data reveals deep-water, high relief slumps or scours found at each MPA, which likely has hard substrate and are ideal for focal species in their juvenile and adult life cycle stages. Underwater photographs from NOAA show evidence of oyster reefs and sea grass beds (Fig. 12) (which are ideal for the larvae and juvenile stages of the focal species) on the topography with little variance observed in the bathymetric imagery. The underwater photographs also showed evidence that the target, or focal species, are present in the areas of both MPAs (Figs. 10, 11, 12, 13), therefore if these zones are effectively managed, the populations can be restored within the protected habitat as well as outside the protected habitat through emigration. These MPAs fulfill the requirements of being a successful MPA by aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and associated habitats with a network of specific areas of marine environments that are reserved and managed. The underwater photographs also show that the local increase of focal fish populations will extend beyond the MPAs' boundaries due to emigration of species through seasonal and spawning migrations, since some of NOAA's underwater images were outside the studied MPA and continued to show the presence of the target species.

The observed species abundances and the qualitative and quantitative information on MPA 1 and MPA 2 (Figs. 7, 8, 9) can be analyzed in regards to the biomass and habitat preference of species in the snapper-grouper complex. The biophysical success is based on the correlation of focal species abundance with the benthic substrate; these biophysical analyses of Marine Protected Areas through underwater images and bathymetric post-processed imagery can give marine conservation organizations further information on how to adjust current Marine Protected Areas or where to place future MPAs.

Lisa Diamond's Contact Information

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