The Mona Island MPA 13 Years After No-take Designation: Testing the NEOLI paradigm

El AMP de la Isla de Mona 13 Años Después de la Designación No Tomar: Probando el Paradigma NEOLI

L'AMP de L'île Mona 13 Ans Après la Désignation de Non-prise: Test du Paradigme NEOLI

JACK C. OLSON[1], RICHARD S. APPELDOORN[1], MICHELLE T. SCHÄRER-UMPIERRE[2], and JUAN J. CRUZ-MOTTA[1]
[1]*Department of Marine Sciences, University of Puerto Rico Mayagüez, Puerto Rico 00681-9013 USA.*
**Olson.jackc@gmail.com*
[2]*HJR Reefscaping, Cabo Rojo, Puerto Rico 00623 USA*

EXTENDED ABSTRACT

Introduction

Marine protected areas (MPAs) are capable of rebuilding biodiversity and increasing fishery output. However, MPA success is not always achieved, and assessment of MPA performance is necessary for management accountability to stakeholders. MPA success requires adequate design, compliance and time. Success probability is enhanced if an MPA meets 4 of the 5 NEOLI criteria: No-take, Enforced, Old, Large, and Isolated, but often some of these factors are not accounted for when assessing MPA performance (Edgar et al. 2014). Here we present preliminary results of a study evaluating patterns of temporal variation of fish assemblages of two MPAs with distinct management and enforcement plans: the no-take area of the Mona Island Natural Reserve, an offshore island between Puerto Rico and Hispaniola, and the La Parguera Natural Reserve, off the southwest coast of Puerto Rico. Both are considered large and old by NEOLI criteria, but differ in no-take status and degree of isolation, with enforcement unquantified in both areas.

The Mona Island no-take zone (NTZ), formed in 2004, covers the full Mona insular platform and is the largest no-take zone in Puerto Rico (81 km^2) (Schärer-Umpierre et al. 2014). The NTZ includes an extensive coral reef and colonized hardbottom habitat complex, has small coastal seagrass beds, and entirely lacks mangroves (Schärer-Umpierre 2009). Absence of traditional Caribbean nursery habitat is thought to restrict the abundance and occurrence of reef fish taxa at Mona relative to sites on the Puerto Rican insular platform (Schärer-umpierre 2009). Populations of resident reef organisms are characterized as largely self-recruited due to strong currents in the Mona Passage (Baums et al. 2006, Taylor and Hellberg 2006). A prior assessment of the NTZ, conducted 5-years after no-take designation, found only marginal changes in abundance for large, commercially important species, with the largest increases in biomass and abundance detected for smaller species of groupers and early life stages (Mateos-Molina et al. 2014). Insufficient recovery time was cited as a potential factor limiting the recovery of commercial species previously exposed to a high degree of fishing pressure. The second study location, the La Parguera Natural Reserve (LPNR), is located on the southwest coast of Puerto Rico. This area of the insular shelf is approximately 10 km wide and contains one of the most well developed reef systems on the island (Morelock, Schneidermann, and Bryant 1977). The LPNR has never had spatial fishing protections despite attempts to establish regulations (A. Aguilar-Perera, Schärer, and Valdés-Pizzini 2006). The shoreline and nearshore islands are fringed with mangroves adjacent to extensive seagrass beds both of which are important nursery and foraging grounds for local fish species (Rooker 1995 Burke, Kenworthy, and Wood 2009, Aguilar-Perera 2004). Recently, a large scale, multi-year survey of fish assemblage distribution and structure within the LPNR was conducted (Pittman et al. 2010). This survey found low numbers and sizes of commercially important species (particularly snapper, grouper, and large parrotfish) relative to baseline data collected in 1980 - 1981 (Kimmel 1985).

The study described herein provides a statistically sound and ecologically meaningful evaluation of changes that may have occurred in the fish assemblage structure within the Mona NTZ and LPNR after 13 years of divergent management strategy. Fishery-independent data collected in this project supports government accountability to regional stakeholders and aids in the science based management of the Mona Island NTZ and other MPAs in Puerto Rico.

Methods

Sizes and densities of the non-cryptic reef fish assemblage within the Mona Island NTZ and La Parguera Natural Reserve were collected with timed diver transects (10 min., 30 X 2 meter). Reef fish sizes and abundances were estimated via five centimeter length bins by trained surveyors. The experimental sampling frame in both MPAs partitions variance into three spatial, and two temporal scales. For purposes of statistical analyses, each MPA was broken into geomorphological zones, 500-m radius sites, and 60 $meter^2$ transects. Transect locations in the Mona NTZ were maintained from baseline data collected by Schärer-umpierre 2009. In the LPNR, transects were assigned randomly within fore-reefs sites defined in baseline sampling. Data analysis was conducted in R-studio software. A two-way ANOVA with post-hoc Tukey HSD was used to test the null hypothesis of no difference in biomass (g/m^2) and density ($fish/m^2$) between years and zones in La Parguera. Densities and sizes at Mona were assessed by zone and year with a mixed model ANOVA, and subsequent pairwise one-way ANOVA.

Preliminary Results and Discussion

Univariate analysis revealed significant increases in mean density within shelf-edge and mid-shelf zones in La Parguera since 2005 (+0.35 fish/m^2, $F_{1,63}$ = 12.60, p = 0.0007; +0.27 fish/m^2, $F_{1,47}$ = 9.98, p = 0.002, respectively (Figure 2). Pairwise comparisons of zones at Mona found a significant increase in density within the East/West combined zone (mean increase +0.20 fish/m^2, $F_{1,44}$ = 7.19, p = 0.01) (Figure 1). This increase in density was accompanied by a highly significant, 100% increase in mean biomass in the zone (+93 grams/m^2, $F_{1,44}$ = 7.76, p = 0.008)(Figure 1). No significant change in biomass over time was detected in La Parguera. The observed increase in biomass and density in the East/West combined zone at Mona may be explained by historic fishing pressure on the island's western reefs. Differences in benthic habitat composition between the two zones may also play a role in determining the recovery potential of resident fish populations, although this has yet to be assessed. At present, the increased density in the two seaward zones is unexplained. A second round of data collection and analysis, and scheduled stakeholder surveys, may help to further explain some of the trends discussed herein.

KEYWORDS: No-take zones, MPA, reef fish, compliance, ecosystem-based management

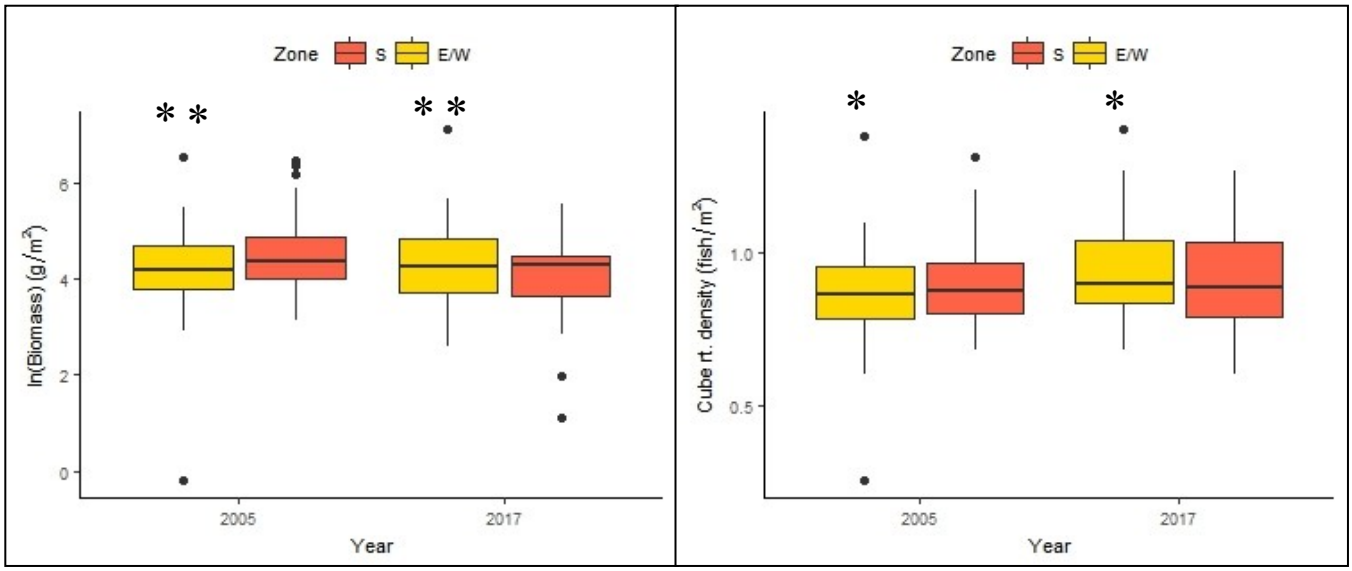

Figure 1. Transformed biomass (g /m^2) and density (fish /m^2) from the Mona NTZ with significance between years indicated by " * " (p < 0.05 = *, p < 0.01 = **). A mixed model ANOVA was used to test significance between years.

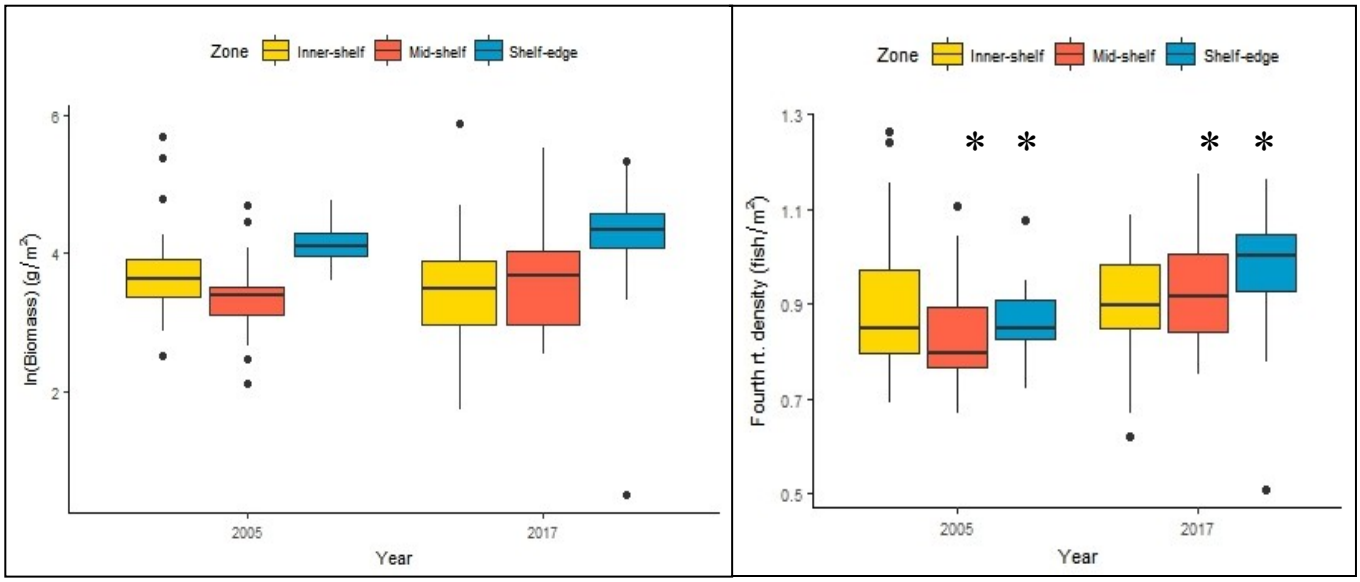

Figure 2. Transformed biomass (g /m^2) and density (fish /m^2) from the La Parguera Natural Reserve. Significance differences in density between years for the mid-shelf and shelf-edge zones indicated by " * " (p < 0.05 = *, p < 0.01 = **). A two way ANOVA with post-hoc Tukey HSD test was used to identify significance changes between zones and years.

LITERATURE CITED

Aguilar-Perera, A., M. Schärer, and M. Valdés-Pizzini. 2006. Marine protected areas in Puerto Rico: historical and current perspectives. *Ocean and Coastal Management* **49**(12):961-975.

Aguilar-Perera, A. 2004. *Coastal Habitat Connectivity of Reef Fishes from Southwestern Puerto Rico.* Ph.D. Dissertation. University of Puerto Rico, Mayaguez, Puerto Rico USA. 159 pp.

Baums, I.B., C. Paris, and L. Chérubin. 2006. A Bio-oceanographic filter to larval dispersal in a reef-building coral. *Limnology and Oceanography* **51** (5):1969-1981.

Burke, J.S., J. Kenworthy, and L. Wood. 2009. Ontogenetic patterns of concentration indicate lagoon nurseries are essential to common grunt stocks in a Puerto Rican bay. *Estuarine, Coastal and Shelf Science* **81**(4):533-43..

Edgar, G.J, R.D. Stuart-Smith, T.J. Willis, S. Kininmonth, S.C. Baker, S. Banks, N.S. Barrett, et al. 2014. Global conservation outcomes depend on marine protected areas with five key features. *Nature* **506** (7487):216-220.

Mateos-Molina, D., M.T. Schärer-Umpierre, R.S. Appeldoorn, and J.A. García-Charton. 2014. Measuring the effectiveness of a Caribbean oceanic island no-take zone with an asymmetrical BACI approach. *Fisheries Research* **150**:1-10.

Morelock, J., N. Schneidermann, and W.R. Bryant. 1977. Shelf reefs, Southwestern Puerto Rico. Reefs and related carbonates - ecology and sedimentology. *Studies in Geology* **4**:17-25.

Pittman, S.J., S.D. Hile, C. Jeffrey, R. Clark, K. Woody, B.D. Herlach, C. Caldow, M. Monaco, and R.S. Appeldoorn. 2010. Coral reef ecosystems of Reserva Natural de La Parguera (Puerto Rico): spatial and temporal patterns in fish and benthic communities (2001 - 2007). *NOAA Technical Memorandum NOS NCCOS* **107**. 202 pp.

Rooker, J.R. 1995. Feeding ecology of the Schoolmaster Snapper, *Lutjanus apodus* (Walbaum), from Southwestern Puerto-Rico. *Bulletin of Marine Science* **56**(3):881-894.

Schärer-umpierre, M.T. 2009. *Using Landscape Ecology to Describe Habitat Connectivity for Coral Reef Fishes.* Ph.D Dissertation, University of Puerto Rico, Mayaguez, Puerto Rico USA. 216 pp.

Schärer-Umpierre, M.T., D. Mateos-Molina, R.S. Appeldoorn, I. Bejarano, E.A. Hernández-Delgado, R. Nemeth, M. Nemeth, M. Valdés-Pizzini, and T. Smith. 2014. Marine managed areas and associated fisheries in the US Caribbean. *Advances in Marine Biology* **69**:129-152.

Taylor, M., and M. Hellberg. 2006. Comparative phylogeography in a genus of coral reef fishes : biogeographic and genetic concordance in the Caribbean, *Molecular Ecology* **15**(3):695-707.