A Point for Comparison: The Flower Garden Banks National Marine Sanctuary

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ABSTRACT

A reoccurring goal listed during the creation of Marine Protected Areas (MPAs) is to return the region to a former state. However, limited data is available that describes or characterizes this former condition. Data collected from ecosystems with comparatively limited anthropogenic impacts, can provide invaluable information in suggesting what former states may have looked like. One example is the Flower Garden Banks National Marine Sanctuary which is located 180 kilometers off the coast of Texas. These relatively isolated and pristine banks are capped by substantial scleractinian coral communities, forming excellent habitat for over 200 species of fish. While fishing is permitted, it is limited by difficulty of access. In 2006, NOAA's Biogeography Branch, in collaboration with the Sanctuary, initiated the first quantitative assessment of fish resources throughout the diveable portions of the Sanctuary. The sampling design and methodologies employed were identical to those that the Branch has utilized in other more impacted regions of the US Caribbean. Initial analyses reveal that fish density and species richness at the Sanctuary were almost two times greater than that found within the US Caribbean and biomass was approximately six times higher. This was due in large part to the presence of sizeable piscivores of the genera *Mycteroperca* and *Dermatolepis*. The Sanctuary is one of few minimally impacted locations remaining within the Tropical Western Atlantic. As such, these findings should be considered when attempting to establish a former state or evaluate effectiveness of an MPA in meeting its management goals.

KEY WORDS: MPA, Flower Garden Banks, US Caribbean, fish biomass, fish density

Un Lugar para la Comparación: Santuario Marino Nacional Bancos Jardín Florido

La restauración de condiciones previas es una de las metas más comunes en la creación de Reservas Marinas (RM). Sin embargo, datos describiendo o caracterizando la condición anterior son escasos. Una alternativa para información sugiriendo condiciones anteriores es el uso de data sobre ecosistemas poco alterados por impactos antropogénicos. Un ejemplo es el Santuario Marino Nacional Bancos Jardín Florido, que se encuentra a 180 kilómetros de la costa de Tejas. Estos aislados y pristinos bancos estan sobrecubiertos por extensas comunidades de corales esclarictinios, lo cual forma un habitáculo excelente para mas de 200 especies de peces. Aunque la pesca es permitida, la misma es limitada por la dificultad de acceso. En el 2006, la Rama de Biogeografía de la NOAA, en colaboración con el Santuario, inicio el primer asesoramiento cuantitativo de los recursos de peces a través de las porciones del Santuario accesibles mediante buceo. El diseño de muestreo y las metodologías empleadas fueron idénticas a aquellas utilizadas por la Rama en otras regiones mas impactadas a través del Caribe de los E.U. Los análisis iniciales revelaron que la densidad y riqueza de especies en el Santuario fueron dos veces mayor que las encontradas en el Caribe de los E.U y la biomasa fue aproximadamente seis veces más alta. Esto fue en mayor parte por la presencia de piscívoros de gran tamaño de los géneros *Mycteroperca* y *Dermatolepis*. El Santuario es uno de los pocos lugares con mínimo impacto en el Atlántico Occidental Tropical. Por ende, estos hallazgos deben ser considerados al tratar de establecer la condición anterior o al evaluar la efectividad de una RM para alcanzar las metas de manejo.

PALABRAS CLAVES: RM, Bancos Jardín Florido, Caribe de los E.U., biomasa, densidad

INTRODUCTION

Worldwide, researchers have been recording coral reef ecosystem degradation for decades, and a current estimate suggests that 50% of the reefs remaining are in danger of collapse (Wilkinson 2004). In the tropical western Atlantic, factors such as coral bleaching, disease, the die off of the long-spined urchin *Diadema antillarum*, hurricanes, over fishing, pollution, and sedimentation have all been implicated in causing the reduction of various coral reef ecosystems components. In an attempt to ameliorate this decline, governments and managers throughout the region designated Marine Protected Areas (MPAs).

MPAs have been proposed as a management tool that will return coral reef ecosystems to a former healthier state, increasing their resiliency to stress, and restoring their fish stocks, as well as providing points for scientific comparison against which to evaluate management efficacy. A large body of literature currently exists demonstrating the effectiveness of MPAs and in particular a smaller component of MPAs known as no-take marine reserves in improving certain measures of ecosystem health (see review by Halpern 2003). The majority of these examples are from the tropics, with a large number from the tropical western Atlantic (e.g. Roberts *et al*. 2001, Ault *et al*. 2005, Mumby *et al*. 2006). Unfortunately, however, few of these studies have adequate data collection prior to MPA implementation resulting in an ill-defined endpoint for measuring success. Without an initially established baseline, the question of what state the system should be returned to remains.

Recently, work by Friedlander and DeMartini (2002) has suggested that examples of comparatively pristine regions within the same ecosystem may serve as a proxy

when local "before" data is absent or insufficient. These regions may be MPAs in their own right or defacto MPAs that have comparatively limited anthropogenic impacts. This paper explores the potential of the Flower Garden Banks National Marine Sanctuary (FGBNMS) to serve as that proxy in the tropical western Atlantic.

METHODS

Study Areas

To meet the objective of this study, we compare values obtained for selected community metrics within the FGBNMS with those obtained from locations in the US Caribbean representing a range of physical features and protection levels (Puerto Rico; St. John, USVI; and St. Croix, USVI) (Figure 1). Data were collected from the FGBNMS in 2006 and were collected and pooled from the US Caribbean between 2003 - 2006 in order to obtain a sufficient sample size for meaningful analysis. Unless otherwise stated, fishery regulations in effect at these locations include size limits, seasonal closures, and number of individuals collected of select species.

The FGBNMS is located in the northwestern Gulf of Mexico approximately 180 km south of Galveston, Texas. It is composed of three banks (Stetson, East and West Bank) the latter two of which are the focus of this study. These two banks reach to within nearly 18 m of the waters surface and support live coral coverage greater than 50% in some areas (Gittings 1998). The distance of the banks from the coastline reduces direct coastal impacts as well as the volume of users. Sanctuary regulations permit hook and line fishing only.

The Puerto Rican study area is located along the southwest corner of the island within the La Parguera National Wildlife Reserve. The broad shelf area contains a variety of habitat types including coral reefs, seagrass, and sand patches, as well as an extensive system of mangroves along the shoreline and on offshore islands (Kendall *et al*. 2002).

The St. John study area encompasses the Virgin Islands Coral Reef National Monument (VICRNM) and Virgin Islands National Park (VIIS) managed by the US National Park Service, as well as territorial waters. It includes the same habitat types as are found in Puerto Rico. The VICRNM was designated a no-take area (with limited exceptions for certain species of jacks and bait fish) in 2001; however, these regulations were not enforced until recently (see Monaco *et al.* 2007 for baseline assessment). The VIIS permits resource harvest by artisanal fishers as allowed in its enabling legislation as well as hook and line fishing.

In St. Croix, the study area was located on the northeastern shelf of the island and encompassed portions of the Buck Island Reef National Monument (BIRNM) also managed by the US National Park Service, and the East End Marine Park (EEMP) managed by the territory. This area includes a lagoon environment as well as a shallow shelf community with coral reefs, seagrass, and sand available to the resident fishes (Kendall et al. 2002). Mangroves are very limited within close proximity to the study area. Portions of BIRNM have been designated no-take since the 1960s, however the majority of the current boundaries including all the deeper waters were only recently designated no-take areas in 2001. These regulations, like VICRNM, were not enforced until recently.

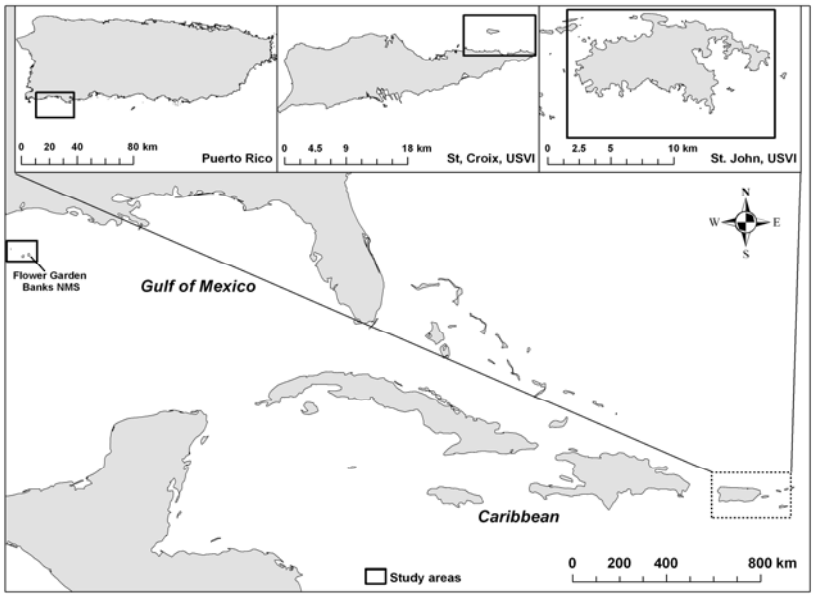

Figure 1. Map of study locations in the Gulf of Mexico and US Caribbean.

Protocols

In each of the study locations, sites were randomly selected across hardbottom habitats using ArcGIS software. The area of hardbottom was delineated using NOAA benthic habitat maps (Kendall *et al*. 2002) and bathymetry models in the US Caribbean. In the Flower Garden Banks, all the area within the study region was delineated as hardbottom. Depth was limited to 33.5 m in the FGBNMS and to the deepest depths delineated by the habitat maps and bathymetry models in the Caribbean (~30 m). To aid comparisons with FGBNMS, only the subset of sample locations from the US Caribbean with a depth greater than 18 m were included thus removing depth as a factor.

Fish surveys were conducted by trained scientific divers along a 25 m long and 4 m wide belt transect (100 m^2) using a fixed survey duration of 15 minutes. The number of individuals per species was recorded in 5 cm size class increments up to 35 cm using the visual estimation of fork length. Individuals greater than 35 cm were recorded as an estimate of the actual fork length to the nearest centimeter. Percent cover of corals, algae, and sponges was estimated within a series of 1 m^2 quadrats placed at randomly selected locations along the transect. An estimate for each site was determined as the mean of four quadrats at the FGBNMS and five quadrats at the other study locations.

Analysis

Analyses were kept to the community metric level as this was to be a preliminary examination of the data. Calculated metrics included mean richness, density and biomass. Species richness and density data did not meet assumptions for homogeneity of variances using Bartlett's test; therefore, nonparametric Kruskal-Wallis tests were performed to explore potential differences in these community metrics between locations. Pairwise comparisons were performed using the Nemenyi test. To explore differences in biomass, data were log transformed to meet assumptions of normality and an Analysis of Variance (ANOVA) test was performed. The pairwise comparisons were evaluated using Tukey-Kramer. All analyses were performed using JMP statistical software. Where differences were found, the data were explored further to investigate which trophic groups were responsible for the differences. Trophic groupings for each taxa were assigned utilizing gut content information provided on the FishBase database (http://www.fishbase.org/). All taxa were divided into piscivore, herbivore, invertivore, or zooplanktivore categories.

RESULTS

The summary statistics along with the cumulative number of surveys at each location are presented in Table 1. Both the Kruskal-Wallis and ANOVA tests performed on the respective community metrics revealed significant differences between locations ($p < 0.0001$ for each test). The highest mean number of species was detected at the FGBNMS; however, this value was not significantly different than in St. John. Both of these locations were significantly higher than either of the other two study locations and Puerto Rico was higher than St. Croix (Figure 2). While density of fish was highest in St. John, it was not significantly different than that observed at FGBNMS. Similarly these two locations were once again significantly greater than both St. Croix and Puerto Rico with densities between two and three times higher. These latter two locations were also significantly different with fish density greater in St. Croix. When examining the breakout by trophic level, the density of piscivores and zooplanktivores were between 1.5 and 2 times that of the next highest values seen in St. John. Density of invertivores in St. John was over two times greater than in FGBNMS (Figure 3).

During the course of the FGBNMS survey *Manta birostris* was observed and recorded along one of the transects. This made a substantial difference in the mean value for biomass. As such it is shown separately from the trophic groups. Even without *M. birostris*, the differences between the FGBNMS and the other locations are significant, ranging from nearly 3.5 times to 6 times that of the other locations. St. John was again significantly higher than the remaining two locations. There was no detectable difference between St. Croix and Puerto Rico. When examining the breakout in terms of trophic groupings, the biomass of piscivores at the FGBNMS was over 4 times that recorded in St. John, zooplanktivore biomass was over 8 times higher, and herbivore biomass was nearly double. Invertivore biomass was between 20% and 40% higher in St. Croix and St. John respectively than in FGBNMS (Figure 4).

Table 1. Number of surveys conducted at each study location along with mean and standard error for each community metric analyzed.

Location	Number of Surveys	indiv/100 m^2		biomass (g)/100 m^2		species/100 m^2	
		Mean	SE	Mean	SE	Mean	SE
FGBNMS	73	312	22	2 8945	7372	25.7	0.46
St John, USVI	222	370	22	8527	585	24.8	0.43
St Croix, USVI	66	159	10	5229	706	16.7	0.60
SW Puerto Rico	61	117	11	3633	396	21.8	0.88

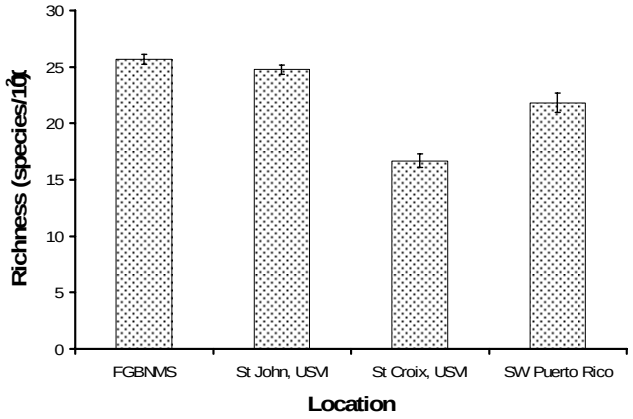

Figure 2. Mean species richness and standard error at each of the study locations.

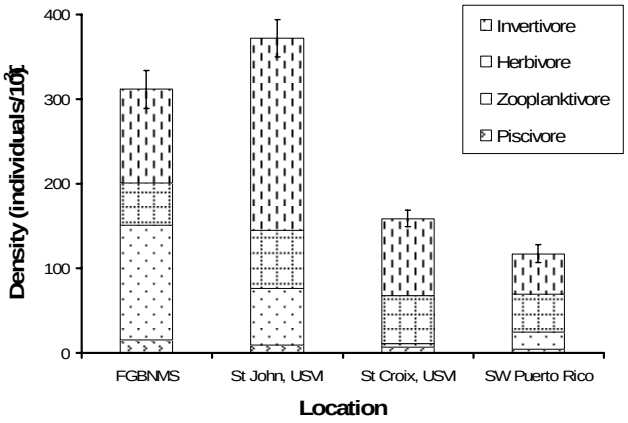

Figure 3. Mean species density and standard error at each of the study locations. Each pattern represents a different trophic grouping.

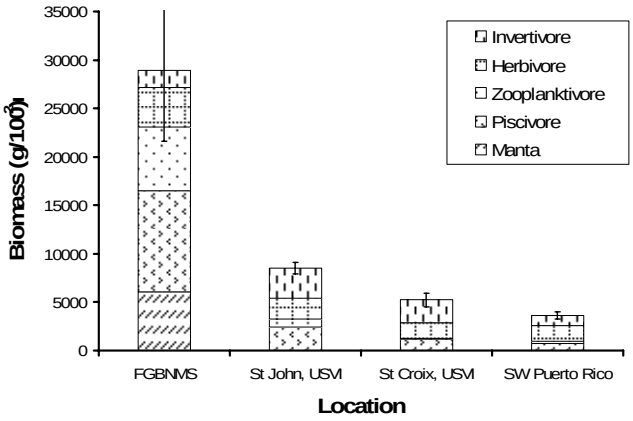

Figure 4. Mean species biomass and standard error at each of the study locations. Each pattern represents a different trophic grouping.

DISCUSSION

Successful management of tropical marine ecosystems with impacted fish populations is frequently defined by increasing the number of species and individuals present, as well as increasing the size of those individuals and thereby their biomass. While generally speaking it is agreed that more is better, an idea of how much more is lacking. The FGBNMS, a comparatively unperturbed reef system, represents an opportunity to investigate what a healthy ecosystem in the tropical western Atlantic should look like in terms of these generally accepted metrics of success.

The results shown here illustrate several defining characteristics of areas with increased levels of resource protection especially the FGBNMS. Mean species richness was highest here with the second largest value coming from St. John. In comparison with St. Croix and Puerto Rico, there are far fewer anthropogenic impacts on the island of St. John much of which is protected as a National Park. The higher number of species found on hardbottom areas in Puerto Rico over St. Croix may be the result of the presence of the extensive mangrove component nearby which is thought to be a nursery habitat for many species. Alternatively, the relatively homogenous low-relief hardbottom in St. Croix may not be capable of supporting a similar level of species diversity.

Density also revealed similar patterns with the FGBNMS and St. John again obtaining significantly higher values. The large difference in piscivore density between FGBNMS and the US Caribbean locations was due primarily to high numbers of individuals from the families' Serranidae, Lutjanidae, and Carangidae. In particular, serranids of the genus *Mycteroperca* encountered at the FGBNMS have been observed only 11 times over the course of 3,500 surveys at all other study locations combined and the genus *Dermatolepis* is entirely absent. The zooplanktivores were also more prevalent at the FGBNMS in comparison with the other locations. This trophic grouping was dominated by two species, *Clepticus parrae* and *Paranthias furcifer*, both of which were found in large numbers throughout the water column. Interestingly, highest mean density overall was found in St. John due primarily to the presence of a large number of invertivores. Gobies, particularly *Coryphopterus personatus*, were frequently observed in the hundreds and account for the majority of this difference.

The community metric demonstrating the greatest difference between the FGBNMS and the more impacted regions was biomass. This was true even without accounting for *Manta birostris*. Further examination of the trophic guilds builds upon the patterns seen with density where the herbivores in addition to both the piscivores and zooplanktivores had substantially higher values in the FGBNMS than at the other locations. Fish biomass in Puerto Rico which is the least regulated of the study locations was found to be the lowest. Interestingly, when biomass was

divided up by trophic grouping, the piscivores became the most dominant members of the community. The high biomass of invertivores in St. John and St. Croix compared with FGBNMS is due primarily to the low numbers of the larger members of that grouping (notably Haemulidae) there. This is likely due to the absence of typical nursery and feeding areas such as mangroves and seagrass beds.

In the majority of cases, marine reserves have been designated in areas already severely impacted and typically with little more than anecdotal data describing the characteristics of the resources in the area. As was shown along the Hawaiian Island chain by Friedlander and DeMartini (2002), there is substantial utility in having areas that can serve as points for comparison in such cases. The FGBNMS is one of few comparatively pristine regions remaining in the tropical western Atlantic. It has a healthy coral community and a fish population that with respect to the metrics chosen for this study, appears to be in a healthier condition than the locations chosen for comparison. The high mean biomass and biomass of piscivores specifically seem to be characteristic of healthy fish populations and the values obtained compare favorably with Friedlander and DeMartini (2002) and are higher than the majority of those obtained by Newman *et al*. (2006) at 34 sites around the Caribbean. It is this structuring of the community more than the absolute values obtained for the different metrics at the FGBNMS that should prove useful to marine resource managers enabling them to more explicitly define the goals, objectives, and milestones they hope to achieve when enacting a specific management decision such as designating an MPA.

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