Biogeographic Characterization of Fish Communities and Associated Benthic Habitats within the Flower Garden Banks National Marine Sanctuary

Sampling Design and Implementation of Scuba Surveys on the Coral Caps

June 2009

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Biogeography Branch
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Cover photos (left to right): Image of Dermatolepis inermis *(CCMA);* Madracis mirabilis *and sponges (E. Hickerson); diver and* Caranx latus *(CCMA); and* Stegastes planifrons, *juvenile* Thalassoma bifasciatum *and large barrel sponge (E. Hickerson).*

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About this Document

This biogeographic characterization is a project formed from the Office of National Marine Sanctuaries - National Centers for Coastal Ocean Science Long-term Agreement. This agreement originates from the common belief of these two programs within NOAA's National Ocean Service that it is critical to have incorporated the best available science when making management decisions regarding our nation's coastal waters. This statement is echoed as each sanctuary undergoes a revision process to their management plans. The revision process evaluates the degree to which each sanctuary meets its goals and allows an opportunity for the public to determine if there are new directions or issues they feel the sanctuary should address. The need for ecosystem based management informed by an adequate understanding of sanctuary living marine resources is consistently raised as a pressing issue in this process. The current document is one of a series of such projects aimed at providing sanctuary managers critical information on the distribution of those resources relevant to the regions they manage. This NOAA Technical Memorandum focuses on providing a spatial and quantitative characterization of the fish communities associated with the coral cap regions of the Flower Garden Banks National Marine Sanctuary. Also included, is a characterization of associated benthic habitats and sections detailing sampling design, methods and the creation of a habitat map essential in selecting sampling strata.

Related projects funded through the Office of National Marine Sanctuaries - National Centers for Coastal Ocean Science Long-term Agreement:

Biogeographic Assessment off North/Central California for the Office of National Marine Sanctuaries: Phases 1 & 2 - Marine Birds, Fishes and Mammals - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/ca_nms2.html

Biogeographic Assessment off North/Central California in support of the National Marine Sanctuaries of Cordell Bank, Gulf of the Farallones and Monterey Bay. Phase II Environmental setting and update to marine birds and mammals http://ccma.nos.noaa.gov/ecosystems/sanctuaries/ca_nms2.html

Biogeographic Assessment of the Channel Islands National Marine Sanctuary to Support Boundary Alternative Assessments - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/chanisl_nms.html

Boundary Options for a Research Area within Grays Reef National Marine Sanctuary - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/grays_boundary.html

Characterization of the Fish, Benthos and Marine Debris at the Grays Reef National Marine Sanctuary - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/grays_nms.html

Biogeographic Assessment of Stellwagen Bank National Marine Sanctuary - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/stellwagen_nms.html

Biogeographic Assessment of the Northwestern Hawaiian Islands to Support the Papahanoumokuakea Marine National Monument - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/nwhi.html

Oceanographic Assessment of Olympic Coast National Marine Sanctuary - http://ccma.nos.noaa.gov/ecosystems/sanctuaries/olympic_nms.html

For more information on this effort please visit the NCCOS CCMA Biogeography Branch web page dedicated to this project at http://ccma.nos.noaa.gov/ecosystems/sanctuaries/fgb_nms.html or direct questions and comments to:

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Executive Summary

OVERVIEW

The Flower Garden Banks National Marine Sanctuary (FGBNMS) is located in the northwestern Gulf of Mexico approximately 180 km south of Galveston, Texas. The sanctuary's distance from shore combined with its depth (the coral caps reach to within approximately 17 m of the surface) result in limited exposure of this coral reef ecosystem to natural and human-induced impacts compared to other coral reefs of the western Atlantic. In spite of this, the sanctuary still confronts serious impacts including hurricanes events, recent outbreaks of coral disease, an increase in the frequency of coral bleaching and the massive *Diadema antillarum* die-off during the mid-1980s. Anthropogenic impacts include large vessel anchoring, commercial and recreational fishing, recreational scuba diving, and oil and gas related activities. The FGBNMS was designated in 1992 to help protect against some of these impacts.

Basic monitoring and research efforts have been conducted on the banks since the 1970s. Early on, these efforts focused primarily on describing the benthic communities (corals, sponges) and providing qualitative characterizations of the fish community. Subsequently, more quantitative work has been conducted; however, it has been limited in spatial scope. To complement these efforts, the current study addresses the following two goals put forth by sanctuary management: 1) to develop a sampling design for monitoring benthic fish communities across the coral caps; and 2) to obtain a spatial and quantitative characterization of those communities and their associated habitats.

SAMPLING DESIGN

In order to meet the first goal, a sampling design was produced to ensure surveys were conducted in an efficient manner. Sampling occurred in 2006 and 2007 allowing an analysis of the data collected from the first year to improve the design subsequently implemented in year two. Candidate sampling designs ranged from simple random sampling to a variety of stratified random sampling scenarios. The designs were selected based on how well they addressed the following four sanctuary objectives: 1) to determine long-term changes in fish community structure using metrics of diversity, density and trophic ratios; 2) to determine long-term changes in density and mean-size of selected economically important taxa; 3) to determine the relationship between physical measures such as habitat type, depth, slope and geographic location with the associated fish community using metrics of diversity, density and biomass; and 4) to find better ways to collect information such that the probability of detecting change over time or space is increased.

This report focuses on sampling the Shallow Coral Cap (SCC) region on East Bank (EB) and West Bank (WB), as this region is readily sampled via basic scuba diving techniques (using standard air or Nitrox). The SCC is the region of the coral caps shallower than 33.5 m and composes 90% of the total coral cap area. Using scuba researchers are able to survey three to four sites in this region per day. The sampling design recommended here can also be used to survey the remaining 10% of the coral caps; however, more technical scuba diving techniques would need to be employed. These necessitate additional equipment and training for the divers and allow fewer stations to be surveyed.

During 2006, a total of 73 sites were surveyed, 49 sites on EB and 24 sites on WB randomly positioned within a strata. In 2007, 32 sites primarily located along the southern portion of EB were surveyed before the mission was aborted due to inclement weather. Fish data were collected at each site along a 25 x 4 m transect and benthic data were collected within four randomly positioned 1 m^2 quadrats located along the transect. At each survey location fish abundance and size frequency data were collected to the lowest possible taxonomic resolution. These data were complemented by data describing the abiotic composition (substrate type, habitat type) and biotic composition of the banks (corals, sponges, algae), and anthropogenic impacts observed (marine debris).

Analysis on the fish data revealed the stratification design incorporating bank, habitat and depth to be the optimal selection. The design optimized sample allocation by incorporating both strata area and variance components. While the resultant six strata: EB and WB high relief shallow, high relief deep, and low relief were the most efficient of those tested, a large sample size was still required to adequately meet the objectives. Potential management options include relaxing the precision requirements (a CV of 10% was used), using a different, less variable proxy (e.g., presence/absence versus density), or continuing to look for more cost effective sampling

designs. An evaluation of the selected sampling design using 2007 data revealed a clear separation between habitat type; however, only a moderate division by depth was apparent. As new data are collected this may be reassessed and depth may no longer be a necessary component

BENTHIC COMPOSITION

Initial data analysis was aimed at addressing the second goal set forth by sanctuary management: to provide a spatial and quantitative characterization of the benthic composition. The benthic data were analyzed to provide coverage estimates for the entire SCC region and then differences between selected strata were evaluated. To explore potential relationships among various cover types, correlation analyses were also conducted. Finally the data were interpolated to form mapped surfaces that could be investigated for spatial trends in the different biota types. Additional analyses examined percentage and distribution of coral bleaching and provided a basic characterization of marine debris. The relationship between the SCC benthic community and others with similar biota was explored through comparisons with three locations in the U.S. Caribbean where identical data collection methods had been employed.

Overall the SCC region was comprised primarily of hardbottom (89%) with limited amounts of rubble (9%) and sand (3%). Rubble was more dominant in the low relief strata (46%) where dead *Madracis mirabilis* had broken apart, compared with the high relief strata (2%). Estimates of coral cover were high for the coral caps as a whole (48%) when compared with algae (13%) or sponges (1%). This value is comparable to historical values reported for live coral cover at the banks of nearly 50% and is between 6 and 11 times higher than values estimated for the U.S. Caribbean locations.

High relief habitats were generally coincident with the upper coral caps and were dominated by colonies of *Montastraea* and *Diploria* while low relief habitats were found typically in deeper waters and were dominated by live *Ma. mirabilis* and rubble. Coral cover tended to be higher on the high relief habitats and lower on the deeper low relief areas, while algae showed the opposite trend. Of the dominant taxa, *Montastraea franksi* and *Mo. faveolata* were more prevalent in the high relief habitats, *Diploria strigosa*, *Montastraea cavernosa*, *Porites astreoides* and *Colpophyllia natans* were distributed throughout the banks; *Ma. mirabilis* dominated the low relief habitat. While coral coverage was estimated to be high, 18% of it was estimated to be affected by coral bleaching. Highest incidences of bleaching were reported in *Millepora alcicornis, Siderastrea siderea* and *Mo. cavernosa.* The high values reported for coral bleaching suggest that the sanctuary may be more susceptible to environmental impacts than previously known.

Algae were more prevalent in the deeper low relief habitat, however it was found throughout the banks. A positive relationship was observed between macroalgal cover and sponge cover as well as depth, while macroalgal cover was negatively related to coral cover. No significant differences were found in sponge cover between strata. However, similarly to algae, sponges were found to be negatively correlated with coral cover.

Marine debris has been demonstrated to negatively impact coral reef environments through entanglement or habitat degradation. Few instances of marine debris were reported during the course of this baseline assessment. Debris observed included anchor, fishing line and rope. The anchors and associated anchor line observed were colonized by sizeable coral heads suggesting a lengthy period of time since their appearance on the reef. More research is required to determine the ecological impact of the other debris items encountered.

FISH CHARACTERIZATION

Analysis of the fish data focused on providing a spatially-explicit characterization and baseline assessment of fish community structure at depths shallower than 33.5 m. This work is a complement to earlier studies which have provided both a more general overall characterization and quantitative information for a comparatively spatially constrained portion of the SCC.

Similar to the benthic data, fish data were analyzed to provide population estimates for the SCC and then differences between strata (those selected for benthic analyses) were evaluated. Correlation analyses were conducted to explore potential relationships between the various fish assemblage metrics and benthic habitat measures such as coverage of coral, algae or depth. Finally, the data were interpolated to form mapped surfaces that could be investigated for spatial trends in the different metrics. Analyses were performed at the community level, family level, species level and by trophic groupings.

A total of 117 species from 37 families were observed during the course of the surveys. With the exception of species richness, which was significantly lower in the low relief habitat than the high relief at either bank, the other community level metrics, biomass, density and diversity were not significantly different among strata. The lower number of species in the low relief habitat is likely a function of habitat complexity.

Two species known only from relatively recent surveys of the coral caps were also observed during the course of this study, *Abudefduf saxatilis* and *Halichoeres burekae*. *H. burekae* is cryptogenic in origin, while *A. saxatilis* is believed to have arrived at the banks from neighboring oil platforms. Also of note are the first sighting of the Nassau grouper (*Epinephelus* striatus) and the second of the goliath grouper (*Epinephelus itajara*).

The three most abundant families observed at the banks were Labridae (35%) dominated by *Thalassoma bifasciatum* and *Clepticus parrae*; Pomacentridae (30%) dominated by species from the genera *Chromis* and *Stegastes*; and Serranidae (14%) primarily composed of *Paranthias furcifer*. Biomass was dominated by species in the family Serranidae (42%) followed by Kyphosidae (15%), Lutjanidae (7%), Carangidae (6%) and Scaridae (6%). The invertivore and zooplanktivore trophic groupings dominate numerically while the piscivores dominate by biomass.

Within the Serranidae, *P. furcifer* was the most abundant species while *Mycteroperca bonaci* and *M. tigris* dominated by biomass. The larger individuals were typically observed near the intersection of the high and low relief habitats on the edges of the coral caps. Of the large bodied groupers *Mycteroperca interstitialis* was the most abundant followed by *Mycteroperca tigris, M. bonaci*, *Dermatolepis inermis*, *Epinephelus adscensionis*, *E. guttatus*, *M. venenosa* and *M. phenax*.

Lutjanidae composed less than one percent of the total abundance of fish observed during the surveys while they composed 7% of the biomass. In order of abundance, *Lutjanus jocu* was the most frequently observed species in the family followed by *L. griseus, L. analis* and *L. cyanopterus*. No discernible spatial patterns were observed at the family level.

Six species of the family Scaridae were observed, all with relatively high sighting frequencies: *Sparisoma aurofrenatum, Sp. viride, Scarus vetula, Sc. taeniopterus, Sp. atomarium* and *Sc. iseri*. The greatest density was observed on low relief habitat which was influenced by the high abundance of *Sp. atomarium* observed there. *Sc. iseri* and *Sc. taeniopterus* densities were significantly greater on both EB habitats than WB. Both *Sp. viride* and *Sc. vetula* were significantly more abundant on high relief habitat.

Three species of Carangidae were observed during the study and are listed in order of sighting frequency: *Carangoides ruber*, *Caranx lugubris* and *Cx. latus*. Collectively, they composed approximately 2% of the total abundance and 6% of the biomass. Spatial patterns were difficult to discern in large part due to the aggregating nature of these species.

Within the family Pomacentridae, the territorial damselfish *Stegastes planifrons* was one of the most abundant species found on the banks. It is typically associated with healthy ecosystems characterized by high live coral estimates. On the banks high numbers of juveniles were found associated with *Madracis*; however, in general, the highest concentrations of the species were found associated with the high relief habitats dominated by *Montastraea*.

A cluster analysis of the density data revealed three distinct fish assemblages on the banks. The first was a deep water (32 m) assemblage typically associated with the low relief habitat. This assemblage was dominated by *Sp. atomarium*, *Stegastes variabilis*, *S. planifrons*, *Gnatholepis thompsoni* and *Opistognathus aurifrons*. A shallow water (24 m) assemblage associated primarily with high relief habitat included most notably *Sp. viride, Sc. iseri* and *Sc. vetula*. The third assemblage contained nearly all the piscivores as well as *P. furcifer, Bodianus rufus* and *Acanthurus* spp. This assemblage was observed spatially where the high and low relief habitats came together (29 m).

Comparisons made with data collected using identical sampling methods at three locations in the U.S. Caribbean revealed significantly higher density and biomass on the FGBNMS coral caps. Biomass on the corals caps was dominated by apex predators, which comprised 36% of the total observed biomass. Apex predators such as *Mycteroperca* are virtually absent from surveys in the U.S. Caribbean as are large sized snappers and jacks. Zooplanktivores are also significantly more abundant and have higher biomass on the coral caps.

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LIST OF ACRONYMS

BB - Biogeography Branch
CCA - crustose coralline algae
CCMA - Center for Coastal Monitoring and Assessment
EB - East Bank
EBH - East Bank high-relief
EBHD - East Bank high-relief, deep
EBHS - East Bank high-relief, shallow
EBL - East Bank low-relief
DCC - deep coral cap
DCS - decompression sickness
DNCC - deep non-coral cap
FGBNMS - Flower Garden Banks National Marine Sanctuary
GOMFMC - Gulf of Mexico Fishery Management Council
LTM - Long-term monitoring
MMS - Minerals Management Service
MMU - minimum mapping unit
MPA - marine protected area
NOAA - National Oceanic and Atmospheric Administration
ONMS - Office of National Marine Sanctuaries
REEF - Reef Environmental Education Foundation
SAFMC - South Atlantic Fishery Management Council
SCC - shallow coral cap
scuba - self contained underwater breathing apparatus
SRS - simple random sampling
StRS - stratified random sampling
USVI - U.S. Virgin Islands
WB - West Bank
WBH - West Bank high-relief
WBHD - West Bank high-relief, deep
WBHS - West Bank high-relief, shallow
WBL - West Bank low-relief