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Distribution, Abundance and Volume of *Xestospongia muta* at Selected Sites in the Florida Keys National Marine Sanctuary

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Abstract. In 1994, the Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP) was initiated to provide status and trends data for the benthic reef resources of the Florida Keys National Marine Sanctuary (FKNMS). Forty sampling sites were selected within the FKNMS. Permanent station markers were installed in 1995 and annual sampling began in 1996. In 2007, an ongoing clionid sponge survey was expanded to include the barrel sponge, *Xestospongia muta,* at all CREMP monitoring stations.

The *Xestospongia muta* sampling method was developed based on existing CREMP project station layout with three 1-meter-wide belt transects providing the maximum spatial coverage within each station.

The distribution, abundance and volume of *X. muta* were analyzed sanctuary-wide, regionally and by habitat type for 103 sampling stations. Sanctuary-wide, 89% of abundance and 93% of volume were observed at offshore deep sites. At offshore shallow and patch sites 6% and 5% of total abundance and 5% and 2% of total volume were recorded respectively. *Xestospongia muta* was not observed at any hardbottom site sanctuary-wide. At the regional level, while sponges the Middle Keys had the greatest abundance and volume, the largest individual sponges were recorded in the Upper Keys.

Key Words: Florida, reef tract, sponge, *Xestospongia muta*

Introduction

Sponges are the most abundant sessile organisms in terms of biomass in many Caribbean reef communities (Diaz and Rützler 2001), and sponge species diversity may exceed that of corals (Wulff 2001). Sponges play many important roles in the reef ecosystem: filtering bacteria and nutrients from the water column, binding corals to the substrate, facilitating reef regeneration, and providing a food source for spongivores (Diaz and Rützler 2001; Wulff 2001). Sponges are also major competitors of corals in terms of reef space. Historically, data collection on sponges has been neglected in monitoring projects because sponge sampling poses a myriad of challenges to researchers. Field identifications can be difficult and sponge systematics is in flux on all taxonomic levels (Wulff 2001).

Since its inception in 1996, the Coral Reef Evaluation and Monitoring Project has documented stony-coral species richness through underwater inventories and percent benthic cover through video transects. These surveys are carried out at permanent stations throughout the Florida Keys National Marine Sanctuary. In 2001, the CREMP began monitoring the abundance and area of bio-eroding sponge species at all CREMP stations. The three clionid sponge species (*Cliona delitrix, C. lampa*, and *C. caribbaea*) recorded by the CREMP are known to be aggressive coral bio-eroders and over-growers (Callahan et al. 2007). In 2005, a fourth clionid, *Cliona varians* (formerly *Anthosigmella varians*), was added to the survey. In 2007, the barrel sponge, *Xestospongia muta* was added.

Xestospongia muta is commonly found on coral reefs and in subtropical hardbottom communities typically at depths greater than 10 m. This sponge is conspicuous and can be accurately identified in the field. It contributes greatly to overall sponge biomass due to its tremendously large size. Oscula diameters have been recorded as wide as 2.5 meters (Nagelkerken 2000). Populations of this species occupy greater than 9% of the available reef substrate in some regions (Zea 1993). Barrel sponges also have a tremendous filtering capacity and are an important source of inorganic nutrients. Sponges, including *X. muta*, host many prokaryotic (especially cyanobacteria) and eukaryotic symbionts and contribute significantly to reef productivity (Wilkinson 1983). *Xestospongia muta* is studied extensively for its secondary metabolite production. These sponges exhibit bleaching which, as in coral, may become fatal. Therefore

monitoring these sponges can be used as a metric for monitoring reef-community health. Mean specific growth rates as fast as 4.04 $year^{-1}$ and as slow as 0.02 $year^{-1}$ have been observed (McMurray et al). Specific growth rates of *X. muta* have been found to decrease with increasing sponge volume according to McMurray et al.

Including *X. muta* in the expanded CREMP sponge survey will provide data on the distribution, the number of individuals, and the size of these individuals in terms of volume. Changes in these values can be monitored over time at all of the CREMP stations throughout the Florida Keys National Marine Sanctuary. These data will help to elucidate the population dynamics, community structure, and health of these important and often understudied reef organisms.

Material and Methods

The same survey method was employed at each CREMP site. Thirty-eight sites (Fig. 1) comprised of 103 sampling stations were surveyed for *X. muta* in this 2007 study. The sites represent four habitat types: offshore shallow reefs, offshore deep reefs, patch reefs, and hardbottom communities. The CREMP sampling within the FKNMS encompasses three regions defined as Upper Keys (north Key Largo to Conch Reef), Middle Keys (Alligator Reef to Moser Channel), and Lower Keys (Looe Key to Smith Shoal) (Beaver et al 2006).

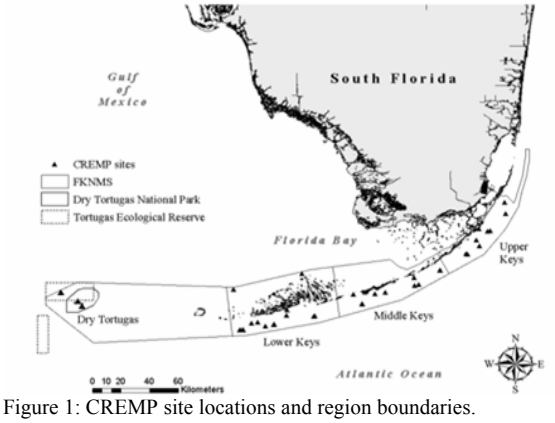

Figure 1: CREMP site locations and region boundaries.

Each sampling station within a site is permanently marked with two stainless steel reference stakes. Two steel poles, three plastic chains, and three measuring tapes mark a station's boundaries and define sampling transects (Fig. 2).

The sponge survey area is defined by three 1 meter wide belt transects within an existing CREMP station (Fig. 2). The survey area is delineated by a diver who swims directly above the transect tape and holds a meter stick perpendicular to the tape and parallel to the reef surface. The total station survey area is approximately $66m^2$. The diver records the location and volume of each *X. muta* encountered as well as notes on bleaching, disease, and scleractinian interactions. Every sponge observed can be relocated within the sampling station.

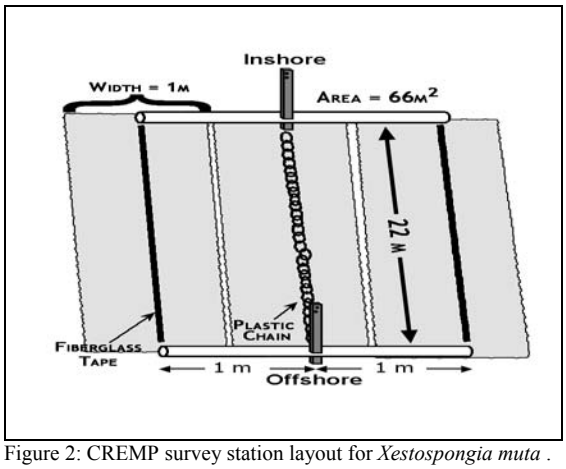

Figure 2: CREMP survey station layout for *Xestospongia muta* .

Because of the morphological plasticity of this sponge, volume was measured by approximation to various geometric solids such as cubes, prisms, cones, and spheres (Wulff 2001). The frustum, or truncated cone usually approximated the shape of *X. muta* most accurately. The radius of the apex (R1) and radius of the base (R2) were measured along with the height of the sponge (H1). These measurements were calculated as the volume of the frustum. The radius of the oscula (R3) and the depth of the oscula (H2) were also measured. The volume of this cone was subtracted from the volume of the frustum to provide a more accurate total sponge volume. The final equation for frustum volume calculations was:

$$1/3\Pi*H1[(R1^2 + R2^2) + (R1*R2)] - 1/3\Pi R3^2*H2$$

A custom designed underwater datasheet explicitly designed for this survey allowed for measurements to be recorded easily and accurately. Larger sponges were approximated to inverse frustums or cylinders. In 2008, underwater maps were created to relocate sponges previously sampled and identify new recruits at CREMP stations.

Results

Data on the distribution, abundance and volume were analyzed sanctuary-wide, regionally and by habitat type for 103 sampling stations. One CREMP station equals one sample.

Sanctuary-wide Distribution by Habitat Type

Sanctuary-wide, 89% of abundance was observed at offshore deep sites, while sponges at offshore shallow and patch sites made up 6% and 5% of abundance respectively (Fig. 3). Offshore deep sites contained 93% of total sponge volume, while sponges at offshore shallow and patch reefs contributed only 5% and 2% respectively (Fig. 4). No *X. muta* were observed at any of the three hardbottom sites sanctuary-wide.

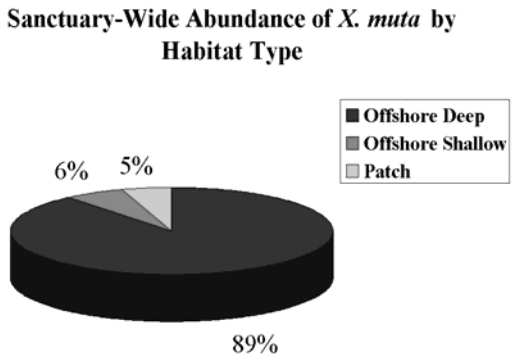

Figure 3: Sanctuary-wide abundance of *X. muta* by habitat type. No individuals were found at any CREMP hard-bottom stations.

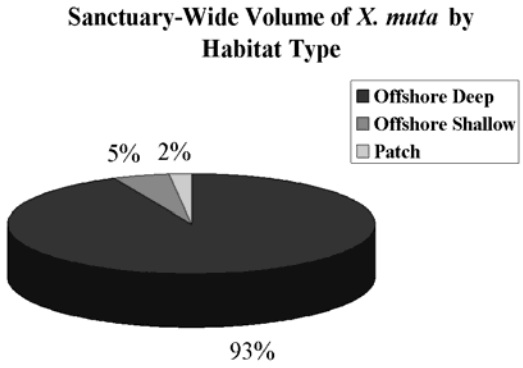

Figure 4: Sanctuary-wide volume of *X. muta* by habitat type.

Abundance: Regionally and by Habitat Type

At the regional level, sponges at sites in the Middle Keys (29 stations) contributed the greatest mean (+/- 1 SE) abundance (0.051 +/- 0.015 individuals/m^2). Abundance ranged from 0.015 individuals/m^2 at several stations to 0.333 individuals/m^2 at Tennessee Deep station 4. This station had the greatest *X. muta* abundance of all those surveyed by the CREMP. Sponge abundance recorded in the Upper Keys (28 stations) was 0.023 +/- 0.011 individuals/m^2, while the abundance in the Lower Keys (46 stations) was 0.046 +/- 0.012 individuals/m^2 (Fig. 5)

When abundance is examined by habitat type, the greatest abundance (0.172 +/- 0.043 individuals/m^2) was at offshore deep sites in the Middle Keys. The Upper Keys deep sites had the least sponge abundance (0.101 +/- 0.036 individuals/m^2), while the Lower Keys deep sites had a sponge abundance of 0.143 +/- 0.021 individuals/m^2 (Fig. 6).

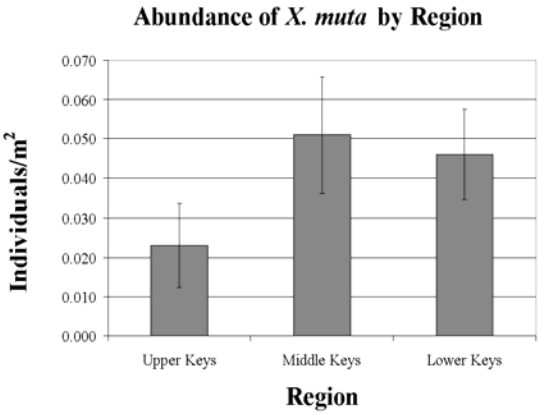

Figure 5: Abundance of *X. muta* by region

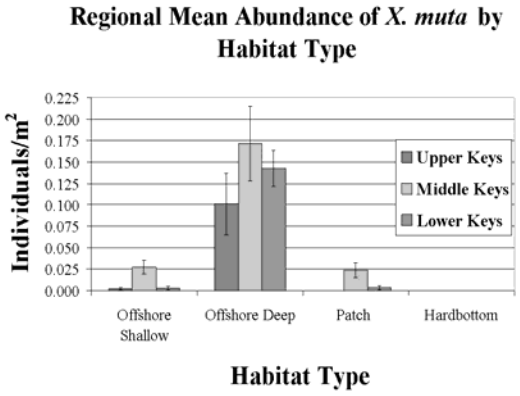

Figure 6: Regional mean abundance of *X. muta* by habitat type. No individuals were recorded at Upper Keys' patch reefs

Volume: Regionally and by Habitat Type

In all regions offshore deep sites had the highest mean (+/- 1 SE) sponge volume. The Middle Keys' deep stations had the greatest sponge volume (2100 +/- 1057 cm^3/m^2). The Upper Keys' deep reefs had the next highest sponge volume (1609 +/- 624 cm^3/m^2). The Lower Keys' deep reefs had the least *X. muta* volume with 960 +/- 172 cm^3/m^2 (Fig.7). The lowest sponge volume by station was 8.31 cm^3/m^2 at Sand Key Deep station 3, and the greatest sponge volume by station was found at Tennessee Deep Station 4 with 7207 cm^3/m^2. The largest individual sponge was recorded at Molasses Deep station 1 (133,070 cm^3), while the smallest

individual sponge was recorded at Eastern Sambo Deep station 3 (1.05 cm^3). The largest individuals by sponge volume were at Upper Keys' deep stations (Fig. 8).

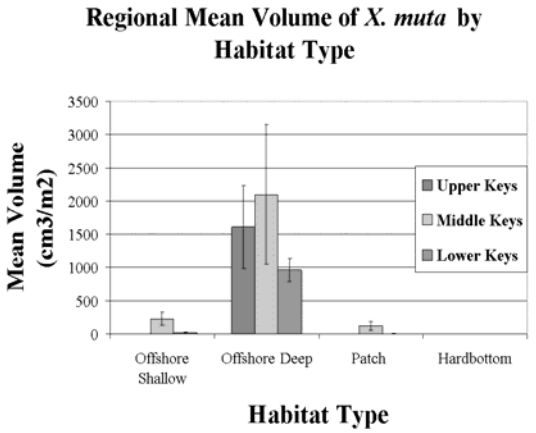

Figure 7: Regional mean volume of *X. muta* by habitat type

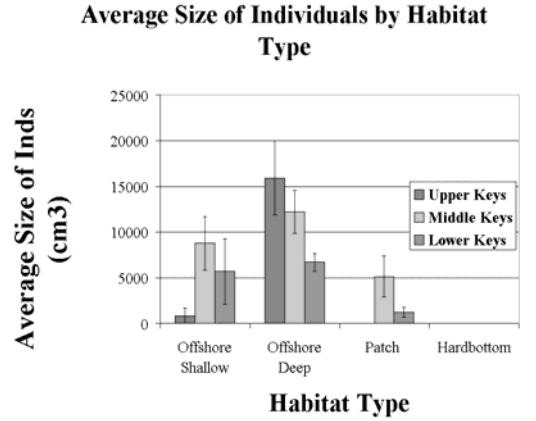

Figure 8: Average size of individual *X. muta* by habitat type

Surface area

When sponge data for all CREMP stations are averaged, the surface coverage of *X. muta* is under 1%, but when only data for the offshore deep sites are considered, surface area increases. The average *X. muta* coverage at offshore deep sites is 1.26%. The range varies from 1.71 cm^2/m^2 or 0.26% to 295 cm2/m2 or ~4.5% at Tennessee Deep station 4.

DISCUSSION

Xestospongia muta is Most Abundant at Deep Sites

In the present effort we have surveyed offshore shallow reefs, offshore deep reefs, patch reefs, and hardbottom habitats for the presence of the barrel sponge, *Xestospongia muta*. We obtained measurements on the number of individuals and volume to describe the population. This initial survey will serve as a baseline year for additional years of monitoring and further research projects.

It was expected that sponge abundance and volume dominated the FKNMS at the offshore-deep reef sites. Sponges at Middle Keys' deep sites averaged 0.172 individuals/m^2. *Xestospongia muta* is typically found at depths greater than 10 meters. The CREMP offshore-deep sites are the only sites sampled with these depths. However, *X. muta* was not present at every offshore deep site sampled. In the Upper Keys none were observed at the two stations comprising the Carysfort deep site. This was the only deep site sampled that had no *X. muta*. The depth range at this site is between 12.5 m and 16.2 m which is a typical depth range of *X. muta* habitat. Additional research on water-quality conditions and ocean currents may provide insight as to the absence of the sponge at this site. At Western Sambo deep in the Lower Keys, *X. muta* was present at two stations with a depth of 12 m, but absent at the third station, which had a shallower depth of 6.7 m. Nutrients and particles in the water column at this shallow station may be insufficient to support these large sponges. There are observational data for the presence of *X. muta* at shallow reefs (less than 5 meters in depth) in the Caribbean (Smithsonian Tropical Research Institute 2003). Data recorded in this study from offshore shallow reef sites (Fig. 6) support those observations. Shallow reef sponges were less barrel-shaped than those at deep sites, but were vase-shaped and usually projecting out from under an overhang. Few sponges were recorded at patch reef sites (0.007 individuals/m^2), but at several non-CREMP patch sites (less than 10 meters in depth) several barrel sponges were observed (M. Bertin pers. obs.).

Sponge volumes in this study ranged from 1.05 to 133,070 cm^3. This range is similar to those (24.05 to 80,281.67 cm^3) observed by McMurray et al. *Xestospongia muta* covered an average of 1% of available reef substrate at CREMP stations, but this sponge covered 4.5% of available substrate at Tennessee Deep station 4. This cover value is about half of that reported by Zea in 1993 (>9%).

No observations of bleaching and disease were recorded in this 2007 study. However, spots determined to be grazing scars were observed on several individuals. Parrotfish are known grazers of *X. muta* and the grazing is increased on those sponges that have bleached (Dunlap and Pawlik 1998). This may be from reduced chemical defenses in the bleached sponge (Dunlap and Pawlik 1998). Additional years of study may provide greater knowledge of in situ bleaching, disease, and grazing identification. Several sponges were observed with large holes which were surmised to be damage from anchors.

This study showed that the greatest abundance and volume of *X. muta* is at the CREMP offshore deep reef sites (Figs. 3 and 4, 14 expected individuals/100 m^2 at deep CREMP sites versus 0.9 and 0.7 individuals/100m^2 at offshore shallow and patch sites).

Acknowledgements

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