

**CRCP Project # 819,**

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**Determining patterns of staghorn coral recovery to establish targets for Caribbean reef restoration.**

### ***Abstract***

This project was funded for two years by CRCP (FY13-14) and built upon one year of pilot work conducted in FY12 funded by NMFS-SEFSC and SERO as an NRC postdoctoral research fellowship (Huntington). The goals of the project were to characterize natural, robust *Acropora cervicornis* populations in different regions, including various aspects of *A.cervicornis* condition, function (growth and tissue condition), and resident fish assemblages. To this end, we conducted surveys at sites in four regions (i.e., Dry Tortugas, Southeast Florida, Belize, USVI) designed to span the range of natural *A.cervicornis* density present each region. In addition, we conducted similar surveys within restored populations of *A.cervicornis* at two sites in Puerto Rico with high density restored *A.cervicornis* populations. Lastly, we undertook three hypothesis-driven studies in the Dry Tortugas region only, to investigate the potential for positive feedbacks between the sheltering reef fish community and high density stands of *A. cervicornis*. A macroalgal bioassay was used to determine the relative bioavailability of nutrients in the water surrounding high density versus low density stands of *A. cervicornis*. Wild tissue collections of *A. cervicornis* occurred at these same sites to compare nutrient concentration and zooxanthellae density within colonies. Lastly, a transplant experiment was conducted at these sites to see if higher coral condition could be induced in coral fragments transplanted from a single (sparse) colony into the high density *A. cervicornis* site compared to the sparse site.

Locations for all data collection are given in the file 'Site coordinates and inventory.xls'

### **COMPONENT DATA SETS - METHODS:**

#### **1) Acerv and Fish Surveys**

Sampling sites were selected to capture the gradient of *A. cervicornis* present within each location. Field time and logistics constrained the number of sites sampled in each location, with 14 sites in USVI, 17 sites in the DRTO, and 4 sites in Broward County, FL. Within a site, four replicate belt transects (10 x 2 m) were placed at a constant depth contour. Transects were not placed randomly; rather each transect was initiated at a single *A. cervicornis* colony (when present) and extended 10m in the direction that visually encompassed the greatest abundance of *A. cervicornis*. In this way, the maximum abundance of *A. cervicornis* occurring at each site was targeted for surveying. The start of each transect was marked with a metal nail driven into the benthos to facilitate repeat sampling. All *A. cervicornis* with a center point inside the belt transect were measured for maximum length (L), width (W), and height (H) to the nearest cm, including both dead and live components of the colony. Partial mortality was estimated as the percent of dead skeletal material present. Each *A. cervicornis* unit was then categorized as an unattached "fragment"; an individual, attached "colony" with distinguishable boundaries; or an aggregated "thicket" in which individual colony boundaries could not be distinguished. For thicket formations, the maximum L, W, and H within the 10 x 2-m transect was recorded. Colony ellipsoid volume (cm<sup>3</sup>), derived from the L, W, and H measurements, can be used to

estimate total linear extension (TLE) of branches within the colony as a measure of *A. cervicornis* abundance from location-specific regression models (Kiel et al. 2012, Huntington and Miller 2014).

The diversity, abundance, and size structure (for biomass conversion) of fish assemblages associated with the *A. cervicornis* were quantified within the four replicate belt transects, following the methods used by Lirman (1999) to assess site-attached fishes among *A. palmata*. Transects were standardized to slow 4-minute swim time for a single pass of the transect length during which the tops, sides, and interstitial spaces among the *A. cervicornis* branches were examined for cryptic individuals. All observed fishes within the 2 m transect width and < 1m above the *A. cervicornis* colonies maximum height were identified to species, with life stage, and fork length (cm) recorded, then binned to size categories. Fish surveys were conducted during midday (between 11:00 and 14:00) to standardize sampling among sites.

Surveys were conducted in:

Dry Tortugas (Pulaski Shoal) in 2012, 2013, 2014

Belize (Carrie Bow Cay) in 2012

USVI (St Thomas) in 2012 and 2013

Puerto Rico (Margara and Matthews restoration sites) in 2014

Miami Dade Co, FL (Sunny Isles) in 2014

Resultant raw data is given in 'Acerv\_ColonySurvey.xls' and 'Fish\_survey.xls'

## **2) Acerv branch growth:**

***Ho: Branch extension rate does not differ between colonies growing in dense vs. sparse Acerv stands.***

Up to three colonies on each transect were haphazardly selected to measure growth as branch extension rate. Individual branches, located at the crown of the colony with a single apical, were tagged with a cable tie benchmark 3 cm from the apical tip. Ten branches were tagged per colony if enough were found to meet these criteria. Growth and survivorship of tagged branches were assessed 6-8 weeks after the initial tagging, depending on the location. All branch growth measurements were conducted in summer months between May and September, with the exception of the Southeast Florida/Sunny Isles location, which was tagged in spring. In total, 2,034 branches were tagged among the four study locations.

Resultant raw data is given in file 'Branch\_Growth.xls'

## **3) Acerv tissue condition:**

***Ho: Tissue nutrient content and zooxanthellae concentrations do not differ between colonies of A.cervicornis resident in dense versus sparse stands.***

According to permit restrictions, seven *A.cervicornis* branch tips were collected in June 2014 from each of four sites in Pulaski Shoal, Dry Tortugas National Park. One branch tip (~ 10 cm) was collected from each of seven, haphazardly selected colonies at each site. Two sites were very dense stands of *A.cervicornis* and two were sparse sites. Immediately following collection, samples were frozen until analysis. Tissue was then blasted off the skeleton with a water pick, homogenized, and a subsample centrifuged and washed to calculate zooxanthellae density. The remaining coral tissue was dried at 50°C and sent to FIU for nutrient analysis. Zooxanthellae density was calculated using a hemocytometer and normalized to the coral skeleton surface area, which was calculated using the wax dipping method (Veal et al. 2010).

Resultant raw data is given in file 'Wild\_ACER\_tissueCondition.xls'

#### 4) Macroalgae Bioassay

***Ho: Macroalgal aliquots placed for temporary growth in dense versus sparse Acerv stands will not differ in their tissue nutrient content.***

A red macroalgae (*Laurencia sp.*) was collected from a single location in the shallow waters around Garden Key in the Dry Tortugas. Macroalgae was cleaned of epiphytes and rinsed in seawater. Macroalgal samples of 7-8g were spun for 30s in a salad spinner to remove excess water and initial wet weights recorded. The algal samples were then sewn into clear mesh bags that did not restrict water flow or light to the algae when deployed *in situ*. We selected four of the Dry Tortugas sites to outplant our macroalgal bioassay: two high density *A. cervicornis* sites (mean TLE =  $2,766 \pm 95 \text{ cm/m}^2$ ) and two sparse density sites (mean TLE =  $251 \pm \text{cm/m}^2$ ). Ten replicate macroalgae bags tethered to a polypropylene line were deployed in May 2014 at depths between 4-6m. At the dense *A. cervicornis* sites, the line was woven amongst the *A. cervicornis* thickets such that the mesh bags were suspended at the crown of the corals. At the sparse sites, the line was anchored to the substrate. After four days, all sample bags were recovered, spun to remove excess water, and final wet weight recorded (n=40). Macroalgal tissue was then rinsed in fresh water, dried at 50°C, ground into a homogenized powder and sent to the Seagrass Ecosystems Research Lab at Florida International University (FIU) for tissue nutrient (CNP) analysis.

Resultant raw data is given in the file 'Macroalgae\_Bioassay.xls'

#### REFERENCES

- Huntington BE, Miller MW. 2014. Location-specific metrics for rapidly estimating the abundance and condition of the threatened coral *Acropora cervicornis*. *Restor Ecol.* 22(3):299-303.
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