Restoration of an Injury due to a Vessel Grounding upon Stony Coral in the Florida Keys

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INTRODUCTION

A Nearshore Patch Reef in the FKNMS was Damaged by a Boat Grounding

On August 8, 2002, the 40' cabin cruiser ran aground on a patch reef 0.5 nautical miles off Boca Chica Key in the Florida Keys National Marine Sanctuary (FKNMS) (Figure 1). The patch reef is dominated by the stony coral *Montastraea faveolata* but also harbors other stony corals, soft corals, sponges, macroalgae, seagrass and various species of fishes and invertebrates.

The grounding site consisted of a single path and numerous concentrated areas of injury extending approximately 41 meters (Figure 2). A total of 596 coral fragments (> 5 cm) and/or whole colonies were injured as a result of this grounding. The area of impact was 35.13 m^2 of injury to living corals and framework.[1]

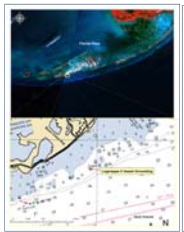

Figure 1. Location of *Lagniappe II* grounding

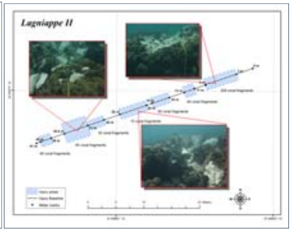

Figure 2. Graphical representation of the injury area

RESTORATION

473 Coral Fragments Were Stabilized Along the Injury Track

According to the National Marine Sanctuaries Act (NMSA), the goal of restoration activities is to return injured coral communities as much as possible to pre-injury, or "baseline" conditions. The baseline conditions are typically measured in the undisturbed reef communities adjacent to the injury area.

National Coral Reef Institute (NCRI) of Nova Southern University Oceanographic Center was contracted by the responsible party and conducted the restoration of the *Lagniappe II* grounding site from August 24 to 28, 2002 and on October 5, 2002. Figure 3 illustrates the general location and distribution of the 473 stabilized coral fragments along the injury tract. All coral fragments were of the species *Montastraea faveolata* with the exception of one *Porites astreoides* fragment.

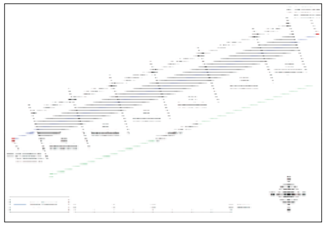

Figure 3. General location and distribution of the stabilized coral fragments.

Figure 4. Diver preparing for coral restoration (top) and attached coral fragments (bottom).

MONITORING DESIGN

Transect Lines and Monitoring Stations Were Established to Monitor the Long Term Recovery of the Restoration

NCRI designed and implemented the monitoring protocol based on the elements outlined in the Draft Restoration Plan created by NOAA and FDEP.[2-3]

Six stainless steel pins were installed (at transect ends and center) to mark the injury tract transect and the control transect. The control transect was established in an area approximately nine meters north of the injury area transect. The control transect was placed in an area that was qualitatively similar in complexity and cover to the injury area.

A total of 24 restoration and control stations were established along each transect (Figure 5). Stations were defined by a 0.75 m^2 quadrat placed adjacent to each transect at predetermined meter marks. Station tags (16 restoration and 18 control) were installed along each transect. Some individual tags were used to mark two stations, one on either side of the transect at the meter marker.

Monitoring of the *Lagniappe II* restoration was conducted in October 2002, January 2004, June, 2009 and August 2010. Digital images of each station were taken at each monitoring event. Due to the shallow water depth along each transect, each individual quadrat (station) consisted of four images (Figure 5).

The goal of monitoring is to determine whether the restoration is providing services in a manner consistent with the restoration goals. If the restoration is successful, differences in the mean coral cover among transects are the same each year.

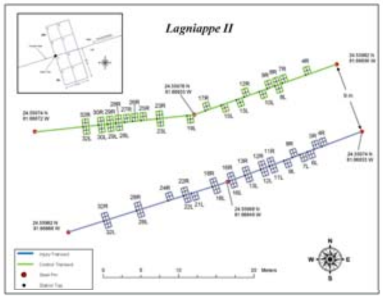

Figure 5. *Lagniappe II* injury (blue/bottom), reference (green/top) transects and quadrat placement. Red dots indicate permanent pin placement and black dots indicate quadrat marker location. The colored squares identify the 0.75 m^2 quadrats, and the black lines within define the area of individual photographs taken.

DATA ANALYSIS

Random point count analysis using CPCe; Repeated measures ANOVA using SPSS

For Factor A (Transect)
H_O: Percent coral cover is the same in each transect.
H_A: Percent coral cover is not the same in each transect.

For Factor B (Time)
H_O: Percent coral cover is the same each year.
H_A: Percent coral cover is not the same each year.

For A x B interaction
H_O: Differences in percent coral cover among transects are the same each year.
H_A: Differences in percent coral cover among transects are not the same each year.

Coral Point Count with Excel extensions (CPCe) was used to estimate the percent cover of coral and macroalgae for each transect. A statistical test of equality of two proportions was used to determine the optimum number of random points to be projected onto each image. A 35-point per image analysis yielded 3360 points for each transect (Figure 6).

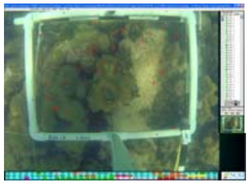

Figure 6. Screen image of Coral Point Count with Excel extensions (CPCe). Yellow square indicates user-defined area of random point projection.

Data comparisons were made using repeated measures ANOVA in SPSS v12.0.1 on non-transformed values. The among subject factor was "transect" and the within subject factor was "time". Mauchly's test indicated the assumption of sphericity had been violated, p<0.05, therefore the degrees of freedom were adjusted using Huynh-Feldt estimates of sphericity (coral ε = 0.862; macroalgae ε= 0.879). Pairwise comparisons was used to detect the difference in percent cover of coral and macroalgae over time.

RESULTS

Coral Cover

Results show that coral cover was the same in both transects $F(1,42) = 1.184$, $p > 0.05$, but coral cover changed over time, $F(2.585, 108.59) = 8.293$, $p < 0.01$. Pairwise comparisons indicated that coral cover was the same for years 2002 and 2004 but was significantly different in year 2010 ; the relationship of coral cover in 2009 to the other years is unclear. Additionally, there was no interaction between year and transect $F(2.585, 108.59) = 1.893$, $p > 0.05$, suggesting differences of coral cover among years were the same in both transects. Coral cover was generally lower in the control transect than in the restored transect by 2010.

Macroalgal Cover

Results show that macroalgal cover was the same in both transects $F(1,42) = .654$, $p > 0.05$, but it changed over time, $F(2.636, 110.713) = 18.628$, $p < 0.05$. Pairwise comparisons indicate that macroalgal cover was different in 2010, but the relationship of macroalgal cover in years 2002, 2004, and 2009 to 2010 is unclear. Additionally, the interaction between year and transect was significant $F(2.636, 110.713) = 3.110$, $p < 0.05$, suggesting differences of macroalgal cover among years was not the same in both transects. Macroalgal cover was generally the same in both transects by 2010.

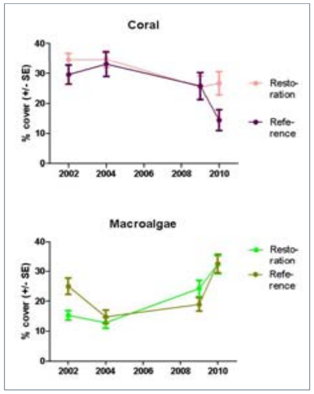

Figure 7. Mean (±SE) percent cover (%) of coral (top) and macroalgae (bottom) in the Restoration and Reference areas from 2002 to 2010.

DISCUSSION

The Results Meet the Restoration Objectives

The goal of restoration is to return injured coral communities as much as possible to pre-injury, or "baseline" conditions. The monitoring results from the *Lagniappe II* restoration site reflect the restoration goals set forth in the NMSA. At the 2010 monitoring event, coral cover in the restoration area was generally higher than that in the reference area. Macroalgal cover was generally the same in both transects at the 2010 event.

The reason for the decline in coral cover between the 2004 and 2010 events, in both the reference and restored transects, is not something we can identify with our monitoring data. There are several potential explanations such as the hurricane season of 2005 and the Caribbean wide bleaching event of 2005. The restored transect experienced a 20% decrease in coral cover from the 2002 (baseline) to the 2010 event, while the reference transect experienced a 50% decrease in coral cover. Though the two transects are only nine meters apart, the reference area may have been subjected to different biotic and abiotic factors such as a vessel grounding, disease outbreak or acute predation. Additional monitoring events between 2004 and 2009 would have been helpful in detecting when these changes occurred.

For macroalgae, the cover was the same in both transects for each event, but had a significant change over time. Specifically, there was an increase in macroalgal cover from the 2004 to the 2009 and 2010 event. Many factors can affect macroalgal cover such as changes in water quality, water temperature, changes in herbivorous populations and seasonality.

Though these results support the intended restoration objectives of the NMSA, it is clear that a greater frequency of monitoring would provide valuable more information on annual restoration trends which could lead to setting better restoration goals and better management of Sanctuary resources.

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