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MONITORING THE NATURAL RETURN OF THE LONG-SPINED SEA URCHIN, *DIADEMA ANTILLARUM,* AND ITS EFFECTS ON THE WORLD'S THIRD LARGEST BARRIER REEF COMPLEX, ANDROS ISLAND, BAHAMAS

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ABSTRACT

The black, long-spined sea urchin, *Diadema antillarum*, was nearly wiped out in the early 1980s by a mysterious disease. In turn over the last couple of decades, this has led to the decline in the Caribbean's coral structures by allowing leafy, green algae to overrun the reefs. This study is monitoring the natural repopulation of these urchins and their herbivory affects. There is little baseline data to date for this geographical area; although at least one parallel study is being done in Jamaica where reef health has increased dramatically as the urchins have returned in large numbers (Edmunds, P.J. & Carpenter, R.C., 2001, Idjadi, J. A. & Haring, N., 2003). Six sites near Forfar Field Station are included in this multi-year monitoring program. Since a few of these sites are now within the confines of the newly created Andros Island Land/Sea National Park, a new, non-invasive method of assessment is being developed. To quantify green, macro algae abundance on the studied patch reefs, Image J is being used to analyze underwater image compilations created from the sites. A container ship wreck off Mastic Point from the 1970's with moderately dense coral/sponge/hydroid cover is being used as a base point for the study. Initially, no *Diadema* had been recorded from that site. Monitoring was initiated in January, 2005 with data collected also in June, 2006, January and June 2007. Recordings of new appearances and densities of *Diadema* are being made by haphazard sampling from station staff and school groups using Forfar. Students and faculty from Central Andros High School are also participating in the data procurement and will be trained to interpret the information once a protocol has been established.

INTRODUCTION

Different environments represent the delicate balance between the animal and plant life that inhabit them. Each organism contributes to the system in its own unique way. Often one single species can have dramatic effects on the balance of its environment. "The impacts of marine disturbances can be profound. Populations of plant and animal species can be substantially reduced across large geographic regions, and there can be collateral and extended effects on other species and surrounding environments" (McKay & Mulvaney, 2001). Throughout the Caribbean, coral reefs are in danger of being overrun by algae. The black, long-spine sea urchin, *Diadema antillarum*, was nearly eliminated in the early 1980s by a mysterious plague that has in turn, over the last couple of decades, lead to the decline in the Caribbean's coral reefs (McKay & Mulvaney, 2001, Bower, 1996, Samarrai & Fariss, 1995, Peterson, 1984, Raloff, 2001, Edmunds & Carpenter, 2001, & Comparitively high densities..., 2001).

Caribbean Reef Health Before *Diadema* Die-off

Before 1983, the Caribbean reefs were dominated by a high diversity and abundance of hard and soft corals. The composition had been more or less stable for hundreds of years. Therefore, there is a clear baseline to use for comparison to the current reef structure (Jackson, 2001).

One of the better sites for comparison is at Discovery Bay, Jamaica; where, some of the earliest and extensive reef research in the Caribbean has taken place since the 1950s (Steneck, 1993 & Edmunds & Carpenter, 2001). In 1978 at Discovery Bay, the amount of live coral ranged from about 32% to 39% coverage. In 1982 at Discovery Bay, the amount of live coral ranged from about 15% to 12% coverage. Note the decrease in coverage after Hurricane Allen in 1979 (Steneck, 1993).

Diadema Population Before Die-off

Prior to the 1983 mass mortality of the *Diadema antillarum,* especially from the mid 1950s – 1970s, a large increase in the numbers of *Diadema* present on Caribbean reefs was noticed. It is believed that this population density increase was due to the over fishing of the other major algal grazers and/or the fish that eat sea urchins. With less competition and predation, *Diadema* became the principle algae consumer of the reef; allowing the population to grow dramatically (Samarrai & Fariss, 1995). In Discovery Bay, Jamaica it was estimated in 1978 that there were from 33 – 40 *Diadema* per m^2 and in 1982, just before the die-off, 21 – 25 *Diadema* per m^2 (Steneck, 1993).

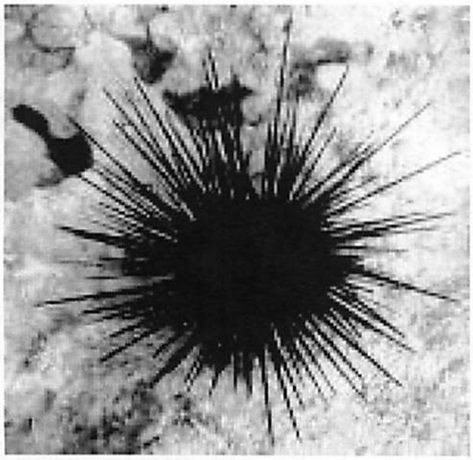

Figure 1. Diadema antillarum.

Black Sea Urchin Plague

The epidemic that caused the mass mortality of *Diadema antillarum* eventually became known as the black sea urchin plague. The specific pathogen(s) responsible is not known, however, it is believed to be a waterborne agent carried by ocean currents. A couple of different species of bacteria isolated from some affected *D. antillarum* could have possibly caused the mass mortality (Bower, S. M., 1996).

Infected *Diadema antillarum* were identified by high amounts of colorless mucous-like material covering their spines. The disease progressed after about thirty-six hours, the *Diadema* seemed listless and became less responsive to prodding. They also started to lose their spines (balding). They became weakly attached to the substrate and were much more vulnerable to attacks by predators. As of yet, which pathogen caused the epidemic is still unknown, there is no known method of prevention or control for the disease should it strike again (Bower, 1996).

Long Term Effects

With other major algal grazers diminished, the Caribbean reefs began to change from reefs dominated by corals to those dominated by macro algae. The macro algae dominance was aided by two major hurricanes, Allen in 1980 and Gilbert in 1989, and a bleaching incident in 1995 that damaged the corals. Corals were unable to recover because the algae out-competed coral larvae for sunlight and substratum (Samarrai & Fariss, 1995, Raloff, 2001 & Solandt & Campbell, 2001). Some areas studied showed coral reduction from sixty percent to five percent in cover area. Many coral species grow slowly, which suggests that it could take a century for the corals to recover (Raloff, 2001).

Diadema eats turf algae that grow on coral reefs too. Turf algae are very thick algae that can grow to be very large. Without *Diadema* herbivory turf algae it can over take the coral reefs. Since the mid 1980's, the Caribbean reefs that were once dominated by scleractinian corals are now dominated by macro algae. This drastic change in reefal conditions was caused by several natural factors, the most important of which is the mass mortality of *D. antillarum* starting in 1983 (Idjadi, 2003, Raloff, 2001, Samarrai, 1995, McKay, 2001).

One reason thought as to why *Diadema antillarum* has not made of a comeback, until recently in a few places, is because most of the surviving populations after the plague were too dispersed, making it difficult for them to reproduce in large numbers. Adult *D. antillarum* have to be within one meter of each other for the gametes to combine and for fertilization to occur to form larvae (Raloff, 2001). The lack of *D. antillarum* remains a serious problem for the Caribbean, but an over abundance of algal grazing sea urchins can also be a problem. For example in the North Atlantic, the lack of predators for the sea urchins is a problem with keeping the sea urchins in check. North Atlantic cod, a natural predator of sea urchins is over-fished, and in the North Atlantic where there use to be vast forests of kelp, now there is a bare rock bottom. The sea urchins have completely grazed the area to nothing (Raloff, 2001). This is why the densities of the *D. antillarum* need to be restored, and also greater fishing restrictions initiated to increase the number of predators and the number of algal grazing fish in that area (Samarrai & Fariss, 1995).

MATERIALS & METHODS

Beginnings of the Study

Initially .5m square quadrants were used to determine densities of *Diadema* and macro algae at potential study sites. Often these sites were selected because few, if any, urchins had been observed there. Disposable underwater cameras were initially used to photo document this (since January 2007, underwater digital cameras have been used). After potential study site were selected, site surface areas were calculated. Locations were selected for the study based on coral/algae density, proximity to Forfar Field Station, ease of access, water depth and clarity, and whether or not evidence could be seen for *Diadema* grazing: Mastic Point, Pigeon Cay, Coconut Grove, Staniard Rock and Three Sisters were selected. Three Sisters consists of many small patch reefs, only three were chosen to investigate. Some of the areas investigated were part of a previous unpublished senior research project by Laura Kriska (2000), College of Wooster, OH. Her markers were utilized rather than installing others some sites are in the new Andros National Park Replenishment Zone.

Current Methods

This study includes the development of several submarine transects selected for inclusion based on the following criteria:

- moderate to heavy coral development that has been or is in resource competition with green macro algae
- accessibility from either onshore staging or close proximity to Forfar Field Station, Blanket Sound, Andros Island

The sites selected include (Common local place names and those used by the Forfar Field Station)

- Southeastern/ windward side Pigeon Cay patch reef
- Barge wreck 200 meters offshore the dug channel at Mastic Point and the nearly adjacent patch reef
- Several small patch reefs located within the Three Sisters patch reef marked and used during the herbivory research of Laura Kriska (College of Wooster, 2000)
- Staniard Rock Wreck
- Coconut Grove barrier reef, near Nichols Town

Records of all *Diadema* sightings by educational groups and intern staff at Forfar are being logged on reference forms. Charts of Andros Island are being used to plot localities and densities of *Diadema*, colonies. The sites will be revisited multiple times annually and new image compilations will be produced. Using a program analysis (ImageJ), the algal areas will be quantified by surface area cover before and after the natural *Di-*

adema reintroduction. Comparisons should show urchin grazing effects.

RESULTS

Locations of sites around Andros are shown with flags as seen on Figure 2.

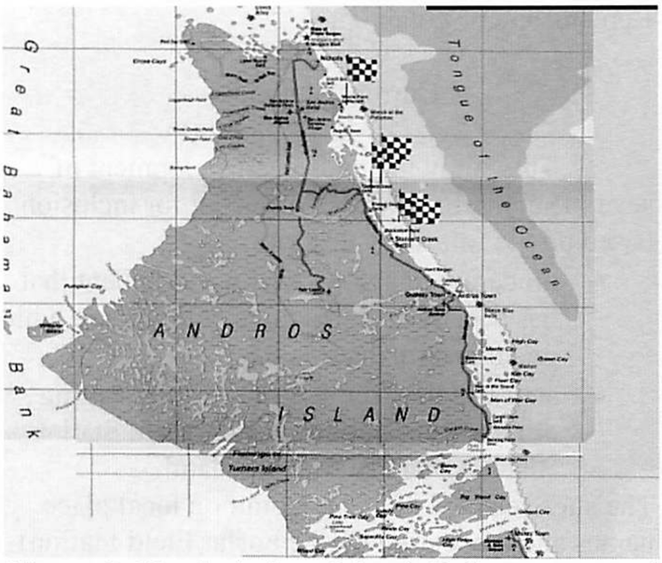

Figure 2. North Andros Island, Bahamas map of sites.

Image compilations have only recently been created to the required resolution, therefore the ImageJ program has yet to be used to determine precise percent coralline and algal coverage at the sites. Visual observations and some early photos of the sites have shown increase in algal cover in sites in which *Diadema* are not present. A tri-color bowling ball with known spectral values for the blue, red, and yellow primary colors permits Photoshop manipulation of the digital images so that true coloration can be reproduced on the photo montages.

Mastic Point

At this location, there have been no *Diadema* present from the beginning of the study. It will serve as the baseline. There are two different sites of interest at this location: labeled as Mastic Point Wreck and Mastic Point Patch Reef. At the Mastic Point Wreck, in particular, there has been a noticeable increase in algae since the beginning of the study. At the Mastic Point Patch Reef, there is little to no algal cover; however, this could be explained by the large number of reef fish that commonly be seen at this location, especially parrot fish. An additional study on reef-grazing fish on this patch reef is currently underway by other USF students.

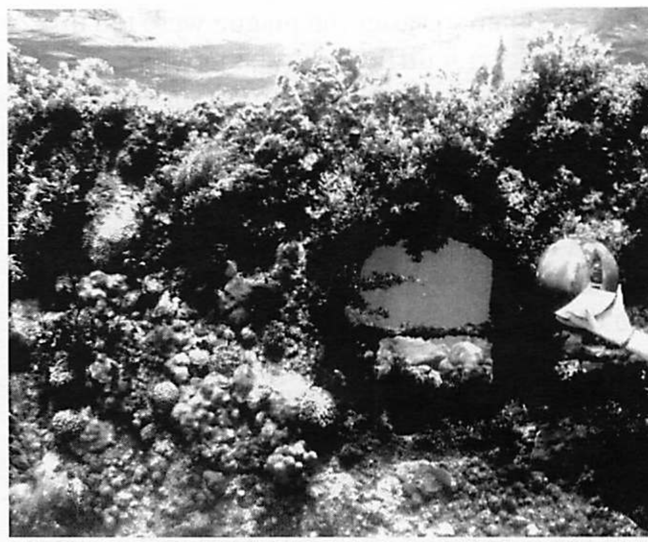

Figure 3. A Portion of Mastic Point Wreck Image Compilation from June, 2007.

Pigeon Cay

At this location there has been three persistent individual *Diadema* that inhabit the coral head studied. Visibly a grazed halo can be seen around the individuals. Plus, there is little algal cover on this site.

Figure 4. Pigeon Cay Coral Head from June, 2007.

Staniard Rock Wreck

This site was added in 2007 (additional sites will also be added as time and resources allow), and has been photographed twice. No *Diadema* have been observed thus far. There is more algal cover present than at Pigeon and Mastic Point Patch Reef, but much less than at the Mastic Point Wreck.

Figure 5. Staniard Rock Wreck from June, 2007.

Coconut Grove

This higher energy site has only been photographed only once, due to safety and water conditions. Few *Diadema* were spotted at this location. There is quite a large abundance of algal cover at this location and it seems to be expanding.

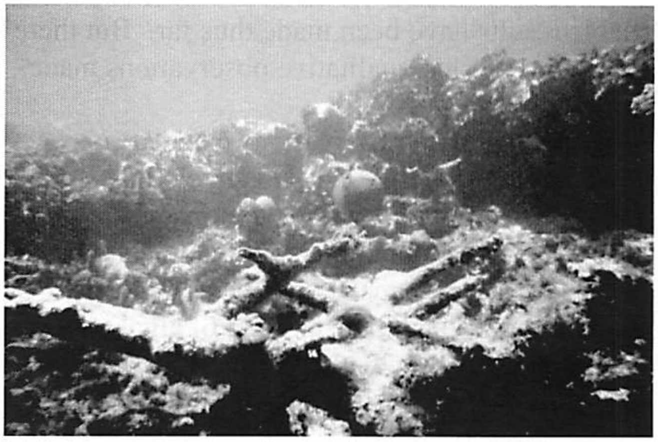

Figure 6. Coconut Grove from June, 2006.

Three Sisters

There are three patch reefs at this location marked by 4 inch squares of PVC that were part of the study (Kriska, 2000). There have been no *Diadema* observed at any of the three thus far. All three sites at this location have significant algal cover; yet less than both Mastic Point Wreck and Coconut Grove.

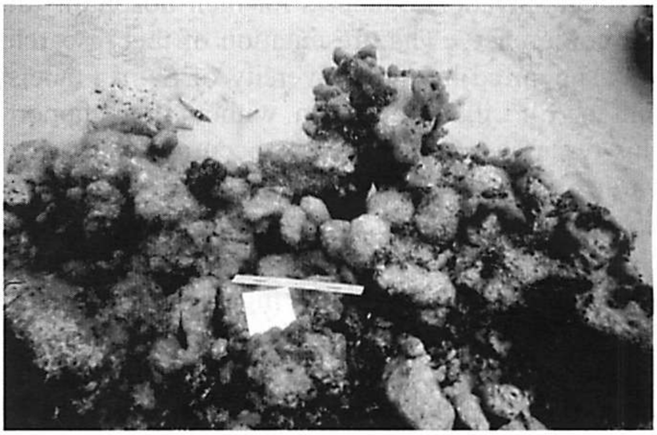

Figure 7. Three Sisters Patch Reef from January, 2006.

CONCLUSION

This study has collected data for approximately three years. Data collection will be continued at each of the locations for an anticipated 15-20 years. More localities will be added as time and resources permit. Image compilations have been a work in progress; therefore, no quantifiable results have been made thus far. But there have been detailed qualitative observations made.

Based on to observations made at sites where *Diadema* are present, it is likely that should *Diadema* return to the study locations where they are not currently found, the coral reef health based on hard coral recruitment, retention, and expansion will improve and the amount of algal cover will dramatically decrease.

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