Translocating Long-spined Sea Urchins to Reduce Macroalgae on Coral Reefs

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INTRODUCTION

Long-spined sea urchins (*Diadema antillarum*) are important herbivores that effectively reduce macroalgae on coral reefs, enhancing coral growth and increasing space for new coral recruits (Fig 1). However, in 1983-84, this sea urchin species suffered mass mortality throughout the Caribbean. The exact cause of this mortality event is still unknown, but researchers believe it was due to a waterborne pathogen spread over long distances through ocean currents. The effects of this die-off on the reef ecology were immediate and combined with overfishing and other stressors, reefs transitioned from coral-dominated to algal-dominated communities, a process known as a phase shift.

The purpose of our study was to test if restoring *D. antillarum* to coral reefs was an effective tool to decrease competition of fleshy green macroalgae, such as *Microdictyon marinum*, on coral colonies (Fig 2). The long-term goal of this study is to improve the health and resilience of coral reef ecosystems off South Eleuthera, and combine this method with coral gardening techniques.

Fig. 1 - *D. antillarum* on a coral reef off South Eleuthera, Bahamas.

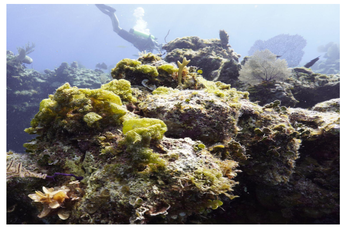

Fig. 2 - Fleshy green macroalgae on a coral reef off South Eleuthera, Bahamas.

RESEARCH QUESTIONS

1. Will *D. antillarum* survive translocation to coral reefs?
2. Will *D. antillarum* alter the benthic composition on the reef?
3. What other grazers and *D. antillarum* predators are present on and around the patch reefs?
4. How does reef rugosity play a role in *D. antillarum* survivorship?

HYPOTHESIS

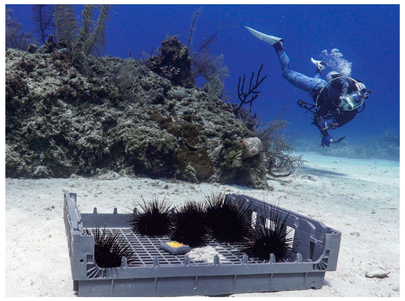

Fig. 3 - Diver outplanting *D. antillarum* to an experimental patch reef.

- If *D. antillarum* are **reintroduced** to coral reefs, then macroalgal cover will **decline**.
- If coral **rugosity** is **high**, then *D. antillarum* will have a **high survivorship** and retention rate.

METHODS

Fig. 4 - Outplanting *D. antillarum* at Tunnel Rock using puncture proof gloves, spatulas and tongs.

Fig. 5 - *D. antillarum* collection and transaction sites around Cape Eleuthera, Bahamas.

During the study, 70 *D. antillarum* were collected from the Cape Eleuthera Marina (collection site) and kept at the Cape Eleuthera Institute wetlab (Fig 5). The *D. antillarum* were fed macroalgae twice a week before being translocated to patch reefs at Tunnel Rock (translocation site) (Fig 5). Using a spatula, tongs, and puncture proof gloves, the *D. antillarum* were translocated to selected patch reefs off South Eleuthera, Bahamas. Six patch reefs were used in this study: three experimental and three control reefs. The *D. antillarum* were translocated to three experimental reefs at densities of two individuals per square meter. At the translocation site, our team descended on SCUBA with *D. antillarum* on crates and carefully placed them onto the experimental patch reefs (Fig 4). Fish surveys were performed using slates to note the abundance of *D. antillarum* predators and herbivores on patch reefs. Survivorship and retention of *D. antillarum* was monitored daily after they were translocated. To do so, the experimental reefs were thoroughly observed with flashlights to locate remaining *D. antillarum*. Additionally, our study examined reef rugosity and how this impacts the survivorship of the *D. antillarum*. Reef rugosity was collected by laying a transect tape on the reef and carefully placing a 4-meter lightweight chain to measure the surface structure of the reef.

RESULTS

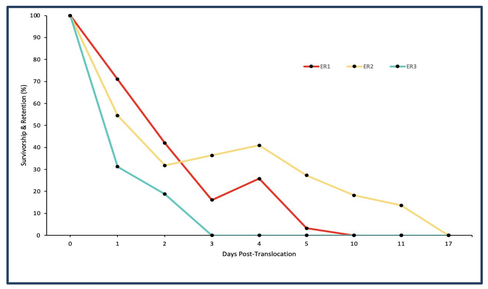

Fig. 6 - *D. antillarum* survivorship post translocation. The three colors represents the three experimental reefs.

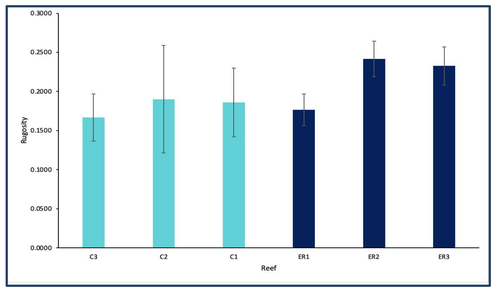

Fig. 7 - Reef rugosity of experimental patch reefs on a scale of 0-1.

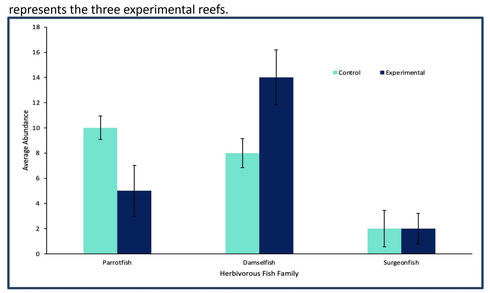

Fig. 8 - Abundance of herbivorous fish. The green color represents control reefs and navy represents experimental.

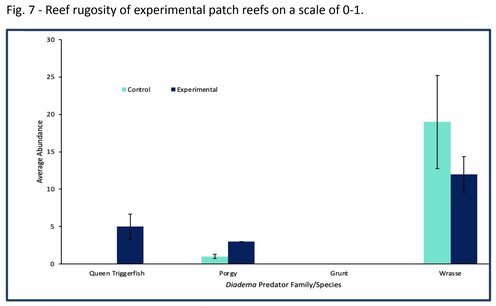

Fig. 9 - Abundance of *D. antillarum* fish predators.

- *D. antillarum* mortality was high on all experimental reefs and experimental reef 2 (ER2) had the highest survivorship and retention rate (Fig 6).
- ER2 had the highest rugosity compared to ER1 & ER3. (Fig 7).
- Parrotfish (family *Scaridae*) abundance was higher on control reefs and primarily juvenile parrotfish were found on all surveys (Fig 8).
- Queen triggerfish (*Balistes vetula*) and jolthead porgy (*Calamus bajonado*) abundance was higher on experimental reefs compared to control reefs (Fig 9, Fig 10).

Fig. 10 - Queen tiggerfish (*Balistes vetula*).

DISCUSSION

Coral reefs in The Bahamas are dominated by macroalgae, mainly due to the loss of herbivorous grazers, such as *D. antillarum*. Our study aimed to reintroduce this urchin species to the reef to reduce algal competition on corals.

When translocating *D. antillarum* to coral reefs, our study showed that high reef rugosity is important to *D. antillarum* survivorship. ER2 had significantly higher rugosity compared to ER1 and ER3, providing more shelter and protection from predators. This finding indicates that the survivorship and recovery of *D. antillarum* could be greatly impacted by climate change, as coral reefs in the Caribbean are becoming less structurally complex due to ocean acidification and hurricanes.

The reefs around South Eleuthera are dominated by fleshy green macroalgae, mainly *M. marinum*. Through our lab and field observations, we found that *D. antillarum* actively graze *M. marinum*, which was not previously documented before this study. Due to high predation on translocated *D. antillarum*, the benthic composition did not change between experimental and control reefs. However, signs of local grazing were observed on a small scale.

Through our fish surveys, we observed a lack of herbivorous fishes on and around patch reefs. The majority of herbivorous fishes observed were juveniles, which had little impact on the benthic composition changing. *D. antillarum* fish predators increased immediately after *D. antillarum* were translocated to patch reefs and subsequently decreased as *D. antillarum* retention declined. Specifically, queen triggerfish (*Balistes vetula*) and jolthead porgies (*Calamus bajonado*) were observed to be the major predators.

Additional studies have found that restoring *D. antillarum* can increase live coral cover supporting this restoration technique as an effective strategy for future research projects (Williams 2021; Cano et al. 2021). Our study showed a small scale decrease in algal cover in response to the presence of the herbivorous grazer, *D. antillarum*.

FUTURE RECOMMENDATIONS

For future research, we recommend selecting sites with less triggerfish to decrease predation on *D. antillarum*. Choosing larger sites with higher rugosity would provide *D. antillarum* with more shelter. Translocating more *D. antillarum* to the patch reefs would bring densities closer to their pre die-off densities (4 individuals per sq. m) and potentially increase survivorship. Our research team is currently testing if deploying a cage will protect *D. antillarum* from predators to ensure their survivorship.

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TEAM *DIADEMA*

Fig. 11 - FAMILY *Diadema*.