Acropora Nursery Operations in Puerto Rico and the U.S. Virgin Islands

2012 Annual Report

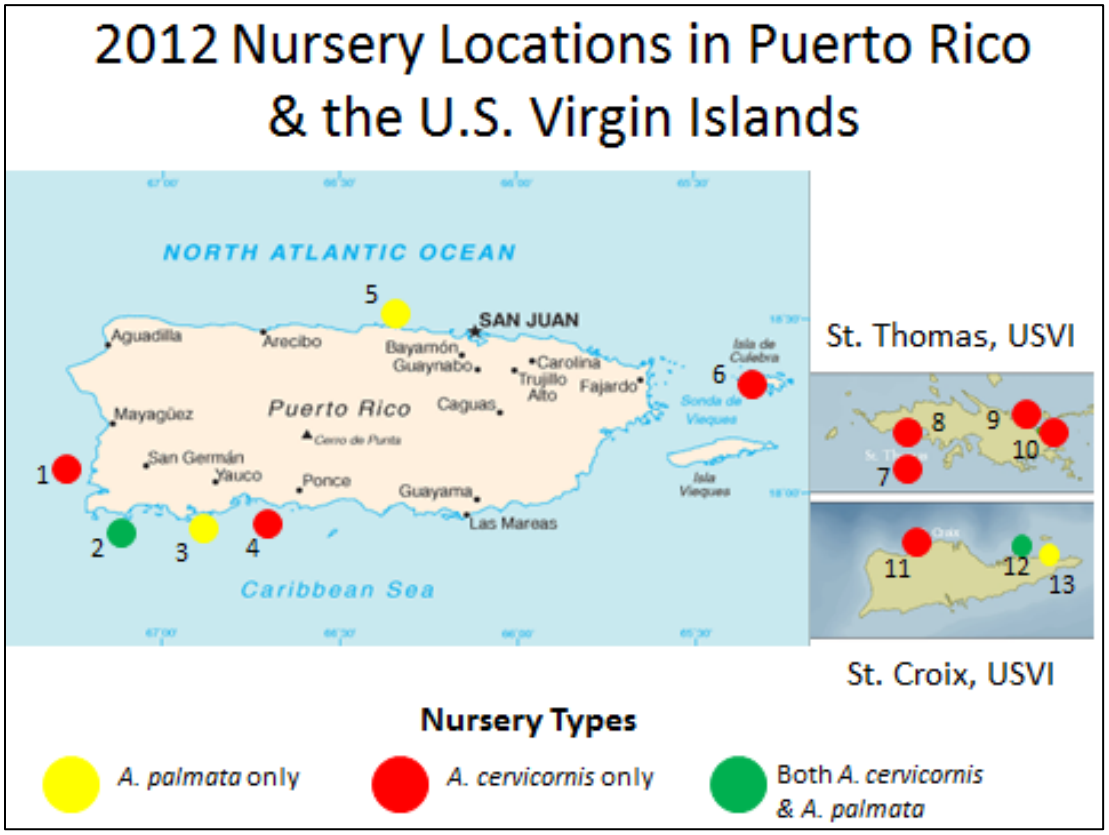

Figure 1: Location of coral nursery operations in Puerto Rico and the U.S Virgin Islands during 2012: 1) Cabo Rojo, 2) La Parguera, 3) Guanica, 4) Guayanilla, 5) Vega Baja, 6) Culebra, 7) Flat Cay, 8) Perseverence Bay, 9) Coki Point, 10) Lindquist Bay, 11) Cane Bay, 12) Green Cay and 13) Teague Bay

Introduction

Both *Acropora cervicornis* and *A. palmata* have suffered dramatic declines throughout the entire Caribbean over the last few decades (Bruckner, 2002) which led to the inclusion of these species as "Threatened" under the Endangered Species Act in 2005. As a result of this decline, adult populations typically have low densities and genetic diversity, resulting in a reduction in genetic connectivity for this genus. The life history traits of this genus (fast growth rates and highly successful asexual propagation through fragmentation) have shown these species to be good candidates for coral nursery programs in the Caribbean (Highsmith, 1982; Lirman, 2010). As these populations continue to decline, proactive intervention is becoming increasingly warranted (Edwards and Clark, 1998).

Over the past 5 years, nursery operations have expanded exponentially from just one nursery in Culebra to 11 nurseries across the region (Figure 1), with funding from NOAA's Coral Reef Conservation Program, the Restoration Center, and Protected Resources Division in collaboration with The Nature Conservancy

and the Gulf of Mexico Foundation. The majority of collected corals are "fragments of opportunity" (Figure 2) that have previously broken from the donor colony by natural events and/ or ship groundings, and are lying in sand or sea grass areas where they are not likely to survive (Lirman, 2000). When fragments are collected from whole colonies of *Acropora cervicornis* and *Acropora palmata*, they are collected from large healthy colonies defined as having a minimum diameter of 1 meter and from reefs where there are healthy stands of *A. cervicornis* and *A. palmata.* Donor colonies usually recover in 3-6 weeks and show no additional mortality or disease after having the fragments removed (Lirman et al., 2010). Collected fragments are either transported underwater to nearby nurseries or placed in bins with seawater on board a vessel if they need to be transported by boat to the nursery sites. The seawater is changed regularly and the bins remain shaded during transit.

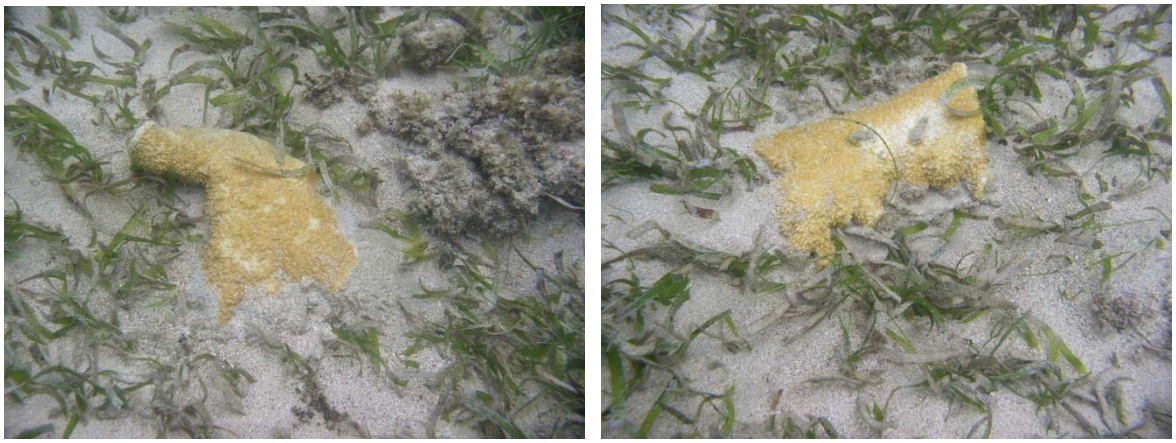

Figure 2: Examples of *A. palmata* fragments found in sand and sea grass that have a low probability of survival due to burial and abrasion by sediment. Segments of partial mortality can be seen on most fragments.

After establishment of a nursery during the first year, no additional coral collection is needed to expand the nurseries as the nursery sites will produce enough coral tissue *in situ* for both expansion and outplanting. Each year, coral outplants are transplanted from the nurseries to reefs impacted by groundings or other physical impacts to aid in the restoration of the damaged reefs or transplanted to reefs where populations were once prevalent but have declined in the past few decades because of disease outbreaks and/or bleaching events to assist in the recovery of the coral populations.

Once fragments are established in the nurseries, genetic sampling will be performed on the nursery colonies. One cm^2 tissue samples will be collected from each clone for genotyping. These samples will be stored in vials with ethanol and sent off to a lab to be analyzed. If it is determined that a particular nursery does not have high genetic diversity, then additional fragments may be collected from the wild in the 2^{nd} and 3^{rd} year of the nursery to increase genetic diversity in the nursery. During outplanting, corals with different genotypes are clustered together to increase the chances for sexual reproduction of these species in the field. As mentioned previously, there has been a reduction in genetic connectivity for these species. The establishment of "reproductive thickets" may help increase connectivity in some areas (Lirman, 2010).

Methods

Acropora cervicornis Nurseries

Once at the nursery site, collected *A. cervicornis* fragments are mounted on a variety of structures to promote growth and survival. Traditional methods included blocks, wire cages, and A-frames, but nurseries throughout the region are switching over to floating line nurseries which include "Floating Underwater Coral Arrays" (FUCAs), Tables or Trees (Figure 3). Line nurseries have been shown to promote higher survival and growth rates compared to their benthic counterparts (Griffin et al., 2012). There is also less disease due to the lack of predators on line nurseries and better water circulation. Line nurseries are also durable during storm conditions and have withstood swells of at least 20 feet. Line nurseries have been used for years all over the world, and to date, there have been no incidents of entanglement with sea turtles, manatees or other marine species. Because of the little to no maintenance required for line nurseries, operational funds can be saved for more outplanting and nursery expansion.

Figure 3: Photos showing a typical 5' x 10' line nursery set up with 5 cm coral fragments (top) and 12 months of coral growth on a line nursery with 25 cm colonies (bottom).

***Acropora palmata* Nurseries**

Fragments of *A. palmata* that are broken off during storm events or ship groundings can settle back on the reef and grow into new asexual recruits, or they are swept off the reef into sand and sea grass beds where they have low rates of survival (Lirman, 2000). Each year, there are thousands of these fragments that are lost to abrasion and burial by sediment in these less ideal habitats (Figure 2). There is a significant opportunity here to save some of these fragments and use them for creating *A. palmata* nurseries in Puerto Rico. The fragments can be brought into nurseries and used as brood stock for the nursery. There is virtually no real take from the environment since these fragments would have otherwise perished if left where they were. Several reefs around Puerto Rico and the Virgin Islands have been identified where there is frequent breakage from either storm events or the usual high wave events experienced each year. These sites could provide the coral fragments needed to start up nurseries in Puerto Rico and the Virgin Islands. Rather than being brought back to a nursery, coral fragments can also be reattached *in situ* to increase to the number of colonies at each of these sites.

Because of the vertical growth of *A. palmata,* this species is not typically grown out on line nurseries. Once *A. palmata* fragments are brought back to the nurseries, they are attached to structures in the nursery where they are allowed to recover. These structures typically include blocks and PVC tubes. After a year in the nursery, new growth on these colonies can be used for creating additional colonies for outplanting. This typically involves cutting tissues into 2-4 cm wafers, attaching them to a cement puck, allowing them to grow in the nursery for 1-2 years and then outplanting these colonies onto the reef (Figure 4). Another option is that the fragments can be brought into the nursery, fragmented immediately, attached to pucks and then grown out for either outplanting and/or used for nursery expansion.

Figure 4: Example of *A. palmata* being grown out blocks in St. Croix, USVI and PVC tubes in Guanica, Puerto Rico.

Outplanting Design and Criteria

Colonies to be outplanted from nurseries onto the reef will meet the following set of criteria:

1) For *A. cervicornis*, have at least 10 cm of linear growth
2) For *A. palmata*, be at least 10 cm in diameter

3) Show no visible signs of disease or injury
4) Have 100% live tissue
5) Show robust coloration, suggesting good health

All corals will be outplanted using one of the following field-tested methods:
1) On a cement puck or disk that is securely fastened to the substrate.
2) Securely fastened to a nail that is driven into the substrate.
3) Securely fastened directly to the substrate
4) Stabilized into the reef using natural crevices or holes.

Site selection will be highly region-specific but the following general guidelines will be applied when selecting outplanting sites:
1) Suitable reef habitat and/or historic presence of the species (in recent decades).
2) Healthy environment for the given region
3) Part of restoration following physical impacts.
4) Increase genetic diversity at sites where there is low genetic diversity to increase chances of sexual reproductive success
5) Not within any permitted marine and coastal construction areas (i.e. dredging, beach nourishment projects, etc.)

Basic guidelines for the outplanting design for each nursery's core sites include:
1) Avoid dominance of one genotype at each site.
2) Maximize the diversity of genotypes from the available stock.
3) Outplant at a diversity of sites to minimize risk.
4) Allow for some manipulation of site design to allow for research.

Ouplanting Effects on Fish Communities

Preliminary data analysis on fish communities collected separately at the Culebra and the Guayanilla sites suggest that fish density and diversity are significantly higher at the outplant sites, particularly for juvenile fishes. Data collected to date from grounding sites in Guayanilla has shown that impacted areas with no restoration have the lowest biomass and diversity. Areas that have been restored using traditional methods of coral reattachment and rebuilding the reef structure are showing similar densities and diversity to reference areas that were not impacted. Areas that were restored using the same methods, but incorporated *A. cervicornis* outplants into the restoration design show higher densities and diversity than the other sites in Guayanilla.

The data from Culebra suggests that outplanting sites have higher fish biomass and diversity than reference sites. Sites within the MPA have higher fish biomass and diversity compared to sites outside the MPA showing the effectiveness of management in that area. Outplanting sites within the MPA have higher fish densities and diversity than areas within the MPA with no outplants.

Summary

During 2012, capacity in Puerto Rico and the Virgin Islands reached almost 10,000 colonies in nurseries throughout the region. Approximately, 5,000 colonies were outplanted during 2012 to over 10 sites across the region. The location of each of the nurseries is listed on the map in Table 1 and a description of each can be found in Appendix I & II. Funding for this work was provided from NOAA's Restoration Center, Coral Reef Conservation Program, and Protected Resources Division in collaboration with The Nature Conservancy and the Gulf of Mexico Foundation. In addition the research referenced this report, the nursery-reared corals and outplanting sites are also being leveraged for research by other partners. Future funding availability will determine how these nurseries continue to operate. As unforeseen circumstances arise, such as ship groundings or storm events, where significant fragments of opportunity become available, there may be a need to create nurseries in other areas; either temporary or permanent. All additional nursery locations or changes will be included in annual reporting and permit renewal proposals. With continued support from CRCP and PRD, NOAA's Restoration Center plans to continue to fund and implement the establishment and expansion of various coral nurseries throughout Puerto Rico and the Virgin Islands over the course of the next several years. There is the opportunity to increase the capacity of these nurseries if additional funding was available, but at current capacity the number of outplants in 2013 could reach 10,000 colonies. Funding availability will determine how many corals may be outplanted in 2014 and beyond.

References

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Appendix I

Description of nurseries in Puerto Rico during 2012

Location	Start-up Date	Primary Operator	Species	# of corals in Nursery	# of outplants to date	Future Annual # outplants	Notes
1) Cabo Rojo, PR	April 2011	HJR Reefscaping	*A. cervicornis*	750	0	750	Due to future funding limitations and maintenance issues at this site, all of the colonies will likely be outplanted during the spring of 2013.
2) La Parguera, PR	December 2011	HJR Reefscaping	*A. cervicornis & A. palmata*	> 1,000	0	500	First outplanting scheduled for spring 2013
3) Guanica, PR	September 2012	NOAA RC, Sea Ventures, HJR Reefscaping	*A. palmata*	150	800*	N/A	Nurseries were set up after Hurricanes Ernesto and Isaac caused extensive damage to *A. palmata* thickets in the area. *Approximately 800 fragments of opportunity were stabilized *in situ*.
4) Guayanilla, PR	2007	NOAA RC	*A. cervicornis*	1,600	3,000	1,200	Nursery set up after the M/V Margara grounding.
5) Vega Baja, PR	May 2011	SAM, VIDAs	*A. palmata*	120	> 1,000*	N/A	Nursery has been shut down because of constant exposure to large Atlantic swells and terrestrial run-off. Future work will focus on stabilization of fragments *in situ.*
6) Culebra, PR	2000	SAM, Corallations & UPR	*A. cervicornis*	3,000	6,000	2,000	Excellent site for outreach and education. Highly accessible to public.

*Number includes number of fragments of opportunity that have been stabilized *in situ* to increase percentage of survival.

Appendix II

Description of nurseries in U.S. Virgin Islands during 2012

Location	Start-up Date	Primary Operator	Species	# of corals in Nursery	# of outplants to date	Future Annual # outplants	Notes
7) Perseverance Bay, St. Thomas	2009	The Nature Conservancy	*A. cervicornis*	600	300	300	Conditions at the nursery site are not optimal. All the corals will be outplanted from the nursery in 2013.
8) Flat Cay, St. Thomas	2009	The Nature Conservancy	*A. cervicornis*	500	200	300	
9) Coki Point, St. Thomas	2009	The Nature Conservancy	*A. cervicornis*	150	0	0	Small exhibition site at aquarium in St. Thomas
10) Lindquist Bay, St. Thomas	2009	The Nature Conservancy	*A. cervicornis*	900	300	300	
11) Cane Bay, St. Croix	2009	The Nature Conservancy	*A. cervicornis*	300	0	0	Excellent site for outreach and education. Highly accessible to public.
12) Green Cay, St. Croix	2009	The Nature Conservancy	*A. cervicornis & A. palmata*	1,000	700	0	Conditions at the nursery site were not optimal. All the corals were removed from the nursery in 2012 and were either outplanted or transferred to the Cane Bay nursery.
13) Teague Bay, St. Croix	2009	The Nature Conservancy	*A. palmata*	1,000	300	300	