ACROPORA CERVICORNIS RESTORATION TO SUPPORT CORAL REEF CONSERVATION IN THE CARIBBEAN

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INTRODUCTION

The Caribbean-wide decline of *Acropora* corals in recent decades has serious consequences to coral reef biodiversity, coastal geology, and to the fisheries and tourism economies of the region. Such is the present situation that the three described Caribbean species are being considered for listing as endangered or threatened species (Precht et al, 2004), a first for reef-building scleractinian corals globally. Even on reefs where measures to address the root causes of coral decline have been implemented, *Acropora* corals do not appear to be recovering, as larval recruitment is for the most part not occurring. A likely hypothesis for a lack of larval-based recovery is that most of the surviving *A. cervicornis* populations are composed of a single local clone, and with self-fertilization inhibited, larvae that would normally re-colonize reefs are not being produced (Bowden-Kerby, 2001). The long-term survival of *Acropora* in the Caribbean is threatened unless root causes of decline are more effectively addressed throughout the region, and unless successful sexual reproduction is restored. On the hopeful side, although greatly decimated, surviving coral populations are assumed to be composed of genotypes more resistant to disease and bleaching, major factors responsible for the coral's decline (Bowden-Kerby 2001).

Counterpart International, Counterpart Caribbean, UWI Discovery Bay Marine Laboratory, and the Honduras Ministry of Tourism entered into partnership in 2004 to help restore breeding populations of staghorn coral *Acropora cervicornis* to sites where root-causes of reef decline are beginning to be addressed. The work has since grown to include Fundacion Global and the Punta Cana Foundation in the Dominican Republic, as well as several private industry partners.

BACKGROUND

The Caribbean staghorn coral *Acropora cervicornis* is a keystone species of crucial importance to biodiversity, fisheries, and tourism interests. *A. cervicornis* is particularly vital as fisheries habitat due to it being the only large open-branched coral species of reef slope, back reef, and lagoon environments, so the loss of this species represents a loss to the biodiversity and carrying capacity of Caribbean reefs. Only 2-3 decades ago, this species was one of the most important reef-building corals on Caribbean reefs, however the species has declined throughout the region, becoming locally extinct on many reefs. In the Discovery Bay area of Jamaica, only three small populations have been located, separated by many kilometres of reef. Causal factors for this decline include frequent or severe disturbance: hurricanes, nitrification, bleaching, disease, predation, trampling, and anchor damage (Hughes, 1993; Crawford, 1995; Diaz et al., 1997; MacIntyre and Aronson, 1997). The decline of Caribbean *Acropora* has also been linked to overfishing and associated lack of predators and herbivores, resulting in increases in coral-killing gastropods (Bruckner et al, 1997), increases in *Acropora*-harming *Stegastes* damselfish, decline of grazing *Diadema* sea urchins, algal overgrowth, and associated coral disease (Lewis, 1986;

Bak, 1990; Hughes, 1994; McClanahan, 1994, 1997a, 1997b; Connell, 1997; Jackson, 1997; Rogers et al., 1997; Szmant, 1997; McClanahan et al., 1996; Nugues et al., 2004).

While fragmented and small, it is hoped that at least some of the remaining coral populations are now fairly stable, being composed of the more resistant survivors of major bleaching and disease epidemics. However, *A. cervicornis* is not returning to reefs where it was formerly common, as sexual recruitment of *Acropora* is rare or absent in the Caribbean (Bak and Engel, 1979; Sammarco, 1985; Quinn and Kojis, 2001). The lack of sexually generated coral larvae may be related to surviving local populations being mostly of a single genotype, so that fertilization during spawning is inhibited (Bowden-Kerby 2001). Unless sexual reproduction can be restored, the long-term survival of *A. cervicornis* in the Caribbean is threatened. Given the extent of the decline of staghorn corals, a more “interventionist” approach may be needed to actively bring about restoration of healthy populations of the species.

With the implementation of no-take MPAs and measures to address the root causes of coral reef decline in several Caribbean countries, patches of increased reef health can be expected to return. Once the fish, crustaceans, and other species that positively influence coral health have become more abundant, corals should begin to fare better on the reefs. Abundant herbivorous fish populations have been shown to keep algae in check, helping enable corals to survive well even in nutrient enriched waters (Szmant, 1997).

The project strategy is to create pockets of greater reef health in and around surviving *Acropora cervicornis* corals with no-take areas, using techniques such as removal of coral predators, weeding excess seaweed, keeping *Stegastes* damselfish in check, and experimental introduction of sea urchins to control disease-harboring algae (Nugues et al, 2004) around *Acropora* populations. The strategy described in this report involves propagation of 10-30 cm staghorn coral branches taken from healthy populations of *A. cervicornis,* for propagation on wire frames and on ropes suspended above the substratum.

METHODS

The methods are based largely on experiments carried out in Puerto Rico (Bowden-Kerby 1997, 2001). In Honduras, initial experimental sites were set up on the three main Bay Islands of Roatan, Guanaja, and Utila. In Jamaica the initial sites were located at Discovery Bay (Quinn, 2005), and then expanded to include Negril, Ocho Rios, and Montego Bay Marine Parks. Work began in June 2004 14 wire mesh frames planted with 10-30cm coral fragments in the Jamaica sites, and with 18 frames were planted in the Honduras sites. Corals were affixed to wire mesh frames with plastic cable ties. Additional frames planted with corals were added in both countries in January and April 2005, as well as at Punta Cana and Sosua Bay in the Dominican Republic.

RESULTS

An overview of *Acropora cervicornis* survival for each Caribbean island site is given in Figures 1 and 2. Not all methods were used at all sites, as indicated. The number of months that the survival data represents is given below each site.

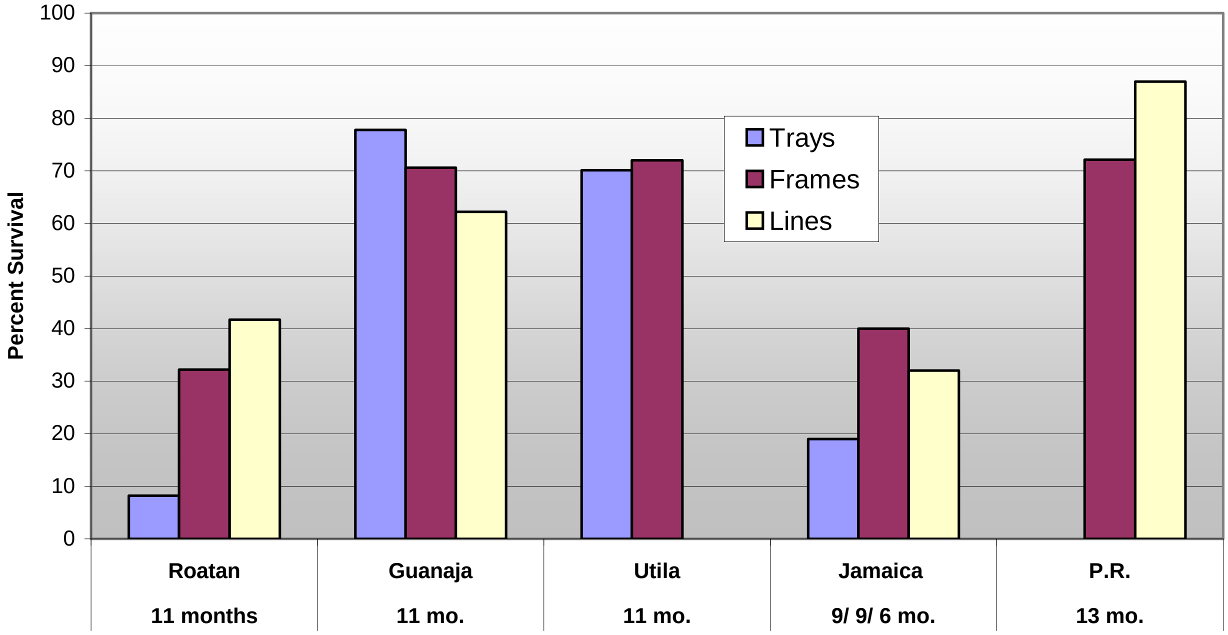

Figure 1. Comparative *Acropora cervicornis* survival based on island and method.

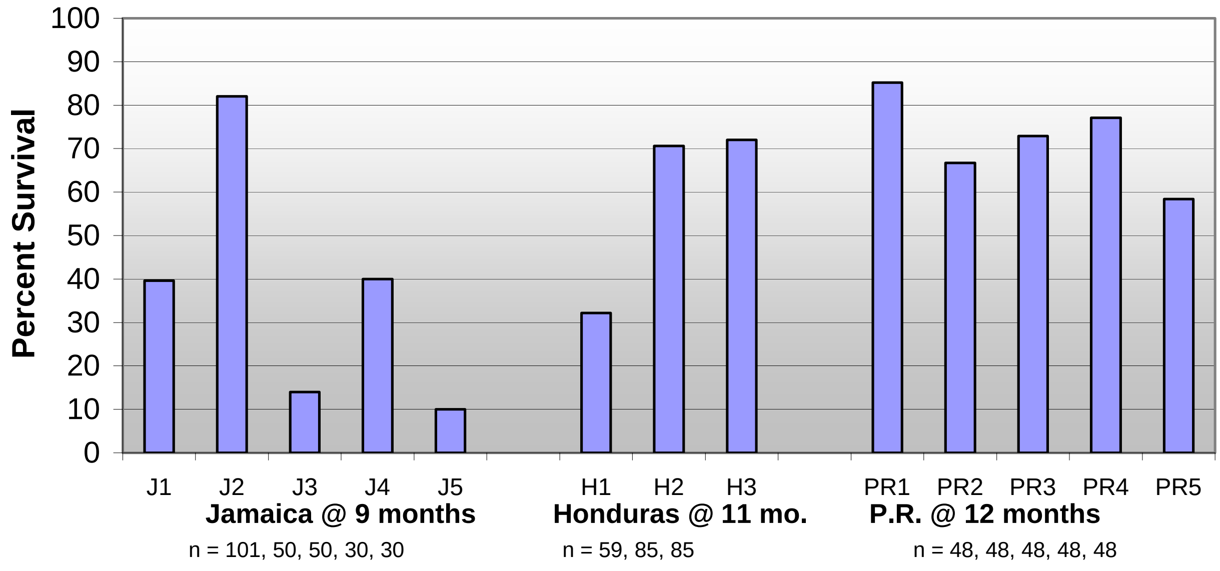

Figure 2. Within country site comparisons of *A. cervicornis* survival on A-frames.

An overview of growth comparisons is given in Figures 3 and 4. While each of these figures is closely related, one gives the mean rate of growth per colony per day, while the other gives the end result as biomass increase calculated as the expected 12 month equivalents.

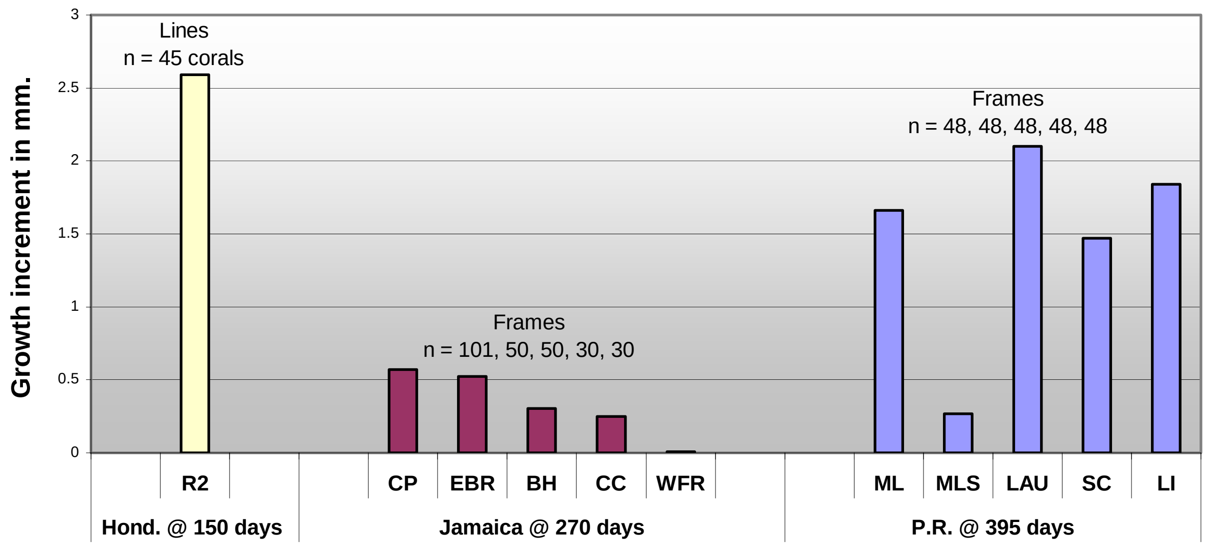

Figure 3. Mean daily growth increment per coral colony in mm; calculated as finishing length – starting length ÷ number of days of culture.

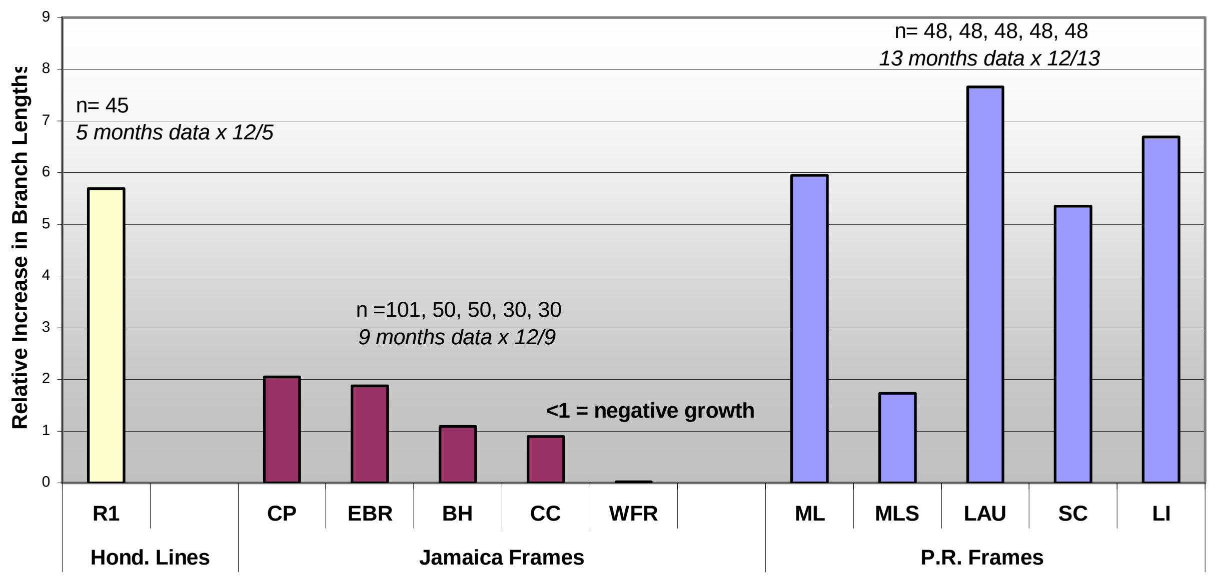

Figure 4. Relative increase in coral biomass, calculated as 12-month equivalents: total of all branch lengths (including dead, broken, and missing branches) ÷ initial branch length ÷ portion of the year represented. ***Anything less than 1 indicates negative growth; a 2 means a doubling of the corals, while a 7 means a 7-fold increase in coral biomass.***

Site details are given in Figures 5 and 6, and show both representative poor and good sites for each of the three methods; with the poorer site having survival drop below 9%, 32%, and 42% for each respective method, while the good site had survival of >60%-78% for each method over the 11-month period thus far.

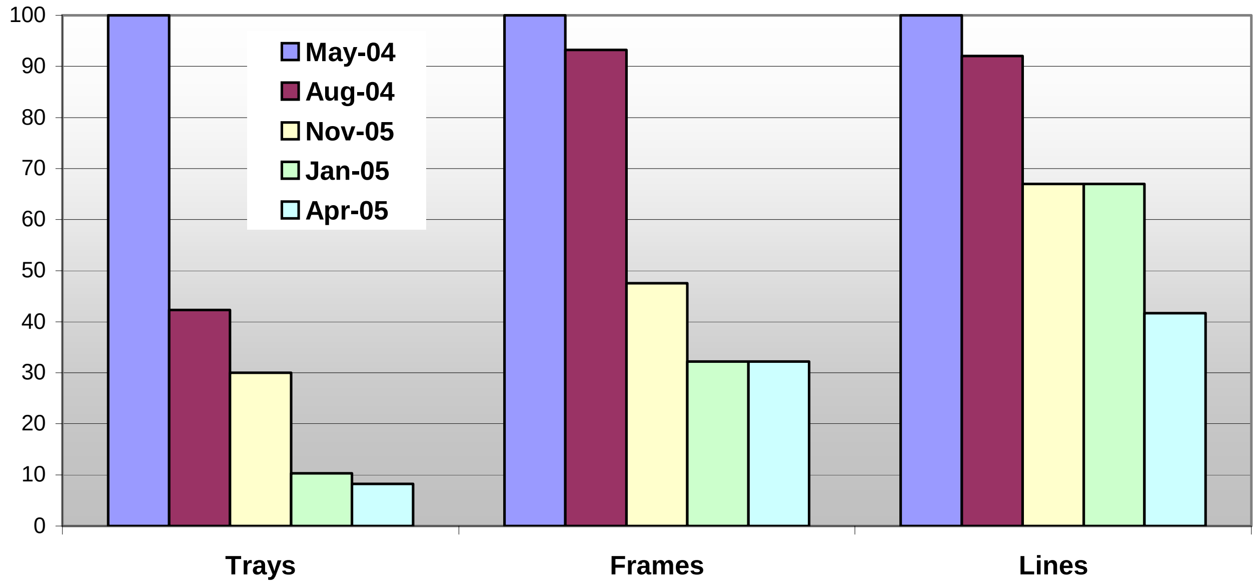

Figure 5. Percent survival over 11 months at Bailey's Key, Roatan (Roatan 1 site), the poorest performing site in Honduras.

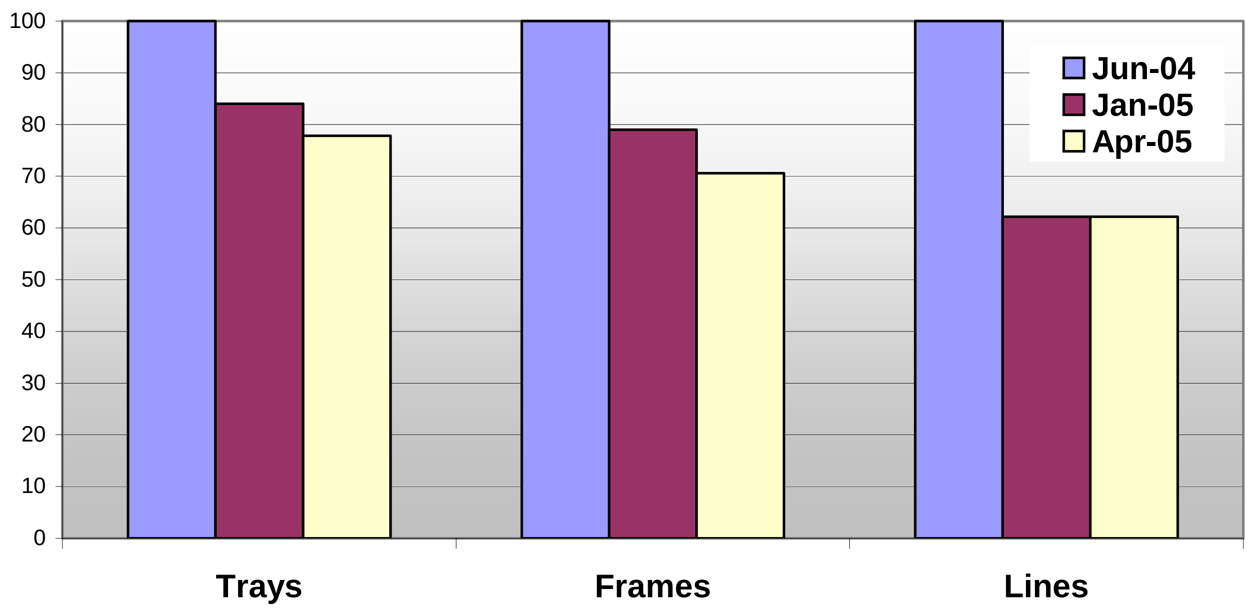

Figure 6. Percent survival over 11 months at Guanaja site #1, one of the best sites in Honduras.

DISCUSSION

While the data is still coming in, these initial results indicate that success of the work is strongly site specific, and that variations in the placing of the frames within the restoration sites can make a big difference to mortality. Predation and algal overgrowth were prevalent at particular sites and on particular frames, resulting in high fragment mortality >90% on some frames, while other frames and sites had 0% mortality over the same period. Frames on sand did considerably better that frames on rock or rubble, being away from lurking places of predatory *Coraliophila* snails and *Hermodice* fire worms, as well as being removed from *Stegastes* damselfish territories. However, if the frames were far from the reef, algal overgrowth became a problem due to a lack of grazing fish. The method of weighing the frames down with cement blocks at some sites resulted in the inadvertent creation of ideal *Stegastes* habitat, with subsequent negative impacts to the corals. The size of the wire mesh also affected this outcome, with small mesh becoming ideal shelter for the damselfish, plus allowing more surface area for the algal farming activities of the fish. Solutions to these problems were implemented in the second phase of experiments in January and March 2005, and involve increasing the wire mesh apertures to 20x 20cm, and locating each frame on bare sand 1-3m from rocky areas, providing a barrier to predators but close enough for herbivorous fish to visit the frames regularly for cleaning.

MANAGEMENT IMPLICATIONS

As *A. cervicornis* is such an important habitat forming species for juvenile commercial fish, and serves as vital bedrooms for grazing fish so important to reef functionality, having a unique and special ecological role as well as great natural beauty, its restoration to reef systems where it has become locally extinct is of particular significance. Restoring healthy breeding populations of staghorn coral at low-cost, even if for relatively limited areas, could have regional management implications. Such pockets of genetically diverse staghorn corals established throughout the Caribbean could potentially help restore the larval-driven recovery processes ultimately vital for the restoration of the species regionally.

The work of rescuing and restoring staghorn corals served as a point of unification between sometimes antagonistic groups: government managers, NGOs, conservationists, fishermen, and the tourism industry. The work supported existing management strategies and heightening coral reef conservation issues during workshops, highlighting the vital importance of no-take marine protected areas in restoring healthy ecological balance to reefs. The research sites were as much as possible located within existing coral reef conservation areas, taking advantage of the increased ecological health, while helping contribute to the recovery of biodiversity within the management areas.

The willingness of the tourism industry to shoulder a higher level of support for coral reef conservation regionally was confirmed during the project, with resort and dive industry sponsored training workshops and restoration sites. Direct and long-term benefits to tourism are expected to result in the project sites, with increased reef diversity and beauty, and high levels of guest interest. It is our vision and hope that the tourism industry, often implicated in reef decline, can become united behind this and other types of reef conservation at local, national, and regional levels, with more direct support for reef conservation in general and specifically by sponsoring the *Acropora* restoration work. A great receptivity exists among resort water sports activity and dive industry staff and there is a need to develop and test the effectiveness of “reef first aid" activities, such as repairing inadvertent damage to corals and removing coral predators from areas of high tourism value.

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