

# Strategy to evaluate *Acropora palmata* outplant design

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*FOREWORD: This document outlines tractable knowledge gaps in applying coral nursery/restocking practices developed rapidly for staghorn coral in its sister species, elkhorn coral. It provides a strategy for specific field experiments that SEFSC and CRF will be pursuing, under advice and input from management partners including FKNMS, NMFS/SERO, Florida DEP and FWC. This does not represent an exhaustive synthesis of related knowledge gaps, but rather a sequence of high priority questions that can be tractably addressed.*

**IMPLEMENTING PARTNERS:** Coral Restoration Foundation and NMFS/Southeast Fisheries Science Center

**GOAL:** Develop science-based guidance on *Acropora palmata* outplanting practice to

- 1) Maximize success (survival and growth) of outplants
- 2) Accelerate the development of restored *A.palmata* thickets
- 3) Bolster remnant *A.palmata* populations

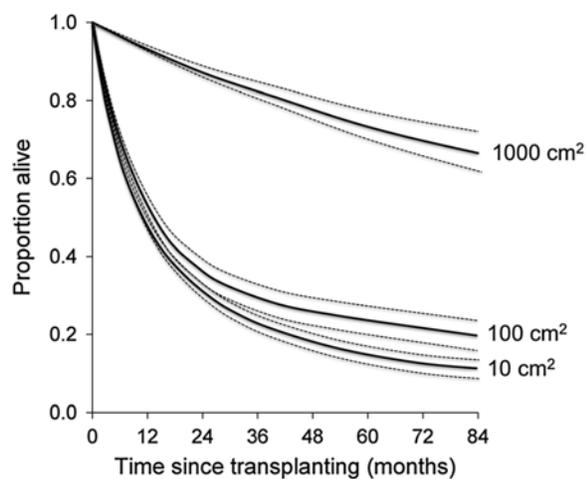
**BACKGROUND:** Much progress has been made in the last decade in the propagation of *Acropora* spp. corals for restoration. Since 2008, much effort in Florida and US Caribbean territories has focused on field nursery propagation of staghorn coral (*A.cervicornis*) and developing science and policy to advance the use of this material in restoring reef populations. Much less culture and virtually no planning/outplanting effort has so far been directed toward elkhorn coral (*A.palmata*), though its habitat distribution, growth form, and genetic structure are markedly distinct from its congener (Baums et al. 2005; Baums et al. 2010; Hemond and Vollmer 2010; Miller et al. 2011). For the first time, the Coral Restoration Foundation (CRF) has built substantial propagated inventory of elkhorn coral and is poised to begin major outplanting activities. This plan describes a collaborative effort between CRF and scientists at NMFS/SEFSC for phased outplanting of *A.palmata* in the upper Florida Keys National Marine Sanctuary to address specific uncertainties in best practices to facilitate not only outplant survivorship and growth, but also recovery goals related to thicket development, enhanced larval production, and bolstering remnant populations.

Existing guidance regarding *A.palmata* outplanting is scant. Johnson et al. (2011) provides the following outplanting guidance, based primarily on experience with staghorn and

in most cases without specific data or scientific reference in support. These general recommendations include:

- Match outplants with origin habitat/environmental characteristics; depth may be particularly important for *A.palmata*
- “at least 5 cm diameter” size fragments for *A.palmata* (no scientific support)
- 50-100 cm spacing to allow access/maximize fertilization potential (no scientific support)
- Background predator abundance and benthic competitors should be avoided
- Rubble should be avoided
- Maximize interspersed of genets
- Spread outplants/risk among several sites
- Current or historical presence of Ap

Other scientific literature regarding *A.palmata* deals with transplanting ‘rescued’ *A.palmata* fragments, either generated by storms or ship groundings (Bruckner and Bruckner 2001;



1: Survivorship of rescued/transplanted *A.palmata* fragments of different sizes in the British Virgin Islands (Forrester et al. 2014)

Garrison and Ward 2012; Williams and Miller 2010; Forrester et al. 2011). However, none of these studies had the luxury of using healthy, unstressed propagated fragments of known genets as are available from CRF nursery culture. The availability of these cultured populations allow us to address more sophisticated questions and restoration goals, over and above the ‘rescue’ of fragments otherwise expected to die. Some information can be gleaned from these transplant studies, however. Generally, larger fragments have higher survivorship than smaller fragments, although the details are difficult to reconcile. Forrester et al.

(Forrester et al. 2014) show the survivorship of fragments of 1000 cm<sup>2</sup> initial size (seemingly slightly over 30 x 30 cm) to be substantially greater than those starting at 100 or 10 cm<sup>2</sup>. However, these were rescued fragments that consistently suffered some tissue loss after transplant which the authors attribute to stress (from breakage and/or transplant). 1000 cm<sup>2</sup> fragments are not considered feasible for volume nursery production nor stress-free transport to outplant sites. Hence, proposed work will focus on testing a smaller range of outplant sizes to maximize both nursery productivity and survivorship/growth.

*A. palmata* is highly restricted in its habitat distribution in the Florida Keys, occurring almost exclusively in fore-reef habitats (Miller et al. 2011). It also occurs, to a lesser extent in back reef/outcrop or 'inner line' reef habitats and some *A. palmata* patches in this habitat type appear to prosper, with high rates of fragment re-attachment (e.g., Turtle Rocks, Horseshoe, Marker 3 Reef in BNP, Williams and Miller pers obs; Looe Key back reef, Causey, pers comm). Preliminary experience with staghorn outplanting in the Keys also suggests that certain genets perform better in different habitat types. Hence, it seems prudent to evaluate the performance of available *A. palmata* genets in these relevant habitat types where it is known to occur.

### **PHASE ONE: Fragment size**

Targeted execution date: May-June 2014

Hypothesis addressed:

H01: Outplants of ~ 8 cm maximum dimension (~40-70 cm<sup>2</sup>) do not differ in (partial and full fragment) survivorship nor growth (proportion of new tissue area added) from those of ~ 10-12 cm dimension (~100 – 150 cm<sup>2</sup>).

Design: N=40 pairs of Large/small fragments transplanted to each of three fore-reef sites (Pickles, Molasses, and French). This outplant will utilize the single most abundant genet (origin from Snapper Ledge). Transplanted to fore-reef spurs at each site (~12-15 ft) without extant live *Apalmata*. Pairs (large and small) will be planted ~ 0.5 m from each other and at least 2 m distant from neighboring pairs. Target 40 pairs at each site for a total of 120 of each size OR 240 total fragments. Response variables will include growth and survivorship of fragments.

## Expt 1: Fragment size

Snapper Ledge genet only

Fore-reef only

2 sizes (~ x and 2x in tissue area)

- \*40 replicates (40 large, 40 small)
- \* 3 (or more) sites
- Aim to standardize the 'disturbance' status (i.e. time since being snipped) for the two treatments
- Frags spaced 0.5m from pair; pairs spaced 2 m from each other



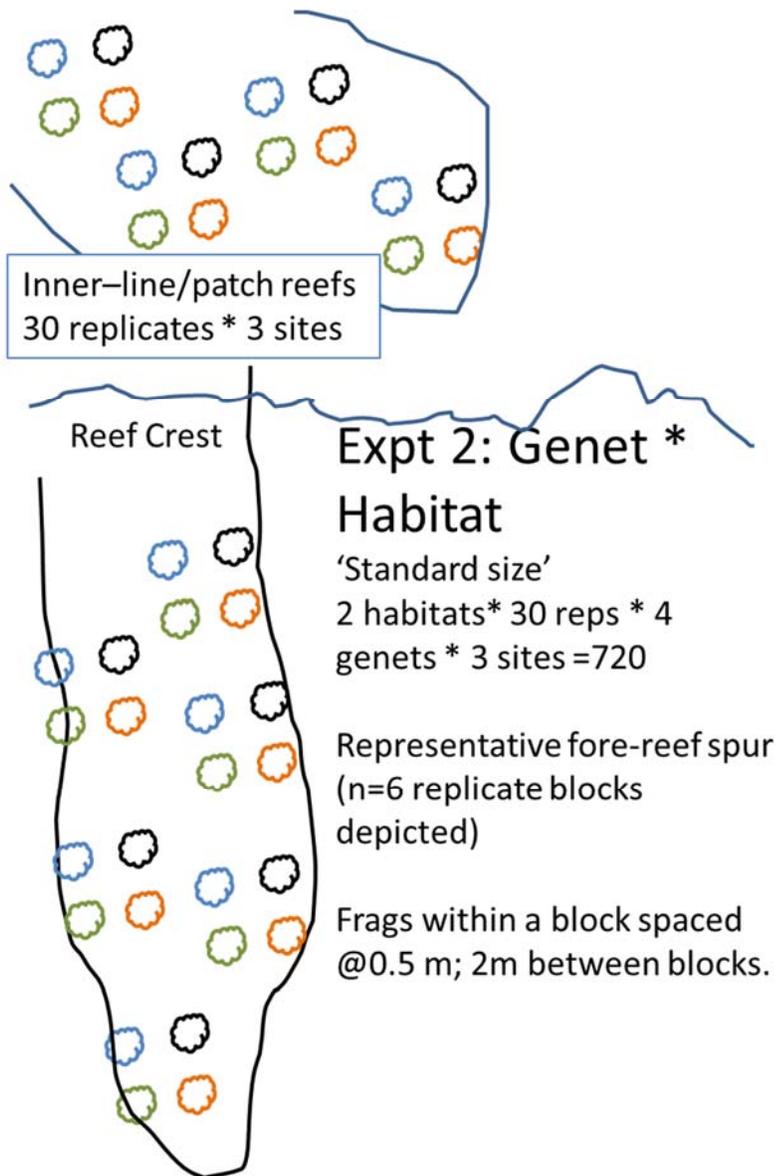
2: Schematic (not to scale) illustration of five replicates depicted on a single reef spur

## PHASE TWO: Genet\*Habitat performance

Targeted execution date: Fall 2014

H02: Outplants of 4 different genets have similar survivorship and growth rates in fore-reef versus non-foreereef habitat types.

NOTE: While the majority of extant/remnant *A.palmata* populations in Florida are restricted to fore-reef habitats, several exceptions (i.e. non-foreereef sites) display thriving populations (e.g., Horseshoe, Turtle Rocks, Marker 3 Reef in BNP). Hence,



Proposed sites: Three fore-reef (Pickles, Molasses, French) and three non-fore-reef (White Bank, south Horseshoe (opposite end of the reef from the extant *A.palmata* thicket), and North Dry Rocks

Design: Four *Ap* genets planted in blocks of 4 on A) fore-reef spurs, B) back reef outcrops, and possibly C) inner line/patch reefs. If we use  $n=20$  at  $3\text{sites} * 3$  habitats; 180 of each genet. Blocks of four fragments (one of each of the four genets @ 0.5m from each other) will be positioned at 2 m spacing. Response variables will be growth and survivorship of fragments.

3: Schematic (not to scale) illustration of several replicates in each of a fore-reef spur and a patch or 'inner line' reef habitat

PHASE I-II SUMMARY:

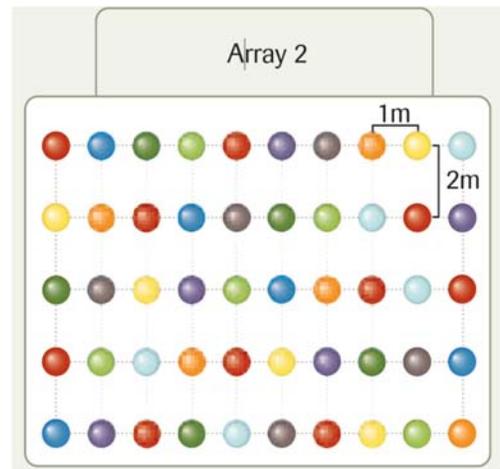
	Genets used	Proposed sites	Treatments	Total frags
Expt 1 (size)	SL	PI, ML,FR	Large and small;	240 (120 large, 120 small for n=40 at 3 sites)
Expt 2 (genet * habitat)	SL, HS, CN, PI	PI, ML,FR (fore-reef spurs) WB, HS (south), NDR ('patch'reefs)	Fore-reef spurs vs. 'inner line'/patch reefs; four genets each	720 (180 of each of 4 genets); N=30 for 2 habitat types

**PHASE THREE: Genet interspersion and spacing to facilitate thicket formation**

Planned execution: Spring 2015

Background: The formation and prevalence of thicket structures of *A.palmata* is a major aspect of the proposed recovery criteria for this species due to the habitat and structural advantages.

Previous outplanting guidance for staghorn coral indicates that for the purposes of maximizing cross-fertilization and larval production, that available genets should be interspersed individually in outplant arrays (Johnson et al. 2011, Box 7). However, *A.palmata* colonies of the same genet commonly fuse when growing in proximity and it is hypothesized that this fusion may enhance the structural integrity of *A.palmata* thickets. Thus, it may be that planting interspersed 'patches' of each genet would enable colony fusion on a small, faster scale, than interspersing all individual genets. Meanwhile, the spacing of individual outplants or outplant patches also requires testing as results to date for staghorn suggest advantages for both lower densities (especially when predator abundance is high) and for higher densities (potential positive feedbacks with resident fishes). Hence, we propose to test if planting mono-typic versus polytypic patches of outplants at different spacings results



4: Suggested *A.cerv* outplanting array from Johnson et al. 2011, Box 7 with each color representing a distinct genet. This is analogous to the 'mixed 1m grid' treatment depicted in Fig 5 below for possible design of Phase III experiment.

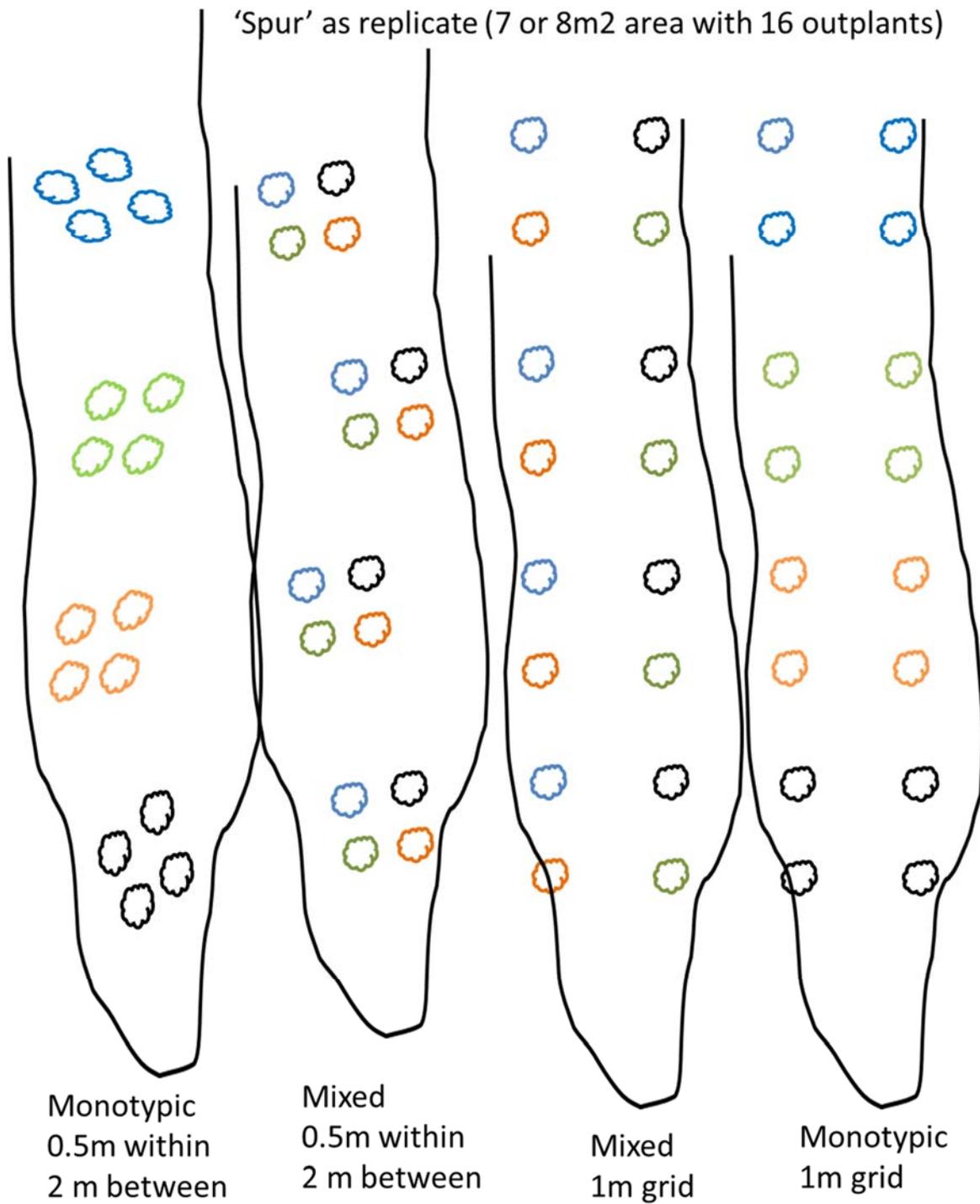
in the greatest cover, structural development, and/or fish occupation (i.e. this experiment involves additional response variables over and above individual fragment performance). This experiment will be confined to fore-reef habitat and involve as many genets as there are adequate fragments available at the time of execution (target 12 genets). We will utilize preliminary results from the Phase I and II experiments for the size and whatever insights regarding genet\* habitat performance to refine this proposed design. It is expected that meaningful results from this experiment would take multiple years to develop as the growth of fragments would be adequate to yield fusion and/or merging into thicket formations

Hypothesis addressed:

Ho1: The scale of genet interspersion and the spacing of fragments does not affect the speed of development of Ap 'thicket' structures.

Design and Sites: TBD (rough idea given in figure below). In addition to fragment growth and survivorship, more reef scale response variable (e.g., fish occupation, degree of colony fusion, or 'thicket size') should be incorporated in this phase. For this reason, it is anticipated that a reef area (e.g., spur) would serve as the experimental replicate rather than the coral fragment.

'Spur' as replicate (7 or 8m<sup>2</sup> area with 16 outplants)



5: Schematic for potential Phase III spur-scale treatments testing outplant spacing and genet interspersión. It is likely that more than 4 genets would be incorporated in this design (as available)

**PHASE IV: Supplementation of wild *A. palmata* populations to enhance genotypic diversity of depauperate stands and/or bolster dwindling natural patches.**

Background: Recent results have shown that remnant *A. palmata* patches in the upper Florida Keys showed a significant decline in genotypic diversity between 2006 and 2010, during a period when the overall abundance of *A. palmata* was actually recovering (Williams et al. In Press). This result strongly suggests that larval production is impaired by low genotypic diversity in this region. Hence, genotypic 'supplementation' of extant low-diversity stands should be considered. Similarly, long-term monitoring of *A. palmata* in the upper Keys has shown that the amount of *A. palmata* dwindles in some individual plots (single spur scale; 7m radius) while others are expanding. We also propose to test the possibility to 'jump start' dwindling or incipient patches of *A. palmata* by genotypically diverse outplants.

Planned execution: Spring 2016

Design and Proposed Sites: TBD

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