Pilot Testing of a Technique for Restoration of Red Mangroves in High Energy Environments

Jason Krumholz[1], Todd Barber [2], and Catherine Jadot[3]

[1] University of Rhode Island Graduate School of Oceanography, Narragansett, RI 02882 [3] School for Field Studies, South Caicos, BWI

[2] The Reef Ball Foundation, Athens GA, 30606

The Three Part Restoration System

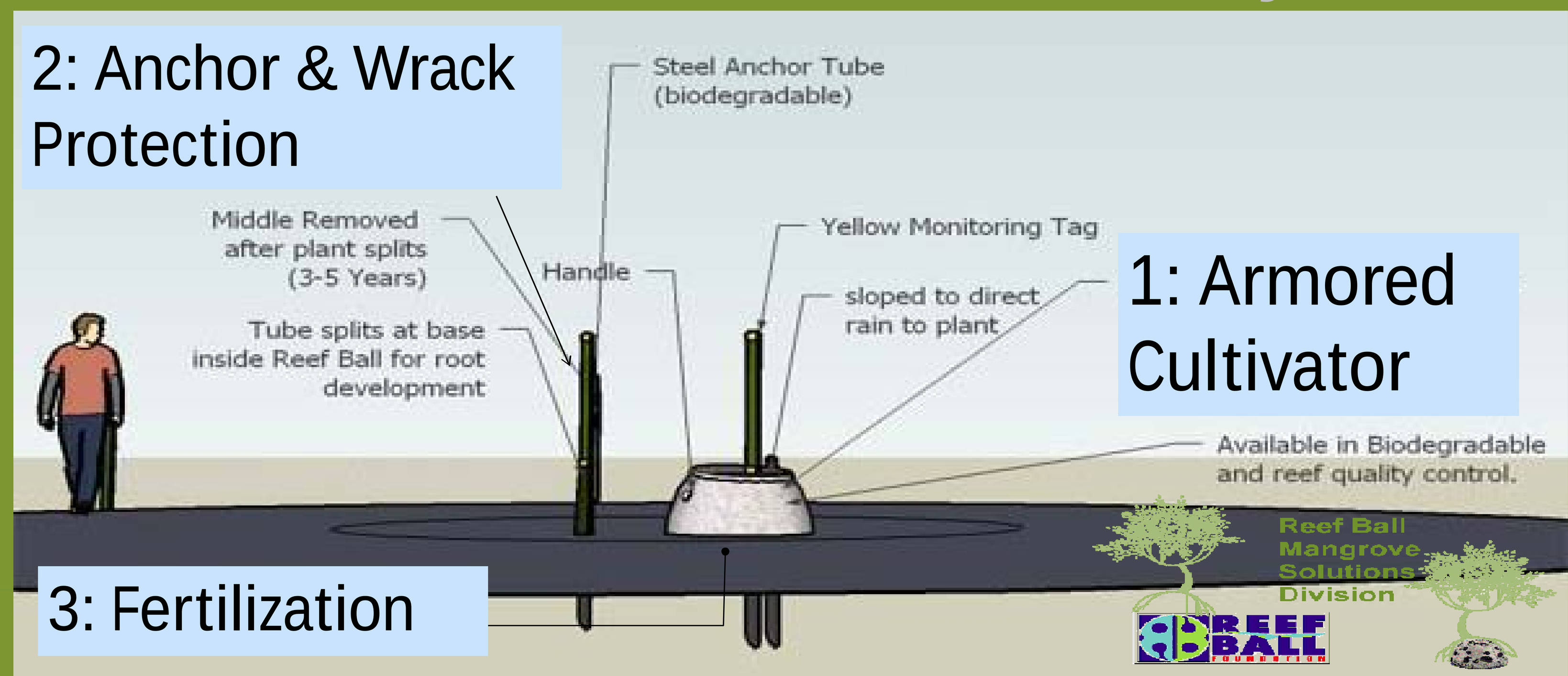

Figure 1: Conceptual drawing highlighting features of red mangrove restoration system.

Armored Cultivator

- •Made from 'reef-safe' pH neutralized concrete.
- •Stabilizes plant against waves , tides and debris.
- •Convex drainage holes provide water exchange while minimizing washout.
- •Can be constructed as permanent or biodegradable.
- •Hollow design creates a controlled space with reduced competition to facilitate initial root development.

Figure 2: Armored cultivator units awaiting deployment.

Wrack Protection & Anchoring

- • Modified from REM Method (Riley and Salgado Kent, 1999).
- •Fits through top hole in armored cultivator.
- •Mangrove grows out of the protector after approximately 12-18 months.
- •Hollow steel anchor tube is cut at an angle to provide access to soil for roots.
- •Presently, the wrack protector is designed to break open and be removed after 3-5 years.
- •We are investigating biodegradable options for this step.

Figure 3: Close up of wrack protection and anchoring system. Anchor tube is angled at the top to enlarge split in wrack protector, helping roots access soil inside the cultivator.

Fertilization System

- •Delivers slow release fertilizer directly to the roots, minimizing risk of washout and damage to sensitive ecosystems.
- •Fertilizer disc made from cement fortified plaster.
- •Designed to last approximately 12 months in situ.
  - ➢Breaking strength after 12 months: 3-5 kg
- •Cast with holes to allow root penetration and exchange.
- •Disc fits snugly into base of cultivator unit.
- •Fertilizer amount and spectrum can be customized for specific projects (e.g. N vs. P limited environments).

Figure 4: Fert –Discs undergoing laboratory tests. Note structural integrity of cement fortified (left) vs. unfortified (right) plaster

Research Summary

Restoration of red mangroves (*Rhizophora mangle*) in high energy environments, while critical for erosional stability, has proven difficult using traditional direct planting or split PVC methods (e.g. Riley and Salgado Kent, 1999). We present preliminary results from a pilot test of a new restoration technique (Figure 1) designed to provide stability, protection, and nutrients to young red mangroves until they are self sufficient. The technique is designed to be as environmentally neutral as possible, by using biodegradable and reef safe materials and delivering fertilizer using a fortified plaster disc to minimize wash out and advection. Preliminary results indicate annual survival rate of 94% with growth equivalent to or greater than controls. No correlation between survival or growth rate and planting depth was observed within the limited range of planting depths used in the pilot study.

Field Pilot Study

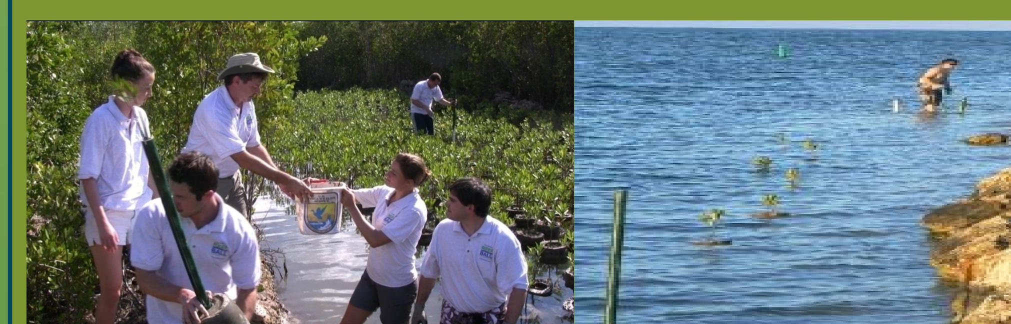

Figure 5: Juvenile mangroves being transplanted from experimental nursery (left) into field pilot site. Note use of armored cultivators with and without wrack protection. (Photos : D. Hudson)

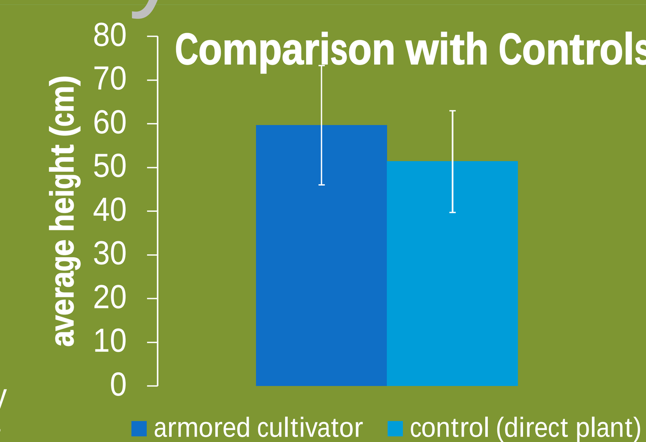

Figure 6: Comparison of growth rates between armored cultivator and controls. Though average height of juveniles in cultivators is slightly higher, the result is not statistically significant (α=0.05, p=0.13)

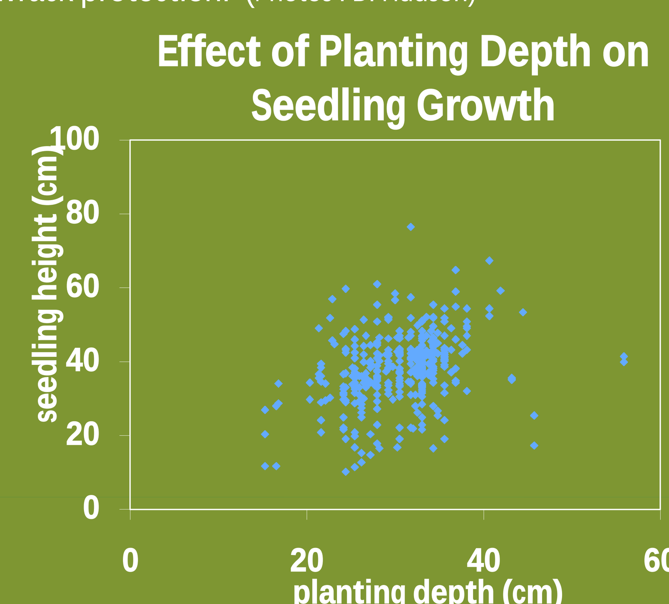

Figure 6: Effect of planting depth on seedling growth in experimental nursery area. No significant relationships are observed, although growth may be retarded at depth extremes. Growth measurements taken at 450 days.

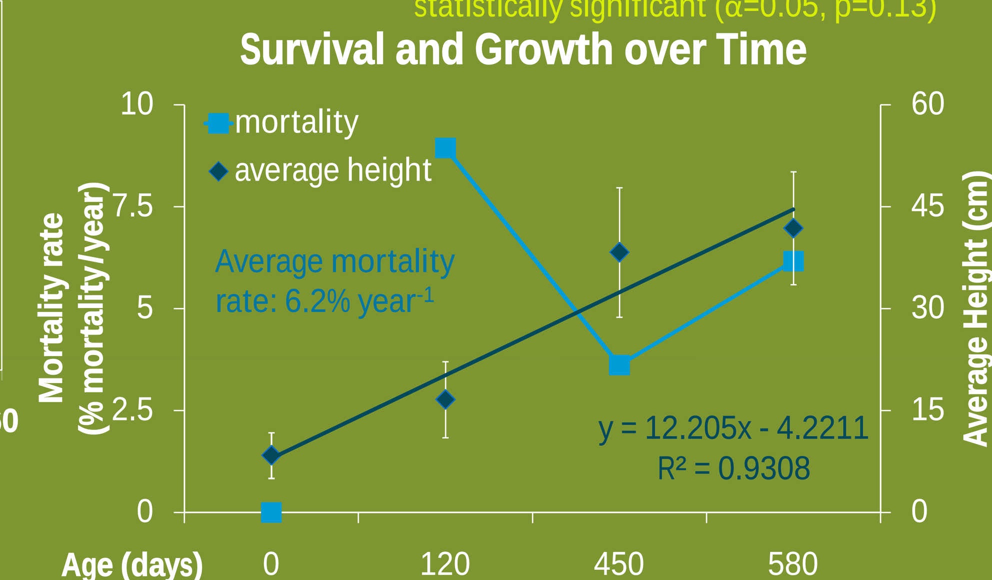

Figure 7: Growth and mortality rate of juvenile mangroves in experimental nursery. Mortality rate is calculated as percent annual mortality where the observed mortality rate at each monitoring event was standardized against the time between monitoring. Linear growth approximation provides best fit to data. Error bars are 1σ

Initial Results

- •850 units of various types deployed in experimental nursery and field pilot sites at Cayman Islands Sailing Club, and South Sound (Grand Cayman, BWI) in November, 2006, January 2008, and June 2008
- •Growth rates are comparable to controls, and growth and survival are within the range of expected literature values.
- •Preliminary results indicate that within the range of conditions observed in this pilot study (which was very limited) growth and survival are not correlated with each other, or with planting depth.
- •Mortality and growth may be impacted at the extremes of the observed range (and beyond), but insufficient data exist to draw any statistically defensible conclusions
- •Future research includes continued monitoring of growth and survival (especially in response to storms), and evaluation of sensitivity of this technique to variation in environmental condition such as planting depth, light, soil type and exposure level

Other Estuarine Uses of Reef Ball Technology

Fisheries

Designed artificial reefs produce habitat and attract commercially and recreationally important fish species. They have been used to augment fisheries, draw fishing pressure away from overfished natural habitats, and mitigate damage to rocky and coral reef environments from anthropogenic activity. **Left:** Grouper cruises a fully overgrown reef ball in Iran. **Right:** Tautog hovering over a reef ball in Narragansett Bay (Photos: www.reefball.org)

Oysters

Designed artificial reefs provide ideal substrate for cultivation of oyster spat or facilitation of natural bivalve recruitment. **Left:** Divers monitor growth of oyster spat seeded onto a reef ball in Maryland. **Right:** A juvenile Black seabass takes refuge inside an oyster covered reef ball. (photos: MES)

Works Cited & Acknowledgements

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Acknowledgements

The authors would like to thank Dr. Candace Oviatt and Brooke Longval (URI/GSO) for facilities use, expertise, and assistance with the nutrient samples. We would also like to thank Tim Austin and James Gibb (Cayman Islands DOE), Ben Chisholm and Larry Beggs (Reef Ball Foundation), Jocelyn Dineen (Scotts Corporation), and David Hudson for their contributions to this work. This project was funded by an NSF IGERT grant through the University of Rhode Island Coastal Institute. Supplies were also donated by the Reef Ball Foundation and the Scotts Corporation.