Development of a Restoration Technique for Red Mangroves (*Rhizophora mangle*) in High Energy Environments

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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 demonstrate an initial field test for a new three part method using armored concrete cultivators (Figure 1) to provide stability, protection and nutrients to young red mangroves until they are self sufficient. In order to minimize wash-out and advection of fertilizers into potentially sensitive systems such as coral reefs, we have developed a semi-enclosed slow release fertilizer delivery system using traditional Osmocote ™ fertilizer encased in cement fortified plaster of paris discs.

The Three Part Restoration System

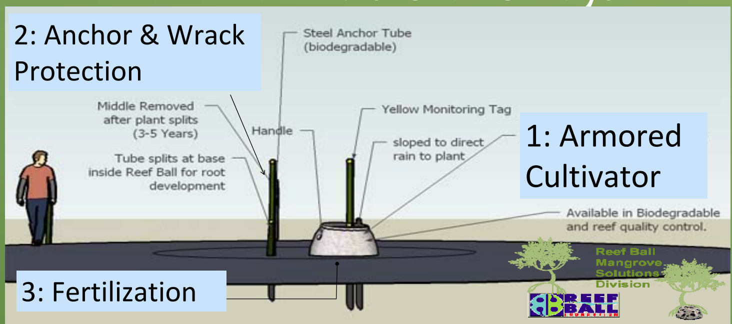

Figure 1: Conceptual drawing highlighting features of red mangrove restoration system. (image courtesy of www.mangrovesolutions.com)

The 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

Figure 2: Armored cultivator units awaiting deployment. (photo: J. Krumholz)

Part 2: 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

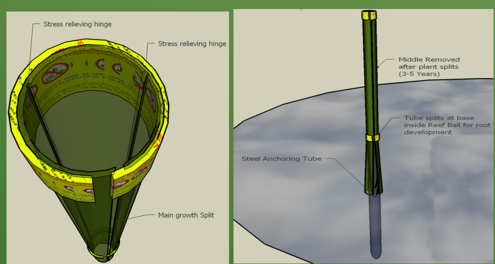

Figure 3: Close up of wrack protection and anchoring system. Wrack protector is hinged and designed to be removed after 3-5 years. Anchor tube is cut at an angle to enlarge split in wrack protector, allowing roots access to soil inside the armored cultivator.

Fertilization System

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

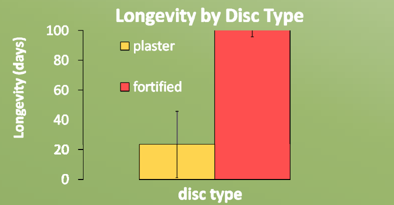

Figure 5: Longevity of Fert-Discs in laboratory setting. Error bars are 1σ

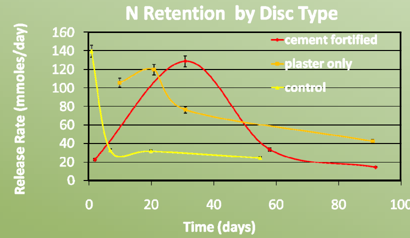

Figure 6: Retention times and release rates of nutrients by Fert-Discs. Error bars are mean RSD .

- Fertilizer application can be customized for specific projects
- Fert-Disc fits snugly into base of cultivator unit
- Preliminary laboratory collected durability and release rates compare well with literature vales, in situ pilot experiments are underway

Field Pilot Study

Figure 7: 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)

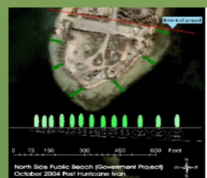

Figure 8: Schematic of proposed future experimental restoration project at Kaibo Beach Club, Grand Cayman, BWI. Proposed planting depths range from 20-40cm.

- 850 units deployed in experimental nursery and field pilot site at Cayman Islands Sailing Club (Grand Cayman, BWI) in November, 2006
- Preliminary monitoring indicates that growth and survival are both within expected values.
- Preliminary results indicate that within the range of anticipated planting depths, growth and survival are relatively consistent
- Mortality at the extremes of this range (and beyond) may be somewhat higher, but data are sparse

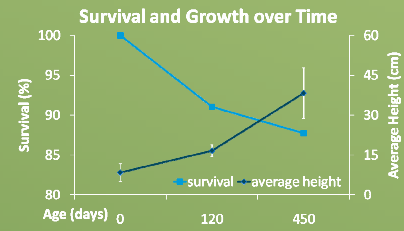

Figure 9: Growth rate and survival of juvenile mangroves in experimental nursery. Error bars are 1σ

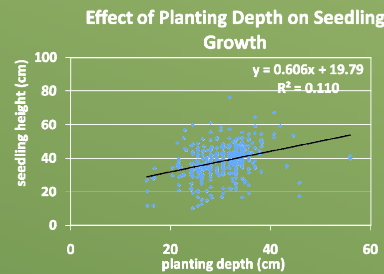

Figure 10: Effect of planting depth on seedling growth in experimental nursery area. Growth measurements taken at 450 days.

Future Work

- More Data is required to determine effect of planting depth on growth and mortality
- Full scale experimental restoration project at Kaibo Beach Club scheduled for April, 2008

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