Living Shorelines: Estuarine erosion control engineering that provides robust habitat benefits:
A novel engineering approach creating stability and resilience using oyster reef technology

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Introduction

Conventional shoreline sediment control structures used in estuarine settings including cement and steel interlocking sheathing, recycled concrete infrastructure (rip-rap) and treated wood bulkheads offer little in marine habitat values. Additionally, these conventional practices typically create a vertical barrier which inhibits or stops wetland-to-upland migration of organisms which need these upland-to-water passages to complete critical life history stages. In this study, conducted on Sapelo Island, GA (**Figure 1**), a partnership team designed and constructed a variety of shoreline sediment control treatments to test the feasibility and potential benefits of using oyster shell technology to enhance habitat benefits and form living oyster reef. The optimal treatment of loose oyster shell placed within polyvinyl bags was based upon the successful oyster reef restoration efforts of the UGA Marine Extension Service, tested within local estuarine waters. Oyster spat recruitment and subsequent oyster reef development provided tremendous stabilization to the structures by the oysters' cementation and calcification processes. The complete array of experimental treatments included polyvinyl netting shell-bags, loose oyster shell and granite rock within a wire gabion matrix, rock and shell bags in gabion and rock only within gabion wires. Although all treatments have preformed well for erosion control this presentation will only describe the "optimal" treatment response related to habitat (oyster reef) formation at the optimal site (Ashantilly; **Figures 2 and 3**). Efficacy metrics are based upon oyster colonization indices including: oyster size, biomass and density. Additionally, the survival of native vegetative plantings in the inter-tidal and supra-tidal zones and the rebound of non- planted native vegetation were also used as a "success" criteria at the Ashantilly site.

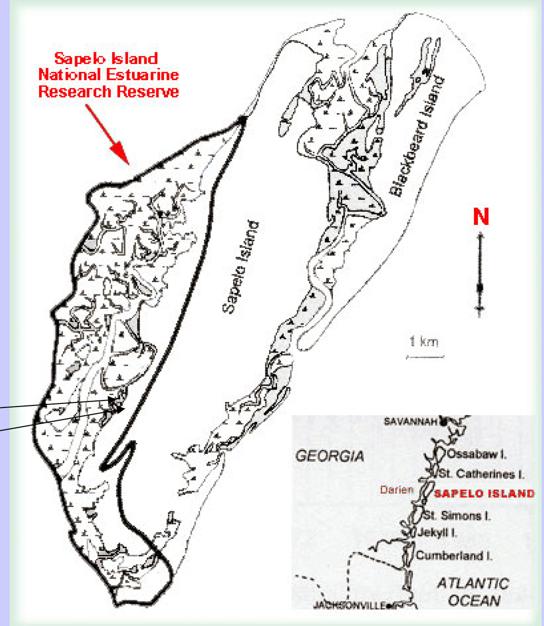


Figure 1. Site map showing island and experimental site locations :

Ashantilly site

Long Tabby site

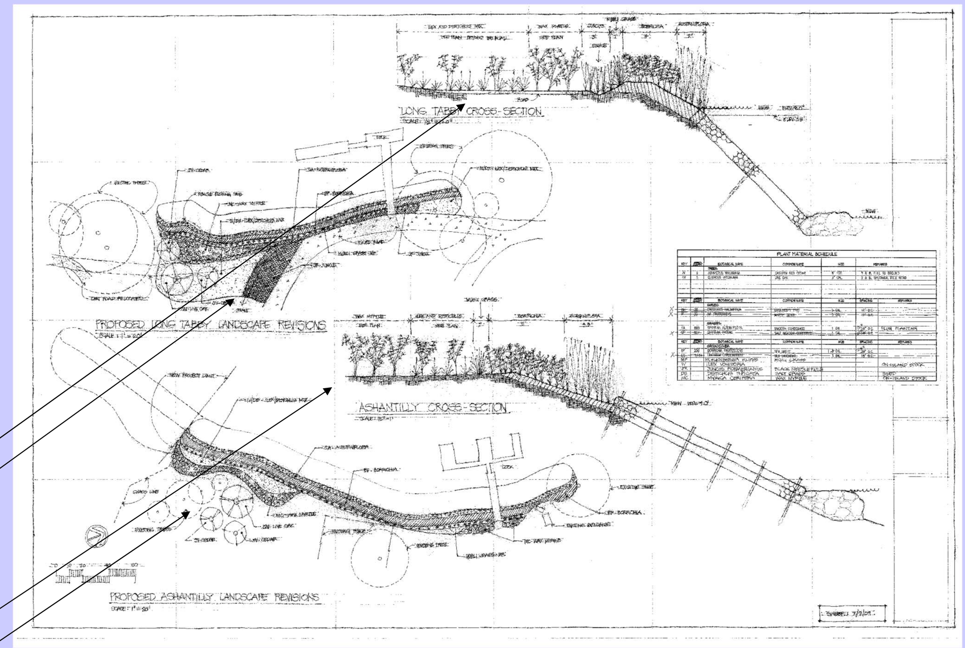
Figure 2. Photo of the Ashantilly site (Pre-construction erosion)

Figure 3. Photo of the Ashantilly site 1 year post-construction; insets:
A: native plant community zonation
B: oyster recruitment

Materials and Methods

Construction: Construction practices at the sites (initiated in January, 2010) included drafting of an engineering plan (**Figure 4);** followed by a 1 to 2 (Rise/Run) mechanical grading of the bank (Ashantilly). A water barrier (geotextile) was emplaced from the low-intertidal zone and up the bank to the primary oyster settlement area.(**Figure 7**). This layer inhibited bank saturation and undermining of the shell bag treatments by tidal and upland run-off waters. Loose shell was then shipped from North Carolina and bagged by local volunteers effort. This shell bagging effort (over 25 sessions resulting in 1573 volunteer hours; **Figures 5 and 6**) was precluded by an educational presentation and discussion on the significance and applications of living shoreline treatments and conservation strategies associated with habitat restoration and human adaptation to sea level rise (SLR). Bagged shell was then barged to the site, emplaced in a bedded array and stabilized using wooden stakes as temporary stabilizers (**Figures 7 and 3**). Following emplacement of the bagged oyster shells, native vegetation was planted by staff and volunteers at intertidal: (*Spartina alterniflora*); transitional: (*Iva frutescens, Distischlis spicata, Borrichia frutescens)* and supratidal: (*Ilex vomitoria, Quercus virginiana, Juniperus viriginica*) zones (**Figure 8**).
Scientific: Pre-construction photo points and biological monitoring of existing habitat (oyster reef and vegetation) elements at the site were recorded for later post-construction (time "0" and years 1 and 2) coverage and colonization analysis. Monitoring methods for oyster (*Crassostrea viriginica*) resources are based upon oyster counts, size measurements(mm), biomass(grams/ dry weight) and mortality (live vs. dead) at multiple (3) ¼ x ¼ meter^2 plots within each of nine (9), equally spaced intervals (40 meters each) along the entire linear length of the shoreline treatment. Expected values for recruiting and comparative oyster density (Hadley et al., 2009; Luckenbach et al., 2005; Brumbaugh & Coen, 2009); and size (Hadley et al., 2009) were obtained and oyster biomass estimates were achieved using the acquired size frequency information and then converted to biomass (grams dry weight per meter squared) according to Dame (1972). Planted vegetation, volunteer vegetation recruitment and oyster recruitment were mapped one year post- construction using standard GPS technology (Magellan MobileMapper 6) by making multiple passes along each mapped parameter (**Figure 11; inset**).

Figure 4. Cross sectional engineering plans of the two experimental sites including schematic of bank slope, #1 granite toe and inter-tidal and supra-tidal vegetation plantings.



Long Tabby Site

Ashantilly Site

Figures 5 and 6: Public participation with shell bagging efforts contributed over 1500 volunteer hours.

Figure 7. Emplacement of the oyster bags showing moisture barrier, temporary wooden stabilizing stakes and granite toe rock at base of treatment.

Figure 8. Emplacement of supratidal native plantings by volunteers overseen by professional arborist contractors.

Results

Preliminary results at year one include: oyster reef assessment of recruitment numbers, biomass, mortality and size (**Figure 9**) across both living shorelines. Additionally, a size frequency distribution was developed to compare oyster growth at the Ashantilly site (**Figure 10**) with the aforementioned alternative living shoreline treatments (see the Introduction). Vegetation was monitored and mapped for percent coverage and location at the intertidal, transitional and supra tidal zones one year after planting (**Figure 11**).

Figure 9. Ashantilly site mean habitat development metrics at one year post-construction. Points are based upon triplicate plot samplings in each of the 9 longitudinal zones (27 total subsamples) of the living shoreline.

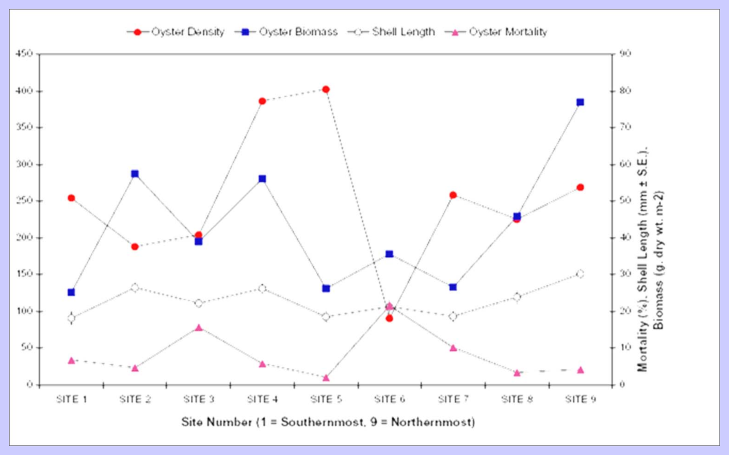


Figure 10. Ashantilly site oyster size (mm) frequency distribution used in estimating total oyster biomass and for a comparative efficacy metric against the less optimal Long Tabby site.

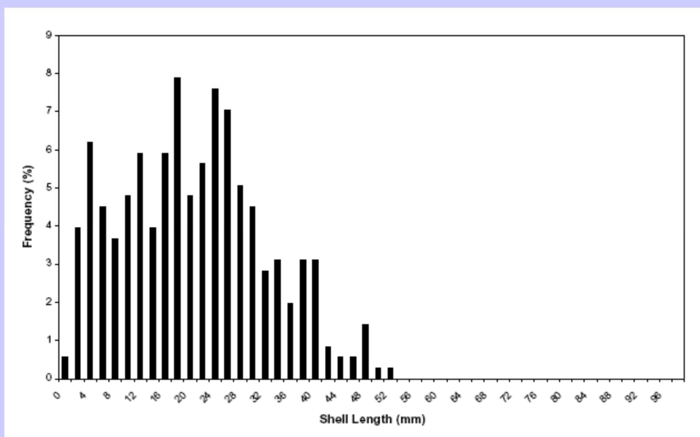


Figure 11. GPS qualitative mapping of the Ashantilly site showing supra-tidal vegetation groundcover, extent of primary natural oyster colonization (red) and the multiple passes GPS mapping technique (inset).

Discussion and Preliminary Conclusions

Several preliminary and highly beneficial ecological and social outcomes have been achieved through the interagency collaboration, policy and public venues associated with this project. The reef has achieved significant stabilization due to colonization and subsequent cementation of recruiting intertidal oysters by Fall 2011 (**Figure 3, inset**). Intertidal oyster settlement in Georgia estuaries can exceed 3000 spat per meter square per month at the two living shoreline sites. Although metrics have not been analyzed on many of the secondary marine biodiversity components of the shoreline, finfish, crustacean and inbenthos abound within the reef and are expected to enhance even more over time. Additionally, by providing marine and terrestrial fauna with a transmigration corridor this type of shoreline enables the migration of macrofauna with essential life-history needs. Public participation and collective partnership educational programming associated with each oyster bagging session have allowed for a tremendous public awareness venue which has precipitated a groundswell of interest. This awareness has occurred not only through the direct applications of the project participants, but also in associated subject matters such as sea level rise (Craft et al. 2008) and human adaptation issues in response to increasing tidal and marine water inundation. The project has promoted components of the climate change education venue including "green" solutions to human and coastal adaptation needs and enhanced public awareness of conservation planning and strategic planning to ensure the maintenance and sustainability of coastal biodiversity. The project is still undergoing longevity and cost analysis in comparison to conventional armoring practices. The results of this project have been met with great appeal in a diversity of venues involving several agencies, practitioner and academic groups. This shoreline erosion control method is anticipated to become a preferred Best Management Practice (BMP) over conventional engineering within appropriate areas of the Georgia coast and possibly regionally. Also, project partners are scheduling a Georgia Marshland and Shoreline Protection Committee presentation for the use of the technology as a "green" alternative to conventional coastal erosion control practices.

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