Living Shorelines: Using created oyster reefs and science to develop better erosion control structures for coastal Georgia.

Scott Coleman[1], **J. Mackinnon[2*]**, T. Bliss[3], C. Lambert[4], S. Knox[5], D. Hurley [6], E. Hoffman [7], T. Angell [8] and T. Havens [9]

* Corresponding author

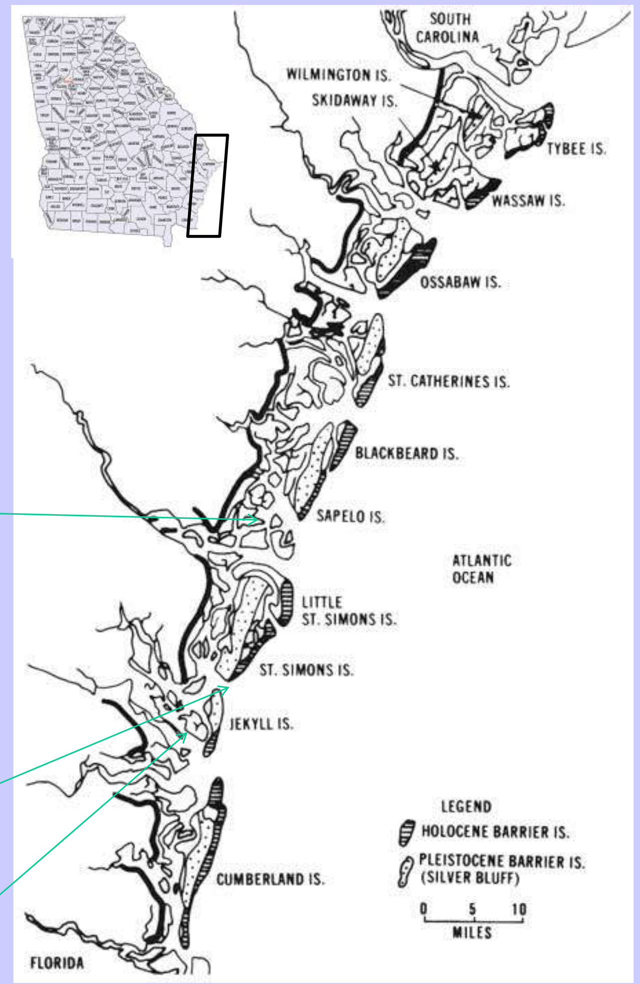
Introduction

Living Shorelines (LS) are novel engineering approaches which provide construction alternatives to conventional shoreline armoring practices such as interlocking sheathing, treated-timber bulkheads, and rip rap (granite bank dumping). Living Shorelines are constructed to protect uplands lying adjacent to estuarine waters from erosion while also providing habitat and wildlife benefits. For several years the partners involved in the projects presented here have experimented with bioengineering and native vegetation plantings to advance and improve shoreline stabilization technology. We have completed three projects to date - Sapelo Island LS and Little Saint Simons LS (LSSI) and a forth (Cannons Point on Saint Simons Island LS) will be implemented this year **(Figure 1)**. Locations for sites have been selected based upon need, available funding, and institutional support for the research. The overarching goals of these collective projects are to use science to quantify the ecological benefits of this type of shoreline erosion control compared to conventional practices, while also experimenting with techniques that would be practical and cost-effective for, and could be adopted by, typical coastal shoreline homeowners. In addition, this novel approach to bank stabilization can be seen as advancing technology that will make an important contribution to the ability of human populations to adapt to Sea Level Rise (SLR) along Georgia's lower coastal plain.

1a. Post Office Creek site, Sapelo Island, Installed: May, 2010

1b. Mosquito Creek site, Little Saint Simons Island, Installed: July, 2013

1c. Cannons Point site, Saint Simons Island, Installation slated for May, 2014



Figures 1a, b and **c.** Site map and photos showing current **(1a, 1b)** and future **(1c)** experimental Living Shoreline locations and current status.

Materials and Methods

Construction practices at the sites included the drafting of an engineering plan **(Figure 2a**: **LSSI)**; which included recommendations for grading the existing bank, materials to be used, and an integrated re-vegetation plan **(Figure 2b).** An oyster bag containment -wrap (geotextile) was emplaced from the banks crest to toe (low-intertidal zone) and then rolled back up the bank encasing the bottom layer of oyster bags **(Figure 3)**. The geotextile layer inhibited undermining of the shell bag "building blocks" by tidal and upland run-off waters, while also stabilizing the bank in a contiguous manner. The LSSI shoreline was also designed with interspersed *Spartina alterniflora* plantings directly within the shell bag area **(Figure 2b).** This approach more closely mimics natural shoreline with a matrix of oyster reef and intertidal emergent vegetation. In addition to altering the vegetation plantings regime of the Sapelo site, the LSSI project included a study of finfish and shellfish presence at the new LS site, as an indicator of habitat quality. This work was conducted by the Marine Extension Service, Shellfish Lab. A bottomless lift net sampling technology was employed to quantify the abundance and diversity of finfish before and after construction of the shoreline **(Figure 4**, **Table 1**; respectively**)**. Similarly, shellfish and motile nekton (such as crabs) were also sampled using standard field methods for spatial occupation and occurrence. Supratidal and intertidal vegetation planting included only appropriate native species (*Spartina alterniflora*, *Spartina bakerii*, *Spartina patens*, *Borrichia frutescens* , *muhlenbergia filipes*, *Ilex vomitoria*, *Andropogon glomeratus* and others). Many of the plants used were relocated from on-island stocks **(Figure 5)**, while others were purchased from state-approved nurseries. Pre-construction photo points and biological monitoring of existing habitat (oyster reef and vegetation) at the site were recorded for later post-construction (time "0" and year 1- year 3; **Figs. 6a, 6b**; respectively) coverage and colonization analysis. Monitoring methods for oysters (*Crassostrea viriginica*) were based upon oyster counts, size measurements (mm), biomass (grams-dry weight) and mortality (live vs. dead) sampling at multiple (3) ¼ x ¼ meter plots within each of nine equally spaced intervals (40 meters each) along the entire length of the shoreline treatment. Vegetation and oyster recruitment were mapped using standard GPS technology.

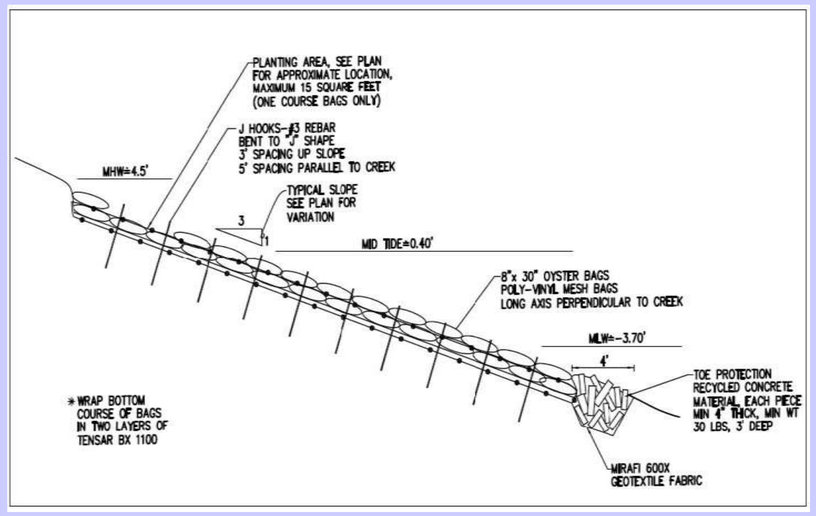


Figure 2a. Engineering schematic for the LSSI site.

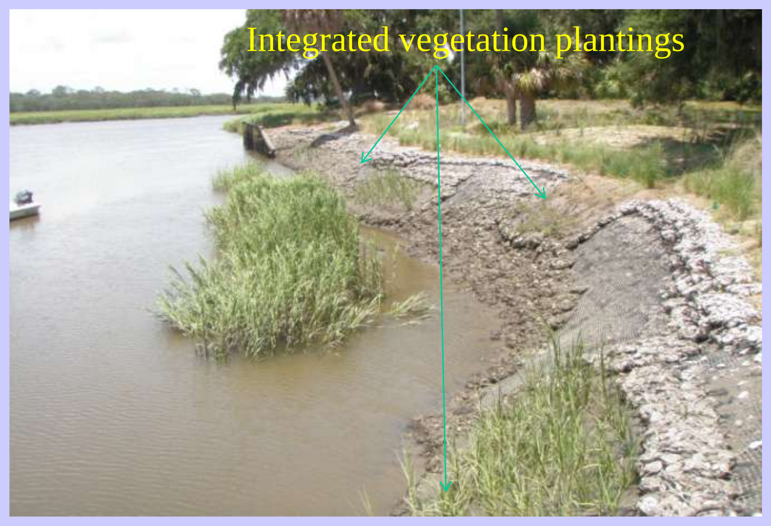


Figure 2b. Actual site (LSSI) during construction.

Figure 3. Photo of bank grading equipment unloading bagged shell and the geotextile fabric used in layering the oyster bags at the LSSI site.

Figure 4. Bottomless lift nets fully-deployed (raised during the peak of high tide). As the tide retreats the nets collect finfish found in association with the Living Shoreline.

Figure 5. AmeriCorps volunteers aid in the removal, relocation and eventual replanting of *Spartina alterniflora* in the intertidal zone of the Living Shoreline.

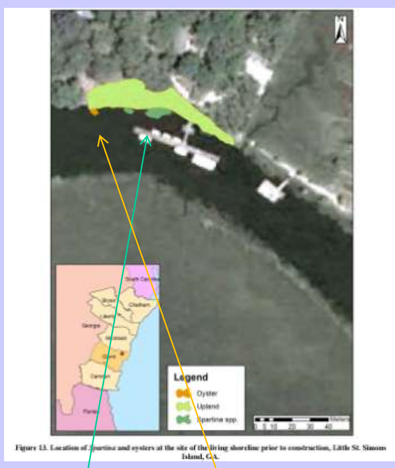


Figure 6a. Pre-construction vegetation and oyster resources of the LSSI site

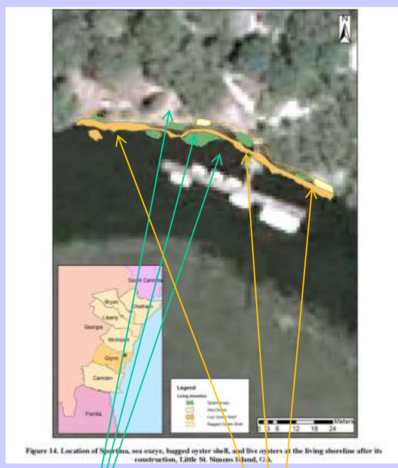


Figure 6b. Post-construction vegetation and oyster resources of the LSSI site

Results

Preliminary results at LSSI site include a 100% increase in finfish species diversity within the LS area after only 6 months of completion **(Table 1, Figure 7)**. Notably, the capture of two juvenile individuals within the demersal (bottom dwelling) species of concern stocks (Dogtooth Snapper *Lutjanus jocu;* snapper-grouper complex) were within the post-construction fish assemblage. Post-construction survival of planted vegetation approached 95% at six months with losses attributed to deer browsing. Significant increases in both bay anchovies **(Table 1)** and grass shrimp (Bliss et al., 2014) were noted after construction of the Living Shoreline. Oyster recruitment (cementation) onto the shoreline across all tidal zones achieved densities between 44-108/m^2 by the end of the first season of available spat recruitment (April- October, 2013). Slight erosion of upland soils occurred directly following construction due a combination of the instability of soils (large grained sands) and the lack of extensive root development by the newly planted (and volunteer) vegetation.

Finfish	Pre - construction	Post - construction
Bay Anchovy	1119	1714
Sheephead	0	4
Silver perch	8	2
Atlantic bumper	0	1
Mojarra	0	2
Threadfin shad	0	33
Bay whiff	0	3
Feather gobi	0	9
Striped killifiah	0	1
Mummychog	6	8
Naked gobi	15	1
Pinfish	0	1
Spot	4	1
Dogtooth snapper	0	2
Atlantic silverside	3	8
Oyster toadfish	2	8
Southern flounder	19	2
Bighead sea robin	1	1
Black-cheeked toungefish	17	8
Northern pipefish	0	1

Table 1. Metrics for finfish species diversity and abundance pre- and post- construction at the LSSI site.

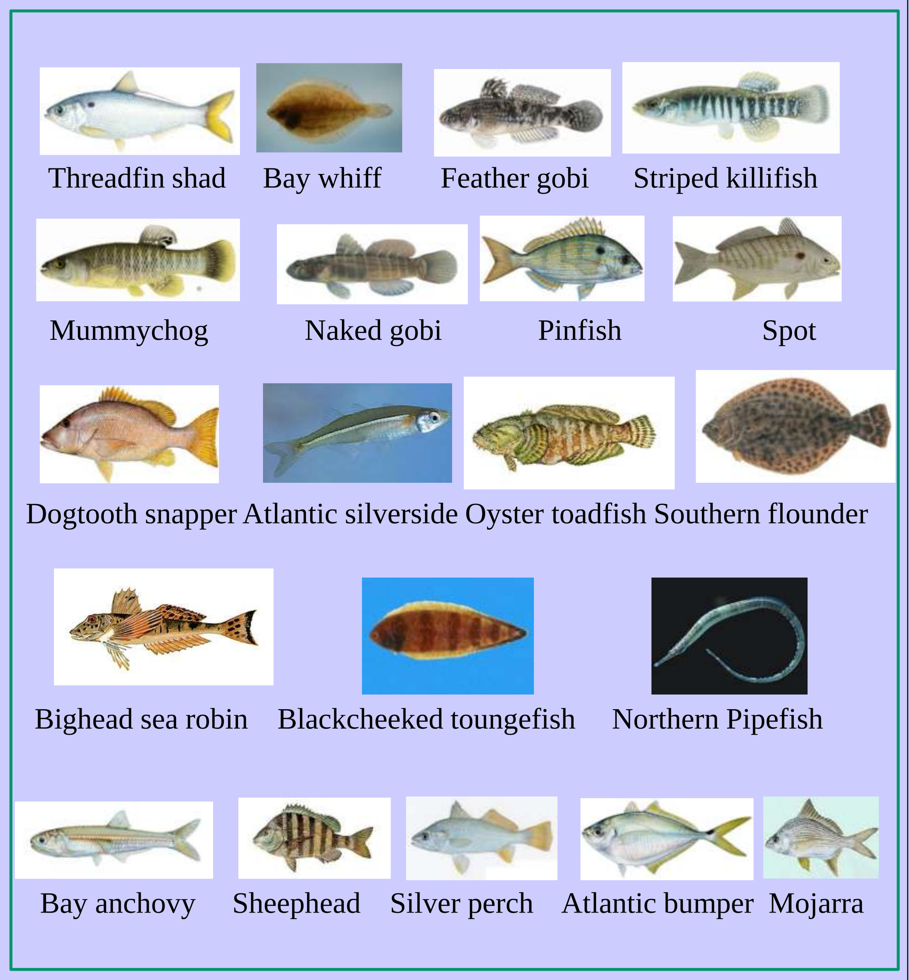


Figure 7. Pictorial display of the finfish diversity captured through-out the first two sample seasons (pre- and post - construction) at the LSSI site. These photos represent, in all cases the adult phase of each species.

Discussion and Preliminary Conclusions

The LSSI Living Shoreline is the third such project conducted by the study authors and partner agencies. Scientific methods have been (and will be) used in all of these Living Shoreline projects, in order to document and quantify the habitat and conservation features of this new shoreline protection and stabilization approach. This information is critically important for demonstrating the utility, effectiveness and beneficial consequences of Living Shorelines to homeowners, public agencies, local municipalities and other entities responsible for managing Georgia's coastal shorelines. This information contributes to our understanding of estuarine processes and can address societal needs in response to sea level rise (Craft et al. 2009). The interspersed vegetative plantings and quantification of native finfish habitat use add conservation value and assessment components to this exciting new technology. The notable increases in grass shrimp (not displayed) and anchovy numbers at LSSI are extremely significant as these species are critical to the diet of predatory finfish (Williams, 1984; Collette and Klein-MacPhee, 2002) as foundation elements of the marsh food web (Baird and Ulanowicz, 1989; Luo and Musick 1991). The post-construction increases in these and numerous other species supports the conclusion that this type of shoreline not only provides enhanced fisheries and habitat value within the immediate area of its deployment, but also contributes to the health and productivity of the entire estuary in which it is sited. The LSSI project has been included within a developing cost-analysis study (GA DNR 2013) comparing conventional soil retention structures with LS, and this information will soon be available to waterfront homeowner. Our Living Shoreline projects have received enthusiastic support from a wide variety of groups, including regulatory agencies, academic practitioners, and nonprofit organizations. We anticipate that this approach will become a preferred Best Management Practice - versus conventional bulkhead-style engineering - within appropriate areas of the Georgia coast, and possibly throughout the Southeast region. The project partners will present Living Shorelines to the Georgia Marshland and Shoreline Protection Committee as a pragmatic, cost-effective and beneficial "green" alternative to conventional coastal erosion control practices, with the added potential for streamlining the permitting process for homeowners who may choose to use this technology.

Literature Cited

Craft, C., J. Clough, J. Ehman, S. Joye, R. Park, S. Pennings, H. Guo and M. Machmuller. 2008. Forecasting the effects of accelerated sea level rise on tidal marsh ecosystem services *Front. Ecol Environ* 2009; 7(2): 73–78, doi:10.1890/070219 (published online 24 Jun 2008).

Baird, D. and R.E. Ulanowicz. 1989. The seasonal dynamics of the Chesapeake Bay ecosystem *Ecol. Monogr.* 59 (4):329-364.

Bliss, T., S. Coleman, J. Mackinnon, D. Hurley and C. Lambert. 2014. , Final Report Prepared For: Southeast Aquatic Resource Partnership: National Oceanic and Atmospheric Administration Community Based Restoration Grant Program Project 3011.

Collette, B.B. and G. Klein-MacPhee. 2002. In. B. B. Collette and G. Klein-MacPhee (eds.). Bigelow and Schroeder's Fishes of the Gulf of Maine. 3rd edition. Smithsonian Press, Washington D.C. Georgia

Georgia Department of Natural Resources (GA DNR). 2013. Living Shorelines along the Georgia Coast. Coastal Resources Division, Brunswick, GA. 56 pp.

Luo, J. and Musick, J. A. 1991. Reproductive biology of the bay anchovy in Chesapeake Bay. Transactions of the American Fisheries Society. 120: 701-710.

Williams, A. B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, D.C.

Author Affiliations

[1]Little Saint Simons Island, Glynn County, GA
[2] Georgia Department of Natural Resources: CRD, Brunswick, GA
[3] Marine Extension Service Shellfish Lab, Savannah, GA
[4] The Nature Conservancy in Georgia, Darien, GA
[5] Saint Simons Land Trust, Cannons Point, Brunswick, GA
[6] Sapelo Island National Estuarine Research Reserve, Sapelo Island, GA
[7] Green Works LLC, Savannah, GA
[8] Verdant Enterprises, Savannah, GA
[9] Coastal Civil Engineering, Savannah, GA

Acknowledgements

Funding for this project were provided by: Little Saint Simons Island, Coastal Wildscapes, The Southern Aquatic Resource Partnership and the NOAA Restoration Center: Community based Restoration Program. Volunteer efforts were sponsored through AmeriCorps NCCC, The Nature Conservancy and Coastal Wildscapes.