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ABSTRACT

A panel session at the Living Shorelines Summit in Williamsburg, Virginia was dedicated to the current understanding of the effectiveness of nonstructural erosion protection methods and marsh sills. Four panelists described their professional experience with either design and construction or monitoring of projects in tidal waters of Maryland and Virginia, including marsh edge stabilization (marsh toe revetments), marsh sills with sand fill, and planted marshes. Their collective experience revealed that planted tidal marshes and supporting structures can be effective alternatives to revetments and bulkheads. Site-specific engineering is required to ensure they provide functional ecological benefits, particularly in medium and high energy settings. Another important factor for effective projects is landowner acceptance of dynamic shoreline conditions and the level of protection provided. Additional project tracking and research is needed to further investigate positive and adverse effects of created tidal marshes and supporting structures.

INTRODUCTION

The principle of living shorelines can be defined as "a shoreline restoration and protection concept that emphasizes the use of natural materials including marsh plantings, shrubs and trees, low profile breakwaters/sills, strategically placed organic material, and other techniques that recreate the natural functions of a shoreline ecosystem" (1). The current paper is a summary of the presentations that were a part of the Living Shorelines Summit held in Williamsburg, VA from December 6 to 7, 2006, with Dr. Kevin Sellner as the facilitator. The most important goals for the panel were to be provocative, to challenge and inspire people about living shorelines projects, and to provide the most current information to increase understanding of the effectiveness of nonstructural and marsh sill approaches. This paper is not a conventional manuscript; rather, it summarizes the collective experience of four shoreline professionals who were directly involved with the design, construction, and monitoring of living shoreline projects. Their work and presentations are summarized below.

THE LIVING SHORELINE: MORE THAN SHORELINE STABILIZATION (Gene Slear)

Approximately 4.7 million cubic yards of sediment cloud the waters of the Chesapeake Bay every year. More than 57% of this sediment load is from tidal erosion, both shoreline and nearshore (2).

Historically, shoreline erosion was managed by installing a wood bulkhead or placing stone against the bank. In the early 1970's, Environmental Concern (EC) constructed a salt marsh channelward of an eroding shoreline at a low-energy cove in Talbot County, Maryland. The marsh thrived, and shoreline erosion was reversed. Over the next two decades, scientists and engineers at EC refined and expanded the initial design, creating sustainable salt marshes in highly erosive environments.

The advantages of the Living Shoreline over the traditional riprap or bulkhead are well-documented. In the interest of clarity, we have presented the advantages in four general categories:

Productivity

The net primary productivity of the salt marsh exceeds that of most ecosystems (3). Tidal marshes provide the primary food sources for the Bay's living aquatic resources (4). Above-ground biomass in created *Spartina alterniflora* marshes on the Atlantic Coast or in Chesapeake Bay quickly reaches parity with natural marshes if basic conditions for marsh establishment and survival are employed (5).

Habitat Enhancement

- 80% of America's breeding bird population relies on coastal wetlands (4).
- 50% of the 800 species of protected migratory birds rely on coastal wetlands (4).
- Nearly all of the 190 species of amphibians in North America depend on coastal wetlands for breeding (6).
- The cost benefit for a living shoreline is significant. For every dollar spent to construct vegetative shoreline stabilization, as much as $1.75 is returned to the economy in the form of improvements to resources, including submerged aquatic vegetation (SAV), fish, benthic organisms, shellfish, waterfowl, and wetland habitat (7).

Water Quality

The salt marsh traps silt and pollutants, including nitrogen and phosphorus contained in stormwater runoff and receiving waters (8, 9). However, only 30% of the nitrogen load is from surface runoff; the balance moves unimpeded to the Bay's waters via sub-surface flow and groundwater. When this flow encounters a salt marsh, denitrification will likely occur. Denitrification is an important but little known marsh process. Simply stated, high productivity plants such as salt marsh vegetation move large amounts of biomass (carbon) below ground to provide electrons necessary to drive a process which converts elemental nitrogen to N_2 (an inert gas), thereby dampening coastal eutrophication (10).

Shoreline Stabilization

Reduction of wave height (wave attenuation) and thus the severity of the impact at the upland bank is a function of wave interaction with the bottom, wave interaction with the sill structure, and wave interaction with marsh vegetation. Knutson *et al.* (8) report that *Spartina alterniflora* (SA) marshes significantly reduced wave height and erosional energy. Wave height was reduced by 50% within the first 5 m of marsh and 95% after crossing 30 m of marsh.

A properly engineered living shoreline will provide as much or more protection than riprap or a bulkhead and will improve water quality and enhance habitat as well. Engineering is site specific. Additionally, SA living shoreline design does not always fit neatly into the regulatory guidelines. This can be frustrating for the landowner who wants to protect the shoreline as quickly and as inexpensively as possible. In Maryland, the shoreline stabilization guidelines state that marsh creation is the preferred methodology and must be used wherever practicable (see new Maryland guideline details on page *xiii*).

INTEGRATING HABITAT AND SHORELINE DYNAMICS INTO LIVING SHORELINE APPLICATIONS (Kevin Smith)

It is common knowledge that shorelines are not stable, but dynamic (11). With the growing number of people moving to coastal communities (12), it can be safely assumed that there will be an increasing demand for the stabilization of shorelines. Traditional methods of shoreline stabilization typically lack a habitat component. Therefore, if we are to preserve and maintain the important role that natural shorelines provide, it is imperative that we develop solutions to address the need for erosion control, and to a greater extent, to address the historic and current loss of shoreline habitat. Living shoreline applications are a method to address this issue. The author defines living shorelines as "a concept based on an understanding and appreciation of the dynamic and inherent values that our natural shoreline would provide and applying those natural principles to shoreline enhancement and restoration projects."

The real challenge exists when we try to construct living shorelines in medium- and high-energy wave environments. Typically, this requires the use of some structural components. These structural components are often necessary to provide vegetation with an adequate growth environment. Further, we often overlook the fact that shorelines have been eroding naturally over time and this betrays a fundamental flaw with structured stabilizers (bulkheads and ripraps): What we see as a problem is actually a very important natural process and something critical to the bay's ecology. In some areas, the author notes that the Bay is sediment starved (in the case of sand), and erosion provides material to replenish shorelines and offshore bottoms. These sediments are critical to maintain existing beaches and near-shore sandy bottoms. Living shorelines offer the right balance between shoreline protection and the natural process of erosion. The concept of living shorelines is not a trouble-free strategy, particularly in medium and higher-energy environments (5). Determining adequate design for structures such as sills and breakwaters, while maintaining habitat function, can be very challenging and hence, is of great importance.

Structural components can be used successfully but must be constructed in a way that provides for habitat. Sills, for example, can do more harm to wildlife than good. Fish and crabs can get trapped behind sills and cannot escape when the tide ebbs. Hence, as above, project design must provide functional ecological benefits.

As with any project, it is imperative that landowners are involved in project goals and fully understand the project and performance they can expect. It is important to provide landowners with a reality check that, contrary to general beliefs, living shoreline projects may provide less protection than other more traditional approaches. They need to understand that shorelines are dynamic, requiring maintenance, such as the replacement of plants and/or sand, more commitment than traditional methods. Shoreline property owners need reasonable expectations within such a complex and dynamic system where success requires site-specific assessment prior to modifications and appropriate design for site characteristics. The key is to continue to develop, design, and place structures that are suitable for the environment, wildlife, and landowner goals.

NONSTRUCTURAL METHODS & MARSH SILLS: HOW EFFECTIVE ARE THEY IN VIRGINIA? (Karen Duhring)

Qualitative field evaluations of 36 tidal marsh protection structures were conducted in 2004 and 2005 in six localities on the Northern Neck and Middle Peninsula of Virginia. Twenty-eight structures were placed adjacent to natural tidal marshes for marsh edge stabilization (marsh toe revetments). Eight were marsh sill projects with sand fill and planted tidal marshes. All of the structures were made with quarry stone and two structures included gabions (wire mesh cages) to contain the stone. Most of these projects were constructed after 2000.

The created marshes were up to forty feet wide with a target slope of 10 to 1. A majority of the projects were in low energy settings and most were in areas where the fetch was less than 0.5 mile. Some of these project sites also had considerable boat wake influence. Nine projects were in high energy settings, and 4 of these sites were in major tributaries with a fetch more than 5 miles. Baseline conditions before installation were not studied, but available information was obtained from permitting records (application drawings, photographs, environmental assessments).

Defining whether each project was effective or not was difficult because there were no standard parameters. The actual need for the structure was determined based on the apparent level of erosion protection needed. Structural integrity was considered sound if there were no visible changes in rock placement, no evidence of eroded marsh edges or upland banks, and no significant changes in wetland slope. Other parameters used to determine project effectiveness were the apparent health of natural and planted marsh vegetation, physical evidence and observations of tidal exchange in and out of the marsh (e.g., wrack lines, dry and wet substrate), the crest height of the stone in relation to the mean high water elevation, and the vegetative transition between wetland and upland habitats.

The upland bank height was low (less than 5 feet) and baseline information indicated real or perceived erosion before installation in almost all of these projects. No active marsh or upland bank erosion was reported in only two cases where there was no apparent need to install any type of structure. Most of the stone structures remained in place with only minor structural damage or movement of rock. Sand placement remained stable with no visual signs of significant changes in marsh slope. Both the marsh edge stabilization structures and marsh sills were generally effective for reducing both marsh edge and upland bank erosion. Tidal exchange appeared to be adversely restricted at some of the large structures at medium energy settings. The marsh vegetation seemed to be healthy, but there were few physical indicators of tidal inundation and access for the movement of aquatic organisms was restricted along the entire length.

These projects were found to be most effective for fringing and embayed tidal marshes and less effective for spit marsh features with open water on two sides. The baseline erosion condition of the spit marshes continued in spite of structures at the marsh edge and planted marsh vegetation also failed. It is not clear why these projects were not as effective for this marsh type.

In addition to the survey of marsh structures, two nonstructural methods were monitored between 2000 and 2006 during routine site inspections and shoreline advisory evaluations. Planted tidal marshes without structures were generally not as effective for reducing upland bank erosion as planted marshes with sills. Although tidal marsh vegetation was successfully established in the intertidal area in some cases, the planted marshes were apparently not wide enough for wave and erosion reduction. The planted vegetation failed at sites where regular high tides reached the upland bank and where overhanging trees cast too much shade. The time of year for planting also mattered. Planted marshes completed in early spring were more successful than those planted later in the summer, probably due to heat stress. Anecdotal reports of grazing by mute swans were also received, similar to Canada geese.

Bank grading is another nonstructural practice in Virginia with and without erosion control structures at the toe of the graded banks. Presently, there are no guidelines for how to incorporate the intertidal area for a wide, planted marsh adjacent to graded upland banks. Boat wake and storm erosion continued at graded banks without a wide intertidal area. Functional riparian buffer habitats were not commonly restored on graded banks, although a dense cover of upland vegetation is recommended for additional bank stabilization and erosion protection particularly where storm waves may strike the bank.

The main finding from the study and observations mentioned was that low stone structures were the most effective for erosion protection where they were placed along the edge of wide, natural fringe marshes adjacent to low banks. Several practices were found to be less effective for reducing erosion or they adversely impacted habitat functions of the tidal marshes. For the marsh protection structures, tidal exchange within the marsh was sometimes restricted by tightly packed stone or the structure height. Structures placed adjacent to spit marsh features were also found to be less effective.

For the nonstructural methods, planted marshes were most successful where regular high tides do not reach the upland bank and when the vegetation was planted in early spring. Graded banks without a marsh terrace or a dense cover of riparian vegetation remained vulnerable to erosion and storm waves. Due diligence by property owners and contractors for routine inspections and repairs was another common factor in effective projects, both structural and nonstructural.

EVALUATION OF MARSH SILLS, GROINS AND EDGING PROJECTS ON MARYLAND'S EASTERN SHORE: A PILOT STUDY OF TALBOT COUNTY (Bhaskaran Subramanian)

Maryland Eastern Shore RC&D Council, Inc. has been working on living shoreline projects for over 20 years (1987-2006) and has completed 258 projects. RC&D wanted to document the success of these projects so as to expand the knowledge base for the concept of living shorelines techniques as a viable erosion control alternative to conventional bulkheads and ripraps. A pilot study of 35 projects (marsh sills, groins, and edging) in Talbot County was conducted as a part of the effort. Parameters included slope of the bank (steep or flat as compared to as-build), bank condition (undercut/slumping), marsh erosion, structure type (sills/groins/edging), structure condition (displacement, sinking, or no change), and the presence/absence of plant species (other than the ones that were planted initially) were studied to assess the success of all projects. The study also involved the development of a Geographical Information System (GIS) database that could aid in decision-making for future projects.

A Global Positioning System (GPS) unit was used in the field to collect and input data related to location and other parameters. A laser level was used to calculate the change in slope along the marsh fringes, and a camera was used to record the current status of the projects for comparative analysis.

After careful analysis of the data, it was found that 83% of banks inspected were stable (no undercut or slumping), and 74% of the marshes exhibited minimal erosion or no erosion. The stone structures in 71% of the projects were in excellent condition. Overall, 32 out of the 35 projects studied were ranked good or improved from initial conditions. Therefore, the pilot study results indicate that living shorelines have been used successfully for erosion control purposes. Further studies are needed to confirm the findings with additional data and analysis needed to determine impacts of fetch, energy of the system, and the role of design type to expand knowledge of living shoreline project success. Plans are in place to inspect the remaining projects in other counties.

PANEL CONCLUSION

It can be concluded that design guidance for living shorelines projects is necessary for successful use of this technology. If designed properly, living shorelines have shown to be an appropriate tool for addressing erosion control issues in many cases. Project design is site specific and a combination of structural approaches (stone sills or breakwaters) with marsh plantings has been shown to be synergistically effective for both erosion protection and providing habitat for aquatic organisms. Though there is skepticism about using rock, it is imperative to understand that in most cases, rock acts as the first line of defense for marsh vegetation. A more robust database and further monitoring of existing projects are critical to understanding project design and possible site-specific success. Maintenance of living shorelines projects is critical. Overall, living shoreline technology can successfully be used for shoreline protection while providing essential habitat in many erosional areas.

REFERENCES

1. Maryland Shorelines Online: Definitions; http://shorelines.dnr.state.md.us/definitions.asp

2. Chesapeake Bay Program. 2005. http://www.mgs.md.gov/coastal/pub/tidalerosionChesBay.pdf

3. Clark, J. 1974. The Conservation Foundation. Washington, D.C. 191 pp.

4. Kesselheim, A.S. and B.E. Slattery. 1995. WOW! The Wonders of Wetlands: An Educator's Guide. Environmental Concern Inc.: St. Michaels, MD and The Watercourse: Bozeman, MT. 278 pp.

5. Matthews, G.A. and T.J. Minello. 1994. Technology and Success in Restoration, Creation, and Enhancement of *Spartina alterniflora* marshes in the United States: Volume 1 – Executive Summary and Annotated Bibliography. U.S. Department of Commerce: National Oceanic and Atmospheric Administration, Coastal Ocean Office. 71 pp.

6. Hammer, D.A. 1997. Creating Freshwater Wetlands. Lewis Publishers, Inc. Chelsea, MI. 298 pp.

7. U.S. Army Corps of Engineers. 1990. Chesapeake Bay Shoreline Erosion Study. Department of the Army, U.S. Army Corps of Engineers, Baltimore, MD, USA. 111 pp.

8. Knutson, P.L., R.A. Brochu, W.N. Seelig, and M. Inskeep. 1982. Wave Damping in *Spartina alterniflora* Marshes. Wetlands. 2:87-104.

9. Tiner, R.W. and D.G. Burke. 1995. Wetlands of Maryland. U.S. Fish and Wildlife Service, Ecological Services, Region 5, Hadley MA and Maryland Department of Natural Resources, Annapolis, MD. 193 pp.

10. Howes, B.L., P.K. Weiskel, D.D. Goehringer, and J.M. Teal. 1996. Interception of Freshwater and Nitrogen Transport from Uplands to Coastal Waters: The Role of Saltmarshes. In: "Estuarine Shores: Hydrological, Geomorphical, and Ecological Interactions" K. Nordstrom and C. Roman (eds.). Wiley Interscience. Sussex, England. pp. 287-310.

11. Hardaway, Jr., C.S. and R.J. Byrne. 1999. Shoreline Management in Chesapeake Bay. http://www2.vims.edu/seagrant/vasg-pubs-pdfs/shoreline.pdf

12. National Ocean Economics Program. 2007. Marine Policy. http://noep.mbari.org/Demographics/demogResults