# Literature Review: Policy and Science of Living Shorelines

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# Section 1: Comparable policy

## Summary

Living shorelines have been identified in various management programs as a preferred or required approach to addressing tidal shoreline erosion. Many differing policy approaches to the requirement, preference or promotion of living shorelines are taking place in the United States. A summary of some of those policies is provided here. These various programs have served as possible options for living shorelines policy in Virginia and can serve a similar role in the development of the general permit for living shorelines mandated by the 2011 actions of the General Assembly and Governor.

At the same time, many living shoreline management efforts are being tied to other "value added" benefits including; best management practices for the reduction of nutrient and sediment loads, for storm amelioration and to offset losses and provide for sustainability in the face of sea level rise and anthropogenic actions. Some of these benefits are being offered as additional rationale for management efforts and are being incorporated, or considered for incorporation into policy. In Maryland, San Francisco Bay and Louisiana, wetlands creation/ restoration on large and small scales are being promoted and undertaken to address wetlands loss as an adaption to sea level rise and for habitat, water quality and storm protection services. *(San Francisco Bay, California Coastal Conservancy* *http://online.sfsu.edu/katboyer/Boyer_Lab/Research_files/LSP_online_version.pdf*
*Maryland Website "Addressing climate Change" http://www.green.maryland.gov/climate.html.*
The EPA, among other governmental and non-governmental agencies identifies the use of living shorelines, and tidal wetlands protection and restoration as an adaption for coastal areas. *U.S. EPA. 2009. Synthesis of Adaptation Options for Coastal Areas. Washington, DC, U.S. Environmental Protection Agency, Climate Ready Estuaries Program. EPA 430-F-08-024, January 2009.* *http://www.epa.gov/oppeoee1/cre/downloads/CRE_Synthesis_1.09.pdf*

## Alabama

State of Alabama Regulations state a preference for use of vegetation for shoreline stabilization. Rule 220-4-.09 implicitly endorses the general principles of living shorelines in subsection (4)(b)6: *"To the maximum extent possible, shoreline stabilization should be accomplished by the* establishment of appropriate native wetland vegetation. Rip-rap materials, pervious interlocking brick systems, filter mats, and other similar stabilization methods should be utilized in lieu of vertical seawalls wherever feasible."
http://www.alabamaadministrativecode.state.al.us/docs/con_/McWord220-4.pdf

## Maryland

### Legislation

Maryland has passed legislation to require the use of living shorelines unless the applicant can otherwise verify the need for a conventional structure. The exemption is allowed through a waiver from the living shoreline requirement.

(See Code of Maryland- http://mlis.state.md.us/2008rs/chapters_noln/Ch_304_hb0973E.pdf)

" IMPROVEMENTS TO PROTECT A PERSON'S PROPERTY AGAINST EROSION SHALL CONSIST OF NONSTRUCTURAL SHORELINE STABILIZATION MEASURES THAT PRESERVE THE NATURAL ENVIRONMENT, SUCH AS MARSH CREATION, EXCEPT ~~IN~~*:*

*(I)* *IN AREAS DESIGNATED BY DEPARTMENT MAPPING AS APPROPRIATE FOR STRUCTURAL SHORELINE STABILIZATION MEASURES; AND*

(II) *(II) IN* AREAS WHERE THE PERSON CAN DEMONSTRATE TO THE DEPARTMENT'S SATISFACTION THAT SUCH MEASURES ARE NOT FEASIBLE, INCLUDING AREAS OF EXCESSIVE EROSION, AREAS SUBJECT TO HEAVY TIDES, AND AREAS TOO NARROW FOR EFFECTIVE USE OF NONSTRUCTURAL SHORELINE STABILIZATION MEASURES."

### Regulation

Maryland has just released proposed regulatory language to implement the living shorelines law (Nov 2012).

01 Shore Erosion Control.

A. The Department may not authorize an erosion control project if:

(1) There is no evidence of erosion and the applicant is unable to document a claim of erosion;
(2) Existing State or private tidal wetlands are effectively preventing erosion; or
(3) The proposed project may adversely affect:
(a) An adjacent property;
(b) Navigation, and the applicant has not adequately offset these impacts;
(c) Threatened or endangered species, species in need of conservation, or significant historic or archaeological resources; or
(d) Natural oyster bars or private oyster leases.

B. A person proposing a shoreline stabilization measure in State or private tidal wetlands that requires a wetlands license from the Board or a general wetlands license, wetlands permit, or general wetlands permit from the Department shall first consider:

(1) No action; and
(2) Relocation of structures threatened by erosion.

C. Except as authorized under §E of this regulation, if the Department is satisfied that neither option listed under §B of this regulation is feasible, the person shall use a nonstructural shoreline stabilization measure.

D. If a structural component is necessary in order to preserve the natural shore, minimize erosion, and establish aquatic habitat, a nonstructural shoreline stabilization measure may include the use of:

(1) A breakwater, sand containment structure, or sill that is acceptable to the Department; or
(2) A beach that is acceptable to the Department, when used for the purpose of habitat enhancement.

E. A person may use a structural shoreline stabilization measure:

(1) In an area identified as appropriate for structural shoreline stabilization measures by the Department, in coordination with the Maryland Department of Natural Resources, and shown on a map approved by the Department under Regulation .01-1 of this chapter; or
(2) At a site where the person has obtained a waiver from the Department in accordance with Regulation .01-2 of this chapter by demonstrating to the Department’s satisfaction that a nonstructural shoreline stabilization measure is not feasible.

.01-1 Structural Shoreline Stabilization Maps.

A. The Department shall develop and maintain maps on its website that:

(1) Display the areas that are appropriate for structural shoreline stabilization measures; and
(2) Are readily available to the public.

B. When determining the areas appropriate for structural shoreline stabilization measures, the Department shall consider:

(1) The presence or absence of a natural shoreline;
(2) Proximity to channels;
(3) As determined by the Department based on site conditions, the presence of high energy waves or a severely eroding shore that would render a nonstructural stabilization measure infeasible;
(4) The extent to which a water-dependent facility requires a bulkheaded shoreline for loading and unloading operations, such as the berthing of commercial vessels;
(5) Impacts to rare, threatened and endangered species, and species in need of conservation; and
(6) Any other site-specific factor, as determined relevant by the Department.

.01-2 Nonstructural Shoreline Stabilization Waiver Process.

A. A person who applies for a waiver from the requirement to construct a nonstructural shoreline stabilization measure under Regulation .01C of this chapter shall:

(1) Use the form provided by the Department; and
(2) Complete the waiver process before submitting an application to obtain a wetlands license from the Board or a general wetlands license, wetlands permit, or general wetlands permit from the Department under COMAR 26.24.02.

B. When evaluating a person’s request for a waiver, the Department shall determine whether the site is suitable to support a nonstructural shoreline stabilization measure by considering:

(1) The width of the waterway;
(2) The bottom elevation and slope at mean low water;

(3) The bottom substrate:
(4) The fetch;
(5) The bank elevation and orientation;
(6) The degree of erosion;
(7) The height and regularity of tides;
(8) Any other physical constraints that would impede or prevent successful establishment of a nonstructural shoreline stabilization measure; and
(9) Any other relevant environmental resources, including a Critical Area buffer and other plant, fish, and wildlife habitat, and the likely adverse or protective impact of a nonstructural shoreline stabilization measure on those resources in comparison to the likely adverse or protective impact of a structural shoreline stabilization measure on those resources.
C. A person may obtain a waiver from the requirement to use a nonstructural shoreline stabilization measure if, to the Department's satisfaction, a structural shoreline stabilization measure is the only feasible alternative that will protect and maintain the person's shoreline.

These regulations are still in draft.
http://www.dsd.state.md.us/MDRegister/3921/Assembled.htm#_Toc338168584

**Financing**

Maryland Water Quality Financing Administration (WQFA) provides low interest rate loans under the two Revolving Loan Fund Programs and grants under the State Bay Restoration Fund Program. Water Quality Revolving Loan Fund (WQRLF) was created during the 1988 session of the Maryland General Assembly for the purpose of providing below market rate of interest loans for water quality projects. Eligible projects include:

- Stream and Wetland Restoration/Non-structural Stabilization (NOT associated with mitigation for permit or violation)
- Correction of Failing Septic Systems
- Shoreline Erosion Control

http://www.mde.state.md.us/programs/Water/QualityFinancing/LinkedDeposit/Pages/Programs/WaterPrograms/Water_Quality_Finance/link_deposit/index.aspx

## Connecticut

New legislation in Connecticut strengthens the existing preference for shoreline erosion solutions that ensure preservation of natural processes and recreational access. New language identifies living shorelines as a feasible, less damaging alternative to structural solutions. Traditional structures are allowed only to protect infrastructure, residential structures and water dependent uses where there are no alternatives and mitigation is provided.

"Structural solutions are permissible when necessary and unavoidable for the protection of infrastructural facilities, water-dependent uses, or existing inhabited structures constructed as of January 1, 1995, cemetery or burial grounds, and where there is no feasible, less environmentally damaging alternative and where all reasonable mitigation measures and techniques have been provided to minimize adverse environmental impacts.

"feasible, less environmentally damaging alternative" includes, but is not limited to, relocation of an inhabited structure to a landward location, elevation of an inhabited structure, restoration or creation of a dune or vegetated slope, or living shorelines techniques utilizing a variety of structural and organic materials, such as tidal wetland plants, submerged aquatic vegetation, coir fiber logs, sand fill and stone to provide shoreline protection and maintain or restore costal resources and habitat; and "reasonable mitigation measures and techniques" includes, but is not limited to, provisions for upland migration of on-site tidal wetlands, replenishment of the littoral system and the public beach with suitable sediment at a frequency and rate equivalent to the sediment removed from the site as a result of the proposed structural solution, or on-site or off-site removal of existing shoreline flood and erosion control structures from public or private shoreline property to the same or greater extent as the area of shoreline impacted by the proposed structural solution."

Municipal zoning commissions review site plans for shoreline structures. This review has associated expenses in costs and time. However, living shorelines are excluded from the site plan review process. This is accomplished by taking them out of the definition of shoreline flood and erosion structure.

"A coastal site plan for a **shoreline flood and erosion structure** (emphasis added) shall be approved if the record demonstrates and the commission makes specific written findings that such structure is necessary and unavoidable for the protection of infrastructural facilities, cemetery or burial grounds, water-dependent uses fundamental to habitability or primary use of such property or inhabited structures or structure additions constructed as of January 1, 1995, that there is no feasible, less environmentally-damaging alternative and that all reasonable mitigation measures and techniques are implemented to minimize adverse environmental impacts."

(c) For the purposes of this section, "shoreline flood and erosion control structure" means any structure the purpose or effect of which is to control flooding or erosion from tidal, coastal or navigable waters and includes breakwaters, bulkheads, groins, jetties, revetments, riprap, seawalls and the placement of concrete, rocks or other significant barriers to the flow of flood waters or the movement of sediments along the shoreline. **The term shall not include** ....(2) any activity, including, but not limited to, **living shorelines projects** (emphasis added), for which the primary purpose or effect is the restoration or enhancement of tidal wetlands, beaches, dunes or intertidal flats."

Connecticut Public Act No. 12-101. http://www.cga.ct.gov/2012/ACT/PA/2012PA-00101-R00SB-00376-PA.htm

## Florida

Northwest Florida Water Management District has a permit exemption for the use of wetland vegetation to address erosion. The only "structure" allowed through the permit is a breakwater constructed of oyster shell.

The criteria for eligible projects are as follows:

1. The restoration of an eroding shoreline of 150 feet or less by planting with native wetland vegetation no more than 10 feet waterward of the approximate mean high water line (MHWL)
2. Plantings shall consist of native vegetative species such as salt meadow hay (*Spartina patens)*, black needle rush (*Juncus roemarianus*), and smooth cordgrass (*Spartina alterniflora*), obtained from commercially-grown stock that is endemic to the geographic area of the Northwest Florida Water Management District.
3. Any invasive/exotic vegetative species that may occur along the shoreline, such as common reed (*Phragmites australis*), shall be removed in conjunction with the planting.
4. If wave attenuation is needed to protect and ensure survivability of the plantings, turbidity curtains shall be installed immediately waterward of and parallel to the planting area, but must be removed within three months after completion of vegetation planting.
5. No filling by anything other than vegetative planting is authorized, except that if permanent wave attenuation is required to maintain shoreline vegetation, an oyster reef "breakwater" is authorized to be established concurrent with the planting, provided that:
   a) The outer edge of the "breakwater" shall extend no more than 10 feet waterward of the approximate MHWL.
   b) The "breakwater" shall be composed predominantly of natural oyster shell cultch such as clean oyster shell and fossilized oyster shell, although unconsolidated boulders, rocks, and clean concrete rubble can be associated with the oyster material. Oyster shell may be packaged in biodegradable bags (i.e. coir fiber) prior to placement in the water.
   c) The "breakwater" shall not be placed over, or within 3 feet (in any direction) of any submerged grassbed or existing emergent marsh vegetation.
   d) The "breakwater" shall be placed in units so that there is a minimum of three feet of tidal channel within every 20 feet of structure, so as to not substantially impede the flow of water, and shall not create a navigational hazard.
   e) All equipment used during construction shall be operated from, and be stored in uplands.

**https://www.flrules.org/gateway/RuleNo.asp?title=Environmental%20Resource%20Permitting%20in%20Northwest%20Florida&ID=62-346.051**

## North Carolina

North Carolina has a General Permit for the construction of riprap or stone sill structures built in conjunction with existing, created or restored wetlands. This permit was established as a counter to the extensive use of the previously established general permit for bulkheads. Permit conditions for the General Permit address structural, vegetative and landscape elements of the project. The current set of criteria has been simplified from the 2005 original permit which had a more complex set of 25 conditions.

The criteria are:

(a) This general permit shall only be applicable along shorelines possessing wetlands, which exhibit an identifiable escarpment.
(b) The structure shall be constructed of granite, marl, riprap, concrete without exposed rebar, or other suitable materials approved by the Division of Coastal Management.
(c) The height of the erosion escarpment shall not exceed three feet.
(d) The riprap shall be placed immediately waterward of the erosion escarpment.

(e) The riprap revetment shall be positioned so as not to exceed a maximum of six feet waterward of the erosion escarpment at any point along its alignment with a slope no flatter than three feet horizontal per one foot vertical and no steeper than one and one half feet horizontal per one foot vertical.
(f) The riprap shall be positioned so as not to exceed a maximum of six inches above the elevation of the adjacent wetland substrate or escarpment.
(g) Where the Division of Coastal Management determines that insufficient wetland vegetation exists along the permittee's shoreline to provide adequate shoreline stabilization, the permittee shall be required to plant appropriate wetland vegetation landward of the riprap revetment as directed by the Division of Coastal Management.
(h) Construction authorized by this general permit will be limited to a maximum length of 500 feet.
(i) No backfill or any other fill of wetlands, submerged aquatic vegetation, estuarine waters, public trust areas, or highground areas is authorized by this general permit.
(j) No excavation of the shallow water bottom, any wetlands, or high ground is authorized by this general permit.
(k) Riprap material used for revetment construction shall be free from loose dirt or any pollutant and be of a size sufficient to prevent its movement from the site by wave action or currents.
(l) If the crossing of wetlands with mechanized or non-mechanized construction equipment is necessary, temporary construction mats shall be utilized for the area(s) to be crossed. The temporary mats shall be removed immediately upon completion of construction of the riprap structure.
(m) The permittee shall maintain the structure in good condition and in conformance with the terms and conditions of this permit or the remaining riprap revetment_shall be removed within 90 days of notification from the Division of Coastal Management.

*History Note: Authority G.S. 113A-107; 113A-118.1;*
*Eff. December 1, 2008; August 1, 2000.*

http://portal.ncdenr.org/c/document_library/get_file?uuid=5f309e70-990a-40eb-9455-09674e8d55f6&groupId=38319

## Fairfax, Virginia

Permitting preference for living shorelines is in use in Fairfax County, Virginia. This approach requires the applicant to demonstrate that a living shoreline project will not accomplish the desired erosion protection goal if they propose some other project design. Essentially the living shoreline design is assumed to the appropriate choice absent a compelling argument to the contrary.

The specific language:

*"Living Shorelines"*: Among all the options, applicants must consider a design that maintains or creates a living shoreline, as an approach for shoreline stabilization, and demonstrate to the Board why a living shoreline approach would not achieve your goals. Properly sited and designed living shorelines will be preferentially permitted over hardened shoreline approaches. The Board does not require mitigation or compensation for properly designed and sited living shoreline stabilizations.

http://www.fairfaxcounty.gov/dpz/environment/finallivingshoreline.pdf

# Section 2: Scientific Literature

## Summary

There are limited studies of projects designed and constructed intentionally as what is generally considered living shorelines, i.e. marsh and or riparian vegetation with or without a structure. That is not to say that the use and to some moderate extent, promotion, of this approach has not been on-going in certain sectors of shoreline construction and management for years. Some studies on the assessment and reports of the efficacy of marsh vegetation for erosion control date back to the 1970s (some of which are cited here). Nevertheless it is only been more recently that living shoreline projects are being assessed for design effectiveness and erosion control as well as the myriad potential effects on the habitat ecosystem services and trade-offs associated with comparison to conventional erosion control structures as well as conversion of one habitat for another in the construction of most living shoreline projects.

Also, recent literature as started to address the efficacy of the use of living shorelines to address historic and on-going losses of habitat and water quality ecosystem services. Jonathan, et al., discuss the services provided by marshes and riparian buffers as a potential adaptation to climate change. *R. M. Jonathan, R. O'Malley and D. S. Ojimaa. 2009. Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. Conservation Biology 23 (5): 1080–1089*

This review looks at some of the available literature specific to living shorelines as well as research on the various elements of a typical project focused on vegetation and structural elements; sand, rock and shell. In general, the literature supports to use of vegetation for erosion control and notes the over-all habitat and water quality benefits of vegetated tidal wetlands. The placement of rock or shell upon non-vegetated intertidal or shallow water changes habitat of the localized area and have a shift in the associated fish community and change in benthic community composition and density.

## Habitat

### <u>Structures</u>

Built structures often provide unnatural sheltered habitats along wave-exposed coasts. Seawalls, pontoons and pilings which are enclosed in marinas and the landward sides of breakwaters running parallel the shore create very sheltered conditions. The reduced water flow, turbidity or abrasion by sediments in these novel sheltered habitats can promote the establishment of assemblages that differ in species richness, composition or relative abundances from those associated with nearby natural exposed rocky habitats. *Bulleri, F. & M. G. Chapman. 2004. Intertidal assemblages on artificial and natural habitats in marinas on the north-west coast of Italy. Marine Biology 145: 381–391. Bulleri, F. and M.G. Chapman. 2010. The introduction of coastal infrastructure as a driver of change in marine environment. Journal of Applied Ecology 47(1): 26-35. Clynick, B.G. 2007. Assemblages of fish associated with coastal marinas in north-western Italy. Journal of the Marine Biological Association of the United Kingdom 86, 847–952. Vaselli, S., F. Bulleri, & L. Benedetti-Cecchi. 2008. Hard coastal-defence structures as habitats for native and exotic rocky-bottom species. Marine Environmental Research 66, 395–403.*

Hardaway et al. (2007) captured fish species commonly associated with reef structures within windows of hybrid living shoreline structures (those with associated rock). *Hardaway, C. S., J. Shen, D. Milligan, C. Wilcox, K. O'Brien, W. Reay, S. Lerberg, 2007. Performance of Sill, St. Mary's City, St. Mary's River, Maryland. Technical Report prepared by Virginia Institute of Marine Science, Gloucester Point, Virginia.*

Sills that are not submerged at high tide (≥0.5 m above the water) prevent aquatic organisms from access the marsh habitat, and sills without vents prevent flushing of marsh and trap sediment and dead vegetation. *Bosch, J., C. Foley, L. Lipinski, C. McCarthy, J. McNamara, A. Naimaster, A. Raphael, A. Yang, and A. Baldwin. 2006. Constructed Wetlands for Shoreline Erosion Control: Field Assessment and Data Management. Submitted to Maryland Department of the Environment, Wetlands and Waterways Program, 1800 Washington Blvd., Baltimore, MD 21230.*

The enhancement of fish and crustacean populations due to oyster reef breakwaters appears to be site specific. One study by Scyphers, et al. 2011, found the blueways between intertidal marsh and oyster reef breakwaters can support higher abundances and different communities of fishes and crustaceans than control plots without oyster reef habitat. Among the fishes and mobile invertebrates that appeared to be strongly enhanced were several economically-important species. Blue crabs (*Callinectes sapidus*) were the most clearly enhanced (+297%) by the presence of breakwater reefs, while red drum (*Sciaenops ocellatus*) (+108%), spotted seatrout (*Cynoscion nebulosus*) (+88%) and flounder (*Paralichthys* sp.) (+79%) also benefited. *Scyphers S.B., S.P. Powers, K.L.Heck Jr, D. Byron. 2011. Oyster Reefs as Natural Breakwaters Mitigate Shoreline Loss and Facilitate Fisheries. PLoS ONE 6(8): e22396. doi:10.1371/journal.pone.0022396.* Another study of concrete pre-cast breakwaters with created Spartina marsh in Alabama found higher than natural oyster densities and foraging in the lee of the structures by spotted seatrout, *Cynoscion nebulosus*, blue crabs *Callinectes sapidus* and Gulf stone crabs *Menippe adina*, red drum *Sciaenops ocellatus*, southern flounder *Paralichthys lethostigma*, and various species of shrimp. *LaDon Swann. 2008. The Use of Living Shorelines to Mitigate the Effects of Storm Events on Dauphin Island, Alabama, USA*. *Mitigating Impacts of Natural Hazards on Fishery Ecosystems American Fisheries Society Symposium 64. http://livingshorelinesolutions.com/uploads/Dr._LaDon_Swann__Living_Shorelines_Paper.pdf*. However, a study of restored oyster reef placed within salt marsh creek systems did not find an increase in mobile fauna and concluded that landscape position is an important factor. *Geraldi, N. R., Powers, S. P., Heck, K. L., & Cebrian, J. 2009. Can habitat restoration be redundant? Response of mobile fishes and crustaceans to oyster reef restoration in marsh tidal creeks. Marine Ecology Progress Series 389, 171-180. doi:10.3354/meps08224.*

In a study of natural, marsh sill (living shorelines) and on-shore revetment treatments in the Chesapeake Bay, Bilkovic and Mitchell (in review) found that marsh-sills had lower benthic infauna biomass than natural marshes. Not surprisingly, epifauna suspension-feeders were most prevalent at sites with artificial structure (riprap and marsh-sill). In all cases, nearshore shallow water habitat had greater numbers of infauna than in intertidal environments. Conversion of existing habitat to marsh-sills may cause a localized loss of benthic productivity and while possibly enhancing filtration capacity by epifauna. *Bilkovic, D.M. and M.M. Mitchell (in review). Ecological tradeoffs of stabilized salt marshes as a shoreline protection strategy: effects of artificial structures on macrobenthic assemblages. PLoS ONE.* Other studies on the secondary production of artificial structures have also found increases in secondary production of the epifauna. However, in a comparison of secondary production in marsh sill habitat, salt marsh, seagrass, tidal flats and oyster reefs, it was shown that while marsh-sill productivity was high because of epifauna assemblages, that the adverse effects of the structures on the macrobenthos in adjacent habitats may diminish these reported benefits. *Wong, M., C. Peterson and M. Piehler. 2011. Evaluating estuarine habitats using secondary production as a proxy for food web support. Marine Ecology Progress Series 440: 11–25.*

### Vegetation

A general overview of the scientific literature on living shoreline projects ecosystem services and design considerations is provided by Currin and others (2010). Among other services provided by living shorelines is a discussion of the habitat provision of fringing marshes- those typically part of a living shoreline project. The studies review showed a preferential use of marsh edge by species including blue crab and other nekton, and use of fringing marsh at comparable rates to extensive marshes. *Currin, C.A., W.S. Chappell and A. Deaton. 2010. Developing alternative shoreline armoring strategies: The living shoreline approach in North Carolina, in Shipman, H., Dethier, M.N., Gelfenbaum, G., Fresh, K.L., and Dinicola, R.S., eds., Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop, May 2009: U.S. Geological Survey Scientific Investigations Report 2010-5254, p. 91-102.*

## Water quality

### Sediment trapping

Marshes trap and retain sediment as a result of drag produced by vegetation which slows water velocity allowing deposition. *Leonard, L. and A. Croft. 2006. The effect of standing biomass on flow velocity and turbulence in Spartina alterniflora canopies. Estuarine, Coastal and Shelf Science 69:325-336. Leonard, L.A. 1997. Controls of sediment transport and deposition in an incised mainland marsh basin, southeastern North Carolina. Wetlands 17: 263-274*.

Fringing marshes typically constructed as part of living shoreline projects may have comparable sediment retention capacity as extensive marshes if they have similar edge habitat where the highest rates of deposition occur. *Christiansen, T., P. L. Wiberg, T. G. Milligan, Flow and Sediment Transport on a Tidal Salt Marsh Surface. 2000. Estuarine, Coastal and Shelf Science, 50(3):315-331., Neubauer, S., I.C. Anderson, J.A. Constantine, and SA. Kuehl. 2002. Sediment deposition and accretion in a mid-Atlantic (U.S.A.) tidal freshwater marsh. Estuarine, Coastal and Shelf Science 54: 713-727.*

A comparison of the functions and values of fringing salt marshes to those of meadow marshes along the southern Maine/New Hampshire coast showed differences in soil organic matter content, plant species richness, and percent cover of high and low-marsh species. More sediment was trapped per unit area in fringing marshes than in meadow marshes, but this difference was not significant. *Morgan P.A., Burdick D.M., Short F.T. 2009. The functions and values of fringing salt marshes in northern New England, USA. Estuaries and Coasts 32:483–49.*

### Nutrient Removal

A review of 57 studies indicates most wetlands reduce nutrient loading, though some may have increase loads of soluble N and P. *Fisher, J. and M.C. Acreman. 2004. Wetland nutrient removal: a review of the* *evidence. Hydrology and Earth System Sciences 8(4): 673-685. B. Welsh. 1980. Comparative nutrient dynamics of a marsh-mudflat ecosystem. Estuarine Coastal and Marine Science 10(2):143-164.*

Fringing marshes have been demonstrated to effectively remove groundwater nitrate inputs. *Tobias, C.R., S.A. Macko, I.C. Anderson, E.A. Canuel and J. W. Harvey. 2001. Tracking the fate of a high concentration groundwater nitrate plume through a fringing marsh—A combined groundwater tracer and in situ isotope study. Limnology and Oceanography. V. 46:1977–1989.*

### Dissolved Oxygen

Marsh sill design has effects on the flushing and thereby the temperature and dissolved oxygen of the water behind the structure. In one study water behind the sill had lower dissolved oxygen and elevated temperature relative to the nearshore shallow water *Hardaway, C. S., J. Shen, D. Milligan, C. Wilcox, K. O'Brien, W. Reay, S. Lerberg, 2007. Performance of Sill, St. Mary's City, St. Mary's River, Maryland. Technical Report prepared by Virginia Institute of Marine Science, Gloucester Point, Virginia.*

## Structural Stability

### Vegetation energy reduction

Few studies examine the role of vegetated wetlands in wave attenuation and energy reduction. Of those that do, there is considerable variability in the relationship of vegetated marsh to energy reduction based on differences in tidal amplitude, energy regime, species, plant height and density among other factors. Nevertheless, all studies find a significant difference between vegetated and non-vegetated slopes in wave energy reduction and attenuation. These studies support the conclusion that marsh vegetation can reduce wave height and energy. A few of the citations are offered here.

In the Chesapeake Bay, within the first 2.5 m of cordgrass marsh 64% of wave energy was dissipated and minimal wave energy persisted beyond 30m. *Knutsen et al. 1982. Wave damping in Spartina alterniflora marshes. Wetlands vol. 2:87-104.*

In New England, measurements within 7m of both fringe and meadow marshes, showed the height of the waves reduced by 63%, and only 33% reduced over 7m in areas without marsh. Similarities included aboveground and belowground peak season biomass and the ability to dampen wave energy. Both marsh types reduced the height of waves coming onto the marsh surface by 63% only 7 m into the marsh. *Morgan P.A., Burdick D.M., Short F.T. 2009. The functions and values of fringing salt marshes in northern New England, USA. Estuaries and Coasts 32:483–49.*

In northern Europe, mactrotidal marshes dominated by S. angelica can reduce wave heights by more than 50% in the first 20 meters. *I. Moller. 2006. Quantifying saltmarsh vegetation and its effect on wave height dissipation: Results from a UK East coast saltmarsh. Estuarine, Coastal and Shelf Science 69 (2006) 337-351.*

On average, waves reaching the marsh were eliminated over a distance of ~80 m, although a marsh distance of ≥100 m was needed before the maximum height waves were fully attenuated during high tides. These attenuation distances were longer than those previously found in American salt marshes, mainly due to the macrotidal and exposed conditions at the present site. The ratio of water depth to plant height showed an inverse correlation with wave attenuation rate, indicating that plant height is a crucial factor determining the efficiency of wave attenuation. *S. L. Yang, B. W. Shi, T. J. Bouma, T. Ysebaert and X. X. Luo. Wave Attenuation at a Salt Marsh Margin: A Case Study of an Exposed Coast on the Yangtze Estuary. Estuaries and Coasts (2012) 35:169–182 DOI 10.1007/s12237-011-9424-4*

**Erosion Abatement**

Some recent studies have called into question the validity of the role of coastal wetlands in the protection of shorelines from wave stress. However a meta-scale literature review finds widespread agreement that coastal wetlands provide protection from erosion and wave damage. *Gedan, K. B., M. L. Kirwan, E. Wolanski. E. Barbier and B. R. Silliman. 2011. The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm. Climate Change 106:7-29.*

The wave-attenuating capacity of uncontained oyster shell breakwaters is limited because the loose shell reefs scatter. *Scyphers, S.B., S.P. Powers, K.L. Heck Jr, D. Byron. (2011). Oyster Reefs as Natural Breakwaters Mitigate Shoreline Loss and Facilitate Fisheries. PLoS ONE 6(8): e22396. doi:10.1371/journal.pone.0022396*

**Fetch**

Several sites with perpendicular fetch in excess of 0.8km with and without sills supported highly ranked marshes (Bosch et al. 2006). Therefore, a precise threshold of marsh survivability cannot be made based on fetch in absence of other site characteristics. *Bosch, J., C. Foley, L. Lipinski, C. McCarthy, J. McNamara, A. Naimaster, A. Raphael, A.Yang, and A. Baldwin, 2006. Constructed Wetlands for Shoreline Erosion Control: Field Assessment and Data Management. Submitted to Maryland Department of the Environment, Wetlands and Waterways Program, 1800 Washington Blvd., Baltimore, MD 21230.*

Hardaway and Byrne (1999) classified average fetch exposures very low, low, medium and high as < 0.5 mile, 0.5 to 1 mile, 1-5 mile and 5-15 miles, respectfully. *Hardaway, Jr., C.S. and R.J. Byrne. 1999. Shoreline Management in Chesapeake Bay. Special Report in Applied Marine Science and Ocean Engineering Number 356. Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia.*

http://web.vims.edu/physical/research/shoreline/docs/ShorelineErosionInCBay.pdf

**Sand**

The sand for the planting substrate behind the sill should contain no more than five percent (5%) passing the number 200 sieve and no more than ten percent (10%) passing the number 100 sieve. The material shall consist of rounded or semi-rounded grains having a median diameter of 0.6 mm (+/- 2.5mm). *C. Scott Hardaway, Jr., C.S., D. A. Milligan and K. Duhring. 2010. Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments. Final report to the Virginia Coastal Zone Management Program, Department of Environmental Quality, Richmond, VA.*

## Slope

In general, a slope of no steeper than 10:1 is used for marsh restoration activities. Burke, D.G., E. W. Koch and J. Court Stevenson. 2005. *Assessment of Hybrid Type Shore Erosion Control Projects in Maryland's Chesapeake Bay – Phases I & II*. Final report for Chesapeake Bay Trust, Annapolis, Maryland; *Bosch, J., C. Foley, L. Lipinski, C. McCarthy, J. McNamara, A. Naimaster, A. Raphael, A.Yang, and A. Baldwin, 2006. Constructed Wetlands for Shoreline Erosion Control: Field Assessment and Data Management. Submitted to Maryland Department of the Environment, Wetlands and Waterways Program, 1800 Washington Blvd., Baltimore, MD 21230; Garbisch and Garbisch. 1994. Control of Upland Bank Erosion through Tidal Marsh Construction on Restored Shores: Application in the Maryland Portion of Chesapeake Bay. Environmental Management 18(5): 677-691.*

## Design

General design guidance for living shorelines in Virginia is provided based on an assessment of 9 projects in Virginia. *C. Scott Hardaway, Jr., C.S., D. A. Milligan and K. Duhring. 2010. Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments. Final report to the Virginia Coastal Zone Management Program, Department of Environmental Quality, Richmond, VA.*

## Section 3: Draft Criteria for a Living Shorelines General Permit for Virginia

There should be two categories of shoreline activities for this general permit. The categories reflect the relative environmental adverse effect due to project construction and potential for consequences due to failure.

**A. Group One: Non-Structural Activities.** Activities that improve growing conditions for wetlands and/ or riparian buffer vegetation. May also include the use of native oysters as part of erosion control projects. Minimal constraints, allow everywhere except not within SAV habitat.

1) **Existing tidal marsh improvements, new marsh creation and/or beach nourishment** May include use of:
   a) Coir logs and/or coir mats following standard installation and maintenance guidelines.
   b) Sand fill. Sand will contain less than 10% very fine (passing through 100 sieve). Source of material shall be provided.

2) **Native oyster shell contained by organic fiber or biodegradable polymer bags**.
   a) Does <u>not</u> include concrete structures which incorporate oyster shell.
   b) Any oyster containment bag constructed out of a polymer (i.e. plastic) must be made of material that meets ASTM Method and Specification for biodegradation of plastic materials in the marine environment, i.e. polycaprolactone (PCL) and polyhydroxyalkanoate (PHA).
   c) Should not be placed in vegetated wetlands.

**B. Group Two: Rock sill with tidal marsh**

1) The average minimum fetch across waterway is at least 0.5 mile.

2) The proposed sill is the only erosion protection structure for a particular shoreline section. The general permit shall not apply to projects with an existing or proposed bulkhead or revetment landward from and parallel to the sill. Group One activities can be included along the same or different shoreline sections.

3) An existing or created tidal marsh at least 8 ft wide must be included.

4) Maximum water depth at sill location -3 ft MLW, and/or a distance of no greater than 30 feet from Mean Low Water to landward side of sill.

5) Sill design specifications
   a) Sill not placed on vegetated wetlands or SAV
   b) Sill height 0 - +1 ft above Mean High Water
   c) Trapezoidal shape, channelward face of sill should have a slope no flatter than 2:1. End slopes should be 1.5 or 2:1
   d) Filter cloth under the sill

e) Quarry stone. Broken concrete may be re-used for core material if it is already in place on the shoreline within the marine environment. Concrete core must be capped with stone on the channelward side of the sill. Concrete cannot include exposed re-bar or other demolition debris.
f) Sill windows/gaps at least 5 feet wide for each 100 linear feet of sill. Window height no greater than half the full height of the sill.
d) May include use of sand fill. Sand will contain less than 10% very fine (passing through 100 sieve). Source of material shall be provided.

**C. Additional Conditions**

1) **Riparian modifications**. Activities such as bank grading, bank shaping, land disturbance, tree removal, and terracing should be allowed where necessary to establish wide, gradual slopes and an integrated wetland-upland vegetation buffer.
   a) Standard erosion and sediment control practices should be included.
   b) Water Quality Impact Assessments, formal landscape agreements and other requirements of local CBPA programs should be included.

2) **Vegetation Plan.** Wetland and/or riparian buffer planting plan(s) shall be provided if needed, including native plant species, quantity, relative location (plan view), elevations (cross-section), planting schedule, and fertilizer use. Plan should incorporate necessary species and planting densities to meet minimum standards for vegetated cover.

3) **Vegetated Wetland Impacts.** If impacts are proposed as part of the integrated project, there can be no net loss of areal vegetated wetlands.

## Section 4: Contacts and VMRC Support Documentation

The following people were contacted via email, phone or in person conversations regarding living shorelines policy, permits or environmental issues as background for the report:

Denise Clearwater- Maryland DER

Rachel Gittam- PhD student UNC Chapel Hill studying living shorelines

Doug Huggett- North Carolina Department of the Environment and Natural Resources

John Fear - North Carolina Department of the Environment and Natural Resources

Carolyn Currin- NOAA National Ocean Service, Center for Coastal Fisheries & Habitat Research, Beaufort

Rebecca Ellin- NERRS North Carolina

Kathleen Waltz- New Jersey DEP

Mark Biddle- Delaware Department of Natural Resources and Environmental Control

Jeff Jorgenson- Marine construction and Salvage

Bob Winstead- Riverworks

Walter Priest- (formerly) NOAA Habitat Restoration Center

Jessica Thompson- Christopher Newport Univeristy, professor

The following people were contacted regarding the efficacy and environmental issues of living shorelines with folks affiliated with a new Corps of Engineers initiative known as SAGE (Sustainable Approaches to Geomorphic Engineering). This group includes:

Charles Chesnutt, Corps IWR

Deb Larson-Salvatore, Corps IWR

Denise Reed, University of New Orleans

Kate Barba, Director, National Policy and Evaluation Division, N/ORM7
Office of Ocean and Coastal Resource Management, NOAA

Kim Penn, NOAA National Policy and Evaluation Division, N/ORM7
Office of Ocean and Coastal Resource Management

The following people participated in formulation of draft criteria through meetings, email and phone conversation. The process was initiated with VIMS-CCRM staff through three meetings to review, discuss and draft criteria. After meeting with other VIMS personnel and after developing a working draft for criteria, two more meetings were held with VMRC, DCR and Corps participation.

Scott Hardaway- Shoreline Studies, VIMS

Lyle Varnell, Assistant DRAS, VIMS

Dr. Carl Hershner, CCRM, VIMS

Dr. Donna Bilkovic, CCRM, VIMS

Julie Bradshaw, CCRM, VIMS

Karen Durhing, CCRM, VIMS

Molly Mitchell, CCRM, VIMS

Christine Tombleson, CCRM, VIMS

Chip Neikirk, Deputy Chief, Habitat Division, VMRC

Randy Owen, VMRC

Nancy Hankins, Norfolk Corps

Joan Salvati, DCR

**In support of VMRC Integrated Guidance and Living Shorelines General Permit**

CCRM staff attended a total of 20 Wetland Board meetings during which the VMRC engineers presented on the development of the Living shorelines General permit. In addition, CCMR attended an open meeting for the public and contractors at the Commission offices in Newport News. VMRC was included in meetings to develop draft general permit criteria. CCRM staff sits on the ad hoc technical advisory committee established by VMRC for purposes of development of the general permit. In addition to attendance at the 3 formal meetings, CCRM has contributed through phone conversations and email exchanges.

The VMRC convened technical advisory committee meeting held at VIMS we discussed the proposed general permit criteria at length. Draft language had been provided by VIMS in advance of the meeting for review by participants. Some of the discussion is captured below.

1. Should the use of oyster shells be allowed. This stems from two concerns- is erosion protection the highest use for shell, and does shell provide erosion protection. Some of the literature suggests that oyster shell contained within bags or cages will "act" like breakwaters and damping wave energy. Other studies have shown that contained shell will provide substrate for oyster spat set and therefore may be an appropriate use in the face of demands for shell for oyster restoration. Ultimately, this question becomes a public policy issue to be resolved through public review. The working group also decided that contained clam shells should be include in this criterion. There is still additional debate on whether to allow the use of live mussels (being used in the Delaware estuary) under the general permit.
2. What, if any, should be the minimum width for tidal wetlands vegetated area. Few studies have looked directly at the erosion abatement capacity of marsh vegetation. And those studies have occurred in areas of differing tidal and wave regimes mostly focused on *Spartina* species. Nevertheless, there is general agreement in the scientific community and among the participants in VMRC process, that marsh vegetation provides erosion abatement. Based on this agreement, and the definition of living shorelines in Virginia law, the proposed criteria include a minimum width of 8 feet. The committee noted that it would be important that the general permit to allow placement of a marsh sill channelward of an existing marsh less than 8 feet wide to avoid conflicts public policy interests in the protection of tidal wetlands and commitment to not net loss. At this time, the group has not resolved what species may be allowed or dis-allowed to meet this particular criterion.

Other discussion items:

- The committee felt fiber logs or shell bags should not be placed channelward of mean low water (mlw) under the "group 1" category projects since the intent and procedures associated with group 1 projects will have minimal constraints and a very streamlined review process.
- We discussed possible appropriate limits on the amount or extent of fill associated with group 1 projects. There was some agreement that fill should be no higher than adjacent wetland substrate and or mhw and that no fill would be placed channelward of mean low water.

- There was general agreement that no monitoring of group 1 activities should be required.
- It is not anticipated that CBPA would typically be involved for the Group 1 activities but this needs to be confirmed. If necessary, a condition could be included limiting construction access and requiring restoration of any access area.
- With regard to application and review procedures for Group 1 activities, the committee felt a simple abbreviated application should be utilized. It could even be more of a checklist similar to the Corps RP-17 checklist. The Group 1 activities would be confined to the intertidal zone (LWB jurisdiction). It may be possible for VMRC to conduct a desktop review to minimize any financial or time impact on wetlands board staff but noted that some localities may prefer to conduct the review. The committee agreed there should be no processing or permit fee.
- The committee discussed whether there should be a provision to allow eradication or control of *Phragmites* under the general permit. The committee suggested that rather than put *Phragmites* control in the GP, the living shoreline guidance documentation could include VMRCs current guidance on the subject. VMRC's guidance recommends those wishing to conduct measures to control *Phragmites* submit a plan to the LWB and that any eradication efforts should include plans for re-vegetation. It was also recommended that the guidance include statements regarding the planting of wetlands vegetation and trimming of overhanging riparian vegetation.
- The committee expressed interest in further clarification of the required fetch of ½ mile or more to qualify for the Group 2 permit. It was suggested that " or active erosion evident" be added to the criteria and noted that a site visit is likely going to be required at these sites and the reviewer could assess the erosion.
- The conditions associated with riparian modifications will need to be coordinated with Joan for compliance under CBPA. The committee agreed that it would help streamline the process if any required WQIA could be combined within a single special living shoreline permit application.
- The committee discussed what minimum standards the permit should require for vegetation plantings and suggested planting should be on 18-inch centers or in conformance with existing guidance.
- With regard to procedures associated with the Group 2 general permit, the committee felt:
    1. There should be either no permit fee or a reduced fee.
    2. No royalty.
    3. Wetland Board and VMRC review with each having an option to require a regular permit if either felt the general permit was not appropriate.
    4. There could perhaps be a single "joint" permit issued by VMRC.
    5. If allowable the public notice requirement should be eliminated and no required notice of adjoining property owners unless the project is within some set distance to a property line. VMRC will confer with their legal counsel regarding the adjacent property owners and public notice streamlining.
- It will be necessary to confirm with the Corps of Engineers that all of the activities authorized under the general permit can be easily processed by the Corps (without the need for an individual permit).