Assessing Cumulative Impacts of Shoreline Modification Workshop Report: Chesapeake Bay STAC Proactive Workshop

Silver Spring, MD
February 2006

STAC Publication 07-003

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The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports periodically to the Implementation Committee and annually to the Executive Council. Since it's creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical conferences and workshops, and (5) service by STAC members on CBP subcommittees and workgroups. In addition, STAC has the mechanisms in place that will allow STAC to hold meetings, workshops, and reviews in rapid response to CBP subcommittee and workgroup requests for scientific and technical input. This will allow STAC to provide the CBP subcommittees and workgroups with information and support needed as specific issues arise while working towards meeting the goals outlined in the *Chesapeake 2000* agreement. STAC also acts proactively to bring the most recent scientific information to the Bay Program and its partners. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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STAC Administrative Support Provided by:
Chesapeake Research Consortium, Inc.
645 Contees Wharf Road
Edgewater, MD 21037
Telephone: 410-798-1283; 301-261-4500
Fax: 410-798-0816
http://www.chesapeake.org

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Executive Summary

Shoreline modification is an issue of growing concern to coastal managers. Coastal managers, economists, and other scientists met to develop an approach to capture the incremental impacts of increasing levels of shoreline modification with respect to their costs and benefits at different levels of shoreline modification. The approach applies the concept of marginal analysis from economics to assess and predict the cumulative costs of shoreline modification in the Chesapeake Bay watershed. The goal is to assess entirely the environmental, social, and economic impacts of additional shoreline modification in a given area. Such an approach would incorporate incremental (human-caused) change in shorelines in a manner that would show as costs in the standard marginal cost curve.

Workshop participants agreed that the approach has merit and outlined the steps to define the marginal cost curve by 1) relating shoreline conditions to the capacity of the area to provide ecological services, and 2) conducting an assessment of the economic cost from ecological damage associated with increasing levels of shoreline modification. This would most likely be implemented using a contingent valuation survey. Alternately, it could be done by employing a stated preference survey to assess the external costs of increasing levels of shoreline modification. A hedonic property price analysis combined with available information on shoreline condition was recommended for approximating the private benefits of shoreline armoring, and some of the external market costs (decreased property values from visual disamenties to neighbors). Improved understanding of cumulative impacts may provide a scientific basis for a shift from single project management/permitting to local planning based on an established threshold beyond which shoreline hardening should not be approved.

Problem Statement

Since 1968, Maryland Department of Natural Resources' Shore Erosion Control has supported 800+ structural and 325 non-structural shoreline modification projects and Virginia has permitted several thousands of shoreline projects to dissipate wave energy, maintain navigation channels, control shoreline erosion, repair storm damage, protect from flooding, store sediment, and promote commercial or recreational activity (Hardaway and Byrne 1999). Comprehensive shoreline conditions inventory data collected by the Virginia Institute of Marine Science (VIMS), Center for Coastal Resources Management for Maryland and Virginia documents extensive shoreline armoring and concomitant loss of natural shorelines in the states of Maryland and Virginia. Shoreline armoring helps property owners by decreasing shoreline erosion and protecting property, and property owners have the legal right to protect their shoreline property. However, these projects cause the loss of intertidal habitat. While it is commonly noted that structures reduce sediment loading into the Bay, this misrepresents the reality that the Bay's shorelines are naturally erosional for the most part. Sediment from eroded shorelines create and maintain intertidal and shallow water habitats. Taken individually, the adverse environmental impacts associated with a shoreline stabilization structure may appear insignificant (Shipman and Canning 1993). However, eroding shorelines are fundamental to the character of the Chesapeake Bay ecosystem, and there is a growing concern regarding the cumulative ecological effects of shoreline armoring in Chesapeake Bay.

The permitting process reviews each proposed project individually, allowing property owners and planners to ignore the cumulative effect of shoreline modification. The $100 million/year Federal Shore Protection Program has been criticized for assigning disproportionately high values to private interests and not enough value to environmental interests. The resulting cost-benefit analyses favor seawall construction over natural dunes and vegetation (Marlowe 1977). Better estimates of the direct and external impacts of shoreline modification are needed for improved shoreline management and planning. The following summary shows how the economic concept of marginal analysis can be applied to assess more accurately and predict the ecosystem costs of each additional shoreline modification project.

Cumulative Effects

The Council on Environmental Quality (CEQ) defines cumulative effects as, "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions…" (National Environmental Policy Act, 40 CFR ~ 1508.7). Cumulative effects may be additive or synergistic in nature, and may last beyond the life of the project that causes the effects. Common examples of cumulative effects include acid rain, climate change, loss of open spaces, and loss of biodiversity (Cooper 2004). To minimize the potential for cumulative effects, the CEQ recommends assessing projects in terms of the capacity of the affected resource, ecosystem, and/or human community to accommodate additional effects (CEQ 1997).

Economic Valuation and an Eqiu-Marginal Principal

Marginal analysis examines the way in which the benefits of a good or service vary with the aggregate level of the good or service produced. For example, when a minimum habitat area is necessary to support a species, the marginal benefit of preserving an additional acre depends on whether that acre is needed to meet the minimum. Likewise, the cost of each additional shoreline modification project should take into account its effect, relative to the cumulative effects of the previous shoreline modification projects.

In basic price theory, the marginal costs of producing more of a good or service is plotted against the incremental gains generated by having that additional unit produced (usually measured as "willingness to pay"). The

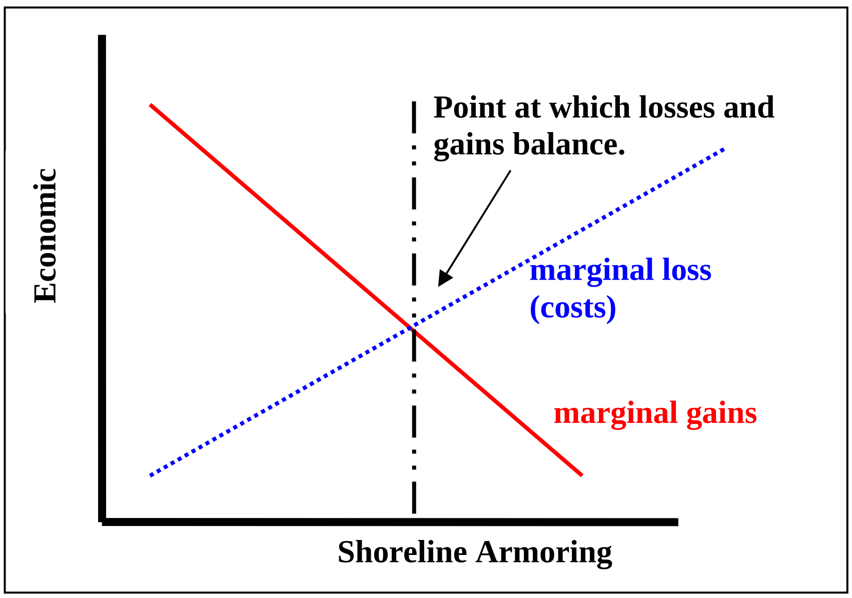

Figure 1. 1. Generic marginal cost graph. In general, the marginal gain will go down from left to right, and the marginal loss will go up. While they are shown here as lines, they are probably both curved.

x axis measures units of shoreline armoring in a given area, with these units increasing as you move away from the origin. The y axis measures economic value in dollars, also increasing as you move away from the origin (Figure 1).

Consider first the marginal gains. Under the assumption that the shoreline armoring projects with the highest value were prioritized, we would expect the marginal gains curve to be declining (i.e. those projects with the highest economic value [represented by relatively high willingness to pay] are closer to the origin). The economic benefit of any unit of shoreline armoring can be determined by identifying that unit on the x-axis and tracing up to the red *marginal gains* line and over to the value axis. To understand the marginal cost curve, one only needs to realize that each unit of shoreline armoring induces some external impact on the environment. Thus, each unit of shoreline armoring is associated with some loss of ecosystem services. These external impacts are in addition to any private construction costs. To simplify matters, assume marginal construction costs are constant at $c; that is, you pay $c per unit of shoreline armoring regardless of whether it is the first project built or the last project built. To introduce external costs, one needs to measure the marginal impact of each unit of shoreline armoring in terms of lost ecosystem services and translate that loss into a dollar metric. This dollar metric represents the economic value of ecosystem services lost due to construction of shoreline armoring. Add this to the constant marginal construction costs, and you have the marginal cost curve. The marginal loss curve tracks the costs, or ecosystem services losses imposed by shoreline modifications. The marginal gains curve tracks the additional benefits derived from incremental shoreline modifications. The system is optimized at the point where the losses and gains balance.

The economically efficient level of shoreline armoring is defined as that point at which the marginal benefit of an additional unit of armoring just equals the marginal cost. To see this, note that the marginal benefit of each unit up to the optimum exceeds the marginal cost of providing the unit.

The challenge in applying the marginal approach to assessing cumulative impacts of shoreline modification is in defining the cost (loss) and benefit (gains) curves.

<u>Calculating the Marginal Loss Curve</u>

The marginal loss is the sum of the construction, dredging, and environmental costs. The construction and dredging costs are measured in dollars and determined by the market. The environmental costs include the mitigation of potentially vast or irreversible damages, and the cost of ecosystem services lost over time. In this case, a damage assessment is needed to relate shoreline conditions to the capacity of the area to provide habitat, fishing, clean water, and other services.

If the value of a system is measured in terms of what it generates for humans, ecological costs (or services lost) can be measured in dollars. Stated preference methods (such as contingent valuation) could be used to derive a dollar amount for services lost as a result of a shoreline modification project. What value do we lose by replacing wetlands and shoreline vegetation with bulkheads? Expressing the ecological cost in dollars has an added advantage in that it provides a common currency for the assessment. One way to conduct a stated preference survey is to: 1) Distill damage assessment models into visual and text descriptions of what services that state of the system can support; and 2) Survey individuals to assess the values people place on changes in condition of the shoreline and the services it provides. Some of the difficulties in doing this are detailed below.

Calculating the Marginal Gain Curve

The marginal gain curve reflects benefits for the property owner (and any attendant environmental benefits). A hedonic property price analysis can derive the value placed on shoreline modification from observed property market transactions, tracking how sale prices change with hardening strategy. A complete analysis will consider the "viewshed" taking into account shorelines in the property owner's view in addition to the owner's own shoreline. If a project lowers the property values of neighbors, those costs should be noted and included in the marginal cost analysis. Environmental benefits, such as improved habitat and reduced sediment, could possibly be converted to dollars with contingent valuation as described above.

Application in the Permit Context

Estimates of marginal costs and benefits of shoreline armoring in a given area will provide the permitting agency with a tool for assessing the impact of proposed shoreline projects on the area. In a permitting context in which the goal is to assess the marginal losses and gains, modification projects would be allowed until the point where the lines cross, where increased costs are greater than the increased gains. Ideally, the permit decision would be made based on an understanding of where a project is on the cost curve, and thus what is given up if the permit is issued. An informed decision can then be made on whether the cost is acceptable.

Challenges

In standard economic theory, increasing scarcity will typically lead to increasing value in a continuous fashion. But in ecological services, often there are thresholds at which value changes dramatically. The response of an ecosystem to coastal development is often a discontinuous, highly non-linear function – ecosystem benefits may be suddenly lost once a development threshold is exceeded.

It also is likely that, in many developed bays and estuaries, the critical thresholds have been crossed, resulting in current living in less ecologically desirable states. If the threshold has been extensively exceeded, increased modification of the shoreline will cause little additional cost as there are few remaining resources to damage. At the same time, if the goal is to make improvements in shoreline quality, the improvement projects will only make small differences in ecosystem services. However, each incremental improvement will move the system closer to the threshold point.

The current system drives only in one direction – toward incremental losses. **Thus, the management goal needs to become a process to minimize changes in a dynamic system.** The approach should be in three phases:

1.) determining if a project is designed to minimize ecological change;

2.) conditional on having minimized its ecological effect, determining if the gains exceed the costs.

3.) determining whether the creation of transferable rights for the shoreline development is worthwhile.

It is difficult to believe that every project has benefits exceeding costs. Some projects are, by their very nature, devastating to the environment and their impacts cannot be minimized to an acceptable level. When it is obvious that a proposed project would push the system past a threshold (however poorly defined that threshold is), the permitting agency can request of the applicant additional justification relative to the threshold or deny the permit.

Policy makers need to recognize that the cost of the bulkhead is more than just the cost of putting in the bulkhead – it also is the cost of the ecosystem services lost.

For all of these management approaches, a strictly enforced regulatory program is required. That is, one cannot have a permitting system in which some individuals avoid it or misguide it. In order to accommodate changes that may occur over time, it might be useful to establish a set of shoreline development caps and rights to portions of the caps. The rights would be transferable given the concurrence of the permitting agency. The concurrence would be based on the transfer being consistent with the established cap and rights to portions of the caps. The market or planning/regulatory system would evolve around those caps and develop in ways to reduce impact. Setting a cap makes the tradeoffs apparent and puts the personal benefit of a modification project in the context of the larger, cumulative problem.

There are several ways to accommodate the degree of impact of a project. One of the best regulatory tools is to charge more for a higher impact project. Another means to move the system from one that minimized impacts to one that achieves no impact is to require tradable permits or change the ratio of mitigation from 1:1 to something greater (i.e., for every acre of wetland lost, require that five acres be restored).

A non-regulatory approach requires planners to look at the entire system in evaluating the appropriateness of each change. Once planners set an amount (i.e., percentage) of shoreline that can be hardened, they can allow developers some flexibility in how new shoreline modification projects are built and distributed. This idea is being applied to regulate phosphorus concentrations in Virginia rivers. Developers there cannot alter the net amount of phosphorus coming off their riparian property, but maintain the flexibility to decide if phosphorus will be controlled by leaving some natural buffer to filter pollutants, installing storm water detention basins/infiltration ponds and swales, reducing fertilizer application, etc. Economics can inform these decisions, collapsing variables into a common unit (dollars) to ensure that gains balance the losses.

The following difficulties in applying the marginal gain approach to shoreline modification were recognized:

- This type of model requires a significant amount of data and environmental cost data are lacking. In the absence of knowledge of unperceived values, the tendency is likely to undervalue the services provided by a system. Counteracting that tendency when creating the model, will require erring on the side of caution by valuing the ecosystem services as high as justifiably possible.

- The costs and benefits may be realized by different sectors requiring a societal (i.e. non-economic) decision. What if many people gain just a little, but a property owner loses a lot? Does a $1 cost to 10,000 citizens outweigh a $5,000 cost to a property owner? If economic efficiency is not the primary basis on which decisions are made, project costs may be imposed on a particular group. For example, should shorefront landowners' potential benefits override the potential benefits of the fishing or boating public?
- How site-specific will a model be?
- What should describe the y axis? Is one wetland like another? Criteria are required for whatever is going to be measured.
- Uncertainty – is it really known what will happen? Thresholds vary by events.
- Sequencing – If "bad" projects are permitted early on, how are they later replaced with better projects?
- Benefits from shoreline stabilization are more certain than costs (e.g., revenue from real-estate sales).
- There is limited quantitative data on downstream impacts. How does erosion of one property owner's shore affect his/her neighbor? If the construction of a hardened shoreline deflects surge to a neighbor's shoreline, what recourse is possible? How can the permitting process take into account downstream impacts? Another less obvious downstream impact is the point at which the hardened shoreline becomes the norm, and generates a change in the community esthetic to a preference (visual) for the non-natural shoreline.
- How would these data be integrated? Do we need to know how every species is affected by shoreline modification, or can impacts measured from one species by used as an indicator of what is being lost?

<u>Data Needs</u>
Damage Assessment. A better understanding of the ecological services impacted by shoreline modification is necessary to support a contingent valuation survey. How does shoreline structure relate to ecosystem function? How do bulkheads really impact plant and animal distribution, fecundity, and survival? How does changing the shoreline affect the flood regime? How is a community or user group-valued species affected by the addition of one more bulkhead project? Hershner and colleagues have developed a conceptual model that considers the ability for a suite of shoreline condition(s) to support a healthy ecosystem. The model needs to be field validated and peer reviewed with the latter perhaps undertaken in a science workshop
Scale. At what scale are services realized? At what scale do impacts begin to affect the ecosystem's ability to perform functions? If shoreline locations x and y are hardened for a total of 10% more hardening, what will be the change in watershed ecosystem services score? Supposed structures were removed to lower the percentage of a shoreline hardened from 42% to 29%. How would that affect ecosystem services and contingent value?

Values. How is the change from beach biodiversity to marsh or stone biodiversity compared? Does the number of species matter more than the specific species represented?

What values should be applied to each species, especially when there is no direct market for them (i.e., recreational species, charismatic species with no harvest like marine mammals or endangered species, etc.)? What should these systems look like?

Next Steps

Pilot Project. A pilot project is the most time and cost effective way to move forward. Workshop participants and others will work with the STAC to select a place where information is available to undertake the hedonic analysis. Information on shorelines and faunal distributions will be collected to develop a first order assessment of a cost curve and populate the damage model. Finally, the contingent evaluation will complete the cost curve. The pilot project will help clarify the uncertainties associated with the approach and data certainty will guide where it is appropriate to use the result. If a product is less certain, the pilot could be used as an educational tool. With more certainty, it can be used to make permit decisions.

Outreach. One of the challenges is to raise the visibility of shoreline modification as an issue. Once validated, the conceptual model can be used to show municipal officials, property owners, and others how various percentages of hardened shoreline impact the services they value. Key questions include: How will communities and services change with different amounts of hardened shoreline? What are the community values? What do coastal and lake communities manage for in their shoreline planning?

Much remains to be done to adopt the approach. Fortunately, there is ample evidence of the impacts of exceeding thresholds and associated impacts in coastal systems. Adapting these examples into cost marginalization theory for routine application remains a formidable endeavor for the future.

Data and Literature Cited and Suggested Reading

Cooper, L. M. (2004), Guidelines for Cumulative Effects Assessment in SEA of Plans, EPMG Occasional Paper 04/LMC/CEA, Imperial College London. http://www.env.ic.ac.uk/research/epmg/CooperCEAGuidelinesJuly04FINAL.pdf

Council on Environmental Quality. 1997. Considering Cumulative Effects Under the National Environmental Policy Act. http://ceq.eh.doe.gov/nepa/ccenepa/ccenepa.htm

Cumulative Effects Assessment http://www.adb.org/documents/guidelines/environmental_assessment/Cumulative_Effects_Assessment.pdf

Hardaway, C.S. and R.J. Byrne. 1999. Shoreline management in Chesapeake Bay. Special Report in Applied Marine Science and Ocean Engineering No. 356. Virginia Institute of Marine Science, Gloucester Point, VA, 54 p.

Virginia Institute of Marine Sciences. 2006. The Comprehensive Coastal Inventory Program (CCI) Online GIS Databases. http://ccrm.vims.edu/gisdatabases.html

Williams, G.D. and R.M. Thom. 2001. Marine and Estuarine Shoreline Modification Issues. Battelle Marine Science Laboratory, Sequim, WA, 136 p.

Appendix 1: Workshop Participants

Holly Bamford, NOAA Office of Response and Restoration
Marcia Berman, Virginia Institute of Marine Science
Allison Castellan, NOAA Office of Coastal Resource Management
Melissa Fagan, Chesapeake Bay Program STAC and Chesapeake Research Consortium
Matthew Fleming, Maryland Dept. of Natural Resources
Scott Hardaway, Virginia Institute of Marine Science
Kirk Havens, Virginia Institute of Marine Science
Lamere Hennessee, Maryland Geological Survey
Carl Hershner, Virginia Institute of Marine Science
Rob Hicks, Virginia Institute of Marine Science
Paula Jasinski, NOAA Chesapeake Bay Office
Jean Kapusnick, Army Corps of Engineers, Baltimore
Ruth Kelty, NOAA National Centers for Coastal Ocean Science
Keelin Kuipers, NOAA Coastal Services Center
Craig Landry, East Carolina University
Doug Lipton, Maryland Sea Grant
Audra Luscher, Maryland Dept. of Natural Resources
Gary Matlock, NOAA National Centers for Coastal Ocean Science
Dan Miller, Hudson River National Estuarine Research Reserve
Susan Roberts, National Research Council, The National Academies of Science
Kevin Sellner, Chesapeake Bay Program STAC and the Chesapeake Research Consortium
Chris Spaur, Army Corps of Engineers, Baltimore
Ivar Strand, University of Maryland (emeritus)
Robert Wieland, Maine Street Economics

Appendix 2: Ongoing Efforts to Improve Shoreline Management

On-going efforts to improve shoreline management include:

- National Academy of Science: Mitigating Shoreline Erosion Along Sheltered Coasts. The NAS study examines the impacts of shoreline management on sheltered coastal environments and identifies conventional and alternative strategies to minimize potential negative impacts to adjacent or nearby coastal resources. Sheltered coastlines (e.g., estuaries, bays, lagoons, mud flats, deltaic coasts) were selected because they are not as well understood as open coasts. Impacts examined include: loss of intertidal and shallow water ecosystems, effects on species, and loss of public trust uses. The study aims to provide a framework for collaboration between different levels of government, conservancies, and property owners to aid in making decisions regarding the most appropriate alternatives for shoreline protection. (http://dels.nas.edu/osb/sheltered_coasts.shtml)

- NOAA Office of Coastal Resource Management and Restoration Center - Shoreline Management Technical Assistance Toolbox.
  The toolbox provides coastal managers, local decision makers, and other interested parties with information about and easy access to management tools, case studies, and other resources available for addressing shoreline management issues. The site focuses on management approaches that avoid shoreline hardening, including policy tools (e.g., set backs, planning, shoreline zoning, etc.) and alternative "soft" shoreline stabilization methods (e.g., marsh restoration with breakwater sill). (http://coastalmanagement.noaa.gov/shoreline.html)

- NOAA Coastal Services Center - Shoreline Change Conference II (May 3-5, 2006). This conference brought together researchers and coastal managers interested in shoreline change and coastal management decisions. Presenters and participants reviewed technology, tools, data, and procedures used to analyze shoreline change, as well as federal programs that are developing and applying shoreline data sets. The workshop emphasized state and community-level management applications and challenges, with the ultimate goal of unifying local and national needs. Conference goals were to: 1) foster dialogue among researchers and coastal managers about tools, data, and procedures used to make coastal management decisions; 2) explore policy, planning, and regulatory approaches to managing erosion hazards; and 3) facilitate a coexistence of local needs with national needs and objectives. Presentations are available at http://www.csc.noaa.gov/shoreconf/.

- NOAA Chesapeake Bay Office. Funded a study through VIMS for developing a protocol to assess conditions under which living shoreline treatments may be a preferred protection strategy. NCBO's NEMO Program (Non-Point Source Education for Municipal Officials) is a mechanism for transferring information to municipal officials. There may be an opportunity to partner with NEMO for training and information transfer.

- Virginia Institute of Marine Science. Staff are currently examining impacts of shoreline hardening on fish habitat. This includes identifying what is the tipping point for modification of shorelines for fish habitat? Results indicate that a small number of bulkheads can result in significant habitat degradation. VIMS staff have also developed conceptual models for shorelines system capacity to provide services, i.e., habitat and fishing. The models integrate data from the Virginia and Maryland Shoreline Inventory (http://ccrm.vims.edu/disclaimer_shoreline_situation.html. They are complete but validation through field sampling.

- NOAA's Coastal Services Center (CSC). CSC and ACOE (US Army Corps of Engineers) are supporting a national shoreline management study in Florida. CSC is chairing the agency roles working group that is reviewing approaches for addressing shoreline issues. The primary product will be a set of case studies showing how agencies structure partnerships to address shoreline management problems (i.e., beach nourishments, setbacks…..). One case study focuses on the California Coastal Sediment Management Group.

- ACOE (Baltimore District): VIMS will develop for ACOE and MD DNR an ecosystem risk assessment tool that delineates risk of habitat loss through shoreline erosion. The model will consider anthropogenic modifications and development along the shoreline as a mechanism for assessing the future capacity of marsh and beach environments to persist. A GIS-based tool that includes an inventory of dilapidated bulkheads will assist ACOE and MD DNR identify restoration areas in the future. (http://ccrm.vims.edu/gisdatabases.html)

- Maryland Department of Natural Resources – Shorelines Online. This internet portal centralizes information and data on shoreline and coastal hazards management in Maryland. It provides data distribution capabilities, internet mapping tools, technical/financial assistance, and educational information. Interactive mapping tools allow for viewing, integrating, and displaying physical, environmental, land use, and shoreline-specific information including historical shorelines (1880s to 2003) and site-specific rates of change. One limitation of this database is that, because a bulkheaded shoreline will show no change, no change does not always mean that it is a low energy area appropriate for living shoreline. The effort needs to be coupled with the shoreline inventory. (http://shorelines.dnr.state.md.us/)