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Coastal Resource Management Planning

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In this issue:

Sea level rise and development patterns put wetlands and other shoreline resources at risk.

Sustaining public benefits from shoreline systems will require comprehensive management and planning.

Comprehensive Coastal Resource Management Plans will assist localities with information about important natural resources, preferred shoreline management options, potential use conflicts, and risk reduction.

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Coastal Resource Management Planning

About 11% of shoreline in Virginia tidal waters have been hardened with bulkhead and riprap revetment structures and on average 18 miles of shoreline continue to be hardened each year.

Shoreline management in Virginia has evolved over the past 40 years to keep pace with increased understanding of these complex systems. In 1972 the Tidal Wetlands Act was focused on minimizing impacts on marshes. Over the next 30 years, other parts of the shoreline system – beaches, mudflats, riparian buffers (adjacent wetlands) - were also recognized as valuable. By the turn of the century, integrated management acknowledged that all components of the system needed to be managed in concert to optimize public benefits. Now we understand the entire system is changing, driven by climate and development. As a consequence management must expand to include planning for future conditions. Comprehensive coastal resource management plans now under development by the Center for Coastal Resources Management are the response to this need.

Anticipated Pressures

The Commonwealth of Virginia has extensive areas of shallow tidal water supporting essential habitats for plants and animals. Important habitats include tidal wetlands, submerged aquatic vegetation (SAV) and estuarine beaches. The two foremost pressures that have the potential to significantly alter ecosystems and the services that they provide to society are coastal development and climate change.

- Coastal development can involve shoreline alteration and adjacent uplands. Shorelines are often altered to protect against erosion. The most common strategies currently employed are bulkheads and riprap revetments which sever the land-water connection.
- The Chesapeake Bay is extremely vulnerable to climate change as rates of relative sea level rise are currently more than double the global mean and rising (~4.2mm/yr in Chesapeake versus 1.7 mm/yr globally). As climate change continues, sea level rise rates are expected to increase and additional negative effects will likely include intensified coastal flood and storm events, increased shore erosion, inundation of wetlands and low-lying lands, and salt-water intrusion into groundwater.

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Areas with shoreline and riparian development effectively prevent the migration of coastal habitats landward in response to climate changes. This issue will intensify unless shoreline management and land use planning begin to consistently consider cumulative impacts of activities. An examination of land use plans for low-lying areas (below 1-m) along the US Atlantic Coast indicated only approximately 10% of lands have been set aside for conservation and that almost 60% of the land is expected to be developed and thus unavailable for the inland migration of coastal habitats (Titus et al 2009).

The amount of shoreline hardening occurring can vary among years (e.g. high permit activity following a significant storm event), but overall long-term trends can be an indication of what our future shorelines will look like. Based on current average rates of shoreline hardening, approximately 9-18% of additional Virginia shoreline will be hardened 50 - 100 years into the future (assuming no shifts in management practices and no accelerated activity due to sea level rise and storm events). Likewise, approximately 27% of riparian lands in Virginia have been developed and development pressures continue.

As a first step to understanding this complex issue, we characterized existing shallow water habitats in Virginia tidal waters and predicted climate driven changes within the next 50 to 100 years (http://ccrm.vims.edu/research/climate_change/index.html). Coastal habitats experienced significant reductions under the simulated sea level rise scenarios (with a range of 0.5 - 5 foot rise in sea level by 2100).

- Seagrass beds: In lower salinity waters, current beds may experience losses due to sea level rise of 13-24% by 2050 and 27-76% by 2100. Development induced degradation of water quality has the potential to exacerbate losses.
- Eelgrass beds: In high salinity waters, if temperature is elevated by a few degrees Celsius and sea level rises, eelgrass beds may experience 65-94% loss by the year 2050
- Tidal marshes and beaches: approximately 38% of tidal marshes and 85% of beaches are moderately-highly vulnerable to sea level rise due to adjacent development which prevents landward migration

Preserving landscapes that allow for the transgression of the Bay's essential shallow-water habitats should be a high conservation priority. The loss of these habitats could significantly alter the character of the Chesapeake Bay from a highly productive shallow water estuary that provides crucial spawning and nursery habitat for numerous species to one with reduced ecosystem function.

Strategies for addressing some of these shoreline management issues have been developed and integrated into policy in several coastal states. In particular management of tidal shoreline erosion has moved from traditional shoreline hardening to alternative approaches that use soft stabilization or living shoreline treatments. These adaptations are known to promote ecosystem resilience in the face of climate change.

The Shoreline Management Model

Processes that contribute to erosion include: high wave energy generated during storm events, tidal currents, upland runoff, sea level rise, boat wake activity, deforestation, and sediment starvation. While all of these processes may act upon a reach of shoreline at any given time, storm events by far contribute most measurably.

Shoreline protection has evolved over the last 40 years. We have learned that traditional techniques for erosion control can have immediate adverse impacts on intertidal habitat, and longer term impacts on resource sustainability. The choices made can severely impact the stability of adjacent shorelines and alter the ecosystem on site indefinitely. Any action that severs natural processes and connectivity between the upland and the aquatic system will result in some impact.

Providing guidance to property owners and decision makers on the issue of shoreline protection has been a focus of activities within CCRM since its inception. Over the last several years, the guidance has evolved to reflect the growing need to maximize long-term ecological services and sustainability of coastal resources, while still providing the best possible solutions for erosion control. To that end, CCRM has developed a number of products and service tools to improve the capacity of property owners as well as local and state coastal managers to make informed decisions.

The Shoreline Management Model (SMM) is an automated, science-based decision support tool that integrates management decisions across the coastal profile (Figure 1). Using GIS technology and best available geo-spatial data, the model determines the most ecologically appropriate management technique to counter erosion control on a reach by reach basis. The model gives preference to erosion control options that preserve the connection of the various habitats across the natural landscape profile.

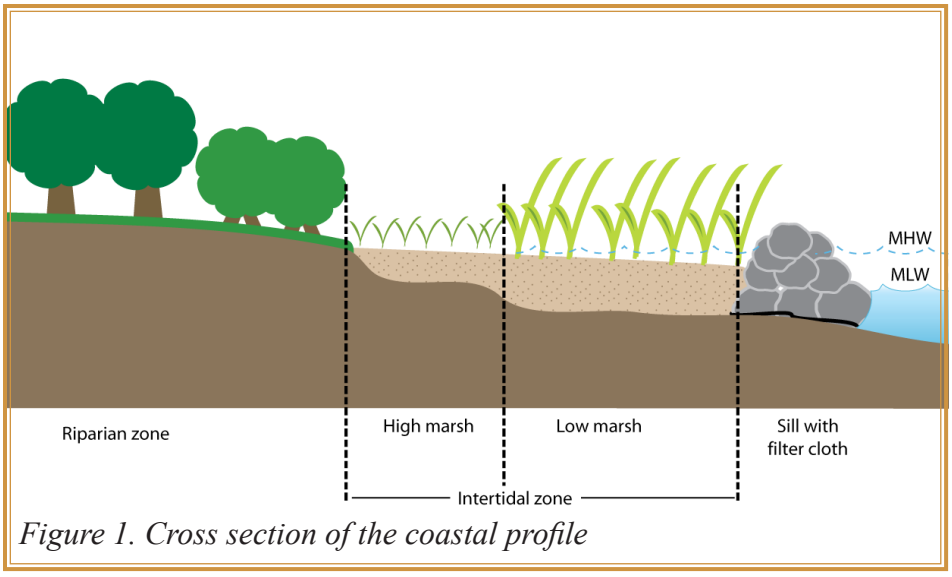

Figure 1. Cross section of the coastal profile

The SSM is a logic model which follows the Decision Tree Guidance developed previously by CCRM (http://ccrm.vims.edu/decisiontree/index.html).

The Decision Tree guides the user through a series of questions pertaining to site conditions. Based on the responses the user follows a decision path which leads to a recommendation for shoreline treatment. The SMM has developed algorithms which follow the same flow path of questions and searches the GIS databases for the data to answer those questions. The GIS data required to run the model is gathered from a number of databases, including the VIMS Shoreline Inventory.

The Shoreline Inventory database is an extensive collection of conditional data that has been collected in the field using GPS. The data includes very site specific information that characterizes bank height, shoreline stability, presence of marsh and beach habitat, tree canopy, riparian land use, and existing shoreline structures (http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html).

CCRM developed a model that calculates wave climate potential along the shoreline. External databases such as NOAA's bathymetry data are used to describe the depth of the nearshore subaqueous bottom. Collectively, variations in all these attributes control the appropriateness and effectiveness of a treatment option for a specific site. The SMM integrates this information to return a recommended strategy for countering an erosion problem at a given location along the shoreline. See below for an example.

The scope of treatment options can range from a "do nothing" approach, or "vegetation management" to "revetments" or "breakwaters with beach nourishment" depending on the set of circumstances and conditions found at each site.

A shallow nearshore zone can support marsh growth but the wave exposure requires a marsh sill to protect the plantings from wave energy. If the wave exposure were low, a temporary bio-log would be sufficient.

Output for the SMM will be presented in maps. Using color-coded symbology, these maps will show the recommended treatment options along the shoreline. A sample map is shown for the City of Hampton (Figure 2, p. 5).

An interactive website is also planned where the SMM output as well as other data can be made available. This application will be similar in format to the Shoreline Assessment Mapper (SAM) tool developed to give local government access to information to improve their decision making capacity (http://139.70.26.131:8008/ShorelineAssessmentMapper/).

The SSM will ultimately be part of the Comprehensive Coastal Resource Management Plan (CCRMP).

Comprehensive Coastal Resource Management Plan

A Comprehensive Coastal Resource Management Plan (CCRMP) is a guidance document provided to local governments that offers an eco-system based approach to managing coastal resources. The CCRMP targets riparian lands management; tidal lands including wetlands, beaches, and dunes; subaqueous lands such as SAV and oyster reefs; and non-tidal wetlands. The CCRMP draws information, strategies, and recommendations from a vast array of resource management tools and assessment methodologies developed within CCRM at the VIMS as well as tools and models available from other sources.

Figure 2. Shoreline Management Model output for a section of the Back River in Hampton

A CCRMP addresses a suite of environmental issues, evaluates trends and conditions, and presents options for management. Shoreline protection is one of these environmental issues and the SMM is the tool to arrive at best management options. Below are some other environmental issues and the tools addressed by CCRMP.

- **Flooding:** Flooding can occur during high energy coastal storms and during extremly high tides when lunar tides combined with barometric pressure cause the elevation of the water to exceed normal limits and during heavy rain events. These distinctions are important. Flooding is a site specific problem and must be managed differently than an eroding shoreline.

The CCRMP can use elevation models to identify areas at risk from different types of flooding and discuss possible mechanisms for managing the problem. Today the accuracy of elevation models is limited by the elevation data available for input. Virginia's recent contract to develop LIDAR (LIght Detection And Ranging) for the entire coastal zone of Virginia will provide a new and highly accurate source of data from which elevation models can be generated. These data are expected to be released in 2011 for a large section of the coastal zone.

- **Sea level Rise:** Virginia has the highest current and predicted sea level rise rates anywhere on the east coast of the United States. We currently expect a minimum of 0.70 meters (2.3 feet) of rise in the next 100 years. The impacts of sea level rise have already been seen in communities who note higher water levels during high tides and greater damage from coastal storms. Mitigating impacts associated with these events involves identification of areas at risk (see example in Figure 3, p. 6) and control of future development.
- **Managed Retreat:** Managed Retreat is a planning strategy that allows certain areas which have been previously defended or developed to be reclaimed by natural processes. It can be used as a strategy to mitigate for wetland losses associated with sea level rise by setting aside upland for future inundation and marsh migration. It is also used as a mechanism for shoreline protection since it moves the development

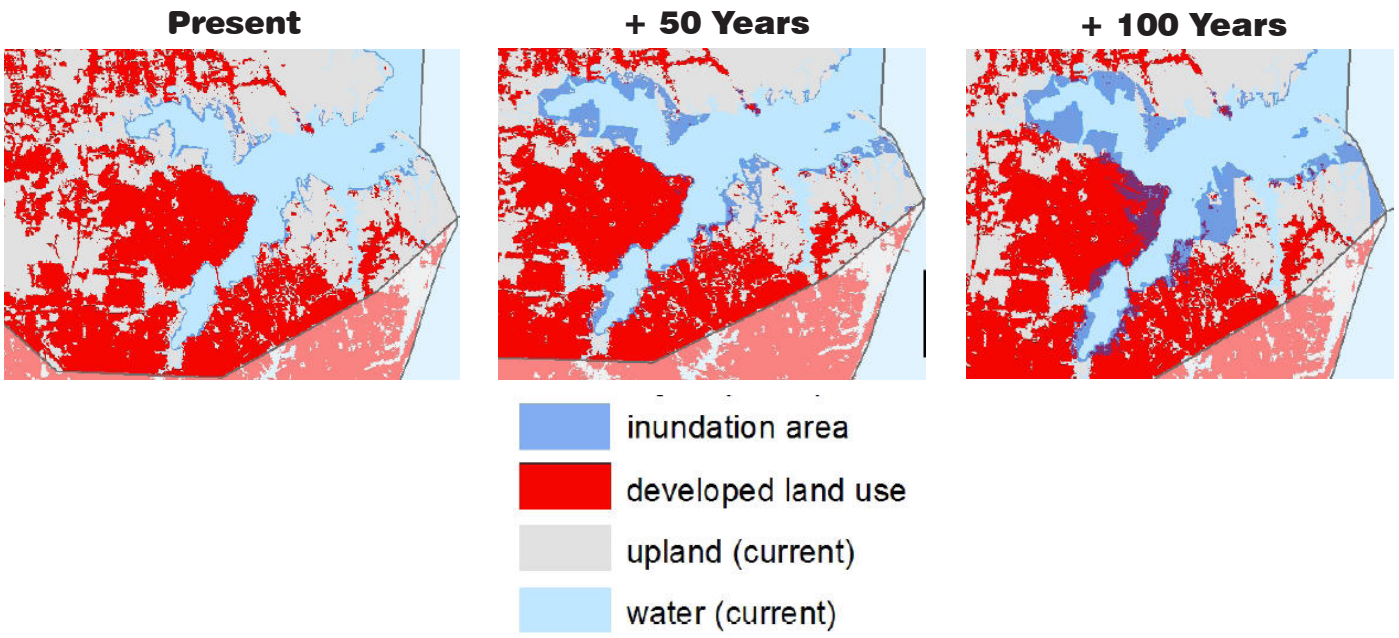

Figure 3. Sea level rise inundation in the City of Hampton's Back River over 100-years

inland and allows the riparian area to buffer or protect inland development.

Vulnerability models developed at the Center have captured the importance of managed retreat. Using coastal development and shoreline hardening as indicators of human response to rising sea level, the relative vulnerability of shallow water tidal habitat was assessed. Within the constraints of the model the vulnerability of these habitats would increase with the presence of existing shoreline structures or riparian development. Why? The developed landscape prevents the natural transgression of intertidal habitat landward as sea level rises. Therefore, intertidal habitat adjacent to unmanaged, natural open space provides the greatest opportunity for inland retreat of the shallow water habitat to occur. Figure 4, p. 7, from one of the Climate Change Vulnerability Models illustrates vulnerability of tidal wetlands based on these assumptions.

- **Sensitive Lands and Aquatic Living Resources:** Sensitive lands are habitats that support important living resources such as nesting areas for birds, finfish nurseries, shellfish growing areas, or species of special concern. They include, but are not limited to beaches and dunes, wetlands, submerged aquatic vegetation, and reefs. The CCRMP will identify the current state of these resources for each locality. It will inform communities on ways in which local planning and zoning impact these habitats.

A priority conservation area assessment tool known as the Virginia Ecological Values Assessment (VEVA) combines various terrestrial and aquatic natural resource layers into a spatial model and ranks land and water mass areas based on the ecological value of the resources present. A sample from the lower Rappahannock River is illustrated in Figure 5, p. 7. This conservation targeting tool allows us to identify areas of critical environmental value and plan for conservation implementation measures.

VEVA is a multi-agency effort funded by NOAA's Coastal Zone Management Program in Virginia. Collaborators include VADGIF, VCU, DCR, VIMS, and DEQ

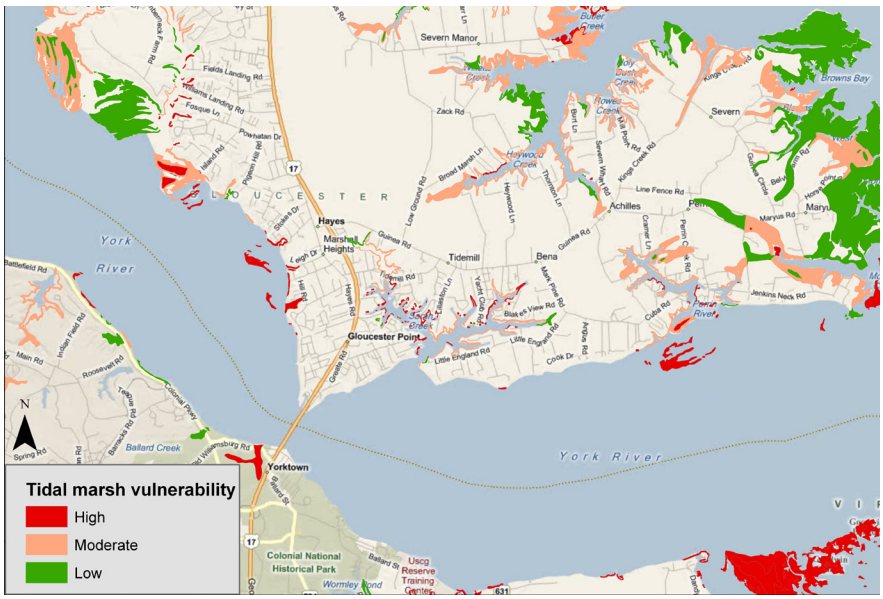

Figure 4. Shoreline hardening and development define the future vulnerability of tidal wetlands along the lower York River (from CCRM, 2009).

The tool is particularly useful for communities who wish to engage in conservation planning.

- **Water Quality:** The leading issue today for local governments is the Virginia Chesapeake Bay Watershed Implementation Plan being developed by the state to address Total Maximum Daily Loads (TMDLs). The plan responds to enforceable policy directives from the Environmental Protection Agency (EPA), and will call on local governments to implement best management practices (BMPs) intended to reduce nutrient loads to the Chesapeake Bay Watershed. To the extent that is reasonable and appropriate, the CCRMP will discuss issues associated with BMPs that mitigate water quality impacts.

- **Societal Conflicts - Public Access, Recreation and Economics:** Public access and recreational opportunities within a locality will be addressed in CCRMPs. As well, the conflict between recreational and commercial use of the waterfront versus conservation of open space will also be discussed within localities where working waterfronts and shallow water fisheries are an important economic base. Other critical conflict examples include aquaculture and SAV restoration. Identifying the extent of these conflicts helps local governments anticipate where obstacles can be expected and where planning for future expansion may present challenges.

CCRM has modeled several of these conflicts using geo-spatial data to delineate where these activities can occur independently, and where their occurrences overlap. The models can compute available area for a specific use or analyze for trade-offs where necessary.

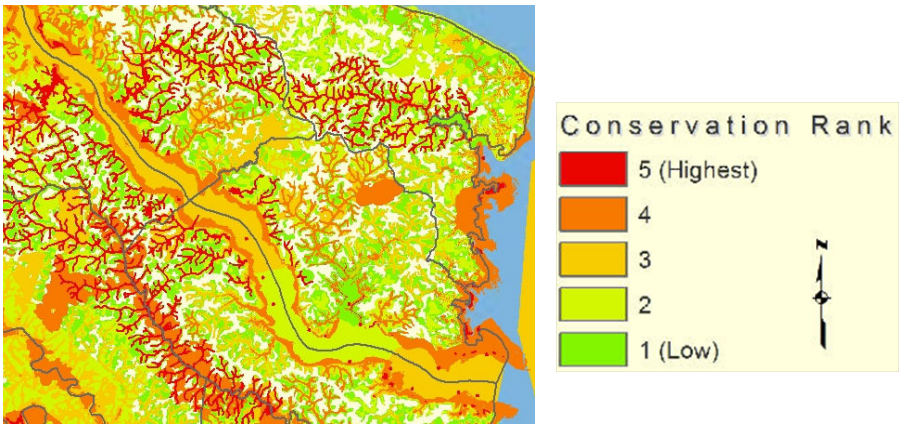

Figure 5. VEVA output for the lower Rappahannock River. Areas in red denote areas of highest ecological value and thus priorities for conservation.

Comprehensive Coastal Resource Management Plans were recommended as an approach to achieve sustained protection of tidal shoreline resources (wetlands, beaches, dunes and riparian buffer) in a report to the Governor and General Assembly of Virginia as mandated by Senate Joint Resolution 35 of the 2010 Assembly (http://leg2.state.va.us/dls/h&sdocs.nsf/By+Year/SD162010/$file/SD16.pdf). This recommendation was included in legislation introduced in the 2011 Session of the General Assembly in Senate Bill 964. The bill has been enrolled (passed the Senate and the House) and awaits the Governor's signature.

CCRMPs will be produced for each locality in Tidewater Virginia. The plans are designed to be incorporated into local government planning and decision–making to stem the tide of adverse environmental effects on coastal resources linked to shoreline development.

The Plans are:

- *One-stop-shop. Comprehensive Coastal Resources Management Plan is a long name for a report that applies an integrated ecosystem approach to a lot of data and provides the best available technical advice for managing shorelines*
- *Produced by VIMS, Center for Coastal Resources Management*
- *For use by local governments, the general public and management agencies*

The Plans can:

- *Identify preferred locations for the use of living shorelines that employ natural habitat elements including emergent marsh grasses, submerged aquatic vegetation, riparian vegetation, coarse woody debris, and oyster reef and shell for erosion protection*
- *Be adapted based on local data*
- *Be web-based to allow easy access to the maps, tables and text*