# A SEA LEVEL RISE RESPONSE STRATEGY FOR THE STATE OF MARYLAND

Zoë Pfahl Johnson
NOAA Coastal Management Fellow

for

Maryland Department of Natural Resources
Coastal Zone Management Division
October, 2000

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Cover: Janes Island State Park. Photo: Lisa Gutierrez, Maryland Department of Natural Resources. 1998.

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The average rate of sea level rise along Maryland's coastline has been 3-4 mm/yr, or approximately one foot per century. Such rates are nearly twice those of the global average (1.8 mm/year), a result probably due to substantial land subsidence. Furthermore, research has demonstrated that sea level rise rates will accelerate in response to global warming, resulting in a rise of 2 -3 feet by the year 2100 (Leatherman et al., 1995). A rise in sea level of this magnitude will undoubtedly have a dramatic effect on Maryland's coastal environment.

While the extent and range of impacts may vary, it is generally agreed that rising sea levels threaten low-lying coastal areas through coastal flooding, coastal erosion, wetland inundation and salt water intrusion. Low-lying coastal plains and barrier islands, such as those located along Maryland's outer coast, its coastal bays, and the low-lying eastern shore, are particularly susceptible to erosion, flooding and inundation. Sea level rise also threatens to exacerbate and prolong the process of erosion along the developed western rim of the Chesapeake Bay. Perhaps most dramatic, however, is the threat sea level rise poses to low-lying islands and extensive marsh systems within the Bay.

Sea level rise has been referred to as the "ultimate planning challenge." While sea level changes have played a historic role in shaping Maryland's coastal environment, understanding how to address the potential for significant, perhaps incremental, change is a difficult task. This challenge is further complicated by the broad spectrum of coastal issues and interests involved, as well as the inherent uncertainty associated with projecting accelerated sea level rise. Despite these challenges, coastal managers around the world have realized the need to begin planning for sea level rise.

Recognizing the need to begin advance planning, Maryland's Coastal Zone Management Program applied for and received a post-graduate Fellow through the National Oceanic and Atmospheric Administration's Coastal Services Center to develop a sea level rise response strategy for the State of Maryland. The Strategy was developed through: (1) an extensive review of related technology, data and research; (2); an assessment of Maryland's vulnerability based on the range and magnitude of impact, the physical characteristics of the coastline, and population and growth patterns; and, (3) an assessment of Maryland's existing response capability. Specific recommendations for reducing the State's overall vulnerability to sea level rise are contained in the proposed Strategy.

Within the network of agencies conducting activities in Maryland's coastal zone, there are a number of programs and directives related to resources and uses likely to be impacted by sea level rise. There are also several programs linked directly to a particular sea level rise issue area (e.g., shore erosion control, floodplain management, tidal wetland administration). Additionally, the State has recognized opportunities to advance sea level rise response planning and, on an incremental basis, sea level rise planning principles have been incorporated into on-going coastal management efforts. Regardless, Maryland's existing response capability provides the State only a moderate degree of protection against the forces of sea level rise. Although a number of management measures are in place, not all were adopted with sea level rise issues in mind;

subsequently, they provide a fragmented approach to the problem and fall short when it comes to mitigating the full range of sea level rise impacts expected to occur throughout Maryland's coastal zone. Furthermore, while the State has been able to incorporate sea level rise issues into a number of independent management efforts, enhanced sea level rise response will only be realized through successful implementation and integration of these initiatives.

Despite the management measures in place and the incorporation of sea level rise issues into recent coastal initiatives, the State will fail to comprehensively address sea level rise in the long-term unless immediate steps are taken to plan for sea level rise response within the network of coastal management agencies. The proposed Strategy will guide the State toward the development of a networked means of response, crossing over inter-governmental boundaries to address the three primary impacts of sea level rise in the State of Maryland (i.e., erosion, flooding and inundation), and the associated environmental and socio-economic implications of each.

The Strategy is comprised of four components, listed below, designed to build upon the others to achieve the desired outcome within a five-year time horizon. The cornerstone of the proposed Strategy is designation of one or more staff within the Department of Natural Resources with expertise in sea level rise planning to oversee implementation.

- ***Outreach and Engagement*:** Engage the general public, State and local planners, and elected officials in the process of implementing a sea level rise response strategy.

- ***Technology, Data and Research Support:*** Gain a better understanding of the regional impacts of sea level rise and applicable policy response alternatives.

- ***Critical Applications:*** Incorporate sea level rise planning mechanisms into existing State and local management programs and on-going coastal initiatives.

- ***Statewide Policy Initiatives*:** Enhance, and where necessary, modify key State statues to remedy barriers and advance sea level rise planning initiatives.

Implementation of the Strategy will evolve over time. It is also a process that will require a sizeable commitment of time and financial resources. However, this process is crucial to the State's ability to achieve sustainable management of its coastal zone. The State must recognize that a "do nothing" approach will lead to unwise decisions and increased risk over time. Moreover, planners and legislators should realize that the implementation of measures to mitigate impacts associated with erosion, flooding, and wetland inundation will also enhance the State's ability to protect coastal resources and communities whether the sea level rises significantly or not.

Carrying out the objectives of the Strategy will be a prudent investment on the part of the State in the light of the appreciable degree of impact expected to occur in the coming years. Maryland will be taking the first proactive step towards addressing a growing problem by committing to the following goals:

- dedicate an individual to the cause;
- educate and engage the public and State and local decision-makers;
- actively support sea level rise research;
- identify and target implementation vehicles;
- recognize and work to remove barriers and obstacles to state-wide policy; and
- strive towards a networked means of response.

Successful implementation of the Strategy will increase awareness and consideration of sea level rise issues in both public and governmental arenas. However, increasing awareness is only one of many steps necessary to ensure an effective plan of response. Maryland will achieve true success in planning for sea level rise by establishing effective response mechanisms at the State and local levels. Innumerable social and environmental resources are at stake. Sea level rise response planning is crucial to ensure future survival of Maryland's diverse and invaluable coastal resources.

## Introduction

Historically, the average rate of sea level rise along Maryland's coastline has been 3-4 mm/year or approximately one foot per century. It is unsettling for coastal planners and property owners alike that these rates are nearly twice the global average, a result probably due to substantial land subsidence. Furthermore, current scientific research shows that continued climate change will accelerate sea level rise rates, resulting in a rise of two to three feet along Maryland's shores by the year 2100. As researchers have already begun detecting impacts associated with sea level rise along Maryland's coastline, the threat of significant change to coastal and nearshore environments is quickly becoming a reality.

While the range and magnitude of sea level rise impact will vary along particular stretches of shoreline, it is generally agreed that the primary impacts of sea level rise include coastal flooding, coastal erosion, wetland inundation and salt water intrusion. These impacts pose a significant threat to the coastal bluffs, wetlands and marshes, tidal estuaries, and sandy beaches that comprise Maryland's coastal environment. Low-lying coastal plains and barrier islands, such as those located along Maryland's outer coast, its coastal bays, and the low-lying eastern shore, are all susceptible to erosion, flooding and inundation. Sea level rise also threatens to exacerbate and prolong the process of erosion along the highly developed western rim of the Chesapeake Bay. Perhaps most dramatic, however, is the inundation risk that sea level rise poses to the low-lying islands and extensive marsh systems within the Bay.

Substantial research has been directed toward analyzing the impact of rising sea levels in Maryland. The Chesapeake Bay, Maryland's Coastal Bays, and the Atlantic Coast have all been the focus of such investigations. In general, these studies have centered primarily on assessing the impact of sea level rise on the coastal environment and have offered only a moderate examination of policy response options. To date, there has been little effort to integrate these studies or to move forward with the development and implementation of policy response strategies.

Therefore, Maryland's Coastal Zone Management Program applied for and received a post-graduate Fellow through the National Oceanic and Atmospheric Administration's Coastal Services Center to accomplish the following:

- gain a better understanding of sea level rise and its potential impact along Maryland's coastline,
- determine Maryland's current response capability,
- increase public awareness of sea level rise and coastal hazard issues, and
- enhance Maryland's ability to respond to sea level rise.

In addition to the above goals, the objective of the Fellowship was to develop a sea level rise response strategy for the State of Maryland. Accordingly, this paper provides an assessment of Maryland's vulnerability to sea level rise and presents a strategy aimed at reducing vulnerability over time.

The first section of the paper contains an overview of related technology, data and research. Building on the available research, an assessment of Maryland's vulnerability based on the range and magnitude of impact, the physical characteristics of the coastline and population and growth patterns is presented in the second section. The third section is devoted to an analysis of the State's existing response capability and an identification of planning needs. The paper concludes with a proposed strategy for developing a networked means to respond to sea level rise. The strategy, comprised of four components (outreach and engagement; technology, data and research support; critical applications; and, state-wide policy initiatives), will guide the State through the process of mitigating the primary impacts of sea level rise in the State of Maryland, and the resulting environmental and socio-economic implications of each.

## Technology, Data and Research

Maryland has made great strides in obtaining up-to-date sea level rise information through various research efforts. In recognition of the level of regional vulnerability, a number of studies, in addition to several current efforts, have concentrated on coastal areas within the State of Maryland. The following research efforts have greatly increased our understanding of the regional impacts of sea level rise and applicable policy response alternatives.

***U.S. Geological Survey*** **(USGS).** A major question for sea level rise researchers is whether trends in sea level rise are a recent phenomena or whether we are experiencing the results of a much longer physiographic cycle. To help gain a better understanding of the cyclic nature of sea level rise, USGS is conducting research in the Chesapeake Bay to compare decadal and annual tide gauge records with rates of sea level change on century to thousand-year time scales. Using sediment core samples collected in the Patuxent River basin, USGS is attempting to reconstruct the detailed pattern of relative sea-level change over the last 6,000 to 8,000 years. More information on the this project can be found at http://pubs.usgs.gov/factsheet/fs102-98.

***National Oceanic and Atmospheric Administration (NOAA).*** Current tidal data shows that rates of sea level rise in the Chesapeake Bay are nearly twice those of the global average. Data gathered from tide gauges, however, does not provide an accurate measure of whether the sea level is rising or the land is sinking. To calculate *relative* sea level rise, tide gauge data must be correlated with data on vertical land movement (e.g., land subsidence). NOAA's National Geodetic Survey (NGS) is currently conducting a project which utilizes Global Positioning System (GPS) receivers in combination with tide gauge data. NGS has installed a network of GPS receivers throughout the Chesapeake Bay region in close proximity to tide gauge stations to continuously monitor the absolute motion of the earth's crust. GPS measurements are combined with tide gauge data, ultimately resulting in an accurate estimate of sea level rise in the Chesapeake Bay. Initial research findings, suggesting a marked increase in relative sea level rise in the vicinity of Cambridge, Maryland, are published in the March 24, 1998 issue of *EOS, Transactions*. Additional information on this project can be found at http://www.grdl.noaa.gov/GRD/GPS/Projects/CB/cb.html.

***University of Maryland.*** The University of Maryland has been a major contributor to sea level rise research over the years. Significant research has been directed toward analyzing the correlation between rising sea levels and marsh response. Most notably, research in the Blackwater Wildlife Refuge has focused on assessing the ability of marshes to accrete at rates comparable with relative sea level rise. Additional research has concentrated on understanding: variables associated with land subsidence resulting from ground water withdrawal and glacio-isostatic readjustment; impact of nutria and muskrat on marsh vegetation; and the effect of prescribed burning on the ability of the marsh to withstand threats associated with sea level rise.

In addition to the substantive research conducted on marsh response, the University's Laboratory for Coastal Research published two major documents which greatly advanced the public's understanding of sea level rise impacts in coastal Maryland. The first, "Future Sea Level Rise Impacts: Maryland's Atlantic Coastal Bays," prepared by Claudio R. Volenté and Stephen Leatherman in 1992, calculated historical shore erosion rates and, in combination with existing topographic data, projected future shoreline positions for eight realistic sea level rise scenarios for the years 2020, 2050, and 2100 in the northern Coastal Bays. Impacts associated with each sea level rise scenario were provided along with an examination of potential sea level rise response strategies (i.e., retreat, accommodation, and protection). The second document, "Vanishing Lands: Sea Level, Society and the Chesapeake Bay," along with its accompanying video, prepared jointly by the Laboratory for Coastal Research and the Chesapeake Bay Field Office of the U.S. Fish and Wildlife Service, is an excellent educational and public outreach tool. Using a compilation of graphics and historical photographs, the document provides a thorough assessment of sea level rise impacts on estuarine dynamics, coastal land loss, and societal response.

In addition, the *Maryland Law Review*, a publication of the University of Maryland Law School, published an article entitled, "Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches without Hurting Property Owners." The article, authored by James G. Titus, Sea Level Rise Project Manager with the Environmental Protection Agency (EPA), concentrates primarily on low-lying coastal issues, in particular those management issues associated with wetlands, public access, and public trust rights along coastal bays. The article also addresses legal issues associated with sea level rise response strategies, centering on Maryland's existing statutes. The opinions expressed in the article are those of the author and do not represent the opinion of the EPA.

***U.S. Environmental Protection Agency.*** The EPA has also been a lead research institution focused on assessing both the consequences of sea level rise and options for human response. While numerous studies have been undertaken by the EPA, several offer the State a greater understanding of regional vulnerability. The first, "Potential Impacts of Sea Level Rise on the Beach at Ocean City, Maryland," published in October 1985, examines the potential implications of sea level rise on "a typical Atlantic Coast resort," with a particular focus on strategies for addressing coastal erosion.

A second study, "Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the U.S. Atlantic and Gulf Coasts," published in *Climate Research* (in press), utilizes existing topographic data to illustrate land below the 1.5 and 3.5 meter contours. The 1.5 meter contour roughly represents areas that may be inundated at high tide if sea level rises 50 centimeters or more (Titus, 2000). The maps denote approximately 58,000 square kilometers of land along the Atlantic and Gulf Coasts below the 1.5 meter contour. Despite a lack of detailed topographic data for Maryland's Eastern Shore, the maps generally imply that outside the states of Louisiana, Florida, Texas, and North Carolina, which comprise 80% of the low-lying land, the largest

vulnerable populated region is located between Dorchester County, Maryland and Accomac County, Virginia.

The EPA is currently embarking on a new study to assess planning responses to sea level rise in the State of Maryland. This study, focused on areas identified through the mapping effort summarized above, is seeking to establish areas "likely" to be protected from a rise in sea level. The purposes of the exercise are: to provide site specific information to be incorporated into a digital-elevation based assessment and mapping project of land lost to sea level rise; to help to foster the process by which state and local governments begin to decide which shores should remain as natural wetlands, beaches, and mudflats, and which shores should be protected; and to improve the scenarios of coastal habitat loss for a companion project analyzing the impact of sea level rise on shorebirds (EPA, 2000). Similar assessments are underway in the states of New Jersey, Massachusetts, Rhode Island and North Carolina.

***National Estuarine Research Reserve (NERR).*** The NERR program, administered by the National Oceanic and Atmospheric Administration, has dedicated sizeable funds to support sea level rise research in the Chesapeake Bay. Concentrated primarily on linkages between marsh stability and sea level rise, this research contributes greatly to our global and regional understanding of sea level rise: Rooth, J., 1999; Kearney and Stevenson, 1991; Ward et al., 1988; Kearney et al., 1988; and Brush and Thornton, 1992. Copies of these reports are available through the Chesapeake Bay National Estuarine Research Reserve Program, administered by the Maryland Department of Natural Resources, Coastal Zone Management Division.

***Maryland Geological Survey.*** The Maryland Geological Survey (MGS) has been the primary agency investigating and mapping the extent of shore erosion in Maryland for many years. Given the strong linkage between historical sea level rise and trends in shore erosion, MGS's research has greatly increased the knowledge of sea level rise-induced erosion. MGS currently is updating and revising historical shoreline position maps and erosion statistics (e.g., acreage lost, rate of loss) produced in the 1975 assessment, *Historical Shorelines and Erosion Rates* (Conkwright, 1975). To date, MGS has completed revising and digitizing an atlas of historical shoreline maps for tidewater Maryland (Hennessee and others, 1997; Kerhin and others, 1994-2000). Shoreline positions (between the years 1841 and 1976) were converted from print to digital format and are displayed over an orthophoto base in a series 100 *Shoreline Changes* maps. Since publication of the *Shoreline Changes* map series, digital shorelines derived from orthophotography conducted from 1988 to 1994 also have been produced. MGS is now in the process of updating the *Shoreline Changes* maps with the most recent shoreline positions (1988 to 1994) and will soon begin a comprehensive update of the historical shoreline change statistics on a county-by-county basis.

The continued efforts of MGS to assess the magnitude and range of shoreline erosion on a state-wide basis provides invaluable information in support of sea level rise research. In response to

recommendations of Maryland's Shore Erosion Task Force (2000), the Department of Natural Resources is in the process of conducting three to four pilot studies in which the historical shoreline change data produced by MGS will be correlated with high-resolution digital topographic data to project future shoreline positions for the purposes of assessing both economic and environmental impact of sea level rise.

## Conclusion

The research summarized above has greatly enhanced our understanding of the regional implications of sea level rise and provides a sufficient knowledge base from which to move forward with the development of a response strategy for the State of Maryland. Using this research as a foundation, the following section provides an assessment of Maryland's vulnerability to the impacts of sea level rise.

## Maryland's Vulnerability to a Rise in Sea Level

For millions of years, rising and falling sea levels have been the primary influence shaping coastlines around the world. Therefore, it is not surprising that the Chesapeake Bay began forming fifteen thousand years ago as rising sea levels drowned the lower valley of the Susquehanna River. Although the average rate of sea level rise decreased dramatically approximately 5,000 years ago, allowing the development of the Bay's extensive salt marshes, sea level is continuing a slow but steady upward progression. Current research shows that sea level in the Mid-Atlantic region has risen approximately one foot, or 3 - 4 mm/year in the last century (See Figure 1).

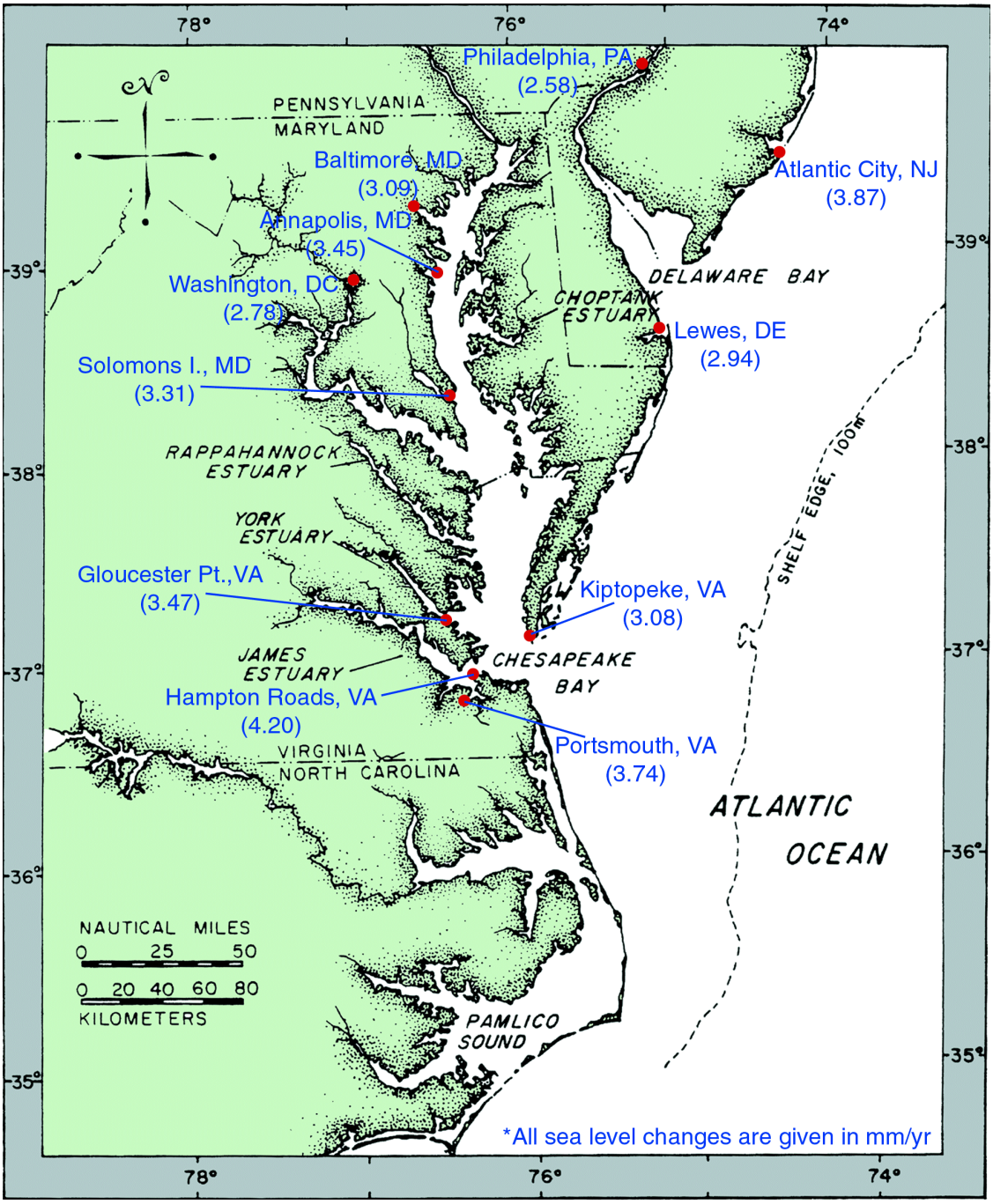
Measurement of sea level at any particular location is relative. Relative sea level rise is the sum of global (eustatic) sea level change plus changes in vertical land movement at a particular location due to tectonic (e.g. faulting), neotectonic (e.g., glacio-isostatic readjustment, postglacial rebound) and anthropogenic impacts (e.g., subsidence due to groundwater extraction). The current rate of sea level rise along Maryland's coastline is nearly twice that of the global average (1.8 mm/year), a result probably due to substantial land subsidence and glacio-isostatic readjustment.

Assuming an acceleration of sea level rise rates due to global warming, the Intergovernmental Panel of Climate Change (IPCC) currently estimates that global sea levels will continue to rise an average of 5 mm/year, with a range of uncertainty of 2 - 9 mm/years (IPCC, 1995). Using global sea level rise scenarios from the IPCC and observations of global sea level rise, scientists can project relative sea level rise scenarios for the U.S. coastline. To account for uncertainty, three scenarios of relative sea level rise (low, mid, and high) have been projected along the Mid-Atlantic coast. By the year 2050, it is anticipated that sea level will rise between 8 and 12 inches (low-rise scenario), 12 - 16 inches (mid-rise scenario), and 20 - 24 inches (high-rise scenario) (Nicholls and Leatherman, 1996). A rise of this magnitude will undoubtedly have a dramatic effect on Maryland's coastal environment.

Researchers generally agree that the primary impacts of sea level rise include coastal flooding, coastal erosion, wetland inundation, and salt water intrusion. Maryland's coastline, made up of the varied landscapes of the Chesapeake Bay, the Coastal Bays, and the Atlantic Coast, is highly susceptible to all such impacts. Given the diversity of Maryland's coastline, the magnitude of impact will vary from region to region according to physical site characteristics. Geology, topography, bathymetry, fetch, surface/ground water condition, man-made features, and the frequency and intensity of extreme events, all affect the degree of impact over time at a given location. As a causal force, sea level rise influences on-going coastal processes, thereby increasing the vulnerability of coastal areas already under natural and human-induced stress. While Maryland will be subject to the full range of sea level rise impacts, risks associated with shoreline erosion, inundation, and coastal flooding pose the most significant threat.

**Figure 1.**

## SEA LEVEL TRENDS IN THE MID-ATLANTIC




Source: Larsen. 1998. *Rising Sea Level in the Chesapeake Bay*. USGS.

***Shoreline erosion.*** Erosion is one of the most significant problems currently facing Maryland's diverse coastal environment. Today, approximately 31 percent of Maryland's 4,360 mile coastline is experiencing some degree of erosion. While the range and magnitude of erosion varies both within and among the State's physiographic regions, the problem affects all 16 coastal counties along the Chesapeake Bay and the Coastal Bay watersheds. Studies estimate that Maryland loses approximately 260 acres per year to shore erosion (SETF, 2000). Sea level rise, while not a driving force in itself, is considered a causal factor which influences on-going coastal processes that drive coastal erosion, in turn making coastal areas ever more vulnerable to both chronic (on-going) erosion and episodic events (e.g., Nor'easters, tropical storms, hurricanes).

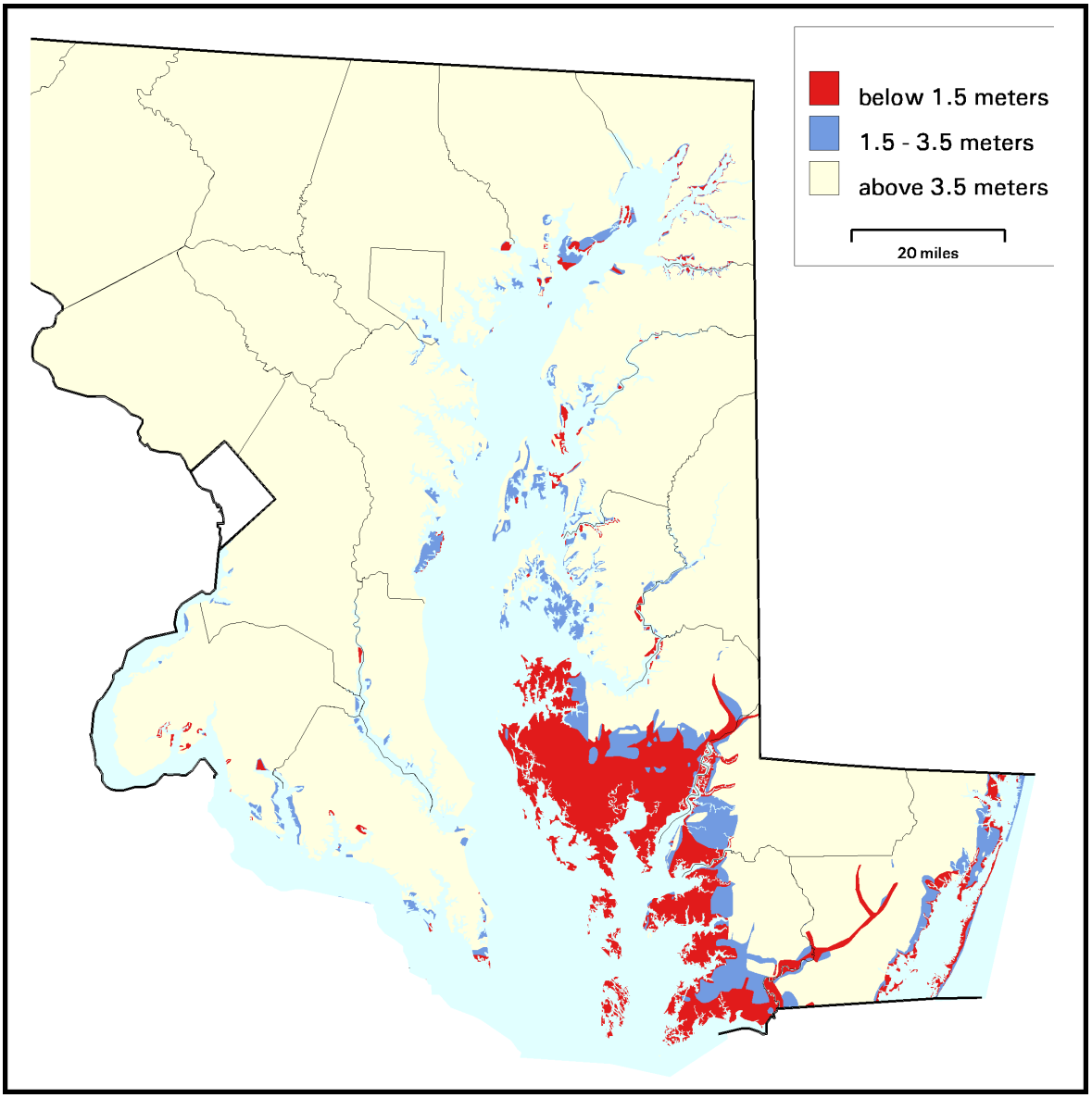
***Coastal Flooding.*** Much like the coastal processes that drive erosion, sea level rise influences coastal storm events by increasing the height of storm waves, enabling them to extend further inland. In low-lying coastal areas, a one foot rise in sea level could translate into a one foot rise in flood level, intensifying the impact of flooding and storm surge to homes, businesses, and roadways. Maryland's coastline is susceptible to Nor'easters, tropical storms, and hurricanes. While it is still undetermined whether climate change will increase the probability of such events, it is relatively clear that elevated sea levels will exacerbate the coastal flooding associated with these episodic storms.

***Inundation.*** For many coastal areas, slope is the primary variable controlling the magnitude and range of sea level rise impact over time. Steeply sloped areas will experience little horizontal displacement of the shoreline as sea level rises, while gently sloping areas have a much larger zone of potential inundation. Inundation is the total submergence of land by water, occurring on a gradual basis. In areas such as Maryland's Eastern Shore where elevation change may only be as much as 1 foot per mile, gradual submergence of a large geographic area, including large expanses of tidal wetlands, is quite likely over time. As depicted in Figure 2, a significant portion of the Eastern Shore is less than 1.5 meters above sea level. The areas in red roughly portray land that may be inundated at high tide if sea level rises 50 centimeters or more (Titus, 2000).

The State's vulnerability to sea level rise-induced erosion, flooding and inundation is based on a combination of factors, including: the range and magnitude of impact, the physical character of the coastline, population growth and development patterns, and the response capacity of state and local coastal management programs. The following assessment of regional vulnerability is based on the first three of these factors. An assessment of the response capacity of state and local coastal programs is contained in the following section. Given Maryland's highly diverse coastal environment, the discussion of vulnerability is best framed within the context of Maryland's primary coastal environments: coastal wetlands, urban and developed shorelines, Bay islands, coastal bluffs, barrier islands, and the low-lying coastal plain.

**Figure 2.**

## LANDS CLOSE TO SEA LEVEL




Source: Titus, James G. 1998. Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners. *Maryland Law Review* 57(4): 1307.

## Coastal Wetlands and Marshes

There are approximately 261,000 mapped tidal wetlands in the State of Maryland, ranging from the estuarine marshes found in the seaside Bays adjacent to Ocean City and Assateague Island to the palustrine scrub shrub and forested wetlands found near the heads of tide of the tributaries of the Chesapeake Bay. They play a key role in Maryland's estuarine environment, providing vital food and habitat for finfish, shellfish, crustaceans, waterfowl, and mammals such as foxes, raccoons, deer, muskrats, nutria and otter. In addition to inhibiting flooding and providing shore erosion control, tidal wetlands help protect water quality by absorbing non-point source pollutants and reducing sediment loads to receiving waters.

Maryland's coastal wetlands and marshes will be heavily impacted by a relative rise in sea level. While erosion can damage the wetland edge, coastal marshes are particularly susceptible to submergence. In systems where the vertical accretion rate is not equal to or greater than that of sea level rise, wetlands are at risk of permanent submergence. There is a strong correlation between past marsh loss and relative sea level rise within the Blackwater Wildlife Refuge on the Eastern Shore. The results of studies conducted by the University of Maryland show that approximately 3,460 acres of Blackwater's marsh were converted to open water between 1938 and 1989.

Many interlinking variables determine the ability of a marsh system to withstand a rise in sea level, including: sediment supply, elevation of the marsh surface, tidal range, exposure to wind and waves, frequency and intensity of storm events, and invasive species (e.g., nutria). Man-made barriers (e.g., bulkheads, roads) also influence the sustainability of wetlands and marshes by: (1) reducing the availability of upland sediment sources, and (2) eliminating the potential for marsh systems to migrate landward as sea level rises. Understanding the link between sea level rise and marsh survival is important in terms of detecting the variables that can be controlled or modified to enhance the resiliency of the overall marsh system.

## Urban and Developed Shorelines

Like many coastal areas, early settlements in the Chesapeake Bay formed around water access. As a result, many of Maryland's urban centers are concentrated in the coastal zone. Numerous coastal developments, ranging in intensity from Baltimore's Port and Inner Harbor, historic Annapolis and the intensely developed Ocean City, to small waterfront communities and a scattering of marinas and water-dependent industries, extend up and down Maryland's shores. As the State's population continues to expand in these developed areas, the economic and social impacts of sea level rise will be immense over time. Sea level rise-induced coastal flooding, storm surge, and elevated water levels are the predominant concerns for developed areas.

Intuitively, one can assume any development in close proximity to the water's edge, at a low-lying elevation or within coastal flood boundaries, will be susceptible to the impacts of sea level

rise. This includes roads, bridges, harbors, ports, railroads, utilities, coastal drainage systems, commercial developments, communication facilities, residential communities, and marinas and other recreational facilities. More specifically, sea level rise will impact urban and developed shorelines by placing increased stress on pilings, piers, docks and elevated structures. The amount of land available for water-dependent structures and uses may be diminished as land is lost to erosion or becomes inundated or submerged over time. Sewage treatment plants and other public infrastructure may become threatened, and higher water levels may impact sewage and stormwater outfalls. Additionally, sea level rise will increase the vulnerability of existing structures to coastal storm damage.

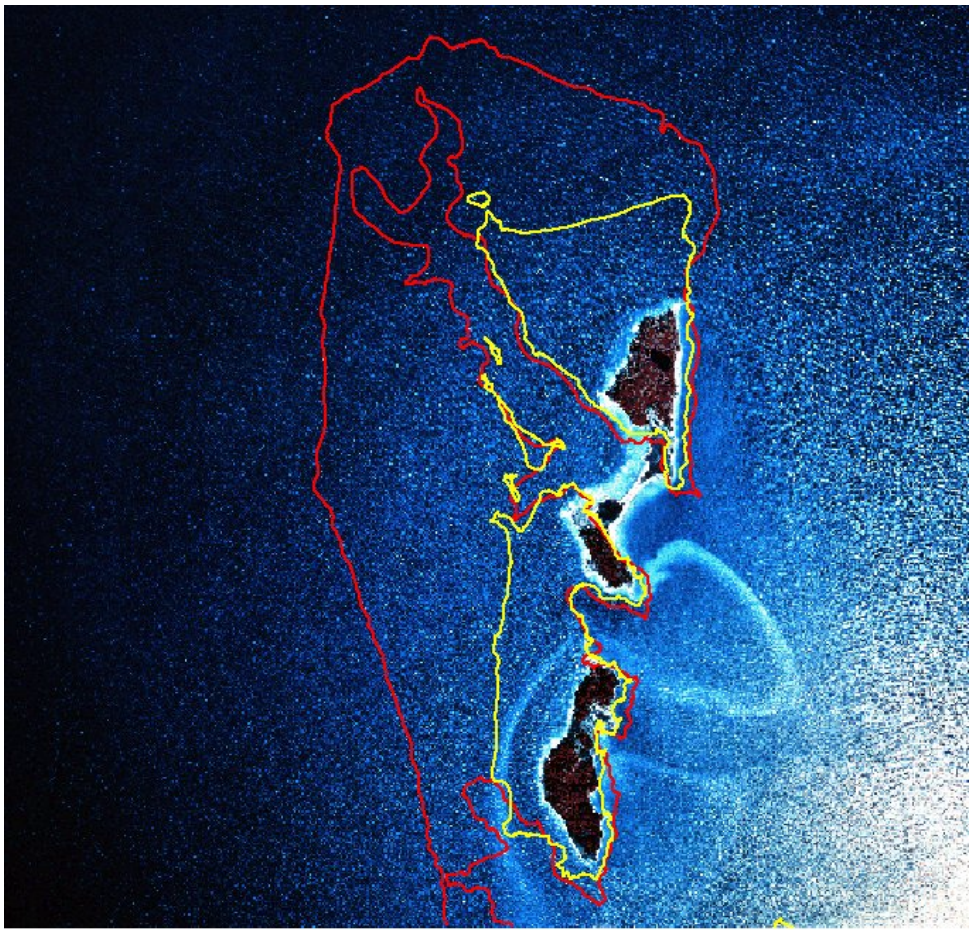
**Bay Islands**

Islands within the Chesapeake Bay are a remnant of the changing course of the Susquehanna River. Comprised mainly of fine-grained clay deposits, the majority of the islands are situated a few miles from the Eastern Shore, paralleling the main stem of the Bay (Leatherman, 1995). In addition to their historic and cultural significance, the Bay islands serve to protect the coastal mainland from the brunt of coastal storm events. Bay islands, like off-shore barrier islands, absorb the impact of coastal storm events, reducing the impact of wind and waves on the coastal mainland.

Regrettably, the Bay's islands have slowly but progressively succumbed to the forces of erosion and inundation. The magnitude of island loss was first quantified by J.F. Hunter, under the auspices of the Maryland Geological Survey (MGS) in 1914, during a survey of Sharps, James and Tilghman Islands. Hunter found that between 1848 and 1910 the smallest of these islands, Sharps Island, was reduced in area from 438 to 53 acres. Today, Sharps Island no longer exists. During approximately the same time period, James Island diminished in size from 976 to 490 acres, while Tilghman Island was reduced from 2,015 to 1,686 acres. Both islands have continued to experience rapid erosion, as illustrated by Figures 3 and 4. In 1994, James Island measured approximately 92 acres, and Tilghman approximately 1,302.

**Figure 3.**

**JAMES ISLAND**
**(1847 - 1994)**



1847
1942

SCALE 1:24,000

Source: Digital Orthophoto quarter-quad (DOQQ) produced by the MD DNR. Date of photography: 4/8/94. Digital Shorelines compiled by the Maryland Geological Survey, 1997.

**Figure 4.**

**TILGHMAN ISLAND**
**(1847 - 1994)**

1847
1942

SCALE 1:35,000

Source: Digital Orthophoto quarter-quad (DOQQ) produced by the MD DNR. Date of photography: 4/8/94. Digital Shorelines compiled by the Maryland Geological Survey, 1997.

Graphically documented in both the publication, *Vanishing Lands: Sea Level, Society and Chesapeake Bay* and the accompanying video presentation, prepared by the University of Maryland and the U.S. Fish and Wildlife Service, the threat sea level rise poses to the remaining island communities within the Chesapeake Bay is daunting. Table 1 provides a vivid illustration of dramatic shoreline change and resulting human response.

**Table 1. Island Size Comparison**

| Island | Historic acreage (date) | Recent acreage (date) | % lost | Comments |
|---|---|---|---|---|
| Poplar | 1,400 (1670) | 125 (1990) | 91 | Residential Abandonment in 1930 |
| Sharps | 890 (1660) | 0 | 100 | Drowned in 1962 |
| St. Clements | 400 (1634) | 40 (1990) | 90 | Residential Abandonment in the 1920's |
| Barren | 700 (1664) | 250 (1990) | 64 | Residential Abandonment in 1916 |
| Hoopers | 3,928 (1848) | 3,085 (1942) | 21 | Submerging |
| Bloodsworth | 5,683 (1849) | 4,700 * (1973) | 17 | Submerging |
| Holland | 217 (1668) | 140 (1990) | 35 | Residential Abandonment in 1992 |
| Smith | 11,033 (1849) | 7,825 (1987) | 29 | Submerging |
| * mostly marsh | | | | |

Modified from Leatherman (1995).

Today, efforts to restore several Chesapeake Bay islands, including Smith Island, are underway. Smith Island, the last permanently inhabited Maryland island in the Chesapeake Bay, is experiencing severe erosion, flooding, inundation, and loss of wetlands. Sea level rise is a particular concern for Smith Island, as almost the entire island is less than 3 feet above sea level. Concerned for the land and their way of life, the local citizens of Smith Island lobbied their governmental representatives to help address the ongoing erosion and expected eventual loss of their island. The Smith Island Environmental Restoration and Protection Reconnaissance Study was completed by the U.S. Army Corps of Engineers in May 1997. The study suggested four primary restoration projects to provide protection from severe erosion, reduce wetland loss, minimize local flooding, and lessen impacts to established SAV beds. Additional planning and project design is underway for several of the identified projects and construction has been initiated on the Tylerton Shore Protection Project, cost-shared by the Maryland Department of Natural Resources.

The total cost for construction expenses on Smith Island is likely to be between $15 - 20 million (Van Liew, pers. comm.). The level of commitment and fiscal resources, on the part of Federal, State and local agencies, to protect Smith Island and other Bay Islands from rising sea levels, only foreshadows the degree of involvement the State will be facing to protect the coastal mainland and its natural resources in the coming years.

## Coastal Bluffs

A significant portion of the Chesapeake Bay shoreline is composed of bluffs, ranging in height from a few feet to over a 100 feet. Bluffs less than 20 feet in height exist throughout the Bay and its tributaries, while bluffs in excess of 20 feet (high bluffs) are commonly found along the western shore. Calvert County, alone, has over 12 miles of steep, actively eroding bluffs ranging from 30 to 100 feet in height (Wilcock et al., 1993). Historic erosion of coastal bluffs in Maryland has caused appreciable damage to coastal properties, structures, utilities, and roads.

Due to the number of mechanisms which drive bluff erosion, it is difficult to correlate a direct link between sea level rise and erosion. However, it is generally agreed that sea level rise will increase the base height of storm waves, causing more frequent wave attack at higher elevations along a bluff. As a result, prolonged erosion and exacerbated damage is anticipated. Without appropriate measures, improvements such as houses, driveways, sewer pipes, or roads can be damaged or destroyed by bluff erosion. Guarding against such impacts, which will increase over time due to sea level rise, is the primary motivation for installing erosion control structures along Maryland's coastal bluffs.

## Barrier Islands

Fenwick and Assateague Islands, backed by a system of coastal bays, including the Isle of Wight, Assawoman, Chincoteague, Newport, and Sinepuxent Bays, form the barrier between Maryland's mainland and the Atlantic Ocean. Barrier islands, such as Fenwick and Assateague, are highly dynamic coastal landforms, under constant pressure from the driving forces of waves, wind, ocean currents, and storm surge. These forces, coupled with rising sea levels, act to continually reshape barrier islands, as well as to advance landward migration of the island itself. Landward migration is a barrier island's natural response mechanism to a rise in sea level. As sea level rises, sand generally moves landward and upward, eventually being pushed or washed over by storms or waves onto the bay side of the island. Barrier island migration is influenced not only by the rate of sea level rise and the availability of sediment, but also by human interference (Leatherman, 1979). The construction of jetties at the Ocean City inlet has reduced sediment transport from the north, compromising the natural process of barrier island migration and causing increased erosion along the northern portion of Assateague Island. Extensive development in Ocean City, on Fenwick Island, has also limited natural coastal processes. The

development of Ocean City and the inlet jetties are both factors which affect the resiliency of Maryland's outer coast to rising sea level.

In addition to influencing natural coastal processes, rising sea levels amplify the magnitude of coastal storm events, increasing damage to developed portions of Maryland's barrier islands, backshore Bays, and coastal plain. In low-lying areas, a one foot rise in sea level could translate into a one foot rise in flood level, intensifying the impact of coastal flooding and storm surge to homes, businesses, and roadways. In some areas the difference between a 100 year flood (1% annual probability) and a 10 year flood (10% annual probability) is about 1 foot vertical (i.e., if the normal sea level were to rise 1 foot, events which had a 1% probability would now have a 10% probability). Such increased suceptibility to coastal flooding will likely result in significant damage to waterfront infrastructure.

## Low-Lying Coastal Plain

The lower Eastern Shore of the Chesapeake Bay is characterized as a low-lying coastal plain due to its nearly flat terrain with very little topographic relief. The coastal plain region comprises one of the largest expanses of coastal wetlands along the Mid-Atlantic coast, and, in addition to hosting a mix of forestry and agriculture activities, is home to much of the State's seafood industry. Coastal land-use on the Eastern Shore ranges from urban development, primarily concentrated in small civic centers such as Cambridge, Crisfield and St. Michael's, to small waterfront communities located all along the western fringe of the peninsula.

Maryland's low-lying coastal plain, consisting of very fine or unconsolidated sands, silts, and clays, or lighter organic material (marshes), is particularly susceptible to sea level rise-induced erosion. Erosion poses an appreciable threat to property owners, the public and both the terrestrial and aquatic resources of the coastal plain. An increase in the amount of erosion can be expected due to a rise in sea level, exacerbating the degree of land loss and impacts to public and private properties. Sea level rise-induced erosion will also affect sensitive resources in the coastal plain. Such resources include: sandy beaches, a rare resource in Maryland; naturally vegetated shoreline buffers that provide habitat and improve water quality; and tidal wetlands, which provide valuable aquatic habitat and nursery areas for many species (including economically important fisheries). In addition, increased erosion will cause larger amounts of sediment and nutrients to enter the water column, degrading water quality and, in turn, aquatic resources.

## Conclusion

As demonstrated above, Maryland's coastal zone is highly susceptible to the impacts of sea level rise. In the short-term, coastal areas already under natural and human-induced stress are most vulnerable. Of these, the islands and lower Eastern Shore of the Chesapeake Bay are in critical

need of protection. However, much larger portions of Maryland's coastal zone will become threatened over time. Given the diversity of coastal environment and the anticipated magnitude of associated impacts, the State's response strategy needs to include both short and long-term objectives to address the three primary impacts of sea level rise (erosion, flooding and inundation), in addition to the resulting environmental and socio-economic implications of each. The following section provides an assessment of Maryland's existing response capacity and offers recommendations for reducing the State's overall vulnerability to sea level rise.

## Sea Level Rise Response Planning in the State of Maryland

Sea level rise has been referred to as the "ultimate planning challenge." While sea level changes have played a historic role in shaping Maryland's coastal environment, understanding how to address the potential for significant, perhaps incremental, change is a difficult task. This challenge is further complicated by the broad spectrum of coastal issues and interests involved, as well as the inherent uncertainty associated with projecting accelerated sea level rise.

Despite these challenges, coastal managers around the world have realized the need to begin advance planning for sea level rise. Consequently, a great deal of research has been published on the impact of sea level rise in the coastal environment, as well as the socio-political aspects of sea level rise response. This research, including that of several state coastal zone management programs (e.g., Maine and Washington), outlines the mechanics and tools for sea level rise response planning at the state and local level and provides excellent information for any entity undertaking a similar planning process. Findings worth noting include:

- State governments have the primary responsibility for developing strategies to mitigate adverse impacts associated with sea level rise (MLI, 1994).
- Sea level rise response strategies should be directed toward existing and on-going coastal management issues (Klarin et al., 1990).
- Focus should be on the likely impacts, not merely the possible (MLI, 1994).
- In many cases, sea level rise vulnerability can be mitigated by anticipatory planning at the state and local level (Pew, 2000).
- Meaningful preparations can take place now, despite scientific uncertainty, by building upon current research, utilizing adaptive planning frameworks, and evaluating a range of sea level rise scenarios (MLI, 1994).

Numerous federal, state, and local agencies, as well as multiple private and non-profit organizations work to regulate, administer, and conduct activities in Maryland's coastal zone. Involvement among these organizations varies significantly with respect to missions, mandates, and jurisdictional boundaries. Within the network of agencies, there are a number of programs and directives related to resources and uses likely to be impacted by sea level rise. In addition, there are several programs linked directly to a particular sea level rise issue area (e.g., shore erosion control, floodplain management, tidal wetland administration). The following analysis of existing local and State management programs and on-going coastal initiatives provides an overview of Maryland's existing response capacity. Obstacles which hinder the State's ability to respond in the short and long-term are identified, along with recommendations for remedying the existing barriers and enhancing Maryland's overall response capacity.

***Coastal Zone Management Program.*** Under the guidance of the Federal Coastal Zone Management Act of 1972 (16 USCA. §§ 1451-1464), Maryland's Coastal Zone Management Program is designed to achieve a balance between economic development and resource protection in the coastal zone. The State's coastal zone encompasses 66% of the State's land area, including the towns, cities, and counties which border the Atlantic shore, the coastal bays, the Chesapeake Bay and its tributaries, as well as the open waters of the Bay and countless smaller rivers, creeks, bays and coves. Maryland's Program was established in 1978 to meet the following goals:

- preserve and protect coastal resources;
- protect and promote the economic and social stability of coastal communities in an environmentally compatible manner;
- protect the public interest, safety, and welfare in natural hazard areas;
- locate major facilities only in appropriate coastal areas;
- promote appropriate methods of use of coastal areas; and,
- promote intergovernmental coordination and public participation.

Maryland's Coastal Zone Management Program, administered by the Department of Natural Resources utilizes a networked approach to achieve its goals and objectives. There is no central regulatory agency; rather the Program uses the planning and regulatory programs of several State agencies and local governments. State agency participation is ensured through an Executive Order and Memoranda of Understanding between the Department of Natural Resources, and the Departments of Agriculture, Environment, Housing and Community Development, Transportation, and Planning.

The Federal Coastal Zone Management Act (CZMA) provides Maryland both the resources and incentives to address sea level rise. In the 1990 CZMA Reauthorization, Congress recognized the potential impact sea level rise would have on the coastal environment and encouraged coastal states to begin addressing the issue as follows:

> **Congressional Findings**: §302. The Congress finds that...
>
> (l) Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.
>
> **Congressional Declaration of Policy:** §303. The Congress finds and declares that it is the national policy:
>
> (2) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as

well as the needs for compatible economic development, which programs should at least provide for -

> (B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion -prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands.
>
> (K) the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and sea level rise; and...

(3) to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels on the Great Lakes, and improved predictability in governmental decision-making.

The 1990 Reauthorization also established the Coastal Zone Enhancement Program (CZMA §309) which allows states to request additional funding to amend their coastal programs to support attainment of one or more coastal zone enhancement objectives, including "anticipating and managing the effects of potential sea level rise." It is recommended that the evaluation of sea level rise response planning in Maryland and the accompanying strategy, presented in the following section, constitute the bulk of the State's CZMA §309 Coastal Hazard and Sea Level Rise Assessment and Strategy for 2000 - 2005.

***Maryland Coastal Bays National Estuary Program.*** The Coastal Bays Program was created in 1996 to assist the region in developing a comprehensive plan to restore and protect Maryland's Coastal Bays. The Program is a partnership among: the towns of Ocean City and Berlin; Worcester County; Maryland Departments of Natural Resources, Agriculture, Environment and Planning; the National Park Service; and the U.S. Environmental Protection Agency. The following action items related to sea level rise issues were incorporated into the Comprehensive Conservation and Management Plan (1999), the primary management tool guiding protection and restoration activities.

- Determine code changes necessary to address sea level rise and erosion problems in Worcester County.

- Incorporate sea level rise response strategies into Worcester County planning efforts.
- Amend local floodplain ordinances to require one foot of freeboard above the 100 year floodplain base flood elevation for development within the tidal floodplain.
- Examine sea level rise and shoreline migration during the development of small area management plans.
- Investigate the use of "rolling easements" in other jurisdictions that are highly susceptible to sea level rise and investigate the feasibility of purchasing "rolling easements."
- Work with existing programs (i.e., Rural Legacy, Program Open Space) to protect natural shoreline and adjacent landward areas through the purchase of development rights or shoreline easements (or fee simple purchase).

The Department of Natural Resources must continue to work with the Coastal Bays Program and Worcester County to support effective implementation of the action items referenced above.

***Chesapeake Bay Program.*** The Chesapeake Bay Agreement, originally adopted in 1983, formed a partnership between the States of Virginia, Maryland, and Pennsylvania, the District of Columbia, the Chesapeake Bay Commission, and the U.S. Environmental Protection Agency to protect and restore the Chesapeake Bay's ecosystem. In the year 2000, all signatories of the Bay Agreement reconfirmed their commitment to the partnership by adopting a renewed Bay Agreement. The Chesapeake 2000 Bay Agreement addresses climate change, with implied reference to sea level rise, as follows: "*Evaluate the potential impact of climate change on the Chesapeake Bay watershed, particularly with respect to its wetlands, and consider potential management options."* The State of Maryland needs to take an active role in the process of accomplishing this commitment to ensure that sea level rise issues are given ample consideration.

***Maryland's Shore Erosion Task Force, 1999.*** In response to citizen concerns over the State's capacity to control shoreline erosion, the Governor established a Shore Erosion Task Force at the recommendation of Maryland's General Assembly. The Task Force concluded that sea level rise was a significant factor contributing to erosion in the State and that areas subject to shore erosion, sea level rise, and environmental sensitivity should be analyzed for the purpose of prioritizing and targeting shore protection activities at the regional level. Moreover, the Task Force recommended the development of predictive model to identify areas potentially vulnerable to increased erosion due to sea level rise and other on-going coastal processes. The Task Force issued its final report in January, 2000, calling for the development of a Comprehensive Shore Erosion Control Plan for the State of Maryland.

While the findings of Maryland's Shore Erosion Task Force (2000) were well received by the Governor, the Senate Economic and Environmental Affairs Committee, and the House Environmental Matters Committee, a FY2001 budget appropriation for the purposes of

implementing the recommendations of the Task Force on a state-wide basis was not secured. Despite the lack of budgetary support, the Department of Natural Resources (DNR) committed to carrying out key recommendations of the Task Force with the intent that the initiation of certain planning activities will assist DNR in securing the State budgetary support necessary to develop a Comprehensive Shore Erosion Control Plan for the State of Maryland.

With federal grant support (CZMA, § 306 and §309), DNR is currently in the process of conducting several "pilot studies" in which high-resolution digital topographic data (i.e., LIDAR) will be acquired and correlated with the historical shoreline change data produced by MGS to illustrate the magnitude of sea level rise and shore erosion along specific stretches of shoreline. The pilot studies findings will demonstrate the need to acquire high-resolution topographic data on a state-wide basis. The same federal grants are also supporting DNR as they begin working with St. Mary's and Dorchester Counties to establish regional shore erosion control strategies. The Task Force recommended that regional strategies be based on criteria which reflect: (1) magnitude of erosion; (2) environmental impact; (3) impacts to public and private infrastructure; and (4) potential impact of sea level rise. It is anticipated that strategies will include the designation of non-structural and structural shore protection areas, natural shore erosion areas, areas where erosion-based setbacks should be implemented, and areas to target for land conservation and acquisition. The designation of such areas will significantly advance sea level rise response by creating a long-range vision for the management of issues associated with shoreline erosion and tidal wetland loss. The establishment of regional strategies in the two counties will serve as a model for the eventual implementation of the planning process on a state-wide basis.

Every effort should be made to secure the necessary funding to support full implementation of Shore Erosion Task Force recommendations on a state-wide basis. In addition to advancing shore erosion control planning efforts, the development of a Comprehensive Shore Erosion Control Plan that factors in sea level rise issues is an ideal mechanisms to plan for sea level rise. Integral to the process of formulating the Comprehensive Plan will be the development of a full-scale predictive model to project future shoreline positions and potential zones of inundation from sea level rise. The predictive model will contribute considerably to our understanding of sea level rise and provide important information for long-term decision making and resource allocation for sea level rise and shore erosion control planning efforts.

***Shore Erosion Control Program.*** Shore Erosion Control (SEC), a program of the Department of Natural Resources, was established in 1968 by act of Maryland's General Assembly for the purpose of addressing shoreline and streambank erosion problems along the Chesapeake Bay and its tributaries (Natural Resources Article, § 8-1001 through 8-1008). The Program provides both financial and technical assistance to Maryland property owners to resolve erosion problems. Since 1968, the Program has assisted numerous property owners and established more than 800 structural projects and 325 non-structural projects. Approximately 1,100 property owners, along

70 miles of eroding shoreline, have received project management, financial, and technical assistance through the SEC program.

The owner of any property abutting a body of water in Maryland may file an application requesting assistance in the design, construction, management and financing of a streambank or shoreline erosion control project. Technical assistance for both non-structural (e.g., combinations of soils, gravel, stone, etc. with biodegradable protective materials and plants) and structural shore erosion control projects (e.g., bulkheads, stone revetments, jetties, breakwaters) is provided through site evaluations, problem assessments and recommended solutions. The Program currently provides financial assistance in the form of short-term loans and matching grants for non-structural shore erosion control projects. While the Program is authorized to provide 25- year, interest-free loans for the establishment of structural shore erosion control projects, budget constraints between 1992 and 1996 gradually discontinued the availability of financial assistance for such projects. However, in response to the recommendations of the Shore Erosion Task Force (2000), the State has allocated limited funds for FY2001 to provide financial assistance for structural shore erosion control projects to local governments and groups of property owners. The intent of this recommendation is to provide financial assistance for shore erosion control measures in areas where non-structural techniques alone are infeasible and would be ineffective.

The Shore Erosion Control Program is an essential component of the State's current sea level rise response network. The Program has and will continue to be the primary entity providing both technical and financial assistance for the protection of Maryland's shoreline from the forces of sea level rise-induced erosion. While the State benefits from having SEC in place, the alignment of the Program with the recommendations of the Shore Erosion Task Force, particularly the regional shore erosion control strategies, will greatly enhance its overall response capacity. Additionally, it is recommended that the Program evaluate the potential impacts of sea level rise during site review and project design processes. All projects receiving State financial assistance through the SEC should be reviewed to determine the cost-effectiveness of minor alterations in the setback and/or design standard based on life expectancy of proposed structures in relation to projected levels of sea level rise. Where it is cost-effective, all projects should be designed to withstand elevated sea levels either during initial construction or via retrofitting at a later date.

***Local Hazard Mitigation Plans.*** A risk analysis recently conducted by the Maryland Emergency Management Agency (MEMA) identified coastal flooding as a risk for ten of the State's sixteen coastal counties.[1] In addition, eleven local jurisdictions were characterized as storm surge risk

[1] Risk is classified "High", "Medium-High," and "Medium." High risk counties include: Worcester and Dorchester; Medium-High: Talbot, Queen Anne's and Kent; and, Medium: Charles, St. Mary's, Somerset, Wicomico, and Baltimore.

zones.[2] The completion of the risk assessment is the first step in the process of developing State-wide and local hazard mitigation plans, a process currently underway in Maryland. The federal government requires State and local jurisdictions to adopt hazard mitigation plans in order to be eligible for hazard mitigation funding. While every coastal county has adopted a floodplain management ordinance, a requirement for participation in the National Flood Insurance Program, not every coastal county has adopted a hazard mitigation plan. Additionally, most of the local plans that do exist are not comprehensive in nature and many are out of date.

MEMA is currently working with local governments to develop and adopt hazard mitigation plans in accordance with a new set of guidelines. These guidelines recommend that the process of developing a hazard mitigation plan be locally based and conducted by an inter-disciplinary hazard team comprised of both citizens and local governmental entities. The process of developing a hazard mitigation plan is an excellent opportunity to enhance planning for the hazards associated with sea level rise (e.g., coastal flooding, storm surge, and shore erosion) at the local level. Local hazard mitigation planning is perhaps the most comprehensive method to implement measures to protect public safety, health and general welfare in the event of increased storm damage resulting from sea level rise. The State should make every effort to promote consideration of sea level rise and other coastal hazard issues during the development of Local Hazard Mitigation Plans. Agency personnel with expertise in coastal hazard and sea level rise mitigation should participate on the hazard mitigation teams of those coastal counties with a heightened risk of coastal flooding and storm surge.

***State Wetland Conservation Plan.*** The development of Maryland's State Wetland Conservation Plan (SWCP) is an on-going effort to "identify and resolve gaps in current wetlands management for statewide conservation and preservation of wetland ecosystems and their functions through consistent federal, State, public and private participation, while recognizing competing resource needs (MDE, 2000)." The SWCP is being coordinated by the Maryland Department of the Environment, along with a workgroup of professionals from across the State, representing federal, State, and local government, agriculture, mining, and business, and environmental advocacy. The goals of the planning process are to:

- Develop a wetland resources baseline;
- Assess current and potential wetland threats and trends Statewide;
- Increase efficiency of wetlands regulation and management in Maryland;
- Prioritize wetlands for protection and restoration;
- Increase participation in wetland preservation, restoration, enhancement and stewardship; and,

[2] Storm surge risk zones are also classified "High", "Medium-High" and "Medium." High risk jurisdictions include: Dorchester County, St. Mary's County and Ocean City; Medium-High: Worcester and Talbot Counties; and Medium: Wicomico, Somerset, Queen Anne's, Kent, and Anne Arundel Counties.

- Achieve consistency and integration across federal, state, local and private programs affecting wetlands.

The SWCP workgroup has identified sea level rise as a "current and potential threat" to wetland resources in the State and is in the process of compiling applicable data and information on impacts, such as wetland and habitat loss, and shore erosion. The State must make a conscious effort to ensure sea level rise issues, with respect to wetland management, continue to receive attention during the planning process. The designation of wetland migration corridors and the need for management measures to address the impact of hard shoreline structures on potential landward migration should be key issues of the workgroup. The workgroup is also the forum to encourage federal, State and local regulatory programs to evaluate wetlands lost to sea level rise in "no-net loss" estimates. Additionally, the prioritization of wetlands for protection and restoration must include those impacted by sea level rise, not just by human activities.

***Barrier Island Management (Federal, State and Local).*** A great deal of sea level rise response is built into existing policies and management efforts currently employed to protect Maryland's barrier islands from coastal erosion and extensive storm damage. The National Park Service, which manages the southern portion of Assateague Island, has adopted a formal erosion policy which specifies that geologic features (e.g., sand dunes) within the Parks boundaries will be protected from erosion; however, natural shoreline processes (erosion, deposition, dune formation, inlet formation and shoreline migration) not influenced by human actions will continue without abatement (Shoreline Management, §1:4:20).[3] Beach protection, restoration and nourishment efforts on Fenwick Island, home of Ocean City, are cooperatively managed between the State of Maryland, Ocean City, Worcester County, and the U.S. Army Corps of Engineers. Several initiatives, including the Ocean City Beach Replenishment and Hurricane Protection Project[4], the establishment of the Ocean Beach Replenishment Fund[5], and the

[3] In instances where human activities or structures (e.g., jetties) have altered the nature or rate of shoreline processes, the National Park Service reserves the right to investigate alternatives for mitigating the effects of such activities or structures.

[4] The Ocean City Beach Replenishment and Hurricane Protection Project was constructed in two phases. Phase 1, authorized by Maryland's General Assembly (Chapter 286, Laws of Maryland), was a joint project between the State, Worcester County and Ocean City. The project, constructed in 1988, created a 220 foot wide beach through the placement of over 2.2 million cubic yards of sand along an 8.3 mile stretch of shoreline. Phase 2 of the project, including the installation of approximately 1.6 miles of steel bulkhead, 7 miles of vegetated dunes and 28.6 miles of sand fencing, was constructed in 1991. Phase 2 is a cooperative, cost-shared effort, with a 50 year maintenance agreement between the U.S. Army Corps of Engineers, the State of Maryland, Worcester County and Ocean City. Phase 2 was authorized under Section 501(a) of the Water Resources Development Act of 1986 (Public Law 99-662)

[5] The Ocean Beach Replenishment Fund (Natural Resources Article, §8-1103) established a joint funding mechanism for the appropriation of moneys for erosion control and storm protection projects, such as the Ocean City Beach Replenishment and Hurricane Protection Project, along the Atlantic Coast.

formation of the Beach Erosion Control District[6], are effective means to minimize the impact of sea level rise on the island. By sustaining the sediment supply through nourishment efforts and reconstructing foreshore dunes, the impacts of coastal storm events to the ocean-front city have been minimized. It should be noted, however, that absent the development of Ocean City, Fenwick Island would be able to naturally respond to sea level rise by migrating inland. Beach nourishment efforts are an expensive response alternative.

***Calvert County Zoning Ordinance.*** Recognizing the need to address erosion control issues in Calvert County, the Calvert County Commissioners appointed a Cliff Policy Task Force in 1992. After carefully examining bluff erosion issues, including the potential impact of sea level rise, the Task Force formulated specific recommendations for the preservation of cliffs within the County. Subsequently, specific language was added to the County Zoning Ordinance creating a regulatory scheme within which cliffs are classified into three distinct categories based on a prescribed level of preservation. Setbacks within each category are based on a specified distance from the top edge of the cliff or at the position the shoreline is estimated to be in 50 years, whichever is greater. The Zoning Ordinance also sets forth a range of categorical provisions including: prohibiting shore erosion control structures; requiring consideration of relocating structures before permitting shore erosion control devices; permitting shore erosion control structures if it is the only way to protect an existing structure; and prohibiting the installation of shore erosion control measures to protect new structures. The provisions set forth in the Calvert County Zoning Ordinance are an example of the type of progressive planning necessary to protect coastal resources at risk from sea level rise-induced shore erosion. Other local governments in Maryland should be encouraged to follow Calvert County's lead.

***Floodplain Management (Federal, State, and Local)***. The Federal Emergency Management Agency (FEMA) is the primary federal agency with emergency management responsibilities in the coastal zone. It is also the federal agency responsible for implementing the National Flood Insurance Program (NFIP), which provides subsidized insurance for damage to structures due to flooding. Participation in the NFIP is limited to communities in states that adopt local regulations and building standards (e.g., elevation requirements) for development in areas vulnerable to flooding. To participate in the NFIP, communities must adopt, administer, and enforce an ordinance that meets or exceeds federal floodplain management standards. These ordinances allow property owners to purchase insurance protection under the NFIP and make communities eligible for federal disaster assistance after a major flood event. The Maryland Department of the Environment (MDE) is the agency responsible for coordinating the State's participation in the NFIP. In addition to assisting with local ordinance administration and

[6] The Beach Erosion Control District (Natural Resources Article, §8-1105.1) is a fixed area on both Fenwick and Assateague Islands within which land clearing, construction activities, or the construction or placement of permanent structures are prohibited. The District area is reserved solely for activities and uses associated with beach erosion control and sediment control.

providing general technical assistance and local program review, MDE serves as the liaison between FEMA and Maryland's 115 participating counties and towns.

Issues associated with sea level rise are significant with respect to the scope of Federal, State, and local management responsibilities under the NFIP. Flood Insurance Rate Maps developed by FEMA designate areas of special flood risk and hazards, and insurance rates are calculated based on the level of flood risk associated with each designation. Flood Insurance Rate Maps and storm surge models prepared by FEMA, which guide State and local floodplain management efforts, do not evaluate sea level rise factors when establishing base flood elevations or storm surge risk zones. In fact, FEMA maps the 100-year floodplain as it exists at the time of the mapping effort. Future flood conditions, resulting from changes in land use, natural and human changes, or elevated flood levels due to sea level rise, are not considered. To account for the subsequent uncertainty and degree of error present in the current Flood Insurance Rate Maps, MDE requires all communities to adopt standards that call for all structures in the non-tidal floodplain to be elevated one-foot above the 100-year floodplain elevation. However, MDE only encourages the adoption of the one-foot freeboard standard in the tidal floodplain. All coastal counties except Worcester, Somerset, and Dorchester, the three most vulnerable to exacerbated flooding due to sea level rise, have adopted the one-foot freeboard standard. While one-foot of freeboard provides an added cushion of protection to guard against uncertainty in floodplain projections, it may not be enough in the event of two to three feet of sea level rise.

It is unlikely that the federal mapping efforts and floodplain management requirements will be modified to account for sea level rise. Therefore, State and local agencies need to take the initiative to address the potential for increased flooding due to sea level rise. It is recommended that the State amend the Flood Hazard Management Act of 1976 (Environment Article, Title 5) mandating that all counties to adopt standards requiring two or more feet of freeboard in tidally influenced floodplains.

As an incentive to do so, the State should work with all coastal counties, particularly Worcester, Somerset, and Dorchester, to facilitate participation in FEMA's Community Rating System (CRS), an incentive program that recognizes communities which adopt standards in excess of the minimum standards (i.e., one-foot freeboard requirements) by reducing flood insurance premiums for the entire community. Discounts range between 5% and 45% based on the level of public information and floodplain management activities undertaken by a community. However, communities must earn at least 500 credits to qualify for participation. Many communities are close to or within the qualifying range, however have not taken the initiative to apply for participation. To date, only 5 communities, Ocean City, North Beach, and Prince George's, Caroline, and Harford Counties, participate in the CRS.

***Chesapeake Bay Critical Area Program.*** The Chesapeake Bay Critical Area Protection Act (Natural Resources Article, §8-1807) was enacted by the 1984 Maryland General Assembly as a means to reverse the deterioration of the Chesapeake Bay. The jurisdictional boundary of the

Critical Area includes all waters of and lands under the Chesapeake Bay and its tributaries to the head of tide as indicated on the State wetlands maps, and all State and private wetlands designated under Natural Resources Article, Title 9 (now Title 16 of the Environment Article). The boundary also extends to all land and water areas 1,000 feet beyond the landward boundaries of State or private wetlands and the heads of tides, designated under the same Article.

The Critical Area Commission, established by the Act, sets forth Criteria (COMAR, Title 27) for developing detailed local management programs, approves management programs once they are developed, and reviews proposed activities for conformity with local management programs. The Critical Area Program is one of the State's primary management tools for addressing impacts associated with sea level rise. Despite a lack of reference to sea level rise in the Act or implementing Criteria, sea level rise-induced impacts are addressed through the following measures: establishing a 100-foot natural buffer adjacent to tidal waters and tidal wetlands; guiding development and controlling growth in valuable coastal resource areas; regulating the installation of shoreline erosion protection structures; and protecting wetlands through sedimentation and erosion control guidelines. Such measures significantly contribute to the State's overall ability to mitigate adverse impacts associated with sea level rise. Notwithstanding the many benefits of the Critical Area Program with respect to sea level rise response, specific statutory language contained in the Critical Area Act and its implementing Criteria will affect Maryland's ability to adequately plan for sea level rise in the long-term. Particular provisions regarding the 100-foot buffer and jurisdictional boundaries pose potential obstacles to the State's ability to develop a fully integrated response network.

One of the key management measures of the Critical Area Program is the establishment of regulations to ensure the maintenance of at least a 100-foot natural buffer, comprised of natural vegetation, adjacent to tidal waters and tidal wetlands. No new development activities, with the exception of those to support water-dependent facilities, are allowed within the buffer. The 100-foot buffer provides properties located along the Chesapeake Bay a first line of defense against sea level rise-induced coastal erosion and coastal flooding. Furthermore, by limiting development in the buffer to uses which are classified water-dependent, the amount of infrastructure located in areas vulnerable to sea level rise will be minimized in the near-term. Regardless, current provisions which allow the installation of a shoreline protection structure (a water-dependent use) within the buffer will compromise the ability of wetlands and marshes to migrate inland as sea level rises. Additionally, wetlands, marshes, and sandy beaches, located waterward of a shore protection structure will become permanently submerged by rising water in the long-term.

As previously mentioned, the jurisdictional boundaries of the Critical Area are based on the location of State and private wetlands, extending 1,000 feet beyond the landward boundaries of wetlands designated under Title 16 of the Environment Article. Tidal wetland boundaries were established by interpreting aerial photos, in combination with field inspections, to validate vegetation and tidal association and are delineated on a series of approximately 2,000 aerial photomaps produced in 1972. The Critical Area Commission, as well as local jurisdictions, rely

on the 1972 maps series to determine the Critical Area boundary. Critical Area boundaries, however, are not automatically updated in response to changes in tidal wetland boundaries. As sea level rises and wetlands migrate inland, the potential for significant changes in tidal wetland boundaries is quite high. However, tidal wetland maps, originally prepared by the Maryland Department of Natural Resources, are not updated periodically. In fact, there has not been a comprehensive update of the maps since they were originally produced in 1972. Such an update of the tidal wetland maps and associated Critical Area boundaries would be a major undertaking for the State of Maryland, perhaps one that would require a legislative mandate and the expenditure of sizeable State funds. Even if the maps were updated to reflect changes in tidal wetland boundaries, any change to the Critical Area boundary would require approval from local governments and the Critical Area Commission. However, without such changes the State may lose substantial portions of the Critical Area over time.

Maryland will need to address the obstacles presented by the current buffer provisions and the jurisdictional boundaries of the Critical Area Program in order to adequately plan for sea level rise in the long-term. In addition to removing these barriers, the State should consider amending the Criteria for Local Critical Area Program Development (COMAR, Title 27) to support implementation of the regional shore erosion control strategies, to be developed in conjunction with the Comprehensive Shore Erosion Control Plan. One possibility would be to expand the distance of the vegetated buffer in areas experiencing "significant"erosion.[7] The current Criteria require local jurisdictions to expand the buffer beyond 100 feet to include contiguous, sensitive areas, such as steep slopes, hydric soils, or highly erodible soils[8], whose development or disturbance may impact streams, wetlands, or other aquatic environments. Using the updated shore erosion statistics currently being compiled by MGS, the buffer width in areas experiencing greater than 2 feet of erosion per year could be based on a specific fixed distance (e.g., 150 feet) or on the position the shoreline is estimated to be in 50 years (erosion rate x 50 years), whichever is greater. If modifications are made to the Act and implementing Criteria to restrict hard structures within the buffer, expanded buffers could then be used to support other sea level rise response strategies, including the protection of wetland migration corridors and the designation of natural shore erosion areas.

***Wetlands and Riparian Rights Act***. In 1970, the Maryland General Assembly recognized that many wetlands had been lost or despoiled throughout the State by unregulated activities such as dredging, dumping and filling, and that remaining wetlands were in jeopardy. The enactment of the Wetlands and Riparian Rights Act (Environment Article, Title 16) established a comprehensive plan to restrict and regulate activities conducted in wetlands in order to preserve and protect them. The Act mandated the mapping of tidal wetlands and the creation of a

[7] "Significantly eroding areas" are areas that erode 2 feet or more per year.

[8] "Highly erodible soils" are soils with a slope greater than 15 percent, or those soils with K value greater than 0.35 and with slopes greater than 5 percent.

regulatory program to protect the State's tidal wetland resources. Tidal wetlands are managed to provide reasonable use while furnishing essential resource protection. Licenses, issued by the State's Board of Public Works, based on recommendations from the Maryland Department of the Environment (MDE) are required for projects within State-owned tidal wetlands. Permits are issued directly by MDE for projects in private wetlands. A permit or license must be obtained before a person fills, dredges, or otherwise alters a tidal wetland. Applications are evaluated to ensure that appropriate steps are taken to first avoid, then minimize impacts to tidal wetlands. In recent years, the regulatory program has limited the loss of vegetated tidal wetlands to less than one acre per year. More importantly, Maryland is realizing a net gain in tidal wetlands through mitigation and enhancement projects.

Although a moderate degree of sea level rise response is achieved through implementation of the Wetlands and Riparian Rights Act, strict interpretation of §16-201 of the Act, which gives the owner of land bounding on navigable water the right to protect their property from the effects of shore erosion on an individual basis, will ultimately prevent the State from achieving its desired level of sea level rise protection.

> §16-201 (a) A person who is the owner of land bounding on navigable water is entitled to any natural accretion to the person's land, to reclaim fast land lost by erosion or avulsion during the person's ownership of the land to the extent of provable existing boundaries. The person may make improvements into the water in front of the land to preserve the person's access to the navigable water or protect the shore of that person against erosion. After an improvement has been constructed the improvement is the property of the owner of the land to which the improvement is attached. A right covered in this subtitle does not preclude the owner from developing any other use approved by the Board. The right to reclaim lost fast land relates only to fast land lost after January 1, 1972, and the burden of proof that the loss occurred after this date is on the owner of the land. [Emphasis added]

This provision complicates the State's ability to establish regional shore erosion control strategies which may seek to designate natural shore erosion areas, as well as the implementation of specific sea level rise response mechanisms, such as the designation of wetland migration corridors. Strict interpretation of this provision by MDE has historically resulted in the approval of hard shore erosion control structures in areas which may have been suitable for non-structural shore erosion techniques. This practice conflicts with the Criteria of the Critical Area Act which give preference to non-structural shore erosion protection, mandating that structural control measures only be utilized in areas where non-structural control measure would be impractical or ineffective (COMAR, Title 27.01.04). The State will need to closely assess the applicability of §16-201(a) once specific shore erosion control strategies and sea level rise response mechanisms are identified. Depending on the degree of conflict, Maryland may choose to pursue acquisition of affected areas through land conservation programs.

***Economic Growth, Resource Protection and Planning Act.*** The Economic Growth, Resource Protection, and Planning Act of 1992 (the Growth Act) supplied the State with a new method for addressing land use planning, growth, and environmental and resource protection. The Act,

which provides a context for the development of all new and updated land use plans at the local level, is based on the following seven visions: 1) development is concentrated in suitable areas; 2) sensitive areas are protected; 3) in rural areas, growth is directed to existing population centers and resource areas are protected; 4) stewardship of the Chesapeake Bay and the land is a universal ethic; 5) conservation of resources, including a reduction in resource consumption, is practiced; 6) economic growth is encouraged and regulatory mechanisms are streamlined; and 7) funding mechanisms are addressed to achieve these visions (State Finance and Procurement Article, Title 5). Incorporating the seven visions into Maryland's planning and zoning enabling legislation provided local jurisdictions a succinct statement of the State's priorities for local planning (MOP, 1999).

Under the Act, local plans must follow the seven visions. All new and updated land use plans must incorporate a sensitive area element which will describe how a local government will protect streams and their buffers, 100-year floodplains, habitats of threatened and endangered species, and steep slopes. Lastly, local development regulations must be made consistent with comprehensive plans and the new growth policies. As of October 1998, all local governments had revised their comprehensive plans to include sensitive areas elements and had implemented ordinances to comply with the Act.

Building upon the Economic Growth, Resource Protection and Planning Act, the General Assembly passed Governor Glendening's *Smart Growth and Neighborhood Conservation Initiative* during the 1997 legislative session. The Initiative encourages development and economic expansion, but only in locations where it makes the most sense and where the infrastructure is in place, or is planned to support it. State funds to support development (e.g., schools, roads) must be targeted to existing towns and cities and other designated "Smart Growth" or "Priority Funding" areas (PFA's). Additionally, "Smart Codes" legislation (SB207/HB284 and SB208/HB285) was passed during the 2000 legislative session, creating the enabling legislation to draft the Maryland Building Rehabilitation Code and directing the Maryland Department of Planning to draft zoning models to promote infill and mixed-use development.

The premise of the Growth Act and its underlying Smart Growth Initiative is that local plans and zoning ordinances supported by the State are the best tool to establish and guide priorities for controlling growth and protecting finite resources. As such, the State's commitment to effectively plan for sea level rise in the long-term should be reflected in the Act's mandate and implementation initiatives. The Economic Growth, Resource Protection, and Planning Act can enhance the State's ability to plan for sea level rise as follows:

- Maryland's "Smart Growth" strategy should evaluate population growth and development patterns in relation to areas vulnerable to sea level rise and provide local governments the necessary guidance and tools to direct development away from areas likely to be significantly impacted. Many of the management tools are already in place such as

limiting growth outside designated PFA's; the only change required is the directive to consider sea level rise issues when establishing new or modified PFA's.

- Incorporate sea level rise planning principles (e.g., require new and rebuilt structures to be elevated one foot above the base flood elevation, increase setbacks in significantly eroding areas) into the Maryland Rehabilitation Code and the infill and mixed-use zoning models.

- Advocate that local governments address sea level rise issues by amending the sensitive area element of their local land-use plans. Streams,100-year floodplains, habitats of threatened and endangered species, and steep slopes are already considered "sensitive areas;" adding tidal wetlands and marshes, and significantly eroding areas (areas experiencing 2 or more feet of erosion per year) to the list of "sensitive areas" and encouraging local governments to develop sea level rise protection guidelines will greatly further response planning in the State.

## Conclusion

Maryland's existing response capability provides the State only a moderate degree of protection against the forces of sea level rise. Although a number of management measures are in place, not all were adopted with sea level rise issues in mind; subsequently, they provide a fragmented approach to the problem and fall short when it comes to mitigating the full range of sea level rise impacts expected to occur throughout Maryland's coastal zone. Additionally, while the State has been able to incorporate sea level rise issues into a number of independent management efforts, enhanced sea level rise response will only be realized through successful implementation and integration of these initiatives.

## A Sea Level Rise Response Strategy

Despite the management measures in place and the incorporation of sea level rise issues into recent coastal initiatives, the State will fail to comprehensively address sea level rise in the long-term unless immediate steps are taken to plan for sea level rise response within the network of coastal management agencies. The following Strategy is designed to guide the State toward the development of a networked means of response, crossing over inter-governmental boundaries to address the three primary impacts of sea level rise in the State of Maryland (i.e., erosion, flooding and inundation), and the resulting environmental and socio-economic implications of each. The cornerstone of the proposed Strategy is designation of one or more staff within the Department of Natural Resources with expertise in sea level rise planning to oversee implementation.

The Strategy is comprised of four components: outreach and engagement; technology, data and research support; critical applications; and, state-wide policy initiatives. Each component will build upon the others to achieve the desired outcome within a five-year time horizon. The objective, key activities, and implementation timeline for each component are outlined below.

### Outreach and Engagement

Sea level rise issues have commanded a significant degree of public attention in recent years and the Department of Natural Resources continues to receive numerous requests for public presentations and workshops on the topic. To date, the State has utilized one-on-one interviews, issue forums, public presentations, a sea level rise display, field trips, and public workshops to foster a general understanding of sea level rise planning principles and to solicit input on the content and recommendations proposed in the response strategy. Despite these efforts, there remains a general lack of understanding of the magnitude of sea level rise impacts and the connection between global climate change and sea level rise. Therefore, to build support for the implementation of the Sea Level Rise Response Strategy, the State must continue to take an active role in educating the general public.

As the State begins to implement the proposed Strategy, however, outreach efforts will need to take on a more formidable purpose of engaging State and local planners and elected officials in the process of advance planning for sea level rise. The establishment of partnerships with select agencies and organizations is one of the primary means to ensure effective application of sea level rise planning principles at the State and local level.

***Objective: Engage the general public, State and local planners, and elected officials in the process of implementing a sea level rise response strategy.***

***Key Activities:***

- Undertake a broad range of public outreach efforts (e.g., issue forums, public presentations, field trips, public workshops) targeted to a variety of audiences, including: the general public, primary and secondary educators and students, and State and local planners and elected officials.

- Work cooperatively with local governments to review existing plans and implementing ordinances and identify changes and modifications that will enhance sea level rise response.

- Partner with existing land conservation programs (e.g., Greenways, Rural Legacy, Program Open Space, and the Conservation Reserve Enhancement Program) to promote the use of conservation easements and other land conservation initiatives as a means to protect key coastal areas vulnerable to sea level rise and to provide sufficient lands for wetland migration.

- Conduct public outreach activities aimed at garnering political and financial support for the full-scale implementation of the Shore Erosion Task Force recommendations, including the development of the predictive model and a Comprehensive Shore Erosion Control Plan for the State of Maryland.

- Partner with the Maryland Department of the Environment to encourage all coastal counties to participate in FEMA's Community Rating System.

- Continue to identify and engage future partners through on-going outreach activities and participation in new coastal management initiatives.

***Implementation Timeline:***

Outreach and engagement is a critical to the successful implementation of the proposed Strategy. This component will be an on-going element of the process of achieving a networked means of sea level rise response. The proposed activities should be initiated immediately and continue throughout the five-year planning horizon.

**Technology, Data and Research Support**

The substantial amount of research documenting both the magnitude of the sea level rise and its impact on Maryland's coastal resources greatly enhances our understanding of the regional implications of sea level rise. Though there is a sufficient knowledge base from which to move forward with policy response in the State of Maryland, a continued commitment to sea level rise

research is still vital to the State's ability to proceed. The State must continue to support sea level rise research whenever possible.

***Objective: Gain a better understanding of the regional impacts of sea level rise and applicable policy response alternatives.***

***Key Activities:***

- Coordinate and collaborate on existing and proposed sea level rise research.

- Integrate research findings into the Sea Level Rise Response Strategy.

- Provide financial support for future sea level rise research through applicable grant programs.
- Participate in climate variability and climate change research efforts (e.g., the Mid-Atlantic Climate Change Assessment).

- Target funds to support the following data and research needs:

    - high-resolution topographic data (i.e., LIDAR) for all coastal counties;
    - impact of prescribed burning and invasive species (i.e., nutria) on marsh accretion;
    - feasibility of sediment spraying in marsh environments;
    - contribution of groundwater withdrawal on land subsidence in low-lying areas;
    - beneficial use of dredge spoils for Bay island restoration and protection; and,
    - impact of sea level rise on storm surge and base flood elevations.

- Support sea level rise research efforts linking scientific research with specific and applicable policy response strategies.

- Utilizing Geographic Information System (GIS) technology, analyze areas vulnerable to sea level rise (i.e, lands below the three-foot contour, coastal high hazard floodplain areas, tidal wetlands, and significantly eroding areas) in combination with the jurisdictional and regulatory mandates of existing management programs (e.g., Priority Funding Areas, Resource Conservation Areas).

***Implementation Timeline:***

Implementation of this component will extend throughout the five-year time frame. While the State should immediately begin to pursue the activities presented above, the overall implementation timeline may be dependent on the availability of funding. The acquisition of some data and research needs will be constrained by limited funding sources; therefore, it will be necessary to garner public and political support prior to initiating particular research efforts.

## Critical Applications

There are a variety of State and local policies and regulations to target in order to advance sea level rise planning principles. With political support, local comprehensive plans, zoning ordinances, floodplain management ordinances, and capital facilities plans can be amended to address sea level rise issues. At the State level, efforts to target include capital facilities planning (e.g., State Highway Administration), and State-owned lands management programs (e.g., State Forest and Park Service, Land and Water Conservation Service). In addition, the State can make great strides by including sea level rise issues in new and on-going coastal management initiatives. On-going efforts generally have political support, which may be hard to obtain in the near-term for a State-wide sea level rise initiative, and can foster advance planning independent of other implementation activities.

The goal of the third component is to demonstrate successful application of sea level rise planning principles at the State and local level. Amending current policies and regulations to better address sea level rise and incorporating sea level rise issues into on-going coastal initiatives are both critical to the State's ability to accomplish this goal. The key activities outlined below include those applications "critical" to building a networked means of response, and subsequently, to forming the momentum for the State-wide policy initiatives presented in the fourth and final component.

***Objective: Incorporate sea level rise planning mechanisms into existing State and local management programs and on-going coastal initiatives.***

***Key Activities:***

- Incorporate the analysis of Maryland's sea level rise response capacity and the proposed response strategy into the State's CZMA §309 Coastal Hazard and Sea Level Rise Assessment and Strategy for 2000 - 2005.

- Work with all coastal counties to amend existing floodplain ordinances, zoning ordinances, and development codes to require new and rebuilt structures in the tidal floodplain to be

elevated two or more feet above the 100-year base flood elevation and to adopt erosion-based setbacks based on historic erosion rates in areas experiencing 2 or more feet of erosion per year.

- Establish a directive and means to review all new State-funded coastal projects to determine the cost-effectiveness of minor alterations in the setback and/or design standards based on life expectancy of proposed structures in relation to projected levels of sea level rise. Potential changes include: increasing building setbacks to accommodate a change in the shoreline position due to erosion or innundation; designing structures to accommodate a more frequent storm event (25 year vs.100 year flood); and, elevating structures in tidal floodplains two or more feet above the 100 year base flood elevation.

- Continue to work with the Coastal Bays Program, Worcester County, and Ocean City to achieve the sea level rise planning objectives as outlined in the Comprehensive Conservation and Management Plan.

- Participate on the Chesapeake Bay Program's Living Resources Committee to oversee implementation of the climate change commitment ( Chesapeake Bay Agreement, 2000) and to ensure sea level rise issues are given ample consideration during the planning process.

- Utilize the process of developing a Comprehensive Shore Erosion Control Plan for the State of Maryland to advance sea level rise planning principles, such as designating non-structural and structural shore protection areas, natural shore erosion areas, areas where erosion-based setbacks should be implemented, and areas to target for land conservation and acquisition.

- Develop the means to direct the Shore Erosion Control Program to evaluate the potential impacts of sea level rise during site review and project design processes. All projects receiving State financial assistance through the SEC should be reviewed to determine the cost-effectiveness of minor alterations in the setback and/or design standard based on life expectancy of proposed structures in relation to projected levels of sea level rise. Where it is cost-effective, all projects should be designed to withstand elevated sea levels either during initial construction or via retrofitting at a later date.

- Actively support the development of a State Wetlands Conservation Plan, which promotes the following: (1) the designation of wetland migration corridors; (2) discourages the use of hard shoreline erosion control structures in coastal marsh environments; (3) the inclusion of wetlands lost to sea level rise in "no-net loss" estimates; (4) the removal of existing wetland migration barriers; and (5) the protection and restoration of wetlands impacted by sea level rise.

- Support the development of Local Hazard Mitigation Plans, particularly the coastal hazard (e.g., erosion, flooding, storm surge) element, for coastal counties designated at risk from coastal flooding and storm surge by providing staff and financial support.

***Implementation Timeline:***

Initiation of this component should begin immediately and continue through the first four years of implementation. This time period is required to successfully advance sea level rise issues through both the coastal management initiatives and amendments to existing management efforts, as referenced above. It will be imperative to demonstrate the application of sea level rise planning principles at the local and State level in order to move beyond an incremental response to the overall problem. Once the Critical Applications have been accomplished, the State can then move towards advancing State-wide policy initiatives during the remaining year of the five year Strategy.

**Statewide Policy Initiatives**

By systematically targeting existing management frameworks, the State will begin to develop a networked means of response. However, the State's ability to fully develop a response capacity that comprehensively addresses the primary impacts of sea level rise, including the range of associated environmental and socio-economic impacts, hinges on the applicability of State-wide policy frameworks. Enhancements and modifications to the Flood Control and Watershed Management Act, the Chesapeake Bay Critical Area Protection Act, the Wetlands and Riparian Rights Act, and the Economic Growth, Resource Protection and Planning Act will be necessary to successfully plan for sea level rise in the long-term.

***Objective: Enhance, and where necessary, modify key State statutes to remedy barriers and advance state-wide sea level rise planning initiatives***.

***Key Activities:***

- Amend the Flood Hazard Management Act of 1976 (Environment Article, Title 5) mandating that all counties to adopt standards requiring two or more feet of freeboard in tidally influenced floodplains.

- Undertake a comprehensive update of the 1972 tidal wetland maps and the underlying jurisdictional boundaries of the Critical Area Program.

- Expand the Critical Area buffer width in areas experiencing greater than 2 feet of erosion per year. The distance of the buffer should be based either on a specific fixed distance (e.g., 150 feet) or on the position the shoreline is estimated to be in 50 years (erosion rate x 50 years), whichever is greater.

- Amend the Critical Area Act and its implementing Criteria to restrict the placement of hard structures within the 100-foot buffer area in areas suitable for non-structural shore erosion techniques, wetland migration, and natural shore erosion.

- Remedy conflicts between §16-201(a) of the Wetlands and Riparian Rights Act and selected sea level rise response strategies (e.g., natural shore erosion areas, wetland migration corridors).

- Align smart growth strategies to reflect population growth and development patterns in relation to areas vulnerable to sea level rise. Provide a State directive to consider sea level rise issues when establishing new or modified Priority Funding Areas.

- Incorporate sea level rise planning principles (e.g., require new and rebuilt structures to be elevated two or more feet above the base flood elevation, increase setbacks in significantly eroding areas) into the Maryland Rehabilitation Code and the infill and mixed-use zoning models.

- Designate tidal wetlands and marshes and significantly eroding areas (areas experiencing 2 or more feet of erosion per year) as "sensitive areas" under the Economic Growth, Resource Protection and Planning Act; and, provide incentives to local governments to develop sea level rise protection guidelines for inclusion in the sensitive area element of their local land-use plans.

***Implementation Timeline:***

It is recommended that this component not be initiated until the final year of implementation. At that time, the State will have made great progress in advancing sea level rise planning principles through on-going initiatives and amendments to current management programs. At that time, the public and political support at both the State and local level that is critical to the success of the Strategy will be evident. Substantial advancements in our understanding of sea level rise and applicable policy response alternatives will also have been accomplished. The first three components of the Strategy will build the momentum necessary to successfully pursue the policy initiatives listed above.

## Conclusion

Maryland's diverse coastline is highly susceptible to the impacts of rising sea levels. In fact, sea level rise-induced shore erosion and inundation have already begun to make their mark on the character of the State's coastal environment. While coastal areas and resources already under natural and human-induced stress are most vulnerable today, in due time, the finite resources of our State, including its sandy beaches, coastal wetlands, Bay islands, coastal bluffs, and natural barrier islands will become increasingly threatened. The economic and social impact of sea level rise will be immense. Significant amounts of public and private property will be lost to erosion and the developed portions of the coast will experience extensive damage from coastal storm events.

The State, however, does not have an adequate plan of response. Despite the mix of coastal programs and initiatives that address issues associated with sea level rise, Maryland will continue to lack the ability to respond in the long-term unless the State actively pursues the development of a networked response framework. Issues associated with coastal flooding, inundation, and coastal erosion must all be dealt with, along with the range of associated environmental and socio-economic impacts. The proposed Strategy is designed to guide the State through the process of developing such a comprehensive approach to the problem.

Implementation of the proposed Strategy will evolve over time. It is also a process that will require a sizeable commitment of time and financial resources. However, this process is crucial to the State's ability to achieve sustainable management of its coastal zone. The State must recognize that a "do nothing" approach will lead to unwise decisions and increased risk over time. Moreover, planners and legislators should realize that the implementation of measures to mitigate impacts associated with erosion, flooding, and wetland inundation will also enhance the State's ability to protect coastal resources and communities whether the sea level rises significantly or not.

Carrying out the objectives of the Strategy will be a prudent investment on the part of the State in the light of the appreciable degree of impact expected to occur in the coming years. Maryland will be taking the first proactive step towards addressing a growing problem by committing to the following goals:

- dedicate an individual to the cause;
- educate and engage the public and State and local decision-makers;
- actively support sea level rise research;
- identify and target implementation vehicles;
- recognize and work to remove barriers and obstacles to state-wide policy; and
- strive towards a networked means of response.

Successful implementation of this Strategy will increase awareness and consideration of sea level rise issues in both public and governmental arenas. However, increasing awareness is only one

of many steps necessary to ensure an effective plan of response. Maryland will achieve true success in planning for sea level rise by establishing effective response mechanisms at the State and local levels. Innumerable social and environmental resources are at stake. Sea level rise response planning is crucial to ensure future survival of Maryland's diverse and invaluable coastal resources.

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