

## 3.10 Chesapeake Bay: Local Area Coastal Habitat and Environmental Implications of Sea Level Rise: Anticipated Effects by Multicounty Region

*Author: Ann Shellenbarger Jones, Industrial Economics Inc.*

The environmental implications of sea level rise vary in extent and certainty for different habitat types. Section 3.1 provides general background on species and their habitats vulnerable to sea level rise for the mid-Atlantic. This collection of short literature reviews describes where impacts to these vulnerable species may occur in Chesapeake Bay by taking a walk along its shoreline, beginning with Norfolk, Virginia, and continuing up the western side of the bay (traversing the Potomac and Patuxent rivers and up to the Susquehanna River), then returning along the eastern shore of the bay, to the southern tip of Northampton County.

We rely on various published sources of data and information on wetlands, shoreline type and condition, erosion, future shore protection, and habitat types and locations to characterize current and potential future shoreline ecology of Chesapeake Bay.<sup>520</sup>

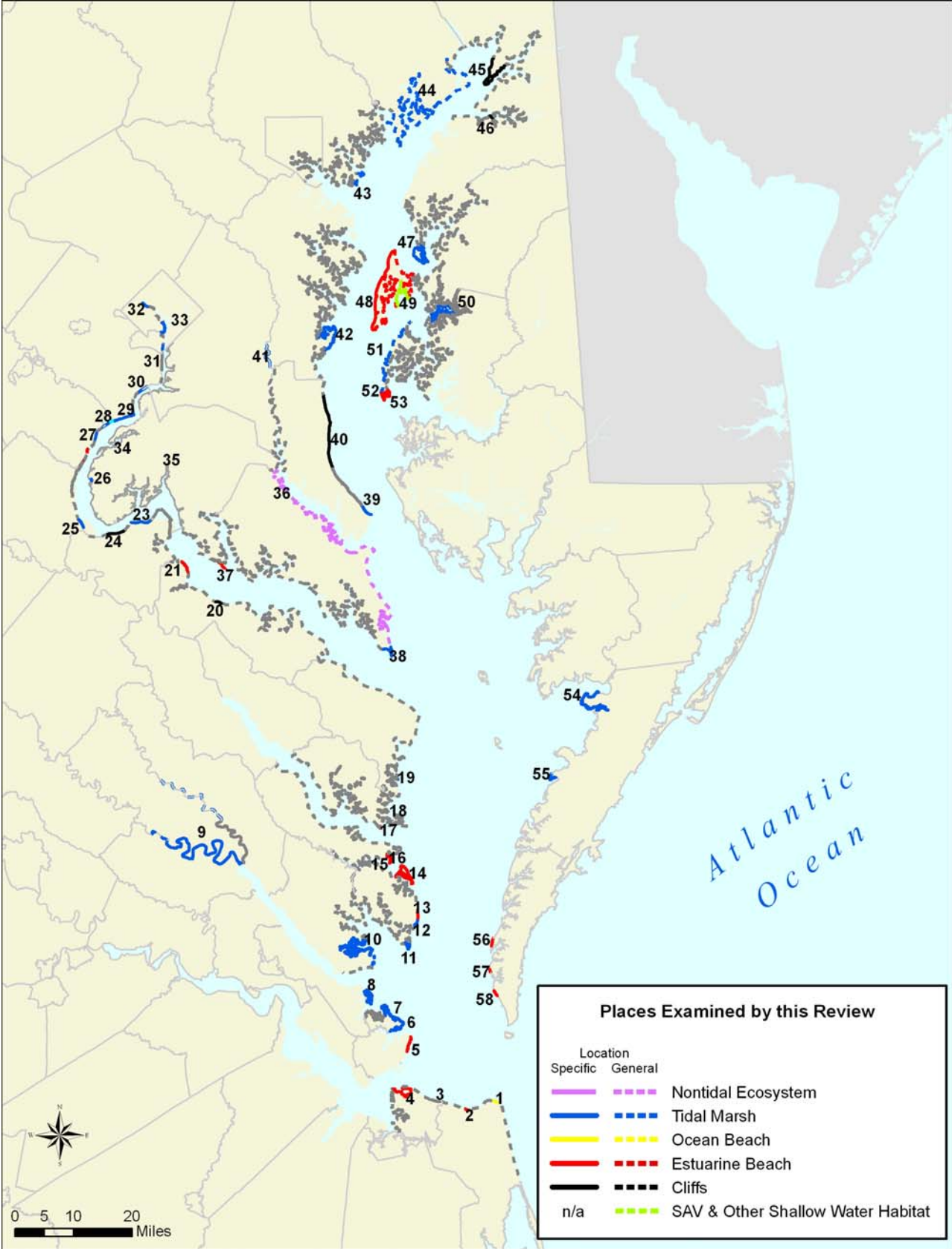
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<sup>520</sup>Sources for wetlands information: Tiner and Burke, 1995 (see note 32); and National Wetlands Inventory. Sources for shoreline type and condition: Comprehensive Coastal Inventory Program, 2005, Shoreline Situation Reports, Virginia Institute of Marine Science (VIMS), College of William and Mary, Gloucester Point, VA, available at <http://ccrm.vims.edu/gis/gisdata.html>. These reports, which will eventually be available for all counties on Chesapeake Bay, include surveys of bank condition (height, erosion extent, vegetative cover, land use), presence and condition of fronting marsh or beach, and the extent and types of shoreline protections. Source for accretion estimates, unless otherwise noted: Reed et al., Section 2.1. Source for erosion information in Maryland: Maryland Shoreline Changes Online, from the Maryland Department of Natural Resources. Available at: [http://shorelines.dnr.state.md.us/sc\\_online.asp](http://shorelines.dnr.state.md.us/sc_online.asp).

These brief literature reviews discuss species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection. Existing literature and knowledge of coastal scientists in the area are sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures or the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. The reviews take account of shoreline features, anticipated shore protection, and the potential for wetlands to keep pace with rising sea level. Where possible, they assess the combined implications of those factors, to indicate predicted retention or loss of current primary habitats. Where available, we delineate effects associated with a particular location (e.g. unique shoreline type, endangered and threatened species) (see Section 3.1 for descriptions of generalized potential responses). Map 3.8 illustrates the regions of Chesapeake Bay and the key locations for which we have data on the species that depend on habitat vulnerable to sea level rise. We discuss the following multicounty sections separately.

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Source for shoreline and habitat types: A set of four maps are available from NOAA's Office of Response and Restoration for all of Chesapeake Bay, showing seasonal changes in the Chesapeake (ESI 1993). Detailed digital maps (GIS format) are available from NOAA's Office of Response and Restoration for the Virginia portion of Chesapeake Bay (ESI 2005). These maps provide detail on shoreline type, nearshore and inshore habitats, and locations of endangered species.



**Map 3.8. Environmental Importance of Habitat Vulnerable to Sea Level Rise: Locations Examined in this Report.** See legend on next page for location name index and associated habitat.

**Legend for Map 3.8**

Location Name Index	Habitat (as mentioned in text for this location).	Location Name Index	Habitat (as mentioned in text for this location).
1. Cape Henry	Ocean Beach	30. Accotink Bay	Tidal Marsh
2. Lynnhaven Inlet/River	Estuarine Beach	31. Dyke Marsh	Tidal Marsh
3. City Beach Park	Estuarine Beach	32. Roosevelt Island	Tidal Marsh
4. Willoughby Bay	Estuarine beach - groinfields	33. Anacostia River	Limited tidal marsh, armoring
5. Grandview Beach Nature Preserve	Estuarine Beach	34. Mattawoman Creek	Estuarine Beach
6. Plum Tree Island Marsh	Tidal Marsh	35. Port Tobacco	Tidal Marsh
7. Ware Stick Island	Tidal Marsh	36. Zekiah and Gilbert Swamps	Nontidal marsh
8. Goodwin Islands	Tidal Marsh	37. Cobb Island	Estuarine Beach
9. Pamunkey and Mattaponi Rivers	Tidal Marsh	38. Point Lookout State Park	Tidal Marsh
10. Gloucester Marshes, Guinea Neck	Tidal Marsh	39. Cove Point	Tidal marsh to north of point, beach to south of point
11. New Point Comfort	Tidal Marsh	40. Calvert County Cliffs	Cliffs
12. Winter Harbor	Tidal Marsh	41. Jug Bay and Patuxent River Park	Tidal Marsh
13. Bethel Beach Natural Area Preserve	Tidal Marsh fronted by Estuarine Beach	42. Shady Side	Tidal Marsh
14. Gwynn's Island	Estuarine Beach	43. North Point State Park	Tidal Marsh
15. Fishing Bay	Estuarine Beach	44. Aberdeen Proving Ground	Tidal Marsh
16. Stove Point	Estuarine Beach	45. Elk Neck State Park	Cliffs
17. Mosquito Point	Estuarine Beach	46. Sassafras Natural Resources Management Area	Cliffs
18. North Point	(geographic)	47. Eastern Neck National Wildlife Refuge	Tidal Marsh
19. Hughlett Point Natural Area Preserve	Tidal Marsh	48. Kent Island	Revetments and some estuarine beach
20. Westmoreland State Park	Cliffs	49. Crab Alley Bay	Submerged aquatic vegetation
21. Colonial Beach	Estuarine Beach	50. Wye Island Natural Resources Management Area	Tidal Marsh
22. Intentionally left blank		51. Tilghman Island - western/bay side	Mix of fringing tidal marsh and estuarine beach
23. Chotank Preserve	Tidal Marsh	51. Tilghman Island - eastern side	Tidal marsh shoreline, shallow water/tidal flats
24. Caledon Natural Area	Cliffs	52. Poplar Island	Tidal Marsh
25. Crow's Nest Peninsula	Tidal Marsh	53. Walnut Point	Armored estuarine beach
26. Nanjemoy Peninsula	Tidal Marsh	54. Saxis Wildlife Management Area	Tidal Marsh
27. Featherstone NWR	Tidal Marsh	55. Parkers Marsh Natural Area Preserve	Tidal Marsh
28. Occoquan National Wildlife Refuge	Tidal Marsh	56. Savage Neck Dunes Natural Area Preserve	Estuarine Beach
29. Mason Neck, Mason Neck State Park, Mason Neck National Wildlife Refuge	Tidal Marsh	57. Cape Charles Coastal Habitat Natural Area Preserve	Estuarine Beach
		58. William B. Trower Bayshore Natural Area Preserve	Estuarine Beach

## 3.11 The Chesapeake Bay Shoreline near Hampton Roads

*Authors: Ann Shellenbarger Jones, Industrial Economics Inc.,  
Christina Bosch, Industrial Economics Inc.*

### Overview

The shores of Chesapeake Bay to the south of Hampton Roads<sup>521</sup> are dominated by the north-facing sandy beaches of Virginia Beach and Norfolk. To the north, the shores of Hampton, Poquoson, and York counties are mostly tidal marsh. The marshes and the species that depend on them are potentially vulnerable to sea level rise. The bay beaches, by contrast, appear likely to survive.

Virginia Beach will be greatly affected by continued local anthropogenic actions, which may or may not follow historical patterns that resulted in the current beach configurations. City planners anticipate that the shoreline of the City of Virginia Beach is almost certain to be protected through armoring or beach nourishment. Sandy beaches may be retained in various protected areas owing to nourishment projects, but will otherwise be eroded in front of protective structures. A 2002 beach management plan includes recommendations for long-term replenishment programs at Chesapeake, Ocean Park, and Cape Henry beaches.<sup>522</sup> If beaches are

lost in other localities to sea level rise, the few plants that are well adapted to the harsh beach environment in these local areas will be lost. Habitat for invertebrates (e.g., sand diggers, sand fleas, horseshoe crabs, and mole and ghost crabs) will be lost. Shorebirds that rely on beaches for forage and nesting (e.g., turnstones, sanderlings, and plovers) will face more limited resources.<sup>523</sup>

Current rates of sea level rise in the Poquoson marshes and some Hampton areas are converting marsh to open water; these marsh areas will be inundated as sea level rise accelerates, converting marsh areas to tidal flats and then open water (Section 2.1). Inundation will eliminate habitat for many marsh inhabitants such as crustaceans, mollusks, and other invertebrates. Turtles (e.g., diamondback terrapins) and birds (e.g., ducks, rails) that forage on the invertebrates will therefore also lose food sources. Habitat for fish (described subsequently) that spend portions of their lives in wetlands will be lost, as will habitat for birds that nest exclusively in marshes (known as marsh-obligates). In this region, the dozens of bird species that use Plum Tree Island marsh will be impacted by continued marsh loss. The ecosystem functions of flood control, erosion buffering, and nutrient and contaminant filtering will be lost as wetlands are submerged.<sup>524</sup>

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<sup>521</sup>Hampton Roads is the large harbor between the confluence of the James and Elizabeth rivers and Chesapeake Bay. We did not look at the tidal habitat of Hampton Roads or its tributaries. In general, as indicated in ESI 2005, the northern shores of the harbor are hardened with riprap and other artificial structures, while the riparian shores of the Nansemond river are tidal marsh. See Map 3.8 for indication of level of detail provided by location.  
<sup>522</sup>Virginia Beach, Beaches and Waterways Advisory Commission, 2002, Virginia Beach Beach Management Plan, accessed on July 25, 2007, at:

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[http://www.vbgov.com/file\\_source/dept/planning/beach\\_management\\_plan.pdf](http://www.vbgov.com/file_source/dept/planning/beach_management_plan.pdf).

<sup>523</sup>Lippson and Lippson, 2006, pp. 26–42 (see note 2).

<sup>524</sup>Lippson and Lippson, 2006, pp.201–239 (see note 2).



Let us now examine the habitat vulnerable to sea level rise and the species that depend on it, from south to north.

### City of Virginia Beach

Sandy beaches with dune systems compose the Chesapeake Bay shoreline of the City of Virginia Beach. The sands reach from Cape Henry (CBIM location 1 on Map 3.8) on the northeastern edge of the county to the inlet at the mouth of the Lynnhaven River, past the Chesapeake Bay Bridge and Tunnel and Little Creek to the mouth of the James River.<sup>525</sup> Net longshore transport on Virginia Beach's Bay side is to the west. Overall trends in the last century show the dunes east of the Lynnhaven inlet advancing into Chesapeake Bay (CBIM location 2). West from the inlet, erosion, beach nourishment, and fill operations as well as condominium development and shoreline armoring have affected the accretion and erosion patterns. Dredging activity for navigation in the Lynnhaven inlet may also be affecting accretion and erosion, temporarily adding sediment to the longshore transport system; some Chesapeake shoreline beaches, such as those at Ocean Park, have required nourishment multiple times to maintain their area. The Virginia Beach resort area on the ocean shore has received beach fill material since the mid-1950s.<sup>526</sup> Given the extensive patterns of nourishment and shoreline protection in place today, minimal additional ecological change from accelerated rates of sea level rise is anticipated.

Studies of beach nourishment indicate that the practice may have minimal biological effects if projects are properly designed, but that projects also have unknown effects related to changing beach slopes, sediment characteristics (e.g., grain size of new material may be different than that of the native material), and potential loss of bay-bottom habitat when beaches are extended

<sup>525</sup>Hardaway et al., 2005, Shoreline Evolution, Chesapeake Bay Shoreline, City of Virginia Beach, Virginia. Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, VA.

<sup>526</sup>Hardaway et al., 2005, p. 9 (see note 525).

waterward.<sup>527</sup> Studies that evaluate long-term effects on biota are not common.<sup>528</sup>

### City of Norfolk

The sandy beaches found in the City of Virginia Beach continue westward along the Chesapeake shoreline in the City of Norfolk (CBIM locations 3–4). The rate of erosion is generally low, and beach accretion occurs along much of the shore. However, just west of City Beach Park, erosion potential is higher. Banks up to 10 feet high line the City Beach Park coast, with breakwaters at portions of their bases (CBIM location 3). Groinfields and breakwaters protect the shore going west across Willoughby Bay (CBIM location 4).<sup>529</sup> The areas protected by groinfields and breakwaters have been deemed “relatively stable” by Hardaway et al.<sup>530</sup> As evidenced by the heavily armored status of the shores today, planners anticipate that shoreline protection is almost certain along the entire bay side of Norfolk. Unnourished sandy beaches lacking protection may be eroded, narrowed, and eventually lost,<sup>531</sup> eliminating the habitat they provide today for invertebrates and shore birds.

### City of Poquoson and City of Hampton

The City of Poquoson is located at the eastern tip of Virginia's Hampton Roads peninsula (CBIM locations 5–7). Planners indicate that the developed portion of the city is almost certain to be protected, whereas Plum Tree Island Marsh (also known as Big Salt Marsh, CBIM location 6) and adjacent areas east of the city are already experiencing loss to erosion and rising sea levels (Section 2.1). Plum Tree Island Marsh, the largest saline marsh in the Lower Chesapeake, covers 4,100 acres, or 44 percent of Poquoson's 9,395-acre total area, and contains salt marsh and

<sup>527</sup>Jackson et al., 2002, p. 420 (see note 139).

<sup>528</sup>Nordstrom, 2005, p. 216 (see note 153).

<sup>529</sup>Berman, M.R., Berquist, H., Killeen, S., Hershner, C.H., Rudnick, T., Schatt, D.E., Weiss, D., and H. Woods, 2002, City of Norfolk Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 378, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

<sup>530</sup>Hardaway et al., 2005, p. 9 (see note 525).

<sup>531</sup>Nordstrom, 2005, p. 215 (see note 153).

remnant forested dune hummocks.<sup>532</sup> The Plum Tree Island National Wildlife Refuge has very limited human access because of the quantities of unexploded ordnance on the island from its prior use as a bombing range. The relative isolation of the area has made it a haven for more than 100 different species of birds, including northern harrier (*Circus cyaneus*), black duck (*Anas rubripes*), sedge wren (*Cistothorus platensis*), sharp-tailed sparrow (*Ammodramus caudacutus*), bald eagle, peregrine falcon (*Falco peregrinus*), black-necked stilts (*Himantopus mexicanus*), and little blue heron (*Egretta caerulea*). A variety of mammals (muskrats, red fox, white-tailed deer) use the higher ground of the refuge. Endangered sea turtles, primarily the loggerhead, use the nearshore waters. Oyster, clams, and blue crabs use the shallow waters and mudflats, and striped bass, mullet, spot, and white perch, among other fish, have been found in the nearshore waters and marsh.<sup>533</sup> Across from the marsh in Hampton is the Grandview Beach Nature Preserve (CBIM Location 5), which has more than 2 miles of beach shoreline on Chesapeake Bay and is home to a population of northeastern beach tiger beetles (*Cicindela dorsalis dorsalis*), federally listed as threatened.<sup>534</sup>

Tidal wetlands with varying degrees of erosion are present throughout the area, and some beaches with low erosion rates line the many small north-facing islands and higher areas such as Ware Stick Island (CBIM location 7) and Cow Island.<sup>535</sup> The highest elevation within the long-established portions of Poquoson is only 10 feet above sea level.<sup>536</sup> Reed et al. in Section 2.1 indicate wetlands loss in Poquoson even with the

current rate of sea level rise. The City of Poquoson's Multi-Hazard Mitigation Plan identifies sea level as a threat to the area, noting in particular that over time there is potential for increased storm surges, erosion, and loss of coastal zone land area, including wetlands.<sup>537</sup> Loss of coastal zone areas may lead to loss of the crustaceans, mollusks, and other invertebrates that live in close association with the wetland vegetation. Habitat for fish that use the mudflats and marshes will be lost, as will nesting habitat for marsh-obligate birds and the protection provided by the refuge for the numerous resident and migrating birds (described previously).

## York County

Fringing tidal marshes line much of the York County bay shoreline, and the Goodwin Islands (CBIM location 8) at the extreme northeast of the county are made up of extensive marsh areas.<sup>538</sup> The Goodwin Islands are protected as a National Estuarine Research Reserve (NERR). Covering 315 ha (777 acres), they are surrounded by intertidal flats, extensive SAV beds (121 ha; 300 acres of eelgrass and widgeon grass), and shallow open estuarine waters.<sup>539</sup> The salt marshes are dominated by salt marsh cordgrass (*Spartina alterniflora*) and salt meadow hay (*Spartina patens*). Forested wetland ridges are dominated by estuarine scrub/shrub vegetation, with a primarily loblolly pine (*Pinus taeda*) overstory, and wax myrtle (*Morella cerifera*) shrub layer. Mixed oak and pine communities, including red oak (*Quercus rubra*), loblolly pine, black gum (*Nyssa sylvatica*), and cottonwood (*Populus deltoides*), are found on upland ridges located on the largest island.<sup>540</sup> As

<sup>532</sup>City of Poquoson Comprehensive Plan, 1999, Environmental Element, accessed on July 17, 2006, at: <http://www.ci.poquoson.va.us/>.

<sup>533</sup>Profile of the Plum Tree Island National Wildlife Refuge, accessed on July, 20 2006, at <http://www.fws.gov/refuges/profiles/index.cfm?id=51512>.

<sup>534</sup>USFWS, 1994, p. 6 (see note 158).

<sup>535</sup>Berman, M.R., Berquist, H., Dewing, S., Glover, J., Hershner, C.H., Rudnicki, T., Schatt, D.E., and Skunda, K., 2001. City of Poquoson Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 369, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

<sup>536</sup>City of Poquoson Comprehensive Plan, 1999 (see note 532).

<sup>537</sup>AMEC Earth and Environmental Inc., 2004, City of Poquoson, Virginia, Multi-Hazard Mitigation Plan.

<sup>538</sup>NOAA, 2005, Environmental Sensitivity Index digital data for Virginia, obtained from the NOAA Office of Response and Restoration.

<sup>539</sup>Chesapeake Bay National Estuarine Research Reserve in Virginia, Goodwin Islands, accessed on November 20, 2006, at

<http://www.vims.edu/cbnerr/reservesites/goodwin.htm>.

<sup>540</sup>Chesapeake Bay National Estuarine Research Reserve in Virginia; Virginia Department of Game and Inland Fisheries. Goodwin Islands National Estuarine Research Reserve. Accessed on November 20, 2006, at <http://www.dgif.state.va.us/wildlife/vbwt/site.asp?trail=1&site=CLP06&loop=CLP>.

of 2002, bald eagles nested on the Goodwin Islands.<sup>541</sup> Presumably, these marsh islands will experience similar effects as those described for other marsh islands, and the surrounding tidal flats and SAV will possibly migrate inland, or eventually be lost (see Section 3.1 for a general description of marsh island, tidal flat, and SAV responses to sea level rise). Reed et al. in Section 2.1 indicate that most lower bay marshes and the fringing marshes along the York River are currently keeping pace with sea level rise through peat accumulation, but would be marginal with a 2 mm per year increase and lost with a 7 mm per year increase.

## Wrapup

Continued nourishment and breakwater protection are anticipated for the majority of Hampton Roads beaches, limiting the likelihood of additional ecological change.<sup>542</sup> At the current rate of sea level rise, Plum Tree Island marsh is losing area. With any increase in rates of sea level rise, continued loss of area is expected because of the unprotected status of the majority of the shoreline.<sup>543</sup> The numerous bird species that frequent it will therefore face

reduced resources. Vegetation and associated fauna may migrate inland as land is lost, but the developed portions of the city may eventually limit their migration and survival.<sup>544</sup> Though the York County marshes (including Goodwin Islands) are keeping pace with the current rate of sea level rise, it is not known that they will continue to do so with increased rates of sea level rise; they may become marginal under a midrange increase (2 mm per year), and are likely to be lost under a high-range scenario (increase of 7 mm per year).<sup>545</sup>

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<sup>541</sup>Watts, B.D., and C. Markham, 2003, The influence of salinity on diet, prey delivery, and nestling growth in bald eagles in the lower Chesapeake Bay: Progress Report, Center for Conservation Biology Technical Report Series, CCBTR-03-06, College of William and Mary, Williamsburg, VA, p. 1.

<sup>542</sup>Author's analysis from Hardaway et al. 2005 (see note 525), Nordstrom 2005 (see note 153), and Jackson et al. 2002 (see note 139).

<sup>543</sup>Author's analysis based on Section 2.1, and AMEC Earth and Environmental Inc. 2004 (see note 537).

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<sup>544</sup>Nordstrom (2005) notes that "fixed human development on eroding shores prevents natural landward migration of coastal landforms" p. 215 (see note 153).

<sup>545</sup>Author's analysis based on Section 2.1.

## 3.12 The Chesapeake Bay Shoreline of Middle Peninsula

*Authors: Ann Shellenbarger Jones, Industrial Economics Inc.,  
Christina Bosch, Industrial Economics Inc.*

### Overview

The Middle Peninsula region comprises Chesapeake Bay shorelines of Gloucester, Mathews, and Middlesex counties. Additionally, the area includes the Rappahannock and Piankatank River shorelines of these counties and several islands in the rivers.

This brief literature review discusses species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection (see Section 3.1 for general background). Existing literature and knowledge of coastal scientists in the area appears to be sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. The overall environmental impact of sea level rise in this multicounty region is likely to include the following:

- The tidal estuarine marshes of Gloucester County are already being submerged, and the Mobjack Bay-facing marshes of Mathews County will be marginal with an increase of 2 mm per year in the rate of sea level rise.<sup>546</sup>

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<sup>546</sup> Author's read of map in Reed et al., Section 2.1 showing wetlands in this area being converted to open water at the current rate of sea level rise; and Moore, K., 1976, Gloucester County Tidal Marsh Inventory. Special Report No. 64 in Applied Science and Ocean Engineering, Virginia Institute of Marine Science, Gloucester Point, VA. pages 42–44.

Marsh vegetation habitat for a range of species, including crustaceans, mollusks, and other invertebrates, will be lost. Birds and fish that forage on these invertebrates will therefore face a changed or limited food supply. Nesting habitat for birds will also be eliminated.<sup>547</sup> If marsh vegetation is lost, the ecosystem functions of flood control, erosion buffering, and nutrient and contaminant filtering will be lost as wetlands are submerged.

- Unnourished beaches in the Middle Peninsula, such as the natural area preserve of Bethel Beach, are already experiencing erosion, and may be lost to accelerated sea level rise. The few plants that are well adapted to the harsh beach environment, and the rare sea-beach knotweed, will be lost. The population of least terns that nests at Bethel Beach may also lose habitat.<sup>548</sup>
- Marsh islands in the Rappahannock and Piankatank rivers are likely to be lost, eliminating valuable nesting habitat for marsh-obligate birds.

### Gloucester County

East of Route 17, Guinea Neck, is vulnerable and already being submerged owing to both erosion and sea level rise (CBIM location 10).<sup>549</sup> The

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<sup>547</sup> Author's analysis based on biological information provided in Lippson and Lippson, 2006, pp. 201–239 (see note 2); and Moore, 1976 (see note 546). For more detail on the impacts of sea level rise to wetland habitat and species, see Section 3.1.

<sup>548</sup> Lippson and Lippson, 2006, pp. 26–42 (see note 2).

<sup>549</sup> Author's read of map in Reed et al., Section 2.1 showing wetlands in this area being converted to open water at the



low-lying area bordering southern Mobjack Bay and Chesapeake Bay is composed of tidal wetlands. It is not likely to be protected and will continue to be lost, decreasing available habitat for the many birds, fish, and other creatures that use the marshes and tidal creeks. Some portions may be able to accrete sufficient sediment or migrate inland, but planners anticipate the construction of shoreline protections, which may preclude migration in protected areas. The 5 to 10 foot higher elevation roughly paralleled by Rte. 17 is likely to limit any inland migration that is not outpaced by sea level rise. As early as 1976, though not explicitly linked with sea level rise, it was observed that formerly reclaimed agricultural land was being converted back to marsh and high marsh vegetation species were migrating inland into forested areas.<sup>550</sup> In the upper reaches of the York River's tributaries, such as the Pamunkey and Mattaponi rivers, tidal hardwood marshes show effects of sea level rise (CBIM location 9). Brackish to freshwater marsh plants are encroaching on these forested areas. Tree death is occurring and further inland migration is hindered by the higher upland elevation behind the forested marshes.<sup>551</sup> Tidal hardwood marshes provide nesting sites for piscivorous species such as ospreys, bald eagles, and double-crested cormorants.<sup>552</sup> The freshwater marshes also host a variety of migratory and breeding birds.

A study examining the relationship of birds to vegetation communities in the Lee and Hill marshes in the lower Pamunkey River indicates that bird communities may change if high marsh vegetation is replaced with lower marsh vegetation. The authors posit that brackish marshes, because of their locations at transitions between tidal freshwater and oligohaline

marshes, may face greater risk than marshes with more extreme, nontransitional salinities. Outlining a scenario in which sea level rise causes a shift of 100 ha from high marsh big cordgrass (*Spartina cynosuroides*) to low marsh arrow arum (*Peltandra virginica*), the authors estimate a reduction in the number of breeding red-winged blackbirds that currently depend on the big cordgrass portions of the marshes.<sup>553</sup> However, a change to an arrow arum-dominated marsh may increase bird density and diversity during winter, particularly for waterfowl and shorebirds. Arrow arum dies back in winter, creating an open mud flat that provides invertebrate prey to birds.<sup>554</sup>

### Mathews County

The Mathews County shoreline, bordered by Mobjack Bay to the south, Chesapeake Bay to the east, and the Piankatank River to the north, has a mix of marshes and beaches. Planners indicate that shore protection is likely or almost certain along Mobjack Bay except for a parcel of public land near the mouth of the East River. On the Chesapeake Bay coast of Mathews County, planners anticipate that the southern third of the coast is likely to be protected, the middle third is unlikely to be protected, and the most northern third, comprising Gwynn's Island (CBIM location 14) and some Piankatank River frontage, is almost certain to be protected. Wetlands and some dunes extend along the county's southern boundary along Mobjack Bay and around New Point Comfort (a Natural Area Preserve) (CBIM location 11). Low elevation woodlands (maritime forest) extend inland from the eroding marshes and dune areas and provide habitat for avian neotropical migrants.<sup>555,556</sup> New

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current rate of sea level rise; and Moore, 1976, pp. 42–44 (see note 546).

<sup>550</sup>Moore, 1976, pp. 42–44 (see note 546).

<sup>551</sup>Gary Fleming, September 11, 2006 email (see note 76) confirming phone call notes, including information regarding his work in the Mattaponi and Pamunkey river freshwater marshes.

<sup>552</sup>Robbins, C.S. and E.A.T. Blom, 1996, *Atlas of the Breeding Birds of Maryland and the District of Columbia*, University of Pittsburgh Press, Pittsburgh, PA, pp. 44, 92–94.

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<sup>553</sup>Paxton, B.J. and B.D. Watts, 2002, Bird Surveys of Lee and Hill Marshes on the Pamunkey River: Possible Affects of Sea-Level Rise on Marsh Bird Communities, Center for Conservation Biology Technical Report Series, CCBTR-03-04, College of William and Mary, Williamsburg, VA, pp. 2, 25–26.

<sup>554</sup>Ibid., p. 17.

<sup>555</sup>Virginia Department of Game and Inland Fisheries, New Point Comfort Natural Area Preserve, accessed on August 3, 2006, at: <http://www.dgif.virginia.gov/wildlife/vbwt/site.asp?trail=1&site=CMT08&loop=CMT>.

Point Comfort hosts a population of the northeastern tiger beetle (federally listed as threatened) and nesting least terns (*Sterna antillarum*).<sup>557</sup> Marshes also line tributaries and the landward facing sides of Winter Harbor (CBIM location 12), the mouth of Strutts Creek, just south of Gwynn's Island, and the southern bank of the Piankatank. On the Piankatank, marsh areas frequently front higher elevation areas.<sup>558</sup> Beaches, most showing signs of high erosion rates, front much of the Chesapeake-facing shore (e.g., adjacent to Winter Harbor, along Bethel Beach, Rigby Island, and Gwynn's Island). Marshes and unnourished beaches on the Piankatank are likely to be lost, because migration inland will be limited by the greater than 10 foot elevations. The marsh areas are expected to accrete sufficient sediment to only keep pace marginally with a 2 mm per year increase above current sea level rise rates, and are likely to be lost with a 7 mm per year rate increase (Section 2.1). Loss of marsh area will lead to loss of the species that depend on it, as described above.<sup>559</sup>

Bethel Beach (CBIM location 13), a natural area preserve separating Winter Harbor from Chesapeake Bay, is currently migrating inland over an extensive salt marsh area.<sup>560</sup> The beach is undergoing high erosion,<sup>561</sup> and is home to a population of the northeastern beach tiger beetle (federally listed as threatened) and a nesting site for least terns, which scour shallow nests in the sand. In the overwash zone extending toward the marsh, a rare plant is present, the sea-beach knotweed (*Polygonum glaucum*). The marsh is

also one of few Chesapeake Bay nesting sites for northern harriers (*Circus cyaneus*), hawks that commonly nest in more northern areas.<sup>562</sup>

Although the shore is able to continue to migrate, these habitats will remain intact, but eventual overwash and inundation of the marsh will lead to the loss of the sea-beach knotweed and the northeastern beach tiger beetle population, as well as the nesting area for least terns and northern harriers.<sup>563</sup>

## Middlesex County

Middlesex County lies on the northern portion of the Middle Peninsula, bordered on the south by the Piankatank River and on the north by the Rappahannock River. The river and bay shorelines are primarily beach, with marsh areas in coves and tributaries such as Broad Creek. As the Rappahannock shore forms a point near Mill Creek, the shoreline becomes predominantly marsh. Stove Point (CBIM location 16) is a defining land feature, an arm of land reaching south into the Piankatank and forming Fishing Bay (CBIM location 15). Its entire eastern shore, approximately 75 percent of which is beach, is protected by bulkheads and riprap as well as a continuous groinfield along its length. Roughly a third of the beach area has high rates of erosion. The peninsula of Middlesex County north and east of Fishing Bay is narrowly connected to the rest of the county between Jackson and Sturgeon creeks. Groinfields, riprap, and bulkheading border the whole peninsula and extend into some of the tributaries, limiting possibilities for shoreline migration.<sup>564</sup>

Apart from the southernmost end of Stove Point, and three small areas on the Rappahannock, planners indicate that shore protection in

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<sup>556</sup>Virginia Department of Conservation and Recreation, New Point Comfort Natural Area Preserve, accessed on August 29, 2006, at:

<http://www.state.va.us/dcr/dnh/newpoint.htm>.

<sup>557</sup>Ibid.

<sup>558</sup>Berman, M.R., Berquist, H., Dewing, S., Glover, J., Hershner, C.H., Rudnicki, T., Schatt, D.E., and Skunda, K., 2000, Mathews County Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 364, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

<sup>559</sup>Lippson and Lippson, 2006, pp. 201–239 (see note 2).

<sup>560</sup>Gary Fleming email on September 11, 2006 (see note 76), including information regarding Bethel Beach.

<sup>561</sup>Berman et al., 2000 (see note 558).

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<sup>562</sup>Virginia DCR Bethel Beach fact sheet, accessed at: <http://www.dcr.virginia.gov/dnh/pgbethel.pdf> on August 3, 2006.

<sup>563</sup>Author's analysis based on biological information for Bethel Beach (see note 562).

<sup>564</sup>Berman, M.R., Berquist, H., Dewing, S., Glover, J., Hershner, C.H., Rudnicki, T., Schatt, D.E., and Skunda, K., 2000. Middlesex County Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 368, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

Middlesex County is likely or almost certain. Most of the county along the Rappahannock River is already protected with groinfields extending on both sides of Sturgeon Creek.<sup>565</sup> Without nourishment, beaches in this area are likely to be lost. Off shore from Mill Creek in the Rappahannock River, Parrott Island, composed of tidal marsh, will not be protected. All the marsh areas in Middlesex County may keep pace with a 2 mm per year increase in sea level rise rates through accretion, but not likely with a rate increase of 7 mm per year. Similarly, Berkeley Island in the Piankatank is unlikely to be protected (Section 2.1). This island will potentially be inundated and submerged, presumably leading to loss of habitat for biota that typically inhabit these ecological communities. These may include crustaceans, mollusks, and other invertebrates that feed on and fertilize the marsh vegetation and the turtles (e.g. diamondback terrapins) and birds (e.g. ducks, rails) that forage on them. Habitat for forage and game fish that spend portions of their lives in wetlands will be lost, as will nesting habitat for marsh obligate birds.<sup>566</sup> Islands are also a particularly desirable nesting habitat for birds, owing to the general absence of larger mammalian predators.<sup>567</sup>

## Wrapup

The three areas where specific data are available for the Middle Peninsula are vulnerable to sea level rise. First, the Guinea Neck marshes will potentially be converted to open water under an increased rate of sea level rise scenario of 2 mm and most likely will be converted at 7 mm (Section 2.1). Presumably, as in other marsh areas, this will result in impacts to the invertebrates such as crabs and shrimp that use the vegetation,

and the birds that feed on them. Likewise, it will eliminate nesting and forage habitat for birds and fish. Second, Bethel Beach may survive with sufficient sediment input, and continued lack of shoreline protections, allowing for survival of the area's northeastern beach tiger beetle and the rare sea-beach knotweed. The beach portion is already experiencing high erosion, and it is estimated that a 7 mm increase in rates of sea level rise might overwhelm the migration processes and lead to marsh inundation in these areas. Third, the tidal marshes in the York River tributaries (the Pamunkey and Mattaponi rivers) are already impacted by sea level rise, and vulnerable to future changes, particularly if changes in salinity drive changes in vegetative cover. In the forested hardwood marshes of the upper reaches, increased salinity is expected to eliminate the forested marsh, which will reduce habitat for eagles and other piscivorous birds.<sup>568</sup> In the brackish marshes in the lower Pamunkey River, inundation may occur if rates of sea level rise increase by 2 mm per year, and is expected with an increase of 7 mm per year. Inundation may increase the percentage of low marsh vegetation (arrow arum), resulting in reduced numbers of red-winged blackbirds and other birds that prefer higher marsh areas, yet habitat for wintering waterfowl would be enhanced because of the likelihood of increased mud flats in winter.<sup>569</sup>

<sup>565</sup>Berman et al., 2000 (see note 564).

<sup>566</sup>Author's analysis based on biological information in Lippson and Lippson, 2006, pp. 201–239 (see note 2).

<sup>567</sup>Eyler et al., 1999 (see note 78).

<sup>568</sup>Author's analysis based on discussion with Gary Fleming, and on Robbins and Blom, 1996 (see note 552).

<sup>569</sup>Author's analysis based on Paxton and Watts, 2002 (see note 553).

## 3.13 The Chesapeake Bay Shoreline of Northern Neck

*Authors: Ann Shellenbarger Jones, Industrial Economics Inc.,  
Christina Bosch, Industrial Economics Inc.*

### Overview

The Northern Neck's Chesapeake Bay shoreline comprises Lancaster and Northumberland counties. The Northern Neck has marsh and beach shoreline, with heavily armored areas along developed shores of the Potomac.

This brief literature review discusses species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection. Existing literature and knowledge of coastal scientists in the area appears to be sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. The overall environmental impact of sea level rise in this multicounty region is likely to include the following:

- The tidal marshes may be lost with rising sea levels, including the marsh-fringed Mosquito Island. The many rare birds that nest in the Northern Neck marshes, including least bitterns, king rails, and black rails, will lose habitat. In addition, the crustaceans, mollusks, and other invertebrates that live in close association with the wetland vegetation will be lost. Ecological impacts will be similar to those expected for other marsh areas that will be lost. That is, habitat for fish that depend on marshes for nurseries and spawning will be lost, as will nesting habitat for marsh obligate birds. The ecosystem functions of flood control, erosion buffering, and nutrient and contaminant filtering will be lost as wetlands are submerged.<sup>570</sup>

- In Northumberland County, shoreline protections will preserve inland areas, but beach erosion will be likely in unnourished areas. Absent site-specific information for areas other than Hughlett Point, presumably, if beaches are lost to sea level rise, the few plants that are well adapted to the harsh beach environment will be lost, and invertebrates, including the northeastern tiger beetle, sand diggers, sand fleas, and crab species, will be lost. Shorebirds that rely on beaches for forage and nesting (e.g., turnstones, sanderlings, and plovers) will face more limited resources.<sup>571</sup>

### Lancaster County

Apart from the peninsular area of North Point (CBIM location 18) in Lancaster County, planners indicate that the county's bay shoreline will almost certainly be protected against rising sea levels. They also indicate that shore protection is unlikely on the county's Rappahannock shore (a primarily agricultural area near the border with Richmond County) and on Mosquito Island (CBIM location 17 in the Rappahannock River). Scrub-shrub, forest, grass and agricultural land cover dominate the shorelines. Although inland migration will not be blocked by protections, the land area is small and as such has limited space in which migrating marshes and forests may establish themselves.<sup>572</sup> Further reducing the likelihood of the area's ability to adapt to rising sea levels, planners anticipate that with a 2 mm per year increase in

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<sup>571</sup>Lippson and Lippson, 2006, pp. 26–42 (see note 2).

<sup>572</sup>Berman, M.R., Berquist, H., Dewing, S., Glover, J., Hershner, C.H., Rudnick, T., Schatt, D.E., and Skunda, K., 2001, Lancaster County Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 371, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

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<sup>570</sup>Lippson and Lippson, 2006, pp. 201–239 (see note 2).



the rate of sea level rise, marshes will marginally be able to retain current area (Section 2.1).

Lancaster County's bay and river shoreline has interspersed marsh and beach areas, with beaches typically occurring at points, and marshes in coves. Shorelines of Fleet's Bay and Dymer, Tabbs, and Antipoison creeks are covered by marshes with minimal erosion rates. Groinfields stretch from either side of Tabbs Creek in Fleet's Bay, around Clark Point in Little Bay, and west of Rones Bay in Dymer Creek. Similar protections are found at the mouth of Mosquito Creek and at the end of Mosquito Point on the Rappahannock River. Riprap is also present along many discrete portions of the county shoreline.<sup>573</sup> Shoreline marshes will possibly be maintained through accretion with a 2 mm per year acceleration in sea level rise, but most areas will be lost under a 7 mm per year acceleration scenario (Section 2.1). The Virginia brackish marshes are home to a large number of rare birds, including the least bittern, the king rail, and the black rail. The rails eat insects, crustaceans, and seeds, and the least bittern feeds on fish or other small animals.<sup>574</sup> Marsh submersion will lead to loss of these food sources for these rare birds, and for more common marsh birds such as the herons and egrets. Habitat for forage and game fish that spend portions of their lives in wetlands will be lost, as will nesting habitat for marsh obligate birds.<sup>575</sup>

### Northumberland County

Northumberland County is densely developed along the Potomac River and on the Chesapeake Bay shoreline. Of 558 miles of Northumberland County shoreline surveyed, approximately 80 percent had marsh coverage, and the remaining 20 had beach.<sup>576</sup> Planners indicate that most of

the county will be protected, leading to likely loss of unnourished beaches and marsh areas through erosion and inundation as a result of the inability to retreat inland and lack of sufficient sediment inputs. Hughlett Point Natural Area Preserve, at the midpoint along the Northern Neck's Chesapeake Bay shoreline, has forest areas fronted by estuarine marshes and sandy beaches line most of its shore (CBIM location 19). The preserve hosts a population of northeastern beach tiger beetles and nesting diamondback terrapins and provides a resting point for migratory birds. In addition, gray foxes (*Urocyon cinereoargenteus*) and river otters (*Lontra canadensis*) are present.<sup>577</sup> Presumably, if beaches are lost to sea level rise, the few plants that are well adapted to the harsh beach environment will be lost. Habitat for insects and other invertebrates such as sand diggers, sand fleas, and beach tiger beetles will be lost. Shorebirds that rely on beaches for forage and nesting (e.g., turnstones, sanderlings, and plovers) will face more limited resources.<sup>578</sup> Loss of the marsh areas will lead to ecological effects as described for Lancaster County.

### Wrapup

The Northern Neck marshes of Lancaster County will be marginal with an increase of 2 mm per year over current rates of sea level rise and will most likely be lost with an increase of 7 mm, eliminating habitat for rare marsh birds. The beaches of Northumberland County are likely to be eroded in front of the expected shore protections, and lost without nourishment. Hughlett Point Natural Area Preserve may be inundated with an increase of 7 mm in sea level rise rates, eliminating habitat for a variety of species, including the federally listed threatened northeastern beach tiger beetle and migratory birds.

<sup>573</sup>Berman et al., 2001 (see note 572).

<sup>574</sup>Rare Marsh-Nesting Birds of Virginia's Coastal Plan. Natural Heritage Resources Fact Sheet. Accessed online at <http://www.state.va.us/dcr/dnh/mrshfact.htm> on June 13, 2006.

<sup>575</sup>Lippson and Lippson, 2006, pp. 201-239 (see note 2).

<sup>576</sup>Berman, M.R., Berquist, H., Killeen, S., Hershner, C.H., Rudnicky, T., Schatt, D.E., Weiss, D., and H. Woods, 2002, Northumberland County Shoreline Situation Report, Special Report in Applied Marine Science and Ocean Engineering No. 379, Comprehensive Coastal Inventory

Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

<sup>577</sup>Virginia Department of Game and Inland Fisheries, n.d., Hughlett Point Natural Area Preserve, accessed on August 3, 2006, at: <http://www.dgif.virginia.gov/wildlife/vbwt/site.asp?trail=1&site=CNN12&loop=CNN>.

<sup>578</sup>Lippson and Lippson, 2006, pp. 26-42 (see note 2).



## 3.14 Lower Potomac

*Authors: Elizabeth M. Strange, Stratus Consulting Inc.  
Ann Shellenbarger Jones, Industrial Economics Inc.*

Species and habitats along the lower Potomac River are potentially at risk because of sea level rise. This study region encompasses the estuarine portion of the tidal Potomac downstream of Mattawoman Creek to Chesapeake Bay. The region contains important habitats for a variety of fish, shellfish, and birds, and a great deal is known about the ecology and habitat needs of these species. Based on existing literature and the knowledge of local scientists, this brief literature review discusses those species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection (see map in Chesapeake Bay review). Although it is possible to make qualitative statements about the ecological implications if sea level rise causes a total loss of habitat, our ability to say what the impact might be if only a portion of the habitat is lost is more limited. A total loss of habitat might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise.

The Lower Potomac's shorelines pass through St. Mary's and Charles counties in Maryland and Westmoreland and Northumberland counties in Virginia's Northern Neck. The Maryland side is largely rural and agricultural, but population and development there are growing rapidly. Northumberland County is densely developed along the Potomac River and on the Chesapeake Bay shoreline. Westmoreland County lies entirely along the Potomac, north and west of Northumberland County. The county is highly developed, but also has many conservation areas.

The habitats found in the Lower Potomac and their likely responses to sea level rise include the following:

- Freshwater tidal marshes in the Lower Potomac are found in the headwaters of tidal tributaries. These marshes are currently keeping pace with sea level rise, largely through sediment and peat accumulation, and are expected to continue to do so (and possibly expand in some areas), even if sea level rise rates increase by 2 mm/yr or 7 mm/yr (Section 2.1).
- Brackish tidal marshes border the Lower Potomac River and the downstream portions of the estuary's tributaries. These marshes are keeping pace with sea level rise today, but are considered marginal with a 2 mm/yr increase in the rate of sea level rise, and likely to be lost to open water or replaced by submerged aquatic plants with a 7 mm/yr increase above the current rate (Section 2.1).
- Unnourished beaches and tidal flats of the Lower Potomac are likely to erode as sea levels rise. Where shores are protected with bulkheads and revetments, erosion will also occur.
- The cliffs and bluffs along the Lower Potomac are unlikely to be protected in most areas (e.g., Westmoreland State Park, Caledon Natural Area). Natural erosional processes will continue, helping to maintain the beaches below.
- Where submerged aquatic vegetation (SAV) occurs along coves, shoreline armoring may lead to loss of SAV due to increased wave energy.

### **Lower Potomac, Maryland Shoreline**

The State of Maryland estimates that there are close to 3,440 ha (8,500 acres) of coastal tidal wetlands in the Lower Potomac River watershed, which extends from the mouth of the Potomac in St. Mary's County upstream to Mattawoman Creek in Charles County. This estuarine portion of the tidal Potomac contains mostly brackish marsh along the Potomac shoreline, with freshwater tidal wetlands in the upper reaches of tributaries such as St. Mary's River.<sup>579</sup>

In St. Mary's County, the Potomac River shoreline, as documented in the County Shoreline Situation Report, is a mix of marsh (20 percent) and beach (35 percent); the remainder is armored or low vegetated banks. Approximately 30 percent of the shoreline is currently protected, primarily with riprap. Along both the Potomac and its tributaries, most of the banks are low (< 5 feet), undergoing minimal erosion, and fully vegetated.<sup>580</sup> The narrow tidal wetlands are about equally divided between areas considered likely to be protected and almost certain to be protected. These marshes are not expected to keep pace with a 7 mm/yr increase in the rate of sea level rise, but they might be able to keep pace with a 2 mm/yr increase in the rate of sea level rise, depending on how the wetlands are managed (Section 2.1).

In the Wicomico River, St. Clements Bay, and Breton Bay, shoreline banks are fronted by marsh (40 percent of shoreline) and a small amount of beach (15 percent); under 20 percent of the shoreline is currently protected.<sup>581</sup> Shoreline protections are likely or almost certain at the mouths of the St. Mary's River, Breton Bay, and the Wicomico River.

Areas adjacent to more rural areas on the Maryland side of the Lower Potomac (e.g., inland side of St. George's Creek, Clements Bay)

<sup>579</sup>Clearwater, D., P. Turgeon, C. Noble, and J. LaBranche, 2000, An Overview of Wetlands and Water Resources of Maryland, prepared by the Maryland Department of the Environment for the Maryland Wetland Conservation Plan Work Group, January.

<sup>580</sup>Berman, M.R., Berquist, H., Dewing, S., Hershner, C.H., Rudnicki, T., Barbosa, A., Schatt, D.E., Weiss, D., and H. Woods, 2003, St. Mary's County, Maryland Shoreline Situation Report, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA, Tables 6 and 7.

<sup>581</sup>Ibid.

are unlikely to have shore protections, allowing the possibility of shoreline retreat. Tidal freshwater marshes at the upper reaches of the Wicomico River, St. Clement's Bay, and Breton Bay could benefit from more fluvial sediments resulting from increased storms resulting from climate change (Section 2.1).

The seasonally flooded Zekiah Swamp Environmental Area, which feeds the Wicomico River, contains freshwater tidal marsh that should be able to maintain pace with a moderate increase in the rate of sea level rise (Section 2.1). However, salt-water intrusion could lead to crown dieback, tree mortality, and potential infilling of the understory with salt marsh vegetation such as *Spartina*.<sup>582</sup> Nonetheless, given the swamp's relatively large area and water volume, if such detrimental effects occur they are likely to be contained to the Wicomico River end of the swamp.

At the mouth of the Wicomico are the developed areas of Wicomico Beach and Cobb Island. Cobb Island has docks, piers, and sandy beaches along its Potomac side, beaches and marsh along the mainland side, and predominantly beach shorelines along the low (0–5 feet) adjacent mainland areas (Cobb Neck). Cobb Island is almost certain to be protected (most areas already are), which is likely to lead to erosion of beaches and conversion of tidal flats to open water without other actions. On the mainland section, shore protection is likely and armoring is almost certain to protect the homes along Swan Point Neck. Wetlands are likely to be inundated in the western Swan Point section of Cobb Neck because of armoring and insufficient sediment accretion.

Farther up the Potomac toward Port Tobacco and the Nanjemoy Peninsula, the majority of the Potomac shoreline is unlikely to be protected, and brackish marshes along the shore will be able to retreat in response to sea level rise. Despite armoring of Port Tobacco, accretion rates for the tidal freshwater marshes at the head of the Port Tobacco River are most likely sufficient to allow the marshes to keep pace with a 7 mm/yr increase in the current rate of sea level

<sup>582</sup>Fleming et al., 2006 (see note 67).

rise. Based on its status as a military site, protection is uncertain at the Blossom Point Proving Ground's highly eroding marshes on the eastern side of the mouth of Nanjemoy Creek.

The Nanjemoy Peninsula is considered an area of great ecological significance and therefore TNC, the Conservation Fund, the Conservancy of Charles County, the Maryland Department of Natural Resources, and the federal Bureau of Land Management have all sought to acquire and carefully manage the area.<sup>583</sup> The TNC-owned rookery along Nanjemoy Creek contains one of the largest great blue heronries on the East Coast. Blue herons nesting within the rookery feed on fish and other aquatic organisms found in the peninsula's wetlands and the shallow waters of the creek and the Potomac River; TNC has also purchased an option for 850 ha (2,100 acres) along Nanjemoy Creek to protect the dwarf wedge mussel, a federally and state-listed freshwater mussel. The creek is one of only four known sites where the mussel is found within Maryland, and is considered the largest and most viable population in the state.<sup>584</sup>

The remaining shoreline along the Lower Potomac in Maryland is characterized by highly eroding beaches up through Mattawoman Creek. These shorelines are unprotected and primarily adjacent to agricultural lands, which should allow for shoreline migration. Two areas of marsh, one at Halfway Creek and one with high erosion at Mallow's Bay, break up the beach shorelines in this reach of the Potomac River.

Where brackish tidal marshes are lost, nesting, foraging, roosting, and stopover areas for migrating birds would be lost. Significant concentrations of migrating waterfowl forage and overwinter in the marshes of the Lower Potomac in fall and winter, including black duck, greater and lesser scaup, brant, mallard, Canada goose, northern pintail, oldsquaw, and scoters.

Hérons and egrets feed on fish and invertebrates, and ducks feed on seeds and submerged plants. Rails, coots, and migrant shorebirds are transient species that feed on fish and invertebrates in and around the marshes and tidal creeks. The rich food resources of the tidal marshes also support rare bird species such as bald eagle, which nest in nearby wooded areas and feed on fish and invertebrates in marshes and tidal creeks, and northern harrier, which nest and forage in marshes.<sup>585</sup>

Fish species common in the brackish waters of the region include resident marsh species such as killifishes, anchovies, silversides, blennies, gobies, and hogchoker. Striped bass and white perch move in and out of marshes year-round. Anadromous fishes, including herrings and shad, as well as marine transients such as Atlantic menhaden and drum species, are present in late spring and early fall.<sup>586</sup> The most visible invertebrates of the brackish marshes are red-jointed fiddler crab, marsh periwinkle, Atlantic ribbed mussel, and common clam worm.<sup>587</sup>

The tidal freshwater marshes support additional species that are rare in brackish environments. Green frog, southern leopard frog, redbelly turtle, Eastern painted turtle, Eastern ribbon snake, and northern water snake are all found in the tidal freshwater marshes of the Chesapeake Bay region. Perching birds such as red-winged blackbirds are common in stands of cattail.<sup>588</sup>

Without nourishment, beaches and tidal flats in front of shoreline protections in this area will erode as seas rise. These habitats often contain a high diversity and abundance of species ranging from microscopic organisms that live between sediment grains and can reach 2 billion individuals per square meter<sup>589</sup> to filter-feeding bivalves and deposit-feeders such as fiddler crabs and mud snails found just below the surface. In turn, numerous predators feed on

<sup>583</sup>U.S. Bureau of Land Management, 2004, Lower Potomac River Proposed Coordinated Management Plan, prepared in cooperation with the State of Maryland Department of Natural Resources, Annapolis. April, p. 72.

<sup>584</sup>Maryland Department of Natural Resources, 2005, Maryland Tributary Strategy, Lower Potomac River Basin Summary Report for 1985–2003 data, Maryland Department of Natural Resources, Annapolis, p. 2.

<sup>585</sup>White, 1989, pp. 107–123 (see note 25).

<sup>586</sup>White, 1989, p. 85 (see note 25).

<sup>587</sup>White, 1989, p. 124 (see note 25).

<sup>588</sup>White, 1989, pp. 107–109 (see note 25).

<sup>589</sup>Bertness, 1999, p. 256 (see note 133).

these invertebrates, including snails, blue crab, and a variety of fishes and birds.<sup>590</sup>

### Lower Potomac, Virginia Shoreline

On the Virginia side of the Lower Potomac, shoreline protection is almost certain throughout Northumberland County, with shoreline protection already in place for much of the developed land (see Section 3.14). Beaches and tidal flats line the Potomac shore of Northumberland County, and low vegetated banks and brackish marsh edge the many coves and inlets.<sup>591</sup> Most of the county is almost certain to be protected, leading to erosion of unnourished beaches and preventing marsh migration.

In Westmoreland County, from the Yecomico River to Currioman Bay, most areas are likely or almost certain to be protected. Much of the likely protected areas of the Potomac shoreline are bordered by brackish marshes, which may be inundated under most sea level rise acceleration scenarios due to insufficient accretion and the inability to migrate. In these areas, wetlands may be replaced by SAV beds.

Farther upstream, Westmoreland State Park has undeveloped bluffs up to 45.7 m (150 ft) high with narrow sandy beaches along the shore. With shoreline protection unlikely, continued cliff erosion is presumed, which will provide sediment to maintain the beach toe against increasing sea level rise.

The highly developed areas near Colonial Beach are almost certain to be protected. Although some brackish marshes may be lost along the Potomac shore, tributaries on either side of the area are unlikely to be protected, which should preserve wetland habitats in these areas. However, unless nourished, the rocky, sandy shoreline at Colonial Beach may be lost due to the close proximity of residential development to the water.

In King George County, the Mathias Point Neck area is almost certain to be protected. The shoreline is a mix of narrow sand beaches, wooded banks, and marsh areas, with jetties and docks extending into the water. There is a large fringing bed of SAV, dominated by milfoil, wild celery, and hydrilla,<sup>592</sup> from the Upper Machodoc Creek to Mathias Point, with smaller beds between Mathias Point and Quantico.<sup>593</sup>

Farther upstream are the Caledon Natural Area and the adjoining Chotank Creek Natural Area Preserve, which is part of the Cedar Grove Farm conservation easements. At the eastern edge of the Caledon Natural Area, shoreline protection is likely on the northern side of Chotank Creek. Protection is unlikely, however, on the southern side of the creek, which may allow sufficient area for wetland migration.

The Caledon Natural Area and the Chotank Preserve provide a diversity of habitats that are potentially vulnerable to sea level rise and shoreline protection. Along the shoreline at Caledon is a narrow strip of sand-gravel beach backed by freshwater tidal marsh dominated by cattails and *Phragmites*. In shallow areas, the marshes are dominated by pickerelweed and arrow arum. Marsh areas are backed by swamp forest of sweet gum and oak. Some of the swamp trees that have died because of excess standing water now provide nesting sites for bald eagles. Red headed woodpeckers are also seen nesting in these areas.

Even if the rate of sea level rise increases by 7 mm per year, these marshes are likely to be able to migrate inland. The marshes provide habitat for catfish, perch, sunfish, and carp, and support numerous turtles, including the red-eared palm slider and its close relative the yellow-belly palm slider, painted turtles, and snapping turtles. Green heron, great blue heron, and the

<sup>590</sup>For general information on the fauna of soft-sediment habitats, see Bertness, 1999 (see note 133).

<sup>591</sup>Berman et al., 2002, Northumberland, Table 4 (see note 576).

<sup>592</sup>Species of SAV are provided as examples; in reality, species vary annually. Long-term trends in SAV from DC to Maryland Point are described in Rybicki, N.B. and J. M. Landwehr, 2007, "Long-term changes in abundance and diversity of macrophyte and waterfowl populations in an estuary with exotic macrophytes and improving water quality," *Limnology and Oceanography* 52:1195–1207.

<sup>593</sup>Maryland Department of Natural Resources, 2005, Maryland Tributary Strategy, p. 15 (see note 584).



occasional egret feed on fish and invertebrates in the marshes. Jones Pond within the marsh was breached by Hurricane Ernesto and is now tidal. The pond attracts numerous waterfowl, including Canada geese, tundra swan, and many duck species, including mallards, canvasback, and black ducks. Upstream of Caledon, residential developments line the shore, which is primarily composed of sandy beaches along the Potomac, with freshwater tidal marshes in the upper reaches of tributaries.<sup>594</sup> In the more densely developed areas, shoreline protection is almost certain. Similarly, even in the less dense areas, shore protection is likely. Shoreline protections will inhibit any inland migration of these shoreline habitats.

With the exception of the southern edge of the headwaters of Potomac and Accokeek creeks, protection is likely or almost certain throughout this region. Between these creeks lies the 1,619 ha (4,000 acre) Crow's Nest Peninsula, an area of substantial conservation interest as well as a target for potential development. The peninsula is ecologically noteworthy for its 1,416 ha (3,500 acre) of unfragmented mature hardwood forest, considered the finest remaining example in the Mid-Atlantic coastal plain, and 283 ha (700 acre) of undisturbed tidal freshwater marsh. The marshes include three vegetation zones, defined according to elevation in relation to mean low water. Below mean low water is a zone of yellow pond lily with clusters of American lotus. Next are mixed stands of pickerelweed, arrow arum, spatterdock, and wild rice. At the highest elevation is a zone of marsh hibiscus, smartweed, cardinal flower, big cordgrass, jewelweed, and beggar-ticks.<sup>595</sup>

In addition to their value as a rare example of pristine freshwater tidal marsh, the marshes of Crow's Nest Peninsula provide habitat for numerous bird species, including some 26 species of waterfowl that use the freshwater tidal marshes and wooded swamps for nesting, migration, and overwintering habitat. These include 10 of 13 North American Wildlife

Conservation Association Priority Wildlife Species. There is also a large great blue heron rookery along upper Potomac creek that supports more than 600 nests. The marshes also provide valuable spawning and nursery habitat for a number of economically important recreational and commercial fish species, including striped bass, alewife, blueback herring, white perch, hickory shad, and yellow perch.<sup>596</sup>

Although currently not developed, the potential for future development makes shore protection along Crow's Nest Peninsula likely. The fringing wetlands would be unable to migrate in these areas if shore protections were implemented (and potentially unable to migrate in the absence of protections, given the bank heights in many areas). However, sediment accretion is likely to be sufficient to maintain wetlands in place even if the rate of sea level rise increases by 7 mm per year above the current rate.

In Aquia Creek, to the north of Crow's Nest Peninsula, shoreline protection is almost certain. Several areas already have breakwaters (e.g., eastern shore of Aquia Landing) that might disrupt sediment transport, potentially preventing sufficient marsh accretion (e.g., in the freshwater tidal marshes on the western side of Aquia Landing). Sandy beach occurs near the mouth of Aquia Creek. The remainder of the county shoreline north of Aquia Creek is also primarily sandy beach, about two-thirds considered by planners as likely to be protected and one-third almost certain. Without nourishment, these beaches are likely to be eliminated in areas where armoring restricts shoreline retreat.

<sup>594</sup>NOAA, 2005 (see note 538).

<sup>595</sup>USFWS, 2000, Final Environmental Assessment: Proposed Accokeek National Wildlife Refuge, USFWS Region 5, October, pp. 11–12.

<sup>596</sup>USFWS, 2000, pp. 12–18 (see note 595).



## 3.15 Upper Potomac

*Authors: Elizabeth M. Strange, Stratus Consulting Inc.  
Ann Shellenbarger Jones, Industrial Economics Inc.*

Species and habitats along the Upper Potomac River are potentially at risk because of sea level rise. The Upper Potomac extends from Mattawoman Creek upstream to the head of tide of the Potomac River near Georgetown in the District of Columbia (DC) and to the head of tide of the Anacostia River near Bladensburg, Maryland. The region contains important habitats for a variety of fish, shellfish, and birds, and a great deal is known about the ecology and habitat needs of these species. Based on existing literature and the knowledge of local scientists, this brief literature review discusses those species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection (see map in Chesapeake Bay review). Although it is possible to make qualitative statements about the ecological implications if sea level rise causes a total loss of habitat, our ability to say what the impact might be if only a portion of the habitat is lost is more limited. A total loss of habitat might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise.

The Upper Potomac is the tidal freshwater portion of the river (salinity less than 0.5 ppt). In this area, the Potomac's eastern shore passes through Charles and Prince George's counties, Maryland, and DC; the western shore passes through King George, Stafford, Prince William, Fairfax, Alexandria, and Arlington counties in Virginia.

With accelerated sea level rise, the habitat effects in this study region may include the following:

- Tidal freshwater marshes are unlikely to be lost, at least not in their entirety. A panel of accretion experts convened for this report

concluded that tidal freshwater marshes in the Chesapeake Bay region can keep pace with sea level rise, possibly even in the face of a 7 mm/yr increase in the current rate of sea level rise (Section 2.1). Thus, it is likely that the tidal freshwater marshes of Mason Neck, Dyke Marsh, Roosevelt Island, and the Anacostia estuary could all keep pace with sea level rise, even if the rate of sea level rise increases by 7 mm/yr. However, erosion may contribute to reductions in the area of marshes, and migration potential is limited because of inland development.

- Small pockets of estuarine beach and mudflat are found at many sites along the shorelines of the Upper Potomac, and in the DC area these habitats are backed by coastal wooded swamps. Some locations (e.g., Indian Head) have more prominent stretches of sandy beach, but for the most part unconsolidated soft-sediment habitats are only a minor component of the shoreline in the study region. These shorelines will erode as sea levels rise, and beaches will be lost except where there is nourishment.
- Where cliffs and bluffs along the Upper Potomac are protected to preserve property, erosional processes may no longer supply adequate sediment to maintain the beaches below.
- Where SAV occurs along coves, shoreline armoring may lead to loss of SAV due to increased wave energy. Where wetlands recede, SAV could spread landward via vegetative spread or if propagules or seeds reach sites with suitable growing conditions.

### **Upper Potomac, Maryland shoreline**

On the Maryland side of the Upper Potomac River, we do not know whether the Department of Defense will choose to protect the shoreline at the Indian Head Naval Surface Warfare Center to the north of Mattawoman Creek. There is currently minimal shoreline protection, and if there is no beach nourishment as seas continue to rise, sand and mud shorelines will erode. The town of Indian Head has a developed shoreline with narrow beaches and piers, and local planners expect that the town is almost certain to be protected. Above Fort Washington shoreline protection is also almost certain; some areas are already protected with riprap.<sup>597</sup> These shorelines will erode in front of hard structures. Not only will this eliminate habitat for beach invertebrates, but increased sedimentation of nearshore waters will also impair SAV and other habitat for popular recreational fish species such as striped bass, largemouth bass, and yellow perch.

Because of the presence of several large parks and undeveloped areas, shoreline protection is unlikely from Indian Head north into Prince George's County, and the high banks in this area will prevent migration. However, the tall cliffs on the Potomac north of the Indian Head facility are likely to be protected to preserve property at the top of the cliffs.

Along the natural shorelines of Roosevelt Island in DC, shore protection is unlikely. The island consists of both upland and swamp forest as well as tidal marsh. Fish in the marsh provide food for herons, egrets, and other marsh birds. Snapping and painted turtles use the nearshore waters and shoreline for forage and resting.<sup>598</sup> The ability of the tidal marshes of the island to keep pace with sea level rise will depend in part on the supply of sediment. Increased inundation of the swamp forest with rising seas could result in crown dieback and tree mortality.<sup>599</sup>

<sup>597</sup>Berman, M.R., Berquist, H., Killeen, S., Nunez, K., Rudnick, T., Schatt, D.E., Weiss, D. and K. Reay, 2006, Prince George's County, Maryland—Shoreline Situation Report, Comprehensive Coastal Inventory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.

<sup>598</sup>National Park Service, Description of Roosevelt Island, accessed at <http://www.nps.gov/gwmp/pac/tri/backgrnd.html> on July 20 2006.

<sup>599</sup>Lippson and Lippson, 2006, p. 218 (see note 2).

Elsewhere in Washington, D.C., the Potomac shoreline is already largely hardened, and therefore minimal additional habitat change is expected as a result of sea level rise. Because it is a major population center, some form of shore protection is almost certain throughout the area. Currently, the District is most likely to use environmentally sensitive means of shore protection rather than allowing inland migration.

Some shores of the Anacostia River may prove an exception to the general approach of preventing migration. Historically, the Anacostia included extensive freshwater wetlands. As human development proceeded, the river was dredged from its mouth at the Potomac in DC to Bladensburg, Maryland, and a stone seawall was built along the shoreline, eliminating virtually all historical wetlands.<sup>600</sup> The tidal Kingman and Kenilworth lakes were dredged, but over time they filled with sediment. In recent decades local organizations have been working to restore some of the former wetlands on the sediments in these lakes. Restoration of the 13 ha (32 acre) Kenilworth Marsh was completed in 1993; restoration of the Kingman Lake marshes began in 2000.<sup>601</sup> Other efforts to restore the river include converting of some seawalls and bulkheads to woodland buffers. As seas rise, local planners expect that some marsh migration may be allowed on Kingman Island, although parts of the island may also be armored to continue to protect some dryland uses, resulting in marsh erosion. Loss of any marsh along the Anacostia would have a notable impact because so little of this habitat is left. Monitoring of the restored habitats demonstrates that these marshes can be very productive. For example, a recent bird survey identified 177 species of birds in the marshes comprising 14 taxonomic orders and 16 families,<sup>602</sup> including shorebirds, gulls, terns, passerines, and raptors as well as marsh nesting

<sup>600</sup>See website describing wetland restoration in the Anacostia by Dr. Dick Hammerschlag of the Patuxent Wildlife Research Center, the lead scientist monitoring recovery of wetland habitats and biota:

<http://www.pwrc.usgs.gov/resshow/hammerschlag/anacostia.cfm>.

<sup>601</sup>Ibid.

<sup>602</sup>Paul, M., C. Krafft, and D. Hammerschlag, 2004, Avian Comparisons between Kingman and Kenilworth Marshes, Final Report 2001–2004, p. 4. USGS publication available online at: <http://www.pwrc.usgs.gov/resshow/hammerschlag/anacostia.cfm>.

species such as marsh wren and swamp sparrow.<sup>603</sup>

### Upper Potomac, Virginia shoreline

On the Virginia side, much of the Prince William County shoreline of the Potomac is sandy beach, and almost certain to be protected.<sup>604</sup> In the few areas where shoreline protection is unlikely, marshes will have little opportunity to migrate because most shores are developed. However, accretion rates in the Upper Potomac are likely to be sufficient to meet most sea level rise acceleration scenarios, including a 7 mm/yr accelerated rate.

Several state parks and federal wildlife refuges in Prince William County adjoin the Potomac shoreline. The Potomac River National Wildlife Refuge Complex includes the Featherstone National Wildlife Refuge across from Leesylvania State Park, the Occoquan National Wildlife Refuge at the confluence of the Potomac and Occoquan rivers on Occoquan-Belmont Bay, and the Mason Neck National Wildlife Refuge across the Bay on the Mason Neck Peninsula (Mason Neck).

The parklands on Mason Neck Peninsula are unlikely to be protected, particularly Mason Neck National Wildlife Refuge and Mason Neck State Park. However, adjacent sites on the eastern end of Mason Neck are almost certain to be protected, which could potentially affect sediment transport in the area and thus affect the ability of the Mason Neck marshes to keep pace with sea level rise.

Wetland loss will reduce habitat for species that are particular conservation targets in the refuge. The Mason Neck National Wildlife Refuge was originally established to protect the federally endangered bald eagle. Today, the refuge hosts seven nesting bald eagle pairs and up to 100 bald eagles during winter. The refuge also has one of the largest great blue heron colonies in Virginia, with an estimated 1,600 nests. In addition to serving as a major heron rookery and a nesting site for bald eagles, the marsh also provides

nesting areas for hawks and waterfowl and a stopover for migratory birds.<sup>605</sup> Herons feed on fish and other aquatic species in the marsh, and teal, mallards, and black ducks feed on marsh plants and seeds.<sup>606</sup> Six bird species, classified as “high priority” by the Atlantic Coast Joint Venture, use the Mason Neck area as overwintering and migration habitat. These include black duck, mallard, pintail, greater and lesser scaup, and the Southern James Bay population of Canada goose. The ducks and Canada goose feed on invertebrates, plant material, and seeds in the flooded marshes and adjacent rivers and lakes. Other priority species such as wood duck, American widgeon, redhead, canvasback, and ring-necked duck use these habitats for foraging and resting. Wood duck and green- and blue-winged teal use the emergent marshes for brood rearing and staging in fall.<sup>607</sup> Studies in marshes of Virginia’s Eastern Shore have found a direct relationship between marsh area and the abundance of bird species in the marsh.<sup>608</sup>

Upriver is Fort Belvoir, where protection is uncertain given the military nature of the site. Accotink Bay, adjacent to the fort, has significant areas of tidal marshes, which may be threatened by shore protections at Fort Belvoir. Among the species using the bay are shorebirds, waterfowl, and ospreys.<sup>609</sup>

Beyond Accotink Bay, the Virginia shoreline of the Upper Potomac is almost certain to be

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<sup>605</sup>The Mason Neck NWR was established in 1969 as the first federally protected refuge for the bald eagle. A profile of the refuge is available at <http://www.fws.gov/Refuges/profiles/index.cfm?id=51610>.

<sup>606</sup>Personal observations of J. Bucknam, interpreter, Mason Neck State Park and USFWS fact sheet “Mason Neck National Wildlife Refuge, Potomac River National Wildlife River Refuge Complex,” available at:

<http://www.fws.gov/northeast/facts/MasonNeck06.pdf>.

<sup>607</sup>Atlantic Coast Joint Venture, 2005, Revised Waterfowl Implementation Plan—Focus Area Report, Lower Potomac River, Virginia, pp. 485–486.

<sup>608</sup>Watts, 1993 (see note 61).

<sup>609</sup>Virginia Department of Game and Inland Fisheries, Accotink Bay Wildlife Refuge, Army Garrison Fort Belvoir. Accessed December 5, 2007 at: <http://www.dgif.state.va.us/wildlife/vbwt/site.asp?trail=1&site=CMN05&loop=CMN>.

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<sup>603</sup>Paul et al., 2004, p. 11 (see note 602).

<sup>604</sup>NOAA, 2005 (see note 538).

protected up through Washington D.C., with the possible exception of habitats within National Park Service holdings. The freshwater tidal marsh within the Dyke Marsh Preserve is one of the last major remnants of the original freshwater tidal marshes of the Upper Potomac River,<sup>610</sup> making it particularly valuable for local populations of fish, birds, and other wildlife.

The marsh proper is dominated by cattails, along with several other common freshwater tidal marsh plants, including arrow arum, sweetflag, and spatterdock.<sup>611</sup> Adjacent to the marsh, the Hunting Creek embayment contains one of the largest mudflats along the Upper Potomac River, providing forage areas for both migratory and resident birds.<sup>612</sup> A survey of the marsh in 2000 found 62 species of fish, 9 species of amphibians, 7 species of turtles, 2 species of lizards, 3 species of snakes, 34 species of mammals, and 76 species of birds in Dyke Marsh.<sup>613</sup> The rare least bittern and the federally listed bald eagle breed in the marsh, and scientists at the University of Maryland believe that other rare species such as black rail and American bittern could also breed there.<sup>614</sup> The marsh also contains the only known breeding population of marsh wrens in the upper tidal Potomac.<sup>615</sup> A fish survey between 2001 and 2004 collected longnose gar, a species on

Virginia's candidate list. There was substantial evidence of the marsh's importance as juvenile fish habitat, with large numbers of juveniles collected, including juveniles of striped bass, American shad, yellow perch, blueback herring, and alewife. All of these are species that are important for commercial and recreational fisheries in the area. Typical marsh residents such as killifishes, which provide food for these estuarine species, were also collected.<sup>616</sup>

Erosion and subsidence are problems in the marsh today.<sup>617</sup> Previous dredging and marsh removal may be contributing factors, in part because these activities eliminated the tidal creeks that drained the marsh.<sup>618</sup> Much of the current emergent marsh is on a shelf of shallow water about 0.91–1.22 m (3–4 ft) above mean low tide and is therefore not inundated during the marsh's typical 3 ft tidal cycle.<sup>619</sup>

Scientists analyzing current marsh conditions to make recommendations to the National Park Service about restoration of the marsh concluded that responses of the marsh's vegetation communities to inundation will require additional study to predict the effects of sea level rise on the existing marsh or any new marsh that is created.<sup>620</sup>

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<sup>610</sup>Johnston, D.W., 2000, "The Dyke Marsh preserve ecosystem," *Virginia Journal of Marine Science* 51:223–273, p. 242.

<sup>611</sup>Ibid.

<sup>612</sup>Ibid., p. 228.

<sup>613</sup>Engelhardt, K.A. M., S. Seagle, and K.N. Hopfensperger, 2005, *Should We Restore Dyke Marsh? A Management Dilemma Facing George Washington Memorial Parkway*, Final Report, submitted to the George Washington Memorial Parkway, National Park Service, National Capital Region, McLean, VA, p. 4.

<sup>614</sup>Gates, J.E., and R. Peet, 2005, *Birds of Dyke Marsh Wildlife Preserve Virginia: A Ten-Year Analysis of Transect Count Data*. Unpublished manuscript submitted to Melissa Kangas of the National Park Service, National Capital Region National Parks, McLean, VA. September 5. pp. 25–26.

<sup>615</sup>Johnston, 2000, p. 248 (see note 610).

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<sup>616</sup>Mangold, M. F., R.C. Tipton, S.M. Eyler, and T.M. McCrobie, 2004, *Inventory of Fish Species within Dyke Marsh, Potomac River (2001–2004)*, U.S. Fish and Wildlife Service in conjunction with Maryland Fishery Resources Office, Annapolis, MD, October 22.

<sup>617</sup>Johnston, 2000, pp. 229 and 242 (see note 610).

<sup>618</sup>Engelhardt et al., 2005, p. 2 (see note 613).

<sup>619</sup>Engelhardt et al., 2005, p. 3 (see note 613).

<sup>620</sup>Engelhardt et al., 2005, p. 7 (see note 613).



## 3.16 Western Shore Chesapeake Bay Shoreline

*Authors: Ann Shellenbarger Jones and Christina Bosch*

### Overview

The western shore region of Chesapeake Bay includes St. Mary's, Calvert, and Anne Arundel counties and Baltimore City and County.<sup>621</sup> Land types in these counties vary from major urban areas such as Baltimore and Annapolis to largely rural areas in Calvert County. The region, particularly Calvert County, is characterized by smoothed shorelines, indicating sufficient sediment supply and longshore transport as compared to the more jagged eastern shore's coves, inlets, and islands.<sup>622</sup>

This brief literature review discusses species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection. Existing literature and knowledge of coastal scientists in the area appears to be sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. The major tributaries to Chesapeake Bay on the western shore are the Patuxent River, a major Bay tributary bordering Calvert, St. Mary's, Charles, and Prince George's counties; the South River and the Severn River in Anne Arundel County; the Patapsco River on the southern side of Baltimore; and the Gunpowder River, straddling the border of Baltimore and Harford counties. Western shore tidal wetlands are primarily located in these tributaries, in particular, at the mouth of the Gunpowder, at Jug

Bay in the Patuxent, and in Sullivan's Cove Marsh and Round Bay Bog on the Severn. Some of these tributaries have been dramatically modified with shoreline protections, yet others have remained largely unchanged. For example, the Patapsco formerly supported populations of anadromous fish, but urbanization along its banks and installation of dams along its course have since prevented their migration.<sup>623</sup> In contrast, the Severn's steep cliffs and deep ravines earned it a designation of Scenic River by the Maryland General Assembly.

The western shore will see a range of impacts from sea level rise in the future. Despite large areas of conservation or parkland and restricted development (e.g. upper Patuxent River, Calvert Cliffs), loss of key habitats may occur. The large degree of shoreline armoring from northern Calvert County through Baltimore will also affect shoreline retreat. The overall environmental impact of sea level rise in this multicounty region are likely to include the following:

- Partial or complete marsh loss is expected in many areas. In the upper Patuxent River, marsh areas have experienced minimal migration despite inundation. Saltwater intrusions may shift the fauna dependent on nontidal wetlands in Shady Side, particularly freshwater fish. The potential loss of the wide mudflats at Hart-Miller Island would eliminate foraging and nesting for the large bird population, including many sensitive species.
- *Beach* loss, particularly in St. Mary's, Calvert, and Anne Arundel counties along

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<sup>621</sup>This review looks at ecological implications of sea level rise from Baltimore County through the northern half of St. Mary's County, including its Patuxent River shoreline.

<sup>622</sup>Stevenson and Kearney, 1996, p. 234 (see note 38).

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<sup>623</sup>Alliance for the Chesapeake Bay, n.d., River Summaries, accessed on May 3, 2006, at <http://www.acb-online.org/about.cfm>.



Chesapeake Bay, may occur in areas without nourishment. The widespread presence of shoreline protection can interfere with longshore transport. Beach loss or reduction may occur even in areas where shoreline retreat is possible. Many invertebrates will lose their habitat, including the northeastern beach tiger beetle (federally listed as threatened).

- The *cliffs* of Calvert County will not be lost, but effects from increased rates of sea level rise and impediments to longshore sediment transport may increase erosion rates above sustainable levels for the resident populations. The Puritan tiger beetle (federally listed as threatened) may lose essential habitat.
- Effects on *nearshore* communities may be observed. In the upper Patuxent River, the spread of SAV more tolerant of deeper depths and higher turbidity (*Hydrilla*) may be accompanied by a decrease in larger fish, though its spread may be tempered by changes in salinity.<sup>624</sup>

Sediment deposition is fairly high along the western shore of Chesapeake Bay, both from land runoff and erosion. Along the bay shorelines, marsh areas are expected to be marginal with a 2 mm per year rate increase in sea level rise and to be lost with a 7 mm per year increase. The ability to migrate will most likely determine their survival. In upper reaches of tributaries, marsh accretion should be sufficient to meet a 7 mm per year increase in the rate of sea level rise (Section 2.1). However, localized areas may have differing rates of accretion, subsidence, and erosion, and some wetlands on the western shore are being inundated (e.g., in Jug Bay on the upper Patuxent). Planners indicate that shoreline protections are almost certain throughout much of Anne Arundel and Baltimore City/County, which will most likely lead to the loss of both intertidal areas and wetlands with sea level rise rate increases of 2 mm per year.

<sup>624</sup>See Section 3.1 for general background on species and habitats vulnerable to sea level rise for the mid-Atlantic. It includes overview information on salinity and other factors not discussed in detail here.

## St. Mary's County, Chesapeake shoreline

Beginning at the southern tip of St. Mary's County, the bay-front shoreline between the Potomac and the Patuxent rivers is primarily narrow sandy beaches with low bank heights (less than 5 feet). Erosion is a significant problem: more than half the beach is eroding, although a large portion of the remaining shoreline is already stabilized with bulkheads or riprap.<sup>625</sup> Erosion is likely to be a problem on the beaches fronting shoreline protections and may be so in other areas as well. In general, beach loss will lead to habitat loss for resident insects and other invertebrates and forage loss for larger predators such as shorebirds.<sup>626</sup> Estuarine marshes line the many small coves. Given existing erosion, these marshes are unlikely to accrete or migrate sufficiently to retain their current size, even in unprotected areas. Wetlands loss harms the crustaceans, mollusks, and other invertebrates that live in close association with the wetland vegetation and the turtles (e.g. diamondback terrapins) and birds (e.g. ducks, rails) that forage on them.<sup>627</sup> At Point Lookout State Park (CBIM location 38), a loblolly pine tidal woodland is already being lost to relative sea level rise. Saltwater intrusion across the fronting estuarine marsh is killing trees as a result of salt stress and increased inundation.<sup>628,629</sup> Tidal hardwoods such as loblolly pines provide nesting sites for piscivorous species such as ospreys, bald eagles, and double-crested cormorants.<sup>630</sup>

## Patuxent River

Erosion is also an issue in the lower Patuxent River. The St. Mary's County shoreline is a mix of low to high banks, mostly with trees and shrubs or residential development, with

<sup>625</sup>Berman et al., 2003, St. Mary's County (see note 580).

<sup>626</sup>Lippson and Lippson, 2006, pp. 26–42 (see note 2).

<sup>627</sup>Lippson and Lippson, 2006, pp. 201–239 (see note 2).

<sup>628</sup>Tiner and Burke, 1995, Plate 7 (see note 32).

<sup>629</sup>Harrison, J.W., P. Stango III, and M.C. Aguirre, 2004, Forested tidal wetland communities of Maryland's Eastern Shore: Identification, assessment, and monitoring, Maryland Department of Natural Resources, Natural Heritage Program, Annapolis, MD, unpublished report submitted to U.S. EPA.

<sup>630</sup>Robbins and Blom, 1996, pp. 44 and 92–94 (see note 552).

significant erosion rates in the higher banks.<sup>631</sup> The immediate shores are primarily vegetated bank with a minimal intertidal area; roughly 15 percent are fronted by sandy beaches and 25 percent by marshes.<sup>632</sup> Erosion is prevalent through all shoreline types. The Calvert County shoreline is assumed to be similar in this region. Planners indicate that shoreline protections are almost certain for the first few miles of the river, but further up are unlikely. Given current erosion rates and low rates of accretion near Chesapeake Bay, marsh areas are likely to be inundated in the protected areas. Some marsh migration may occur at the northern end of St. Mary's County, but the high banks in many locations will inhibit migration, resulting in net loss of marsh areas.

North from the Prince George's and Charles County border, large areas of tidal estuarine marsh line the Patuxent River, changing to tidal freshwater above the Anne Arundel County line.<sup>633</sup> Shoreline protection is unlikely in this area. Sediment inputs are predicted to be high enough to retain marsh area, but naturalists at Jug Bay in the upper Patuxent River (CBIM location 41) have observed inundation and minimal migration of low marsh, with direct conversion of wooded or high marsh areas to open water.<sup>634</sup> The marsh has decreased visibly in size over the last 25 years, with the appearance of more emergent vegetation (e.g., spatterdock, *Nuphar luteum*) as water depth increases. In the Jug Bay Sanctuary, as erosion continues and water levels rise, spatterdock is becoming submerged and is being displaced by the highly invasive *Hydrilla verticillata*, which can tolerate deeper waters and reduced light, and higher suspended sediment loads is filling in open water and unvegetated mudflat areas. Spatterdock, a perennial, grows before *Hydrilla*

in the spring, and has not been affected by the increase in *Hydrilla*.<sup>635</sup> Although *Hydrilla* may displace other native vegetation or become sufficiently dense to prohibit movement of larger fish, the species does improve water quality (as compared to the absence of vegetation) by trapping sediments, contributing oxygen, and increasing carbon dioxide uptake, and may provide sheltering habitat for smaller fish.<sup>636</sup> The increasing water depth has also compounded stress on local vegetation and on the birds that feed on the plants. Migrating populations of Sora rails (*Porzana carolina*), a marsh-dependent species that feed primarily on seed and green plant matter, declined in Jug Bay throughout the 1990s because of overgrazing of one of their primary food sources (wild rice, *Z. aquatica*) by resident Canada geese (*Branta canadensis*).<sup>637,638</sup> Wild rice restoration efforts have been affected by the increasing water depths. The rice survives regular tidal inundation of up to 2 feet, and usually stands in roughly 6 to 12 inches of water, but under additional stresses such as the foraging of resident Canada geese is less resilient. Unusually cold and wet weather in the spring of 2005 and 2006, with associated higher water levels in the marsh, hindered wild rice growth in the lower marsh. Wild rice in the upper marsh areas was not adversely affected, and even

<sup>631</sup>The St. Mary's County Patuxent River shoreline is more than 40 percent low bank (0–5 feet), 10 percent medium (5–10 feet), more than 25 percent high (10–30 feet), and more than 10 percent above 30 feet. Berman et al., 2003 (see note 580).

<sup>632</sup>Berman et al., 2003 (see note 580).

<sup>633</sup>Tiner and Burke, 1995 (see note 32).

<sup>634</sup>Phone conversations on April 27 and December 1, 2006, and email confirmation "Re: Final review of Patuxent section of report," of discussions about Jug Bay, and 25 years of observations there, between IEC and Greg Kearns, naturalist, Jug Bay Natural Area.

<sup>635</sup>Phone conversation, including description of *Hydrilla* and its current presence, characteristics, and relation to spatterdock in the Patuxent marshes. Greg Kearns, naturalist, Jug Bay Natural Area, December 1, 2006.

<sup>636</sup>Nonindigenous aquatic species: *Hydrilla verticillata*, accessed on May 30, 2006, at [http://nas.er.usgs.gov/taxgroup/plants/docs/hy\\_verti.html](http://nas.er.usgs.gov/taxgroup/plants/docs/hy_verti.html); Plant Invaders of Mid-Atlantic Natural Areas, accessed on May 30, 2006, at <http://www.nps.gov/plants/alien/pubs/midatlantic/hyve.htm>; and phone conversation with Greg Kearns (see note 636).

<sup>637</sup>Gough, G.A., J.R. Sauer, and M. Iliff, 1998, *Patuxent Bird Identification Infocenter*, version 97.1, Patuxent Wildlife Research Center, Laurel, MD, available at: <http://www.mbr-pwrc.usgs.gov/id/framlst/infocenter.html>.

<sup>638</sup>Phone conversation, including discussion of sora rail populations, dependence on wild rice, and efforts to monitor and restore wild rice. Greg Kearns, April 27, 2006. Confirmed by email "Re: Final review of Patuxent section of report," on December 1, 2006. Note: smartweeds (*Polygonum* spp.) are also important in diets of sora rails.

increased its coverage dramatically in some areas.<sup>639,640</sup>

### Calvert County/Chesapeake shoreline

Returning to Chesapeake Bay at the mouth of the Patuxent River, Cove Point (CBIM location 39) has a unique shoreline formation, the cusped foreland. The foreland results when sand is moved along a shoreline predominantly in one direction, and then hits a geologic formation that traps the sand. A point forms with sands accreting on the downshore side of the cusp. Cove Point Marsh is a 150-acre freshwater, barrier-beach marsh on the upshore side of the cusp. Numerous state-defined rare plant species, including American frog's-bit (*Limnobium spongia*), silver plume grass (*Erianthus alopecuroides*), various ferns, and unique wetland communities,<sup>641</sup> as well as populations of the northeastern beach tiger beetle, and the Puritan tiger beetle (both federally listed as threatened), and the rare leaf beetle *Glyptina maritima*, are present there. The marsh side is threatened by storm-driven overwash, sea level rise, and residential development on the south side, which has disrupted the migration of the foreland in recent decades. The marsh is continuing to migrate, but will soon hit the northern edge of the development. Shoreline protections to the north may limit sediment inputs to the marsh that would otherwise allow accretion to keep up with sea level rise.<sup>642</sup> The marsh area will slowly be lost as the outer edge is eroded and inundated, endangering the many

rare plants in the marsh. The upstream protections may be leading to significant erosion and coincidental loss of northeastern beach tiger beetle larval habitat areas north and south of the Cove Point pier, the likely causes of decline in the local population.<sup>643</sup>

North of Cove Point are the Calvert Cliffs (CBIM location 40), which formed during the Miocene epoch when Chesapeake Bay was a shallow sea. The cliffs are the remnants of the sea floor, now standing up to 115 feet above the water. Fossilized remains are exposed as wind and water erode the cliffs at a rate up to 2.75 feet per year.<sup>644</sup> The area inland of the cliffs in southern Calvert County is largely undeveloped (primarily because of the presence of the Calvert Cliffs Nuclear Power Station), but more development is present along the northern shoreline. The northeastern beach tiger beetle and the Puritan tiger beetle both depend on the naturally eroding cliffs and the sandy fronting beaches of the Calvert Cliffs for habitat, both as larvae and as adults. Puritan tiger beetle populations at Calvert Cliffs have been declining in recent years, in part owing to habitat loss.<sup>645</sup> The larvae require a moderate amount of cliff face erosion, although exact rates are unknown. Continuous erosion prevents vegetation from establishing on the beaches or cliffs, maintaining the necessary bare substrate for the beetles. In areas where cliff erosion is slowed by increased toe elevation or armoring, the cliff face subsides into a more modest slope, and vegetation then stabilizes it. At Calvert Beach, larvae and adults were absent from the areas stabilized by vegetation, but were present on sandy bluff faces.<sup>646</sup> According to a beetle expert, in areas where beach is entirely submerged at high to mid-tides, few to no Puritan tiger beetles are present.<sup>647</sup> In contrast to areas stabilized by

<sup>639</sup>Phone conversation, including description of observations of vegetation dynamics by Greg Kearns, April, 27, 2006, and confirmed by email "Re: Final review of Patuxent section of report," on December 1, 2006. Aerial photographs described by Kearns have captured these changes in wild rice coverage.

<sup>640</sup>Wild rice also occurs in the freshwater portions of the York, Potomac, and Choptank rivers (Lippson and Lippson, 2006, p. 208, see note 2).

<sup>641</sup>Steury, B., 2002, "The vascular flora of Cove Point, Calvert County, Maryland," *The Maryland Naturalist* 45(2):1–28, pp. 16, 21.

<sup>642</sup>Email communication from Katharine McCarthy, Southern Regional Ecologist, Natural Heritage Program, Wildlife and Heritage Service, Maryland DNR, to Ann Shellenbarger Jones and Christina Bosch, Industrial Economics. "RE: Calvert Cliffs State Park" including confirmation of prior emails, and text in draft report. Sent September 11, 2006.

<sup>643</sup>Knisley, C.B., 2000, Population decline of the northeastern beach tiger beetle in Calvert County, MD. Final Report, submitted to Cove Point Natural Heritage Trust, January 18.

<sup>644</sup>Calvert Cliffs State Park, accessed on May 9, 2006, at <http://www.dnr.state.md.us/baylinks/15.html>.

<sup>645</sup>Knisley, 2000 (see note 643).

<sup>646</sup>USFWS, 1993 (see note 166).

<sup>647</sup>Peer review comment by Barry Knisely on this section on the Western Shore Chesapeake Bay Shoreline, received July 20, 2007.

vegetation, as cliff erosion increases because of loss of toe elevation, winter storm waves shear off large portions of cliff and may kill larvae in localized areas.<sup>648</sup> If erosion occurred at rates high enough to shear off areas to a depth below larvae burrows, Puritan tiger beetles could be eliminated. Impacts to adult Puritan tiger beetles may also occur if sea level rise or increased erosion diminishes the beach habitats used for foraging.<sup>649</sup>

Although natural erosion processes are allowed to continue in the protected cliff areas in the southern portion of the county, shoreline protections in the more northern developed areas are affecting the Calvert Cliffs shoreline. Effects on longshore sediment transport from upstream shoreline protections are an identified cause of increased erosion rates.<sup>650</sup> In addition, there is increasing pressure for shoreline stabilization along the more southern shoreline (in particular near Little Cove Point), and revetments and other shoreline stabilization projects have been recently constructed or are proposed.<sup>651</sup>

Unfortunately, overly rapid erosion is also a threat to the Puritan tiger beetle, owing to shearing of cliff habitat. Shoreline protections are almost certain along much of the developed northern coast of Calvert County, which may increase erosion rates in the unprotected southern cliff areas beyond the range required by the tiger beetles. In the more northern areas where the cliffs are stabilized, the rocky and sandy toes to the cliffs will be lost to inundation with sea level rise, along with the invertebrate community (e.g., burrowing amphipods and hermit crabs) that resides there.

## Anne Arundel County

Anne Arundel County has dense residential development near its primarily sandy bay shoreline. Shady Side (CBIM location 42), at the southern end, is located on a peninsula

surrounded on two sides by the West River, and on a third by Chesapeake Bay. The area is generally at low elevation above the water level and highly developed.<sup>652</sup> Given the already severely limited state of tidal wetlands, the primary effect of sea level rise in Shady Side will most likely be more frequent upland flood events. Large portions of the shoreline are already protected, with future protection almost certain along most of the shoreline.<sup>653</sup> The interior areas of the Shady Side peninsula are marked by nontidal wetlands. The myriad creeks and streams that cross the Shady Side wetlands provide spawning and nursery areas for freshwater, estuarine, and anadromous fish such as striped bass, white perch, spot, croaker, and a variety of forage fish.<sup>654</sup> Increased inundation events in the nontidal freshwater areas with higher salinity water could cause significant habitat decline in freshwater species.<sup>655</sup> Farther north in the county, higher elevations limit the wetlands close to the coastline. However, Anne Arundel County does have a policy of encouraging and supporting nonstructural or hybrid shoreline protection projects. The County provides free technical support, site evaluation, and plant plugs (*S. alterniflora* and *S. patens*) for residents.<sup>656</sup> With the likelihood of almost certain shoreline protections throughout, the current

<sup>652</sup>The elevation ranges from 3 to 10 feet, with an average of 7. Anne Arundel County Small Planning Area Plan for Deale/Shady Side, Section X. Land Use and Zoning, p. 71, accessed on May 5, 2006, at

<http://www.aacounty.org/PlanZone/SAP/DealeSS.cfm>.

<sup>653</sup>More than 75 percent (1,609 out of 2,120) of parcels studied had shoreline improvements in place. Michael, J.A., D.A. Sides, and T.E. Sullivan, 2003, The economic cost of sea level rise to three Chesapeake Bay communities. NOAA, Maryland DNR, and Center for Geographic Information Sciences at Towson University.

<sup>654</sup>Anne Arundel County Small Planning Area Plan (see note 652).

<sup>655</sup>Bay waters at Shady Side average between 5–10 ppt salinity in spring and summer and 10–15 ppt in fall. Average Surface Salinities Map, accessed on May 30, 2006, at:

[http://mddnr.chesapeakebay.net/eyesonthebay/images/bay\\_salinity.jpg](http://mddnr.chesapeakebay.net/eyesonthebay/images/bay_salinity.jpg).

<sup>656</sup>Anne Arundel County, Maryland, Office of Environmental and Cultural Resources, 2006, Emergent Marsh Grass Re-Vegetation Program, available at: <http://www.aacounty.org/LandUse/OECCR/EmergentGrass.cfm>. Program discussed in phone conversation with Jim Johnson, May 30, 2006.

<sup>648</sup>U.S. FWS, 1993 (see note 166).

<sup>649</sup>Barry Knisely (see note 647).

<sup>650</sup>Wilcock et al., 1998 (see note 161).

<sup>651</sup>Barry Knisely (see note 647); and USFWS, 2006, Pre-decisional draft biological opinion on "Chesapeake Ranch Estates/Phase V/Breakwater," Accessed on July 26, 2007, at:

<http://www.fws.gov/northeast/Endangered/tebo/PDFs/CHES.RANCH.BO.revised%20project6.pdf>.



intertidal areas will be inundated by sea level rise. The fringing marshes created through Anne Arundel County's shoreline projects may provide key habitat for marsh invertebrates in addition to protecting upland areas. Several rare birds, including the black rail (*Laterallus jamaicensis*), which is listed by the DNR as in need of conservation, breed in the Anne Arundel County marshes.<sup>657</sup>

### Baltimore City and County

Planners in both Baltimore City and County anticipate that shore protection is almost certain throughout the area. Almost half of the shoreline already has bulkheads or riprap, particularly along the Patapsco River.<sup>658</sup> The remaining narrow muddy shores and mudflats, particularly in the currently less developed sections of the Patapsco, may be lost because of sea level rise if shorelines are protected. In the upper portion of the Back River north of Baltimore, small areas of wetlands may be able to accrete sufficient sediment to retain function, but migration will be prevented by shoreline protection. Directly on Chesapeake Bay, the large marshes at Edgemere (North Point State Park, CBIM location 43) and Hart-Miller Island may be lost to inundation if the sea level rise rate increases by 2 mm per year, and most will likely be lost with a 7 mm per year increase. Hart-Miller Island, created from dredge material and a haven for migrating shorebirds, has extensive mudflats that will be likely to be lost to sea level rise. During spring and fall migrations, daily numbers of shorebirds range from 1,000 to 10,000. The most numerous shorebird species are sandpipers and plovers. The mudflats are also used as a roost site for significant numbers of migrating Caspian terns (*Sterna caspia*). In 2004, small numbers of three high conservation priority species nested and bred on Hart-Miller Island: the coastal plain subspecies of swamp sparrow (*Melospiza*

*georgiana*), listed by the Maryland Department of Natural Resources as "In Need of Conservation in Maryland," the spotted sandpiper (*Actitis macularia*), a rare species in the state, and the willow flycatcher (*Empidonax traillii*), an Audubon WatchList species.<sup>659</sup> These mudflat areas are all susceptible to inundation from sea level rise. Low-elevation islands such as Hart-Miller have limited habitat migration options and will be dependent on accretion rates (or additional dredged sediment inputs) for maintenance of habitats. Loss of these islands and mudflat areas would eliminate the nesting and foraging opportunities currently provided for the shorebirds.

### Wrapup

The Western Shore will see a range of ecological impacts from sea level rise in the future. Most marsh areas near Chesapeake Bay are expected to be marginal with midrange increase in the rate of sea level rise (2 mm per year) and to be lost with a high-range increase (7 mm per year). In upper tributaries, sediment accretion is likely to be sufficient to retain current area under a high-range increase scenario. The extensive shoreline armoring from northern Calvert County through Baltimore City and County will limit shoreline retreat, and eliminate sand and mudflats in front of the protections. Loss of mudflats will eliminate a key stopover for migratory birds (i.e., Hart-Miller Island). With tree death in high marsh and higher water levels already visible in the Patuxent River marshes, sea level rise may induce changes in vegetation types even at current rates and therefore impact the species that rely on them, causing changes similar to those expected in other Bay tributaries such as the Pamunkey in Virginia. In contrast to these potential losses, the protected portions of the Calvert Cliffs will be allowed to continue eroding inland, providing the habitat needed by tiger beetles. Nevertheless, both larval and adult forms of the beetles may suffer impacts of reduced habitat caused by increased erosion and subsequent loss of beach or cliff-face shearing.

<sup>657</sup>Robbins and Blom, 1996, p. 122 (see note 552).

<sup>658</sup>Maryland Coastal Zone Management Program, Department of Natural Resources, 2004, Development of the Maryland Shoreline Inventory Methods and Guidelines for Baltimore County and the City of Baltimore, prepared by the Comprehensive Coastal Inventory Program, Center for Coastal Resources Management, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. NOAA Award No. 14-03-889 CZM049.

<sup>659</sup>Audubon Important Bird Areas, Hart-Miller site profile, accessed on May 5, 2006, at <http://iba.audubon.org/iba/viewSiteProfile.do?siteId=371&navSite=state>.

## 3.17 Upper Chesapeake Bay Shoreline

Author: Ann Shellenbarger Jones, Industrial Economics Inc.

### Overview

The “Upper Bay” region encompasses Harford, Cecil and Kent counties, from the Gunpowder River to the Chester River. The region is primarily rural, with several small cities (Aberdeen, Havre de Grace, Perryville, and Elkton) along the coast and tributaries.

This brief literature review discusses species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection. Existing literature and knowledge of coastal scientists in the area appears to be sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. Overall effects of sea level rise may include the following:

- Most marsh areas will be retained through accretion. On Eastern Neck, some areas are being lost, but efforts are under way to restore the shoreline using protected *S. alterniflora* marshes. Upper Chesapeake Bay will continue to provide spawning and nursery habitat for crabs and fish, as well as provide nesting and foraging habitat for migratory and residential birds, including bald eagles and large numbers of waterfowl.
- The cliff areas at Elk Neck State Park and the Sassafras River NRMA will be left to erode naturally. The cliff swallows and Puritan tiger beetle (federally listed as threatened) will continue to use the unique habitat. Cliff areas surrounding Grove Point and the

Puritan tiger beetle population inhabiting them may be impacted because without nourishment shoreline stabilization may result in loss of beach areas.

- Although some of the beaches may require nourishment for retention, the general lack of shoreline protections will minimize interferences with longshore sediment transport. Beaches are likely to remain intact throughout much of the region.

The Susquehanna, located on the border between Harford and Cecil counties, provides a large (though variable) influx of sediment to upper Chesapeake Bay, as well as almost half of Chesapeake Bay's freshwater input.<sup>660</sup> Much of this sediment is retained above the mixing zone (the estuarine turbidity maximum or ETM), generally above the Chesapeake Bay Bridge.<sup>661</sup> This sediment source provides material for accretion in the tidal wetlands of the region. The other upper Chesapeake Bay tributaries characteristically have large sediment loads as well, and currently receive sufficient sediment to maintain wetlands and their ecological function.

Freshwater tidal wetlands are spread throughout upper Chesapeake Bay, particularly in the upper reaches of the tributaries. Key rivers in the areas include the Susquehanna, the Elk, the Sassafras, and the Chester. With the exception of the Susquehanna, with headwaters in New York that are not considered in this report, all of the rivers

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<sup>660</sup>Bay Trends and Indicators, Chesapeake Bay Program, accessed at: [http://www.chesapeakebay.net/status/status\\_dev.cfm?SID=201&SUBJECTAREA=INDICATORS](http://www.chesapeakebay.net/status/status_dev.cfm?SID=201&SUBJECTAREA=INDICATORS).

<sup>661</sup>Chesapeake Bay Program, 2002, The Impact of Susquehanna Sediments on the Chesapeake Bay, Scientific and Technical Advisory Committee Workshop Report, May 2000.

in upper Chesapeake Bay have tidal wetlands at their head. The high eroding cliffs characteristic of Chesapeake Bay are also found in the region, particularly at the mouths of the Susquehanna, Elk, and Sassafras rivers. The remaining shorelines are primarily a mix of narrow muddy and sandy beaches and low vegetated banks.

## Harford County

The Harford County shoreline is predominantly marsh. Aberdeen Proving Ground (CBIM location 44) is its defining feature, constituting approximately a quarter of the county's area and the majority of its Bay shoreline, from the Gunpowder River north almost to the Susquehanna River.<sup>662</sup> The proving ground is primarily within 5 meters of sea level and contains a large concentration of tidal wetlands (20,000 acres). The extent of shoreline protections is uncertain given the military nature of the site.<sup>663</sup> Structural shoreline protections throughout the proving ground shoreline would eliminate the potential for wetland migration. The wetlands may accrete sufficient sediment to meet a 2 mm per year increase in sea level rise rates, but a 7 mm per year increase would result in loss of the tidal marshes and associated ecological functions. In particular, the large bird populations (bald eagles, great blue herons, double-crested cormorants) that migrate through and nest in these marshes would be affected.<sup>664</sup> If structural shoreline protections are minimal, a combination of sediment accretion and inland migration may occur, and wetlands function are likely to be retained at approximately current

<sup>662</sup>A portion of the Aberdeen Proving Ground is located within Baltimore County.

<sup>663</sup>"Aberdeen Proving Ground Pioneers Approach to Wetland Mitigation," available at: <http://aec.army.mil/usaec/publicaffairs/update/win04/win0420.html>. Although some protections are required at the site under CERCLA actions to prevent migration of contaminated sediments, the majority of the shoreline is extensive wetlands. National Priorities List Fact sheet for Aberdeen-Edgewood available at: <http://www.epa.gov/reg3hwmd/npl/MD2210020036.htm>, and [http://www.apg.army.mil/apghome/sites/directorates/restor/PDF\\_Files/carrolis.pdf](http://www.apg.army.mil/apghome/sites/directorates/restor/PDF_Files/carrolis.pdf).

<sup>664</sup>Maryland DNR Bald Eagle Fact Sheet, accessed on May 23, 2006, at <http://www.dnr.state.md.us/wildlife/baldeagle.html>.

levels. The headwaters of the Bush River, inland of the Proving Ground, are tidal and nontidal wetlands. Large portions of the associated shoreline are almost certain to be protected, which will prevent migration of the wetlands. Accretion in the upper parts of the tributaries may be sufficient to meet an accelerated sea level rise (high range estimate of 7 mm per year above current rates). At the mouth of the Susquehanna, the shoreline of Havre de Grace is mostly developed and armored, with minimal beach or marsh area.

## Cecil County

Across the Susquehanna, in Cecil County, the city of Perryville also has an armored shoreline. Cecil County comprises minimal low-lying land, with most areas above the 20-ft elevation. The majority of the shoreline is not protected, particularly along the Sassafras and Elk rivers, and planners indicate that undeveloped areas are unlikely to be protected in the future. Cliffs line the mouth of the Elk River at Elk Neck State Park (CBIM location 45); despite continuing erosion, planners indicate shore protection is unlikely.<sup>665</sup> The headwaters of the Northeast and Elk rivers are tidal freshwater wetlands, with shore protection considered likely because of the developments on adjacent land. Tidal flats in the Northeast River's upper reaches and adjacent wetlands become important fish spawning areas in the spring.<sup>666</sup> Accretion is expected to be sufficient to meet an accelerated sea level rise because of the large sediment inputs in the Upper Bay, but significant armoring in the developed headwaters could interfere with sediment transport. If accretion rates are not sufficient, wetland migration would be difficult in Cecil County owing to the upland elevation adjacent to the shorelines; consequently, loss of the large tidal fresh marshes could occur. The marshes of the upper reaches of the Elk River are a spawning and nursery area for striped bass and a nursery area for alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), hickory shad

<sup>665</sup>Maryland Shoreline Changes Online, from the Maryland Department of Natural Resources, Available at [http://shorelines.dnr.state.md.us/sc\\_online.asp](http://shorelines.dnr.state.md.us/sc_online.asp).

<sup>666</sup>NOAA, 1994, Environmental Sensitivity Index Maps.

(*Alosa mediocris*), and white perch, as well as a wintering and breeding area for waterfowl.<sup>667</sup>

## Kent County

At the southern border of Cecil County is the Sassafras River, shared with Kent County. Near the mouth of the river are narrow sandy beaches, backed by low bluffs to high cliffs. Because of high sediment input and limited shoreline armoring, beach loss caused by sea level rise is likely to be minimal. Shore protection is unlikely throughout most of the river. Portions of beach and cliff habitat supporting a population of the Puritan tiger beetle (federally listed as threatened) at and around Grove Point, however, may be stabilized resulting in loss of habitat.<sup>668</sup> In contrast, on the southern shore, one section of cliffs at the Sassafras Natural Resource Management Area (Sassafras NRMA, CBIM location 46) has a population of the Puritan tiger beetle. For this reason, the cliffs in the Sassafras NRMA are allowed to retreat naturally. On the bay shore south of the Sassafras River, Kent County has a higher energy shoreline, with agricultural areas leading down to more generally developed shorelines. Groins, jetties, and bulkheads are all in use along portions of the county's Chesapeake shoreline, but the majority of the shoreline is unlikely to be protected. Sandy and rocky shorelines predominate (e.g., Gratitude, Rock Hall) along with forested riparian buffers. Tidal wetlands are rare along the coast, except in sheltered coves. Shoreline migration can readily occur in the unprotected agricultural areas, minimizing ecological losses. In the sheltered areas near Rock Hall, tidal wetlands may be lost because of the almost certain armoring along the developed areas. Loss of wetlands diminishes habitat for the crustaceans, mollusks, and other invertebrates that feed on and provide nutrients for marsh vegetation and the turtles (e.g., diamondback

terrapins) and birds (e.g., ducks, rails) that forage on them. Spawning and nursery areas in marshes for fish will be lost, as will nesting habitat for marsh obligate birds.<sup>669</sup>

At the southern tip of Kent County is the Eastern Neck National Wildlife Refuge (CBIM location 47). Currently, the greatest rates of erosion in the county are found here, on the western shore of the neck and the southeastern tip on the Chester River.<sup>670</sup> Because of its status as a national wildlife refuge, some shoreline protections are being introduced, with the goal of preserving shoreline habitats for the many migratory and residential birds as well as turtles, invertebrates, and the Delmarva fox squirrel (*Sciurus niger cinereus*), federally listed as endangered. In many marsh locations, stands of *Phragmites australis* are the only areas retaining sediment.<sup>671</sup> Practices of removing invasive *P. australis* stands and revegetating with native, noninvasive species have been curtailed in some areas of the refuge, in recognition of the desirable role that *P. australis* plays in retaining soil.<sup>672</sup> Higher levels of substrate accumulation, both below ground and above ground, have been documented in stands of *P. australis* relative to *Spartina* spp.<sup>673</sup> At Eastern Neck, local managers have observed *P. australis* migrating upland into forested areas as inundation at marsh edges increases, although widespread marsh migration of other species has not been observed.<sup>674</sup>

Thousands of waterfowl winter at Eastern Neck, including Canada geese, tundra swans (*Cygnus columbianus*), and a variety of dabbling and diving ducks, such as mallards, buffleheads (*Bucephala albeola*), red-breasted and hooded mergansers (*Mergus serrator*, and *Lophodytes cucullatus*), scaup, and pintails.<sup>675</sup> Migrating and

<sup>667</sup>USFWS, 1980, Atlantic coast ecological inventory: Wilmington, No. 39074-A1-EI-250, USFWS, Washington, D.C. As referenced for the Elk River in the Sealand Limited Site description of NOAA trust resources, available at:

[http://response.restoration.noaa.gov/book\\_shelf/207\\_Sealand.pdf](http://response.restoration.noaa.gov/book_shelf/207_Sealand.pdf) (Table 2).

<sup>668</sup>Barry Knisely (see note 647); USFWS, 1993 (see note 166).

<sup>669</sup>Lippson and Lippson, 2006, pp. 201–239 (see note 2).

<sup>670</sup>Maryland Shoreline Changes Online (see note 665).

<sup>671</sup>Written communication, Tom Eagle, Eastern Neck National Wildlife Refuge, to Christina Bosch, Industrial Economics. "Re: Sea level rise report wrap-up - please respond" confirming text citing Tom Eagle in draft report, including this sentence, sent September 11, 2006.

<sup>672</sup>Ibid.

<sup>673</sup>Rooth and Stevenson, 2000, p. 173 (see note 45).

<sup>674</sup>Tom Eagle (see note 671).

<sup>675</sup>January 2005 waterfowl survey results for Eastern Neck National Wildlife Refuge. Accessed online at



residential birds are a primary component of the Eastern Neck ecosystem. Bald eagles nest at Eastern Neck, usually occupying five to seven active nests at the forested riparian edge.<sup>676</sup> Loss of upland to open water will decrease eagle habitat. Historically, Eastern Neck was a site for black duck (*Anas rubripes*) nesting, along with Smith Island, Barren Island, and other locations in the lower Eastern Shore. However, the three-square bulrush marshes (*Scirpus americanus*) on Eastern Neck have been largely inundated, as have the black needle rush marshes (*Juncus roemerianus*) on Smith Island and other locations, a likely cause of reductions in black duck counts.<sup>677</sup> Loss of tidal marsh at Eastern Neck will reduce suitable habitat for resident and migratory shorebirds. The decreasing size of the upland forested areas will also diminish critical habitat for the Delmarva Peninsula fox squirrel, which resides in forests adjacent to marsh.

## Wrapup

Generally, sediment input to upper Chesapeake Bay is expected to maintain shoreline areas at current rates of sea level rise; marshes will be marginal with a 2 mm per year increase in rates, and lost with a 7 mm per year increase. The Eastern Neck National Wildlife Refuge and the Cecil County marshes in the Elk River are the only areas identified in the Upper Bay as likely to be negatively impacted because of sea level rise. Eastern Neck has already lost marsh areas to open water, and continued loss will limit habitat for bald eagles, the Delmarva Peninsula fox squirrel, and marsh birds. Armoring of the shoreline for developments in Cecil County may limit sediment transport and accretion to marsh areas, thus limiting their extent and suitable spawning habitat for some game fish.

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<http://www.fws.gov/northeast/easternneck/> on 8 June 2006.

<sup>676</sup>Tom Eagle (see note 671).

<sup>677</sup>Ibid.

## 3.18 The Chesapeake Bay Shoreline of the Central Eastern Shore

Author: *Ann Shellenbarger Jones, Industrial Economics Inc.*

### Overview

The central eastern shore region covers the area between the Chester and Choptank rivers. The shore is jagged and sediment-poor, characterized by multiple coves and inlets.<sup>678</sup> On the northern end of Kent Island and the Chester River, marshes are expected to be marginal with an increase of 2 mm per year in the rate of sea level rise and to be lost with an increase of 7 mm per year. South of Kent Island, tidal marshes are marginally keeping pace with current rates of sea level rise, and inundation is likely to occur with an increase in sea level rise rate of 2 mm per year (Section 2.1). Erosion is also a significant issue. Planners expect that shorefront development, particularly on Kent Island and in the Easton-St. Michaels area, will lead to widespread shore protection along Chesapeake Bay and the lower tributaries.

This brief literature review discusses species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection. Existing literature and knowledge of coastal scientists in the area appear to be sufficient in many cases to make qualitative statements about the possible impact if sea level rise causes a total loss of habitat, which might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise. Our ability is more limited, however, to say what the impact might be if only a portion of the habitat is lost. The overall environmental impact of sea level rise seems likely to be the following:

- Large areas of marshes and tidal flats, particularly near the mouth of the Chester

and Choptank rivers and around the Eastern Bay, will be lost. Crabs, juvenile fish, and the larger fish and waterfowl that feed on them will all be affected. The area lies in the Atlantic Flyway, and will affect the ability of migratory birds to feed on the route south in the winter.

- Assuming that shores are protected with structures rather than beach nourishment, many of the remaining beaches will erode up to the shore protection structure. This will reduce the invertebrate population (e.g., mudsnails, tiger beetles, crabs) and therefore stress shorebirds that prey on these species.
- Various marsh areas are likely to be retained. The upper reaches of tributaries, including the Chester and Choptank rivers as well as areas with minimal shoreline protection and low erosion, such as the Wye Island area, are likely to retain current marshes. These areas provide critical spawning and nursery habitat for anadromous fish. Poplar Island will provide a large, isolated marsh and tidal flat area. These regions will continue to support the fish, crustaceans, birds, and reptiles that rely on them today.

### Chester River and Kent Island

The Chester River forms the northern border of Queen Anne's County. Planners expect that its shores are unlikely to be protected from Chestertown in the upper river down to Queenstown. Accretion estimates indicate that marshes along the river will be marginal with an increase in sea level rise rates of 2 mm per year (Section 2.1). Fringing tidal marshes are present throughout this portion of the river, with minimal large marshes. Migration may be possible, but in

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<sup>678</sup>Stevenson and Kearney, 1996 (see note 38).

some areas inshore elevation quickly rises (e.g., elevation rises to 20 feet high within 500 feet of the shoreline along Wilmer Neck) and will impede migration. Birds that breed in the Chester River marshes (e.g., Virginia rail, American black duck) or breed near and feed in the marshes (e.g., great blue and green herons, osprey) will be negatively affected by the habitat and prey loss.<sup>679</sup> Along the river southeast of Eastern Neck, near Queenstown, are large tidal flats.<sup>680</sup> Local planners view shore protection as almost certain along the developed areas between Queenstown and Kent Island, at the mouth of the Chester River. Therefore, unless sedimentation increases significantly, these tidal flats are likely to be inundated if sea level rise accelerates. The Chester River also provides essential spawning habitat for king and Spanish mackerel, cobia, and red drum, as well as forage habitat for flounder and bluefish that feed in marsh and shallow water areas near the mouth of the river.<sup>681</sup> Loss of tidal flats may result in a decline in the resident invertebrates and fish that use the shallow waters as well as the birds that feed on the flats (e.g., great blue and green herons).<sup>682</sup>

Kent Island is highly developed, with shore protection almost certain along the Chesapeake Bay side (CBIM location 48). Historically, the shore along Chesapeake Bay had mostly narrow sandy beaches with some pebbles along low bluffs, with some wider beaches with small dunes. Terrapin Park, north of the Bay Bridge, still has an extensive dune system. The privately owned shores, however, are gradually being replaced with stone revetments. The beaches will be unable to migrate inland, leading to habitat loss for the various resident invertebrates, including tiger beetles, sand fleas, and numerous crab species. Shorebirds that rely on beaches for forage and nesting will face more limited

resources.<sup>683</sup> The Eastern Bay side, by contrast, has several tidal creeks, extensive tidal flats, and wetlands. Planners expect that only two-thirds of these shores are likely or certain to be protected, because Maryland's Critical Areas Act will prevent intense development along one-third of the shore. Given the low accretion rates, the current marshes and tidal flats in these areas are likely to be lost, although some marsh may convert to tidal flat. Extensive SAV beds once grew in the nearshore areas of Eastern Bay, but little remains except in Crab Alley Bay (CBIM location 49), where shore protection is likely or almost certain.<sup>684</sup> Increasing water depths are likely to reduce—and eventually eliminate—the existing SAV (largely a mix of *Ruppia maritima* and *Zannichellia palustris*); a landward migration onto existing flats and marshes will depend on sediment type and choice of shoreline structure (see discussion of SAV in Section 3.1). The loss of tidal wetlands and probable loss of SAV would cause losses to fish and birds as discussed above for the Chester River. Additionally, large shellfish beds in Eastern Bay may be affected by the habitat changes, with uncertain consequences.

### Talbot County/Wye River

East of Kent Island across Eastern Bay is the Wye River, Wye East River, and Wye Narrows. In the Wye River, recreationally important fish include striped and largemouth bass, several catfish and perch species, blue gill, and black crappie. Many smaller fish inhabit the marshes and SAV, including mummichog, striped killifish, menhaden, bay anchovy, hogchoker, and Atlantic silverside. The Wye River also produces an abundant blue crab harvest, as well as oysters and soft-shell clams.<sup>685</sup> The Wye East River and Wye Narrows contain extensive

<sup>679</sup>Robbins and Blom, 1996, pp. 76–77, 92–93, 128–129 (see note 552).

<sup>680</sup>Tiner and Burke, 1995 (see note 32).

<sup>681</sup>NOAA's Guide to Essential Fish Habitat Designations in the Northeastern United States, Summary of Essential Fish Habitat for the Chester River, accessed on July 20, 2006, at <http://www.nero.noaa.gov/hcd/md2.html>.

<sup>682</sup>Author's analysis based on Robbins and Blom, 1996, pp. 50 and 63 (see note 552).

<sup>683</sup>Lippson and Lippson, 2006, pp. 26–42 (see note 2).

<sup>684</sup>Orth, R. J., D. J. Wilcox, L. S. Nagey, A. L. Owens, J. R. Whiting, and A. K. Kenne, 2005, 2004 Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Coastal Bays, VIMS Special Scientific Report No. 146, Final report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD, Grant No. CB973013-01-0, available at: <http://www.vims.edu/bio/sav/sav04>.

<sup>685</sup>Wye Island NRMA Land Unit Plan, 2004, Prepared by the Maryland DNR Land and Water Conservation Service, p. 19.

freshwater marsh. Planners view shore protection as unlikely along the eastern side of the Wye River and in the Wye Narrows, but almost certain along the western side (e.g., the Bennett Point region) and likely along parts of the Wye East River. If the marshes and tidal flats in these areas are lost, the juvenile fish nurseries will be lost and species that feed in the marshes and SAV (e.g., wading birds, striped bass, blue gill, blue crabs) will lose an important food source.

Farther upstream on the Wye East River is the Wye Island Natural Resource Management Area (Wye Island NRMA, CBIM location 50). Steep vegetated banks, 1 to 20 feet in height with some areas eroded to bluffs, are the primary border around the island, with some areas of estuarine marsh forming more gradual slopes to upland areas.<sup>686</sup> The marshes of Wye Island support a large waterfowl population, with a wintering waterfowl count of 20,000 birds such as mallard, canvasback, and ruddy ducks and Canada geese.<sup>687</sup> Local planners indicate that adjacent areas are unlikely to be protected, with the exception of the area south of Wye Island. Current erosion rates in the area are low (approximately 2 feet per year); however, accretion rates are also low and migration is impeded in areas by the upland height and by dense vegetation, which shades the shorelines and inhibits growth of emergent vegetation.<sup>688</sup> Nonstructural and hybrid shoreline protections have been implemented at the Wye Island NRMA site to protect the various habitats.<sup>689</sup> Maryland DNR will manage Wye Island to protect its biological diversity and structural integrity, such that detrimental effects from sea level rise acceleration are minimized.<sup>690</sup>

<sup>686</sup>Ibid., p. 13.

<sup>687</sup>Ibid., p. 18.

<sup>688</sup>Ibid., pp. 33–34.

<sup>689</sup>Burke, D., E.W. Koch, and J.C. Stevenson, 2005, Assessment of Hybrid Type Shore Erosion Control Projects in Maryland's Chesapeake Bay, Phases I and II, Final Report submitted to the Chesapeake Bay Trust, Annapolis, MD, p. 9, and further discussions throughout document.

<sup>690</sup>Wye Island, 2004, p. 12 (see note 685).

## Easton–St. Michaels–Tilghman Island

Planners expect continued development and shore protection in the general area of Easton and St. Michaels, including both sides of the Miles and Tred Avon rivers and most of the land in between. On the bay side of Tilghman Island (CBIM location 51), the high erosion rates will tend to encourage construction of shoreline protection measures, particularly following construction of waterfront homes.<sup>691</sup> Walnut Point (CBIM location 53), at the southern end of Tilghman Island, has been ripped and bulkheaded multiple times after continuing losses of protective measures from storms and high-energy waves. The multiple waterways (e.g., Harris Creek, Broad Creek, Avon River) east of Tilghman Island that flow into the Choptank are also all highly developed. The bay side of Tilghman Island has fringing marsh, nearshore SAV beds, and beaches. On the east side of Tilghman Island, marshes and tidal flats are found extensively along the multiple waterways particularly on the eastern edge of Harris Creek and the borders of Broad Creek.<sup>692</sup> Sea level rise will eliminate most of these marsh and shallow water areas owing to the inability to migrate and their marginal ability to migrate with current sea level rise rates. The loss of beaches and shallow water habitat will eliminate the worms, snails, amphipods, sand fleas, and other invertebrates that live in the beach and intertidal areas and reduce forage for their predators (e.g., oystercatchers, sandpipers, plovers, and glossy ibises). Shallow water habitats, with their resident community of bivalves, worms and other invertebrates, provide a high-density feeding ground for many predators, including fish and wading birds. Loss of shallow water habitat will decrease the SAV that is distributed throughout the coves. Today the SAV provides habitat for many fish as well as forage for waterfowl. Extensive soft-shell clam (*Mya arenaria*) beds are also found in shallow water west of Tilghman Island opposite areas almost certain to be protected.<sup>693</sup> The impact of the

<sup>691</sup>Maryland Shoreline Changes Online (see note 665).

<sup>692</sup>Tiner and Burke, 1995 (see note 32).

<sup>693</sup>NOAA, 1993, Environmental Sensitivity Index summary maps for Chesapeake Bay, obtained from the NOAA Office of Response and Restoration.



armoring and sea level rise on these beds is unknown.

West of Tilghman Island, Poplar Island (CBIM location 52) eroded from more than 1,000 acres during the mid-19th century to less than 10 acres today. It is now being restored to the footprint of 1847 through the beneficial use of dredge material, which is creating shallow water, low marsh, high marsh, and vegetated upland areas.<sup>694</sup> During the creation process, the island has attracted a variety of wildlife, including great blue herons, double-breasted cormorants, and diamondback terrapins.<sup>695,696</sup> The final upland elevations will be 20 feet above mean lower low water, more than high enough to retain its functions as sea level rises for the foreseeable future.

## Wrapup

Large areas of marshes and tidal flats, particularly near the mouth of the Choptank River and around the Eastern Bay, are likely to be lost. These marshes are only marginally meeting current rates of sea level rise, and are predicted to be lost with a 2 mm/yr increase in rate. Crabs, juvenile fish, and the larger fish and waterfowl that feed on them will all be affected. The central eastern shore lies in the Atlantic Flyway and marsh loss will affect the ability of migratory birds to feed on the route south in the winter. Although the northern side of Kent Island and the marshes on the Chester River are keeping pace today, they are expected to be marginal with a 2 mm/yr increase in sea level rise and to be lost with a 7 mm/yr increase. Armoring of developed areas on Kent Island and south to Queenstown is likely to cause inundation of tidal flats and some marsh areas up to the protection structures.

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<sup>694</sup>Poplar Island Environmental Restoration Site, U.S. Army Corps of Engineers, accessed on July 17, 2006, at: <http://www.nab.usace.army.mil/projects/Maryland/PoplarIsland/index.html>.

<sup>695</sup>Ibid.

<sup>696</sup>Robbins and Blom, 1996, double-crested cormorants, pp. 44—45 (see note 552).

## 3.19 Virginia Eastern Shore of Chesapeake Bay

Author: *Elizabeth M. Strange, Stratus Consulting Inc.*

Species and habitats of the Virginia Eastern Shore along Chesapeake Bay are potentially at risk because of sea level rise. This study region includes the bay side of Northampton and Accomack counties. Shorelines of the region contain important habitats for a variety of species, and a great deal is known about their ecology and habitat needs. Based on existing literature and the knowledge of local scientists, this brief literature review discusses those species that could be at risk because of further habitat loss resulting from sea level rise and shoreline protection (see Map 3.8). Although it is possible to make qualitative statements about the ecological implications if sea level rise causes a total loss of habitat, our ability to say what the impact might be if only a portion of the habitat is lost is more limited. A total loss of wetland habitat could occur if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise.

Northampton and Accomack counties have the greatest area of wetlands and dry land in Virginia that are vulnerable to sea level rise, estimated at 47,863 ha (184.8 mi<sup>2</sup>) and 53,923.6 ha (208.2 mi<sup>2</sup>) for Northampton and Accomack counties, respectively. Because most of the land in the two counties is undeveloped or agricultural land, they also have the greatest potential for wetland creation than other Virginia shorelines.

### Bay Side of Northampton County

The bay side of Northampton County is characterized by relatively high lands, including substantial cliffs near the mouth of the bay. This shoreline has some small areas of salt marsh within coves, but is most notable for its beach/dune systems, including some wide sandy beaches near the Town of Cape Charles.<sup>697</sup>

<sup>697</sup>Varnell, L.M., and C.S. Hardaway Jr., 2005, "A risk assessment approach to management of estuarine dunefields," *Ocean & Coastal Management* 48:767-781.

Estuarine beach/dune systems occur in areas of stability and sand accretion, such as the mouths of tidal creeks, embayments, in front of older dune features such as washovers or spits, and against structures like jetties and groins. An estimated 16.42 km (10.2 miles) of dune shore occur along the bay side of Northampton County, mostly fronting headlands.<sup>698</sup>

Shore protection is likely along most of Northampton's bay side shoreline, with the exception of the heads of some tidal creeks. Shore protection often is required on upland banks and interflaves experiencing erosion.<sup>699</sup> Regardless of any shoreline hardening, the high upland elevation of this area would make marsh migration difficult. The lack of lowlands, with the exception of the shoreline near the Town of Cape Charles, means that the primary impact of sea level rise on these shorelines will be erosion. Beach nourishment to protect public beaches is likely, and recently the Board on Conservation and Development of Public Beaches provided \$300,000 for a breakwater and beach nourishment project in the Town of Cape Charles. The dunes themselves are important for erosion control of adjoining lands, and therefore the Commonwealth of Virginia seeks to preserve them under the Coastal Primary Sand Dune Protection Act of 1980.<sup>700</sup>

<sup>698</sup>Hardaway, C.S., Jr., D.A. Milligan, L.M. Varnell, G.R. Thomas, W.I. Priest, L.M. Menghini, T.A. Barnard, and C. Wilcox, 2004, Northampton County Dune Inventory, Technical Report, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA, p. 5.

<sup>699</sup>Lyle Varnell and Scott Hardaway, Virginia Institute of Marine Sciences, written communication, 2/15/07.

<sup>700</sup>Milligan, D.W., C.S. Hardaway, Jr., G.R. Thomas, L.M. Varnell, T. Barnard, W. Reay, T.R. Comer, and C.A. Wilcox, 2005, Chesapeake Bay Dune Systems: Monitoring, Technical Report, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA.

<sup>701</sup>Varnell and Hardaway, 2005, p. 768 (see note 697).

The beaches and maritime forests on the bay side of Northampton County provide habitat for a variety of species, most notably neotropical songbirds and the federally listed threatened northeastern beach tiger beetle.<sup>701</sup> Evidence for the presence of these species comes from surveys in area nature preserves. The Cape Charles Coastal Habitat Natural Area Preserve (Cape Charles Preserve)<sup>702</sup> and the Savage Neck Dunes Natural Area Preserve (Savage Neck Preserve)<sup>703</sup> both provide what preserve staff consider “outstanding” beach/dune and maritime forest habitat for migratory songbirds. Tiger beetles are also found on the beaches of both preserves, as well as the William B. Trower Bayshore Natural Area Preserve.<sup>704</sup>

### Bay Side of Accomack County

The bay side of rural Accomack County is primarily tidal salt marsh, with low-lying lands (less than 2 feet above the wetlands) extending several miles inland. The county as a whole contains nearly a fifth of the state’s dry land within 2 feet of mean high water (MHW), and therefore these marshes are among the most vulnerable in the state.

Local planners expect that most of the bay side shoreline of Accomack County will remain unprotected, with the exception of Onancock Creek, the town of Saxis and the Saxis Wildlife Management Area near the Maryland border, and part of the southern shore of Pungoteague Creek. These unprotected marshes are already migrating inland in response to sea level rise, creating new wetlands in agricultural areas at a rate of 16.2 ha (40 acres) per year (see Section 2.1). Given the anticipated lack of shoreline protection, and the

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<sup>702</sup>Virginia Department of Conservation and Recreation, Cape Charles Coastal Habitat Natural Area Preserve Fact Sheet. Accessed December 5, 2007 at: [http://www.dcr.virginia.gov/natural\\_heritage/natural\\_area\\_preserves/capecharles.shtml](http://www.dcr.virginia.gov/natural_heritage/natural_area_preserves/capecharles.shtml).

<sup>703</sup>Virginia Department of Conservation and Recreation, Savage Neck Dunes Natural Area Preserve Fact Sheet. Accessed December 5, 2007 at: [http://www.dcr.virginia.gov/natural\\_heritage/natural\\_area\\_preserves/savage.shtml](http://www.dcr.virginia.gov/natural_heritage/natural_area_preserves/savage.shtml).

<sup>704</sup>Virginia Department of Conservation and Recreation, William B. Trower Bayshore Natural Area Preserve Fact Sheet. Accessed December 5, 2007 at: [http://www.dcr.virginia.gov/natural\\_heritage/natural\\_area\\_preserves/wmtrower.shtml](http://www.dcr.virginia.gov/natural_heritage/natural_area_preserves/wmtrower.shtml).

marginal likelihood of sufficient sediment input to meet an acceleration in sea level rise of more than 2 mm/yr, the seaward boundaries of these tidal wetlands are likely to continue retreating.

The upland elevations are higher in southern than northern Accomack County, which will make migration more difficult. Marshes in the Hackensack area in northern Accomack County cannot keep pace even with the current rate of sea level rise (Section 2.1). The likelihood of armoring along the inland portions of the tidal creeks south of Onancock could also lead to greater relative wetlands loss along this shoreline compared to the northern part of the county.

The salt marshes of Accomack County support a variety of species, including rare bird species such as the seaside and sharp-tailed sparrow. According to a fact sheet by the State of Virginia, Parkers Marsh Natural Area Preserve in Accomack County provides excellent habitat for sharp-tailed sparrow and Peregrine falcon.<sup>705</sup> Growth and survival of these species could be reduced where shores are hardened, unless alternative suitable habitat is available nearby.

A study in the Eastern Shore indicated that bird communities in large marshes cannot persist in habitat patches of less than 5 ha (12.4 acres)<sup>706</sup> Declines in birds where marsh loss is substantial could have a dramatic effect on local estuarine food webs. Dr. Michael Erwin of the Patuxent Wildlife Research Center has noted that waterbirds and shorebirds are top-level consumers in marshes and an important link in energy and nutrient transport among nearshore, marsh, and upland habitats as well as the surrounding estuary.<sup>707</sup> Loss of these birds could remove a significant amount of biomass from nearshore habitats (e.g., the total biomass of just

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<sup>705</sup>Virginia Department of Conservation and Recreation, Parkers Marsh Natural Area Preserve Fact Sheet. Accessed December 5, 2007 at: [http://www.dcr.virginia.gov/natural\\_heritage/natural\\_area\\_preserves/parkers.shtml](http://www.dcr.virginia.gov/natural_heritage/natural_area_preserves/parkers.shtml).

<sup>706</sup>Watts, 1993, p. 35 (see note 61).

<sup>707</sup>Erwin, 1996, p. 214 (see note 240).

one species of wintering waterfowl exceeded 50,000 kg).<sup>708</sup>

Although gradual inundation in the near term could increase tidal creeks and channels, making the marsh surface more accessible for nekton (i.e., free-swimming finfish and decapod crustaceans such as shrimps and crabs), as tidal flooding increases and the accessible area declines, a decrease in nekton production could occur. For example, Weisburg and Lotrich demonstrated experimentally that growth rates of mummichogs can decrease significantly when they have no access to tidal marsh.<sup>709</sup> As marsh habitats drown, populations of immobile species that cannot survive when permanently inundated could be lost. Mobile species will need to find other suitable habitats, but if these alternative sites provide lower quality habitat, the growth and survival of these populations could decline.

Accomack County lacks the dune/beach shorelines found on the bay side of Northampton County. Nonetheless, the small patches of beach that do occur provide important species habitat. For example, the rare tiger beetle is found in sandy beach habitat in the Parker's Marsh Natural Area Preserve.<sup>710</sup>

There are four major island complexes on the bay side of Accomack County, including Tangier, Smith, Great Fox, and Watts islands. These islands provide nearly predator-free nesting for numerous island-nesting bird species. Erosion and flooding on these islands due to sea level rise could reduce critical habitat and the local populations of these species.<sup>711</sup>

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<sup>708</sup>Ibid.

<sup>709</sup>Weisburg, S.B., and V.A. Lotrich, 1982, "The importance of an infrequently flooded intertidal marsh surface as an energy source for the mummichog *Fundulus heteroclitus*: An experimental approach," *Marine Biology* 66:307–310.

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<sup>710</sup>Virginia Department of Conservation and Recreation, Parkers Marsh Natural Area Preserve Fact Sheet. Accessed December 5, 2007 at: <http://www.state.va.us/dcr/dnh/parkers.htm>.

<sup>711</sup>Watts, 2006, p. 32 (see note 495).