Ongoing Adaptation

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CHAPTER 11

Ongoing Adaptation

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KEY FINDINGS

- Most organizations are not yet taking specific measures to prepare for rising sea level. Recently, however, many public and private organizations have begun to assess possible response options.
- Most of the specific measures that have been taken to prepare for accelerated sea-level rise have had the purpose of reducing the long-term adverse environmental impacts.

11.1 INTRODUCTION

Preparing for the consequences of rising sea level has been the exception rather than the rule in the Mid-Atlantic. Nevertheless, many coastal decision makers are now starting to consider how to prepare.

This Chapter examines those cases in which organizations are taking specific measures to consciously anticipate the effects of sea-level rise. It does not include most cases in which an organization has authorized a study but not yet acted upon the study. Nor does it catalogue the activities undertaken for other reasons that might also help to prepare for accelerated sea-level rise[1], or cases where people responded to sea-level rise after the fact (see Box 11.1). Finally, it only considers measures that had been taken by March 2008. Important measures may have been adopted between the time this Product was drafted and its final publication.

11.2 ADAPTATION FOR ENVIRONMENTAL PURPOSES

Within the Mid-Atlantic, environmental regulators generally do not address the effects of sea-level rise. Many organizations that manage land for environmental purposes, however, are starting to anticipate these effects. Outside the Mid-Atlantic, some environmental regulators have also begun to address this issue.

11.2.1 Environmental Regulators

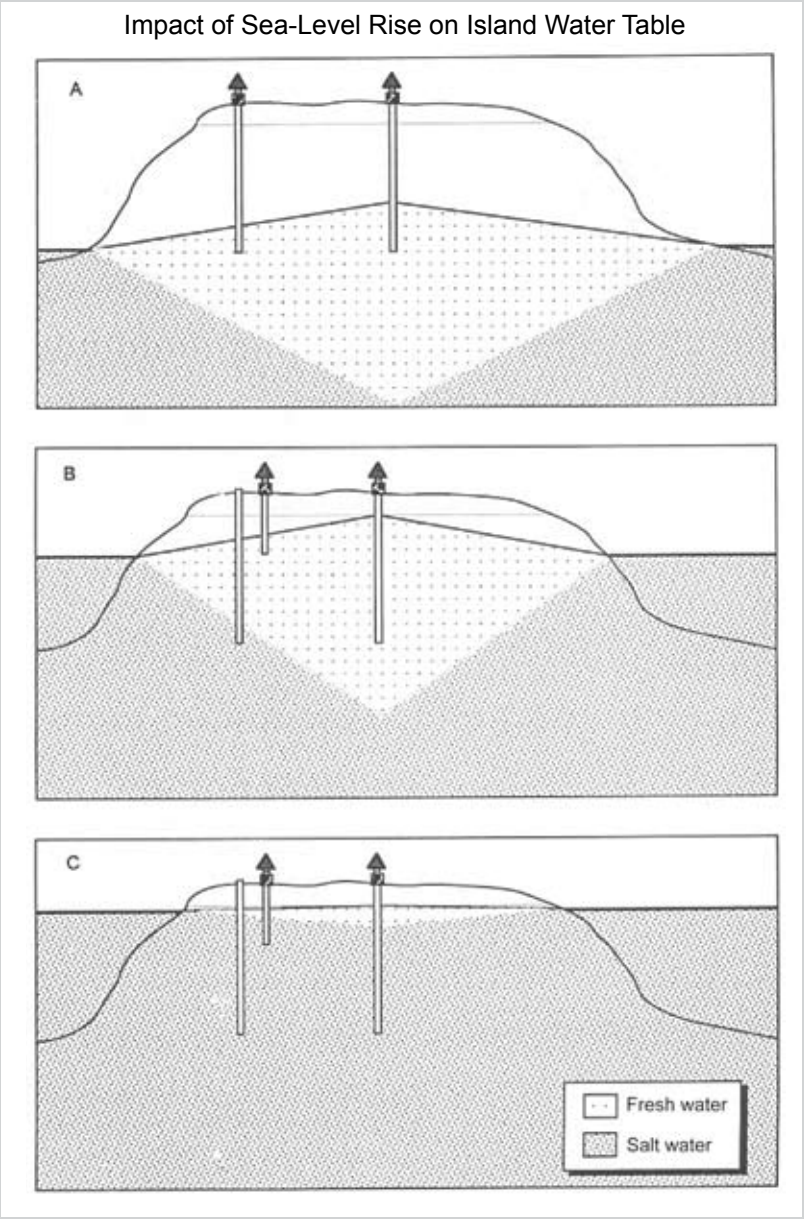
Organizations that regulate land use for environmental purposes generally have not implemented adaptation options to address the prospects of accelerated sea-level rise. Congress has given neither the U.S. Army Corps of Engineers (USACE) nor the U.S. Environmental Protection Agency (EPA) a mandate to modify existing wetland regulations to address rising sea level; nor have those agencies developed approaches for moving ahead without such a mandate (see

[1] Appendix 1, however, does examine such policies.

BOX 11.1: Jamestown—An Historic Example of Retreat in Response to Sea-Level Rise

Established in 1607 along the James River, Jamestown was the capital of Virginia until 1699, when a fire destroyed the statehouse. Nevertheless, rising sea level was probably a contributing factor in the decision to move the capital to Williamsburg, because it was making the Jamestown peninsula less habitable than it had been during the previous century. Fresh water was scarce, especially during droughts (Blanton, 2000). The James River was brackish, so groundwater was the only reliable source of freshwater. But the low elevations on Jamestown limited the thickness of the freshwater table—especially during droughts. As Box Figure 11.1 shows, a 10 centimeter (cm) rise in sea level can reduce the thickness of the freshwater table by four meters on a low-lying island where the freshwater lens floats atop the salt water.

Rising sea level has continued to alter Jamestown. Two hundred years ago, the isthmus that connected the peninsula to the mainland eroded, creating Jamestown Island (Johnson and Hobbs, 1994). Shore erosion also threatened the location of the historic town itself, until a stone revetment was constructed (Johnson and Hobbs, 1994). As the sea rose, the shallow valleys between the ridges on the island became freshwater marsh, and then tidal marsh (Johnson and Hobbs, 1994). Maps from the seventeenth century show agriculture on lands that today are salt marsh. Having converted mainland to island, the rising sea will eventually convert the island to open water, unless the National Park Service continues to protect it from the rising water.



Box Figure 11.1 Impact of sea-level rise on an island freshwater table. (a) According to the Ghyben-Herzberg relation, the freshwater table extends below sea level 40 cm for every 1 cm by which it extends above sea level (Ghyve, 1889 and Herzberg, 1901, as cited by Freeze and Cherry, 1979). (b) For islands with substantial elevation, a 1-m rise in sea level simply shifts the entire water table up 1 meter, and the only problem is that a few wells will have to be replaced with shallower wells. (c) However, for very low islands the water table cannot rise because of runoff, evaporation, and transpiration. A rise in sea level would thus narrow the water table by 40 cm for every 1 cm that the sea level rises, effectively eliminating groundwater supplies for the lowest islands.

Other shorelines along Chesapeake Bay have also been retreating over the last four centuries. Several bay island fishing villages have had to relocate to the mainland as the islands on which they were located eroded away (Leatherman *et al.*, 1995). Today, low-lying farms on the Eastern Shore are converting to marsh, while the marshes in wildlife refuges convert to open water.

Figure 11.1 Allowing beaches and wetlands to migrate inland in the national parks. (a) Cape Hatteras National Seashore (June 2002). Until it was relocated inland in 1999, the lighthouse was just to the right of the stone groin in the foreground; it is now about 450 m (1475 ft) inland. (b) Jamestown Island, Virginia (September 2004). As sea level rises, marshes have taken over land that was cultivated during colonial times [Photo source: ©James G. Titus, used with permission].

Chapter 12). For more than a decade, Maine[2], Massachusetts[3], and Rhode Island[4] have had statutes or regulations that restrict shoreline armoring to enable dunes or wetlands to migrate inland with an explicit recognition of rising sea level (Titus, 1998).

None of the eight mid-Atlantic states require landowners to allow wetlands to migrate inland as sea level rises (NOAA, 2006). During 2008, however, the prospect of losing ecosystems to a rising sea prompted Maryland to enact the "Living Shoreline Protection Act"[5]. Under the Act, the Department of Environment will designate certain areas as appropriate for structural shoreline measures (*e.g.*, bulkheads and revetments). Outside of those areas, only nonstructural measures (*e.g.*, marsh creation, beach nourishment) will be allowed unless the property owner can demonstrate that nonstructural measures are infeasible[6]. The new statute does not ensure that wetlands are able to migrate inland; but Maryland's coastal land use statute limits development to one home per 8.1 hectares (ha) (20 acres [ac]) in most rural areas within 305 meters (m) (1000 feet [ft]) of the shore (see Section A1.F.2.1 in Appendix 1). Although that statute was enacted in the 1980s to prevent deterioration of water quality, the state now considers it to be part of its sea-level rise adaptation strategy[7].

11.2.2 Environmental Land Managers

Those who manage land for environmental purposes have taken some initial steps to address rising sea level.

Federal Land Managers

The Department of Interior (Secretarial Order 3226, 2001) requires climate change impacts be taken into account in planning and decision making (Scarlett, 2007). The National Park Service has worked with the United States Geological Survey (USGS) to examine the vulnerability of 25 of its coastal parks (Pendleton *et al.*, 2004). The U.S. Fish and Wildlife Service is incorporating studies of climate change impacts, including sea-level rise, in its Comprehensive Conservation Plans where relevant.

The National Park Service and the U.S. Fish and Wildlife Service each have large coastal landholdings that could erode or become submerged as sea level rises (Thieler *et al.*, 2002; Pendleton *et al.*, 2004). Neither organization has an explicit policy concerning sea-level rise, but both are starting to consider their options. The National Park Service generally favors allowing natural shoreline processes to continue (NPS Management Policies §4.8.1), which allows ecosystems to migrate inland as sea level rises. In 1999, this policy led the Park Service to move the Cape Hatteras Lighthouse inland approximately 900 m (2,900 ft) to the southwest at a cost of $10 million (see Figure 11.1). The U.S. Fish and Wildlife Service generally allows dry land to convert to wetlands, but it is not necessarily passive as rising sea level erodes the seaward boundary of tidal wetlands. Blackwater National Wildlife Refuge, for example, has used dredge material to rebuild wetlands on a pilot basis, and is exploring options to recreate about 3,000 ha (7,000 ac) of marsh (see Figure 11.2). Neither agency has purchased land or easements to enable parks or refuges to migrate inland.

The Nature Conservancy

The Nature Conservancy (TNC) is the largest private holder of conservation lands in the Mid-Atlantic. It has declared as a matter of policy that it is trying to anticipate rising sea level and climate change. Its initial focus has been to preserve

[2] 06-096 Code of Maine Rules §355(3)(B)(1) (2007).
[3] 310 Code Mass Regulations §10.30 (2005).
[4] Rhode Island Coastal Resource Management Program §210.3(B)(4) and §300.7(D) (2007).
[5] Maryland House Bill 973-2008.
[6] MD C ode Environment §16-201(c).
[7] Maryland House Bill 973-2008 (preamble).

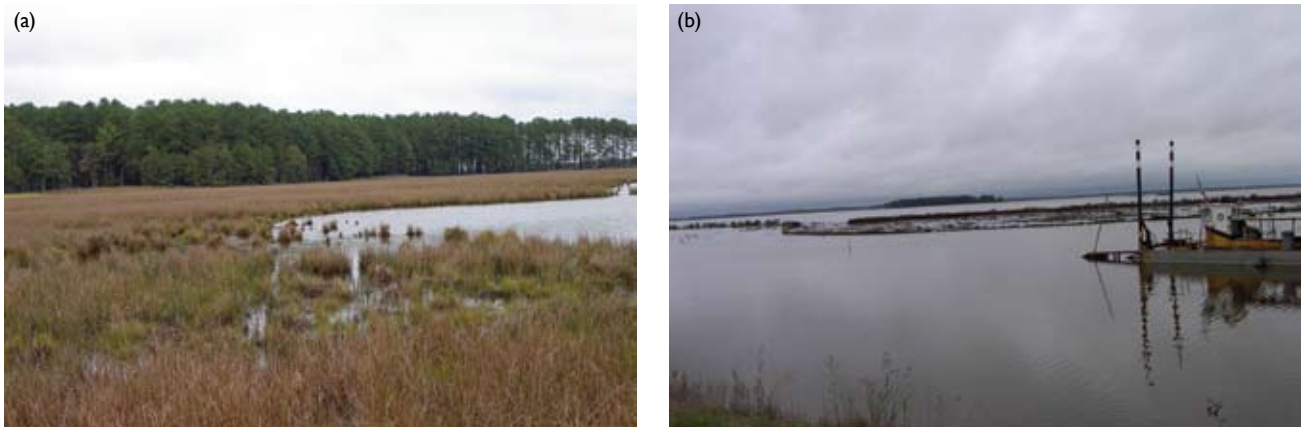


Figure 11.2 Responding to sea-level rise at Blackwater National Wildlife Refuge, Maryland (October 2002). (a) Marsh Deterioration. (b) Marsh Creation. The dredge fills the area between the stakes to create land at an elevation flooded by the tides, after which marsh grasses are planted [Photo source: ©James G. Titus, used with permission].

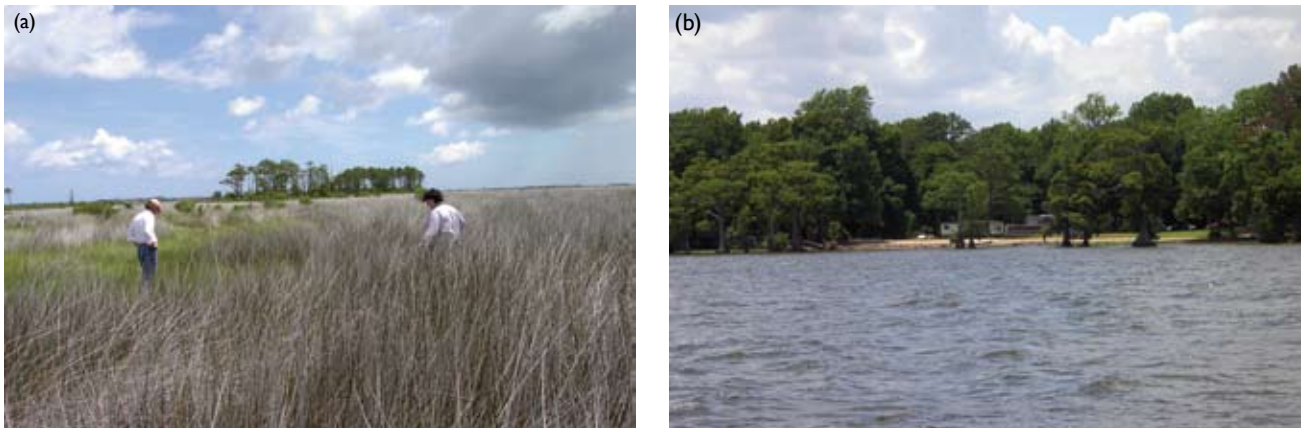


Figure 11.3 The Albemarle Sound environment that the Nature Conservancy seeks to preserve as sea level rises (June 2002). (a) Nature Conservancy lands on Roanoke Island depict effects of rising sea level. Tidal wetlands (*juncus* and *spartina patens*) have taken over most of the area depicted as sea level rises, but a stand of trees remains in a small area of higher ground. (b) Mouth of the Roanoke River, North Carolina. Cypress trees germinate on dry land, but continue to grow in the water after the land is eroded or submerged by rising sea level [Photo source: ©James G. Titus, used with permission].

ecosystems on the Pamlico-Albemarle Peninsula, such as those shown in Figure 11.3 (Pearsall and Poulter, 2005; TNC, 2007). Options under consideration include: plugging canals to prevent subsidence-inducing saltwater intrusion, planting cypress trees where pocosins have been converted to dry land, and planting brackish marsh grasses in areas likely to be inundated. As part of that project, TNC undertook the first attempt by a private conservancy to purchase rolling easements (although none were purchased). TNC also owns the majority of barrier islands along the Delmarva Peninsula, but none of the mainland shore. TNC is starting to examine whether preserving the ecosystems as sea level rises would be best facilitated by purchasing land on the mainland side as well, to ensure sediment sources for the extensive mudflats so that they might keep pace with rising sea level.

State conservation managers have not yet started to prepare for rising sea level (NOAA, 2006). But at least one state (Maryland) is starting to refine a plan for conservation that would consider the impact of rising sea level.

11.3 OTHER ADAPTATION OPTIONS BEING CONSIDERED BY FEDERAL, STATE, AND LOCAL GOVERNMENTS

11.3.1 Federal Government

Federal researchers have been examining how best to adapt to sea-level rise for the last few decades, and now those charged with implementing programs are also beginning to consider implications and options. The longstanding assessment programs will enable federal agencies to respond more rapidly and reasonably if and when policy decisions are made to begin preparing for the consequences of rising sea level.

The Coastal Zone Management Act is a typical example. The Act encourages states to protect wetlands, minimize vulnerability to flood and erosion hazards, and improve public access to the coast. Since 1990, the Act has included sea-level rise in the list of hazards that states should address. This congressional mandate has induced NOAA to fund state-specific studies of the implications of sea-level rise, and encouraged states to periodically designate specific staff to keep track of the issue. But it has not yet altered what people actually do along the coast (New York, 2006; New Jersey, 2006; Pennsylvania, 2006; Delaware, 2005; Maryland, 2006; Virginia, 2006; North Carolina, 2006). Titus (2000) and CSO (2007) have examined ways to facilitate implementation of this statutory provision, such as federal guidance and/or additional interagency coordination. Similarly, the U.S. Army Corps of Engineers (USACE) has formally included the prospect of rising sea level for at least a decade in its planning guidance (USACE, 2000), and staff have sometimes evaluated the implications for specific decisions (*e.g.*, Knuuti, 2002). But the prospect of accelerated sea-level rise has not caused a major change in the agency's overall approach to wetland permits and shore protection (see Chapter 12).

11.3.2 State Government

Maryland has considered the implications of sea-level rise in some decisions since the 1980s. Rising sea level was one reason that the state gave for changing its shore protection strategy at Ocean City from groins to beach nourishment (see Section A1.F in Appendix 1). Using NOAA funds, the state later developed a preliminary strategy for dealing with sea-level rise. As part of that strategy, the state also recently obtained a complete lidar dataset of coastal elevations.

Delaware officials have long considered how best to modify infrastructure as sea level rises along Delaware Bay, although they have not put together a comprehensive strategy (CCSP, 2007).

Because of the vulnerability of the New Jersey coast to flooding, shoreline erosion, and wetland loss (see Figure 11.4), the coastal management staff of the New Jersey Department of Environmental Protection has been guided by a long-term perspective on coastal processes, including the impacts of sea-level rise. So far, neither Delaware nor New Jersey has specifically altered their activities because of projected sea-level rise. Nevertheless, New Jersey is cur-

Figure 11.4 Vulnerability of New Jersey's coastal zone. (a) Wetland fringe lacks room for wetland migration (Monmouth, August 2003). (b) Low bay sides of barrier islands are vulnerable to even a modest storm surge (Ship Bottom, September 2, 2006). (c) Gibbstown Levee and (d) associated tide gate protect lowlying areas of Greenwich Township (March 2003) [Photo source: ©James G. Titus, used with permission].

rently undertaking an assessment that may enable it to factor rising sea level into its strategy for preserving the Delaware Estuary (CCSP, 2007).

In the last two years, states have become increasingly interested in addressing the implications of rising sea level. A bill in the New York General Assembly would create a sea-level rise task force (Bill AO9002 2007-2008 Regular Session). Maryland and Virginia have climate change task forces that have focused on adapting to rising sea level. (For a comprehensive survey of what state governments are doing in response to rising sea level, see Coastal States Organization, 2007.)

11.3.3 Local Government

A few local governments have considered the implications of rising sea level for roads, infrastructure, and floodplain management (see Boxes A1.2, A1.5, and A1.6 in Appendix 1). New York City's plan for the year 2030 includes adapting to climate change (City of New York, 2008). The New York City Department of Environmental Protection is looking at ways to decrease the impacts of storm surge by building flood walls to protect critical infrastructure such as waste plants, and is also examining ways to prevent the sewer system from backing up more frequently as sea level rises (Rosenzweig *et al*., 2006). The city has also been investigating the possible construction of a major tidal flood gate across the Verizano Narrows to protect Manhattan (Velasquez-Manoff, 2006).

Outside of the Mid-Atlantic, Miami-Dade County in Florida has been studying its vulnerability to sea-level rise, including developing maps to indicate which areas are at greatest risk of inundation. The county is hardening facilities to better withstand hurricanes, monitoring the salt front, examining membrane technology for desalinating sea water, and creating a climate advisory task force to advise the county commission (Yoder, 2007).

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