

Introduction



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The National Academies Report On *Mitigating Shore Erosion Along Sheltered Coasts*

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ABSTRACT

Property owners often install structures that harden the shoreline as a way to prevent land loss from erosion or sea level rise. These structures cause changes in the coastal environment that alter landscapes, reduce public access and recreational opportunities, diminish natural habitats, and harm species that depend on these habitats for shelter and food. On sheltered, lower energy coastal areas, erosion often can be managed using nonstructural alternatives such as vegetated, graded bluffs and planted fringing marshes. The National Research Council Committee on *Mitigating Shore Erosion along Sheltered Coasts* concluded that a regional management approach is needed to assess the costs, benefits, and cumulative impacts of structural approaches and to encourage erosion control alternatives that help retain the natural features of coastal shorelines.

INTRODUCTION

Throughout the coastal regions of the world there are a significant number of areas that are partially or fully protected from the high-energy regimes associated with open coastlines, such as ocean-facing beaches. These sheltered coastlines include environments such as estuaries, bays, lagoons, mud flats, and deltaic coasts that may be generally characterized as lower energy systems. Many of the processes that govern erosion and deposition on the open coast also apply to sheltered coasts, but generally at significantly reduced scales. Also, unlike the typically long linear features associated with open coasts, sheltered coasts exhibit characteristics that are distinctively more compartmentalized with discrete areas of the coast encompassing a variety of geomorphic types and biological resources. Typical physical conditions associated with sheltered coasts include relatively low velocity tidal currents and mid-to-low energy wave climates associated with a limited fetch (distance from shore to shore). These conditions promote the formation of ecological complexes (i.e., mangroves, marshes, and mudflats) that are generally not found along open coasts.

Landowners frequently respond to the threat of erosion by armoring the shoreline with bulkheads, revetments, or other structures. Although the armoring of a few properties has little impact, the proliferation of structures along a shoreline can inadvertently change coastal environments and ecosystems. Managers and decision makers have been challenged to balance the trade-offs between protection of property and potential loss of landscapes, public access, recreational opportunities, natural habitats, and reduced populations of fish and other marine species that depend on these habitats.

At the request of the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), and the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), the National Research Council (NRC) of The National Academies conducted a study examining the impacts of shoreline management on sheltered coastal environments and evaluating strategies to minimize potential negative impacts to adjacent or nearby coastal resources. The report (1), released in October 2006, is summarized in this paper.

Study Design

The NRC committee met three times during the course of the study. The first meeting, held in Washington, DC, in June 2005, provided the committee with an opportunity to discuss the background and study expectations with the sponsors. In addition, the committee developed plans for a workshop that was subsequently held in Seattle, WA, in October 2005. The purpose of the workshop was to provide the committee with additional background information, largely focused on an analysis of options available to mitigate erosion of sheltered coasts. In planning this activity, the committee decided not to limit the discussion to marine or estuarine areas, but to include experts from the Great Lakes. The workshop explored the geomorphic settings of sheltered coasts and the strategies used to address land loss from erosion and sea level rise. The workshop brought together approximately 32 professionals with diverse expertise in state and federal regulatory matters, science, engineering, land use planning, and legal issues. The participants came from around the continental U.S. and provided expertise on the range of erosion problems and strategies for managing erosion in a variety of coastal regions.

The committee's report identifies four broad categories of options to address erosion on sheltered coasts:

1. Land use regulation and management;
2. Vegetative stabilization;
3. Hardened structures (armoring the shoreline); and
4. Trapping or adding sediment.

These options are described in the context of the physical environment, ecosystem services and values, and the various regulatory, engineering, esthetic, and financial considerations that contribute to the decision-making process for mitigating erosion.

DISCUSSION AND CONCLUSIONS

Sheltered Coasts and Erosion

Sheltered coasts typically face smaller, shallower water bodies and have more varied shore morphologies than open coasts. In part, this is due to lower ambient wave energy. Lower energy conditions foster habitats and ecological communities, such as marshes and mud flats, typically not found on open coasts. The unique characteristics of sheltered coasts affect the potential technological approaches and the consequences of actions taken to stem erosion and land loss from sea level rise.

Erosion is caused by various natural processes including winds, waves, currents, and tides that transport shoreline sediment; and weathering processes that destabilize landforms such as bluffs and cliffs. The erosion rate may be accelerated by human activities such as construction of dams upstream of estuaries or installation of groins and seawalls that alter the magnitude and direction of sediment transport. Other human activities that increase erosion include dredge and fill operations, wetland drainage, boat traffic, and channel dredging. Sea level rise will exacerbate the loss of waterfront property and increase vulnerability to inundation hazards. It changes the location of the coastline, moving it landward and exposing new areas and landforms to erosion. Additionally, sea level rise is chronic and progressive, requiring a response that is correspondingly progressive.

Current Approaches to Protecting Against Erosion

The pressure to develop and stabilize shorelines in sheltered coastal areas is increasing because coastal populations are growing. More people desire waterfront homes and coastal property values have risen. There are several types of strategies taken to stabilize shorelines. The most common response is a "hold the line" approach that hardens the shoreline with structures such as bulkheads and revetments. Mobile Bay, Alabama, experienced a dramatic increase in the amount of shoreline armoring, from 8 percent in 1955 to 30 percent in 1997, corresponding to the rate of population growth in the area (2). Of greater concern

than the amount or rate of armoring was the associated loss of intertidal habitat, roughly estimated at 4 to 8 hectares (approx. 10 to 20 acres), corresponding to about 10 km of intertidal beach shoreline.

There are alternatives to bulkheads, such as constructed marsh fringes, that are designed to preserve more natural shorelines while still reducing erosion. The selection of the type of response to prevent or offset land loss depends on understanding local causes of erosion or inundation. The NRC report discusses four categories of commonly used techniques to address erosion: (a) manage land use, (b) vegetate, (c) trap or add sand, and (d) harden. These are briefly summarized below.

Manage Land Use

Land use control and land management techniques transfer much of the responsibility for shoreline management from the individual to the community. Interest in and success of this option will depend on local customs which may range from support for individual property rights to enforcement of community standards through strict building codes. The long-term and cumulative benefits of managing land use include: maintenance of ecological integrity (less habitat loss and habitat fragmentation); reduced coastal infrastructure and development; higher water quality; retention of recreational access to the waterfront; higher overall property values; and reduced loss of private property.

Vegetate

Vegetation can be used to stabilize the shore zone and upland banks or bluffs. This strategy is often referred to as a “living shoreline” and is offered as an alternative to hardening techniques. On shorelines fronted by beaches and mudflats, native grasses can be planted into the tidal and supratidal substrate. These techniques work best in areas with a low fetch, where marshes and grasses may have been found in the past. Where the fetch is greater, sand fill, with or without a sill, may be required to attenuate wave energy. In Chesapeake Bay, over 300 marsh fringes have been constructed with an impressive record of performance over 15-30 years for erosion control and wetland habitat creation (3).

Trap or Add Sand

Creating, restoring, or maintaining a beach is often an attractive option for landowners. Trapping or adding sand or gravel provides effective shore protection. To trap sand, structures are installed either parallel (breakwaters) or perpendicular (groins) to the shoreline. Groins reduce the volume of sand that would otherwise be deposited to areas downstream, in some cases leading to erosion of the neighboring beaches. Beach nourishment replenishes sand lost to erosion and protects the adjacent upland from storm wave impacts. Periodic maintenance is usually required and quality sand may be difficult and expensive to obtain. Also, addition of sand displaces the existing intertidal community, changing the habitat to beach and dune.

Harden

The most widely applied shoreline technique is to harden the shoreface by installing a bulkhead, seawall, or revetment. The primary goal of hardening is to protect the coast from wave attack by creating a barrier. On an eroding shoreline, hard structures such as bulkheads increase wave reflection and scour, often causing a decrease in the width of the nearshore environment and an increase in water depth. These processes can contribute to erosion on flanking shores, often causing a domino effect of hardening down the shoreline. As more and more of the shore becomes hardened, the impacts become greater. The cumulative impacts of hardening include permanent removal of sand from the littoral system, loss of intertidal zones, and loss of intertidal and beach habitats.

A shift away from hardening has been slow, in part because there is a greater familiarity with these methods than with alternative approaches such as constructing a marsh fringe or using vegetation to stabilize a bluff. Contractors are more likely to recommend structures such as bulkheads because they have experience with the technology and know the design specifications and expected performance. Landowners often assume that a hard, barrier-type structure will be required to prevent loss of property and protect buildings. In many regions, government regulations may unintentionally encourage shoreline armoring because it is simpler and faster to obtain the required permit(s). However, there are indirect costs associated with mitigation options that armor the shoreline. Many of these costs are borne by the public rather than the landowner.

For example, installation of a groin to trap sand can affect neighboring beaches, while a bulkhead built on an eroding beach will eventually become the shore edge, replacing the beach that provided public access and scenic amenities. Construction on a marshy shoreline can lead to the loss of this highly diverse and productive habitat and the attendant loss of ecosystem services—nursery areas for important fish stocks, removal of excess nutrients from land runoff, feeding areas for migratory birds, and sediment stabilization.

A New Shoreline Management Framework

Changing the current practice of armoring sheltered coasts will require a change in the shoreline management framework. Decision makers should appreciate the costs and benefits of the spectrum of potential solutions to shoreline erosion problems, including potential cumulative impacts on shoreline features, habitats, and other amenities. The management framework should encourage approaches that minimize habitat loss and enhance natural habitats in environments where such methods offer effective stabilization. Overcoming the obstacles associated with the current regulatory environment will require a number of societal and institutional changes in the following areas:

- Improving knowledge of sheltered shoreline processes and ecological services;
- Improving awareness of the choices available for erosion mitigation;
- Considering cumulative consequences of erosion mitigation approaches;
- Revising the permitting system; and
- Improving shoreline management planning.

Conclusions

Until the government regulatory framework addresses sediment transport processes at a regional scale, stabilization of individual sites will often include structures that damage adjacent areas and create a domino effect of coastal armoring. Currently there is no national mandate to document erosion processes on sheltered coasts or develop regional scale plans. Hence, implementation of a regional plan will require a new commitment for coordination among local, state, and federal programs. This might include a regional general permit for projects consistent with the applicable regional plan. The report recommends development of a new shoreline management framework to help decision makers evaluate the spectrum of available approaches to shoreline erosion problems in the context of the environmental setting. The new framework would include assessment of the physical and ecological properties of the shoreline and the potential cumulative impacts.

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