A Report from the National Research Council: Mitigating Shore Erosion Along Sheltered Coasts

Susan Roberts[1]

Abstract. The 2007 National Research Council report *Mitigating Shore Erosion along Sheltered Coasts* examined the impacts of shoreline management on sheltered coastal environments such as estuaries, bays, lagoons, mud flats, and deltaic coasts. Various approaches for stabilizing the shoreline were evaluated for their effectiveness in erosion control and for their impacts on nearshore habitat and adjacent or nearby coastal resources. The report discussed the potential for cumulative impacts from shore protection structures and recommended changes in the regulatory system to shift the trend from shoreline armoring towards less structural approaches that conserve more of the ecosystem services provided by the natural nearshore environment. This paper highlights a few of the findings and recommendations from the report that are of potential relevance to shoreline armoring in Puget Sound.

Introduction

The National Research Council's Ocean Studies Board undertook a study of coastal erosion on sheltered coasts under the sponsorship of the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, and the Cooperative Institute for Coastal and Estuarine Environmental Technology. An ad hoc committee of nine experts in coastal processes, ecology, and management policy was convened to produce a report that would assess the impacts of armoring sheltered shorelines, identify alternatives to armoring, and recommend ways to aid decision makers. As part of the information-gathering process, the committee organized a workshop in October 2005 to bring together experts from around the United States to discuss the science and policy issues of shore protection on sheltered coastlines. The workshop examined the geomorphic settings on sheltered coasts and then explored various erosion control approaches. The membership of the committee and agenda for the workshop are available in the published report (National Research Council, 2007). This paper summarizes portions of the National Research Council (NRC) report's findings and recommendations. The reader is referred to the full report for more complete discussions of issues associated with shoreline armoring on sheltered coasts.

Sheltered Coasts on Puget Sound

Much of Puget Sound can be characterized as sheltered coast because the shorelines are partially or fully protected from the high-energy regime associated with the open ocean coast. Like other estuarine systems, Puget Sound has a convoluted shoreline that segments the coast into relatively small littoral cells, which as a consequence of limited fetch have lower energy. Such low-energy conditions facilitate the establishment of eelgrass, marsh, and mudflat habitats generally not found on ocean-facing coasts. These habitats, known for their high productivity, provide nursery and feeding grounds for many marine species, including valuable finfish and shellfish (fig. 1).

Erosion and landslides from high bluffs provide the major source of sediment for the coarse sand and gravel fringing beaches typically found in Puget Sound, with rivers and streams forming a secondary source of sediment (Thom and Shreffler, 1994). Major storm events, rather than continual wave action, cause most beach erosion, although some areas may experience appreciable erosion as a consequence of boat wakes.

In addition to the impacts of erosion, the effects of rising sea level will exacerbate the loss of waterfront property and increase vulnerability to inundation hazards. In Puget Sound, the local increase in sea level is anticipated to approximate the global trend in sea-level rise (Mote and others, 2008). By 2100, global sea level has been predicted to rise 0.5 m to 1.4 m above the 1990 sea level (Rahmstorf, 2007). The broad range of values reflects uncertainty in the changing rate of sea-level rise under various climate scenarios. Even at the lowest predicted rate for global sea-level rise (0.5 m in 2100), the corresponding landward shift in the shoreline on a coast with a 1:100 slope would be 500 m (approximately 547 yd).

[1]Ocean Studies Board, National Research Council, The National Academies, 500 5th Street NW, Washington, DC, 20001, sroberts@nas.edu.

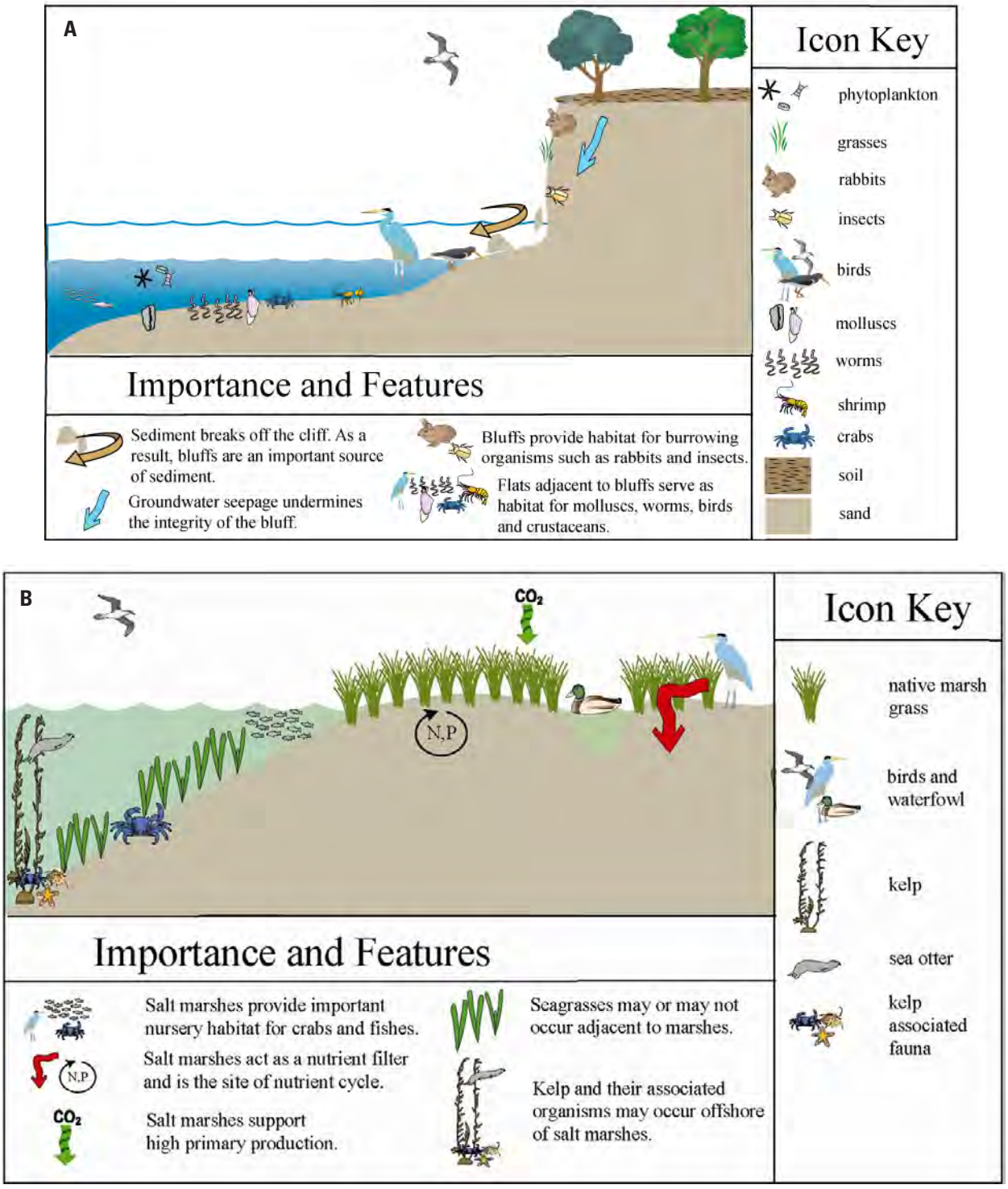

Figure 1. Conceptual diagrams of ecosystem services provided by a bluff (*A*) and a salt marsh (*B*) illustrating some typical components of the ecological communities and outlining the processes that characterize these coastal environments. Source: National Research Council (2007).

Overview of Shoreline Armoring

The dynamic nature of shorelines commonly conflicts with the landowner's desire for a fixed, stable property line. In some cases, buildings constructed close to shore or near the edge of a bluff will be threatened by erosion, whether natural or accelerated by human modifications of the landscape or seascape. The common response to this problem has been to install hard, barrier structures such as bulkheads, seawalls, and revetments to prevent erosion. Global sea-level rise presents another incentive to armor the shoreline as protection against inundation, erosion, and land loss. Because sea-level rise is chronic and progressive, this "hold the line" strategy will likely result in a steady escalation in both the costs of structure maintenance and the consequences of failure. In addition, shoreline armoring often blocks sediment supply, starving the nearshore beaches, and preventing the landward progression of fringing beaches, marshes, and mudflats.

Indirect costs associated with erosion-control measures that armor the shoreline include loss of ecosystem services at the site and in surrounding waters and shorelines (fig. 1). Many of these costs are borne by the public rather than the individual landowner. For example, sea walls and bulkheads may lead to loss of the intertidal zone with subsequent changes in the plants and animals that inhabit these areas. When an installation causes degradation of a marsh, a highly diverse and productive plant and animal community will be lost along with vital ecosystem services such as nursery areas for important fish stocks, removal of excess nutrients from land runoff, feeding areas for migratory birds, and sediment stabilization. Some types of armoring may result in scouring at the edges of structures or disruption of the sediment supply for downstream beaches.

A shift away from shoreline armoring has been slow, in part because barrier-type structures are often installed as a reactive response to an erosion event rather than an integral part of shoreline management planning. Zoning and other proactive land-use planning approaches can be used to limit development where active erosion may undermine buildings or result in substantial land loss. Another factor that inadvertently promotes the use of hard barrier structures is the greater familiarity with armoring 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 frequently assume that only a hard, barrier-type structure will prevent loss of property and protect buildings. Even landowners who would prefer an alternative to hardening may resort to the standard bulkhead because in many regions the regulatory system unintentionally encourages shoreline armoring because it is simpler and faster to obtain the required permit(s).

In the 2007 report, the study committee recommended a regional management approach 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. Creating a more proactive regional approach to shoreline management could address some of the unintended consequences of reactive permit decisions. The NRC report covered many topics related to erosion control on sheltered coasts. This paper highlights two aspects of national shoreline policies from the NRC report of potential relevance to the Puget Sound region.

Cumulative Consequences of Erosion Mitigation Approaches

Although loss of small parcels of shoreline habitat due to armoring may not have a large impact on the ecosystem, the cumulative impact of losing many small parcels will at some point alter the properties, composition, and values of the ecosystem. In addition, the economic, recreational, and aesthetic properties of the shoreline will be altered, with potential loss of public use, access, and scenic values. It is empirically difficult to determine when the cumulative impact of individual armoring projects alter ecosystem processes and substantially reduce the public trust values of the shoreline, hence it has been difficult for policy makers 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 living marine resources that depend on these habitats.

Cumulative impacts encompass the combined effects on legal, social, and physical systems as well as the ecological effects of shoreline armoring. From a legal or regulatory perspective, issuance of even one permit may establish a precedent, potentially facilitating the approval process for future requests for similarly situated structures. Another aspect of cumulative impact is the erosion-enhancing effect of structures such as bulkheads on adjoining properties. Flanking property owners are likely to respond by constructing their own bulkheads, with a domino-type effect up and down the shoreline.

The NRC report recommended inclusion of cumulative effects of shoreline hardening as part of shoreline management plans, accounting for both aesthetic and recreational values and the ecosystem services that stand to be lost. Incorporating potential cumulative effects in the planning process may require a multijurisdictional, regional approach, such as consideration of the level of armoring in Puget Sound, and anticipation of future requests for shore protection structures. If information is insufficient to support a comprehensive assessment of the cumulative impacts of shoreline armoring, a precautionary approach should be used to prevent the unintentional loss of shoreline features and potentially irreversible alteration of the coastal ecosystem.

Decision-Making and Regulatory Processes

The decision-making process for shoreline armoring begins with landowners who decide to alter the shoreline fronting their properties, typically to prevent erosion or inundation. The landowner must then seek the appropriate permits to proceed with construction. The process involves several layers of decision makers, including consultants and contractors such as civil engineers; government regulators, permitting and compliance officials; and policy-makers or lawmakers. The motivations, information sources and needs, and area of influence of the four levels of decision makers are summarized in table 1, which is reproduced from the NRC report.

Government officials at all levels—federal, state, county, and locality—have legal mandates and policies that regulate the shoreline and adjacent lands. Shoreline regulations have been implemented to both protect public trust areas (for example, beach access or wetland protection) and to recognize private property rights with regard to preventing land loss. The balance of these potentially conflicting objectives varies from jurisdiction to jurisdiction. Commonly, regulators limit encroachments below the mean high water line, where state jurisdiction begins in most coastal states, including Washington, although Washington allows for private ownership of some tidelands. It is generally easier for landowners to obtain permits for erosion control structures built directly upland of mean high water.

If a project is to be placed in waters of the United States, then a permit from the U.S. Army Corps of Engineers (USACE) is required. Two federal laws serve as the basis for the federal regulation of shoreline activities: the Rivers and Harbors Act of 1899 and the Federal Water Pollution Control Act (FWPCA; Clean Water Act) of 1972. Through its administration of both statutory programs, USACE plays the central federal role in the regulation of shoreline protection projects.

The U.S. Army Corps of Engineers (2009) issues two types of permits: General Permits (Nationwide and Regional) and Standard Permits (33 C.F.R. sec. 325.5). General Permits, in many cases, do not involve individual review of proposed activities and provide expedited authorizations for certain classes of activities that the USACE has determined are similar in nature and cause only minimal individual and cumulative environmental impacts (33 C.F.R. secs. 322.2(f) & 323.2(h)). For certain activities, General Permits require project proponents to notify the USACE and obtain confirmation that the proposed work is authorized by General Permit (33 CFR sec. 330.6(a)). Adoption of General Permits involves normal rulemaking procedures, such as public notice of the proposed rule and the opportunity for public comment.

Nationwide Permit 27 (NWP 27) for Stream and Wetland Restoration Activities (Federal Register, Vol. 72, No. 47, March 12, 2007, p. 11119) allows activities in waters of the United States associated with enhancement of degraded tidal and non-tidal wetland and riparian areas, as well as the creation of wetlands and riparian areas. In coastal areas, NWP 27 is used primarily for wetland restoration activities, creation of small nesting islands, and construction of oyster habitat. Under some circumstances, NWP 27 could also apply to shoreline protection such as the use of vegetation to stabilize a bank.

Another General Permit, NWP 13 for Bank Stabilization activities, authorizes the construction of structures and fills necessary for erosion prevention (Federal Register, Vol. 72, No. 47, March 12, 2007, p. 11108). Under NWP 13, the permittee must notify the USACE before beginning the work if the structure is longer than 500 linear feet or uses more than 1 cubic yard of fill material per running foot placed along the bank below the plane of Ordinary High Water or the High Tide Line. Thus, smaller bank stabilization activities can be constructed without notifying the USACE. The NWP 13 does not authorize stabilization projects in special aquatic sites.

A Standard Permit is required if the activity does not fall under the conditions of the Nationwide or Regional General Permits. For example, if a property owner wishes to protect an eroding marsh or install a stabilization alternative, such as a sill or breakwater to protect eroding upland, then neither of the nationwide permits mentioned previously could be utilized. The permit applicant would be required to go through the lengthier and more complex individual standard permit process.

The Nationwide General Permits do not have universal application because the States can impose conditions that are more restrictive than those of the USACE. These more restrictive state conditions often center on concerns regarding water quality and consistency with a State's approved coastal zone management plan (16 U.S.C. sec. 1456(c)). Many states have created or incorporated special area management plans and coastal setback zones to protect ecosystems, avoid property loss from erosion, and manage coastal development. In Virginia, for example, the Chesapeake Bay Preservation Act mandates that local governments amend their building codes, subdivision ordinances, and zoning codes to protect wetlands and other coastal habitats.

In general, nationwide permits ease the permitting process and shorten the approval time for activities like installing bulkheads or other vertical shore protection directly adjacent to eroding upland shorelines. As a consequence, property owners who select a shoreline protection alternative that does not encroach into the highly regulated "waters of the United States" can avoid significant transaction costs, lengthy permitting times, and numerous other aggravations.

Table 1. Characteristics of various groups of shoreline protection decision-makers.

Decision-maker	Objectives	Information needs	Information sources	Area of influence
Property owners	* Maximize the use of their property * Aesthetics * Maximize property value	* Effectiveness * Cost * Feasibility	* Handbook and/or online info * Expert / consultant * Government regulator * Neighbors * Flood zone maps	* Individual's property, as well as neighbors' properties
Experts and consultants (includes government scientists and engineers)	* Satisfy the client * Make a profit * Maintain credibility	* Knowledge of shoreline protection options (Structural and non-structural) * Feasibility (that is ease of permitting) * Physics, geomorphology, and ecology	* Professional networks * Experience * Field work * Trade publications * Government agencies * Vendors * Formal Education	* Geographical region in which they work
Government Regulators, Permitting and Compliance Officials	* Implement and enforce the regulations * Resource stewardship	* Knowledge of shoreline protection options (Structural and non-structural) * Physics, geomorphology, and ecology * Legal mandates * Public trust responsibility * Constraints imposed by other regulatory programs	* Reports or the NRC and other expert bodies * Professional networks * Experience * Consultants * Formal education * Legal counsel	* Jurisdiction in which they work
Policymakers and Law-makers	* Re-election * Maintaining the tax base * Resource stewardship * Serving their constituents * Environmental quality * Quality of life * Public health, safety and welfare	* Public trust responsibilities * Current law; its impacts and any unintended consequences * Perception and understanding of the problem to be solved	* Press * Constituents * Staff (trusted experts in the field) * Government agencies * NGOs	* Their jurisdiction, as well as their colleagues' jurisdictions

Note: Large public property owners can have broader geographical influence. SOURCE: NRC (2007).

In some circumstances, this creates an incentive for the permit applicant to avoid federal permit requirements by siting the erosion control project above the mean high water (MHW) line. State and local land-use planning and coastal construction permits may still apply in these cases, but the applicant has simplified the regulatory process by eliminating federal review. This strong incentive to avoid or minimize encroachment into waters of the U.S. has created a bias toward both requesting and allowing certain erosion mitigation options, such as bulkheads and similar vertical structures. Constructing a bulkhead above the MHW line may be quicker and easier than obtaining a permit for a vegetative solution developed in the nearshore waters because it potentially avoids the multiple layers of federal review. In this way, the regulatory framework affects choices and outcomes.

The NRC report concluded that the current regulatory framework for sheltered coasts contains disincentives to the development and implementation of erosion control measures that preserve more of the natural features of shorelines. The report recommended that state and federal agencies (EPA, USACE, and NOAA) convene a working group to evaluate the decision-making process used for issuing permits for erosion control structures to revise the criteria for sheltered coasts, including consideration of potential cumulative impacts. In addition, the regulatory preference for permitting bulkheads and similar structures should be modified to make it easier for landowners to adopt alternative approaches such as living shorelines that conserve more of the ecological features of the natural shoreline.

Conclusion

The NRC study found that reversing the trend in shoreline armoring will require a number of societal and institutional changes including:

- Better understanding of sheltered shoreline processes and ecological services,
- Improved awareness of the choices available for erosion control,
- Documentation of individual and cumulative consequences of erosion control approaches,
- Shoreline management planning that takes into consideration the unique ecological and physical processes of sheltered coasts, and
- A permitting system with incentives that support the goals of the shoreline management plan.

Acknowledgments

The author thanks the members of the NRC committee—Jeff Benoit (chair), C. Scott Hardaway, Jr., Debra Hernandez, Robert Holman, Evamaria Koch, Neil McLellan, Susan Peterson, Denise Reed, and Daniel Suman—who each made invaluable contributions to the production of the report upon which this paper is based.

References Cited

Mote, P.A., Petersen, S., Reeder, Shipman, H., and Binder, L.W., 2008, Sea level rise in the coastal waters of Washington State: Seattle, Wash., University of Washington Climate Impaces Group, and Olympia, Wash., Washington Department of Ecology.

National Research Council, 2007, Mitigating shore erosion along sheltered coasts: Washington, D.C., National Academies Press, 174 p.

Rahmstorf, S., 2007, A semi-empirical approach to projecting future sea-level rise: Science, v. 315, p. 368–370.

Thom, R.M., and Shreffler, D.K., 1994, Shoreline armoring effects on coastal ecology and biological resources in Puget Sound, Washington—Coastal Erosion Management Studies, Volume 7: Olympia, Wash., Washington Department of Ecology Report 94-80.

U.S. Army Corps of Engineers, 2009, Jacksonville District, Regulatory Division: U.S. Army Corps of Engineers website, accessed August 3, 2009, at http://www.saj.usace.army.mil/Divisions/Regulatory/permitting.htm.

Suggested Citation

Roberts, S., 2010, The effects of armoring shorelines—The California experience, *in* Shipman, H., Dethier, M.N., Gelfenbaum, G., Fresh, K.L., and Dinicola, R.S., eds., 2010, Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop, May 2009: U.S. Geological Survey Scientific Investigations Report 2010-5254, p. 85-90.