Chapter 6
Environmental Impacts

6-1. General

Coastal shore protection structures are intended to improve stability by reducing the rate of change in a dynamic coastal system. The environmental impacts may be short-term during construction operations or long-term because of the presence of the structures. The potential environmental impacts, which are similar for each of the coastal shore protection structures featured in this manual, are briefly discussed below. More detailed information may be found in Barnard (1978), Carstea et al. (1975a; 1975b), Ford et al. (1983), Hurme (1979), Johnson and DeWitt (1978), and Mulvihille et al. (1980).

6-2. Physical Impacts

The littoral system at the site of a structure is always moving toward a state of dynamic equilibrium where the ability of waves, currents, and winds to move sediment is matched by the available supply of littoral materials. When there is a deficiency of material moving within a system, the tendency will be for erosion at some location to supply the required material. Once a structure has been built along a shoreline, the land behind it will no longer be vulnerable to erosion (assuming proper function of the structure), and the contribution of littoral material to the system will be diminished along the affected shoreline. The contribution formerly made by the area must now be supplied by the adjoining areas. This can have mixed environmental impacts. The reduction in sedimentation due to decreased erosion may be viewed as a positive effect in many cases. Erosion that is shifted to other areas may result in a negative impact in those locations. Some vertical structures such as bulkheads may cause increased wave reflection and turbulence with a subsequent loss of fronting beach. This is usually viewed as a negative impact. In all cases, the overall situation and the various impacts that result must be evaluated carefully to identify potential changes in the shore and barrier island processes.

6-3. Water Quality Impacts

Impacts of coastal shore protection structures on water quality can be addressed in two categories:

a. Increased suspended solids during construction.

b. Altered circulation caused by structures.

Construction of shore protection structures can result in increased suspended solid loads within the adjoining water body. Recent research results indicate that the traditional fears of water quality degradation caused from suspended solids during in-water construction activities are for the most part unfounded. It has been demonstrated that the increased concentration of suspended solids is generally confined to the immediate vicinity of the construction activity and dissipates rapidly at the completion of the operation. Although these are generally short-term impacts, construction activities should be designed to minimize generation of suspended solids. The dispersion of near-surface suspended solids can be controlled, to a certain extent, by placing a silt curtain around the construction activity. Under quiescent current conditions (less than 0.1 knot) the suspended solids level in the water column outside the curtain can be reduced by as much as 80 to 90 percent. Silt curtains are not recommended where currents exceed 1 knot. Steps must be taken also to avoid the introduction of toxic or other harmful substances resulting from construction materials, equipment leaks, spills, and other accidents. Project specifications should contain provisions that address these concerns. Structures may influence water quality by altering circulation patterns. Modification in circulation may result in changes in the spatial distribution of water quality constituents, differences in the flushing rates of potential contaminants, and changes in the scour patterns and deposition of sediments. Environmental assessment of the effects on circulation should initially emphasize the physical parameters such as salinity, temperature, and velocity. If minimal changes occur in these parameters, then it can be assumed that the chemical characteristics of the system will not be significantly modified. Prediction of changes in circulation and its effect on the physical parameters can be achieved through comparison with existing projects, physical model studies, and numerical simulation.

6-4. Biological Impacts

A wide variety of living resources is present in coastal shore protection project areas and includes species of commercial, recreational, and aesthetic importance. Because shore protection projects exist in arctic, temperate, and tropical climates, biological impacts will generally be highly site-specific and depend upon the nature and setting of the project. The environmental impacts on the benthic communities resulting from suspended solids in the water around shore protection construction are for the most part minor. This is particularly true in the surf zone on open coast beaches where rapid natural changes and disturbances are normal and where survival of the benthic community requires great adaptability. Placement of coastal shore protection structures requires an initial disturbance of the benthic substrate, but it results in the formation of a new substrate composed of structural material and stability of the sediments adjacent to the structure. In many locations the placement of these structures provides new habitat not available otherwise.

6-5. Short-term Impacts

Short-term impacts are usually associated with the actual construction phase of the project. The actual time is typically short (measured in days and weeks) and, therefore, can be scheduled to minimize negative impacts. Transportation of material to the site, preparation and construction using heavy equipment, and back filling and grading will cause temporary air and noise pollution close to the site. Nesting, resting, or feeding waterfowl and fish and other wildlife will be disrupted. Projects should be timed, if possible, to avoid waterfowl and turtle nesting periods and fish spawning periods. Temporarily reduced water quality, discussed in paragraph 6-3, may have biological impacts. However, if the bank is severely eroding or is heavily developed these impacts may be minimal by comparison. Siltation of offshore sea grasses or corals as the result of construction, dredging, and filling at the site may be of short or long duration depending on the composition of the sediment, the currents, and circulation patterns at the site and the locations of these specific resources. Construction impacts at sites with a high percentage of fine material and nearby sea grass bed or corals could be high and require special planning and precautions such as silt curtains. Dredging activities may attract opportunistic foraging fish as well as temporarily destroy benthic habitats. Resuspension of bottom sediments may interfere with respiration and feeding, particularly of nonmotile bottom dwellers. Motile organisms will temporarily flee the disturbed area.

6-6. Long-term Impacts

Long-term effects vary considerably depending upon the location, design and material used in the structure. The impact of a vertical steel sheet bulkhead located at mean low water in a freshwater marsh will be considerably different from a rubble-reveted bank in an industrialized harbor. Vertical structures in particular may accelerate erosion of the foreshore and create unsuitable habitat for many bottom species in front of the structure as the result of increased turbulence and scour from reflected wave energy. On the other hand, rubble toe protection or a riprap revetment extending down into the water at a sloping angle will help dissipate wave energy and will provide reef habitat for many desirable species. Bulkheads and revetments can reduce the area of the intertidal zone and eliminate the important beach or marsh habitat between the aquatic and upland environment. This can also result in the loss of spawning, nesting, breeding, feeding, and nursery habitat for some species. However, birds such as pelicans might benefit. A number of design alternatives should be considered to maximize biological benefits and minimize negative impacts. Table 6-1 summarizes design considerations for improving the environmental quality of these structures.

6-7. Socioeconomic and Cultural Impacts

Secondary impacts are often more controversial than the primary impacts on air, water, noise, and the biota. Land use patterns will often change as the result of construction. However, only two elements normally are directly considered in the design of the structure itself. The structure should be sited to avoid known archaeological or other cultural sites. Secondly, the structure should be designed to be aesthetically pleasing. Coastal shore protection structures change the appearance of the coastline. The visual impact of a structure is dependent on how well the structure blends with its surroundings. The importance of visual impacts is related to the number of viewers, their frequency of viewing, and the overall context. For example, the appearance of a structure in a heavily used urban park is more critical than a structure in an industrial area or an isolated setting. Aesthetic impacts can be adverse or beneficial depending on preconstruction conditions and the perception of the individual observer. Coastal shore protection structures offer a visual contrast to the natural coastal environment. However, many observers prefer a structure to erosion damage. Most coastal shore protection structures improve access to the water's edge for recreation and sightseeing.

6-8. Evaluation of Alternatives

Comparison and evaluation of coastal shore protection alternatives involves examination of economic, engineering, and environmental aspects. Alternatives are evaluated according to how well they meet specified project objectives. Examples of environmental objectives include preservation, protection, and enhancement of aesthetic resources, fish and wildlife habitat, and water quality. Evaluation of the short- and long-term impacts of coastal shore protection structures requires comparison of with-project and without-project conditions. Recognizing the dynamic nature of the coastal system, a forecast must be made of future environmental conditions without the project. These predicted conditions are then compared

Table 6-1
Environmental Design Considerations for Revetments, Seawalls, and Bulkheads

Factor	Design Considerations [1]	Environmental Benefit
Location	Site structure above mean high water	Allows intertidal zone to remain Allows shoreline vegetation to remain Does not interfere with littoral drift
	Avoid wetland sites, spawning beds, shore-bird and turtle nesting beaches	Resource conservation
	Avoid nearby coral reef and seagrass beds	Resource conservation
	Avoid archaeological sites	Preserve historical information
Construction Material	Rubble or riprap	Most desirable, natural and durable
	Treated wood and smooth concrete	Intermediate desirability Less surface area
	Steel sheet pile	Least desirable, least colonizable
	Use largest cost-effective armor stone	More stable physical habitat More size diversity of openings
Design Features	Use riprap or stair-step revetments on a slope of 1 to 1 or flatter when structures are partially submerged	Dissipates more energy More habitat for fish and reef fish
	Use toe protection on structures below mean low water	More diverse habitat Reef-like properties Dissipates wave energy on the bottom
	Use sloping structures and avoid vertical structures especially when a structure is partially submerged	Wave energy not reflected
	Use floating or pile-supported structures for access to vessels	Avoids problems of vertical walls
	Use natural shoreline contours and avoid sharp angles	Aesthetically pleasing

[1] Where applicable and possible.

with the expected conditions resulting from each alternative. Environmental features should be integral parts of the project, not additions made late in design or afterward.