CHAPTER 9

BEACHES AND BEACH NOURISHMENT

9-1. General. Shore erosion is a major problem along many ocean beaches and the shoreline of the Great Lakes. One of the most desirable, cost-effective shore protection alternatives is beach nourishment (Figure 9-1). Beach nourishment is usually accomplished by borrowing sand from inshore or offshore locations and transporting the sand by truck, by split-hull hopper dredge, or by hydraulic pipeline to an eroding beach. These operations result in massive displacement of the substrate, changes in the topography or bathymetry of the borrow and replenishment areas, and destruction of nonmotile benthic communities. However, a well-planned beach nourishment operation can minimize these effects by taking advantage of the resiliency of the beach and nearshore environment and its associated biota, and by avoiding sensitive resources (item 67).

9-2. Types of Beach Nourishment. Four major types of beach nourishment occur along U.S. shorelines: new borrow material not connected with maintenance dredging, maintenance dredging of an existing channel, dumping in the littoral zone to allow beach nourishment, and rehandling of stockpiled material.

a. Borrow Dredging. This type of dredging entails removal specifically for beach nourishment. The major physical impact of dredging borrow material is the mechanical disturbance of the substrate and the subsequent redistribution of suspended sediments and turbidity. Suspension of sediments and turbidities is usually a short-term impact. Once dredging ceases, heavier sediments rapidly settle, and fine sediments are dissipated by waves and currents. Sea bottom borrow pits remain intact for long periods of time unless currents transport sediments into the pits and fill them. If the borrow pits are in an area of low wave energy and the surrounding bottom sediments contain high levels of organic materials, the pits are likely to slowly fill with the organic-laden sediments. Decomposition of the organic material in these pits may result in anaerobic conditions and generally poor water quality.

b. Maintenance Dredging. The use of maintenance dredged material for beach restoration can serve two beneficial purposes: disposal of the material, and restoration of an eroding beach. If such material is selected, it should closely match the sediment composition of the eroding beach and be low in fine sediments, organic material, and pollutants. Sediments containing large quantities of fine materials result in high turbidities and may introduce trace metals and other contaminants into the water. High turbidities and sedimentation may inhibit reestablishment of beach animals that have a specific habitat requirement or may prevent recruitment to the beach by pelagic larvae, particularly if beach restoration occurs during the peak spawning season in spring and early summer. The disposal may interfere with the selection of a nesting beach by sea turtles if beach sediments are significantly changed, and the appearance of such sediments is aesthetically displeasing.

Figure 9-1. A beach nourishment operation under way at Mayport, Florida

Figure 9-2. A sea turtle hatchling moving toward open water on a Florida dredged material beach

c. Dumping in the Littoral Zone. Disposal of dredged material can be by deliberate placement on the sea bottom, where it will be carried by currents and waves to the beach. The dredged material will replenish the eroding beach in a natural manner as it is carried by wave energy. Material can be placed in the littoral zone by hydraulic pipeline or by split-hull hopper dredge.

d. Rehandling Stockpiled Material. Coarse-grained dredged material can be pumped into a holding area, where it is allowed to dewater. Then it can be moved by truck or heavy equipment onto the eroding beach. This technique is commonly applied in small restoration projects.

9-3. Environmental Considerations.

a. Impacts on Beach Organisms.

(1) Animals on high-energy beaches are subject to the effects of seasonal sediment erosion and accretion and major physical changes related to storms. In the Pacific Northwest, animals may be stressed to the 60-foot contour. Beach animals are adapted to survival under these stressful conditions, whereas those animals offshore are generally in a more stable environment and are less adapted to a high level of sediment movement. Burial of nonmotile benthic animals by replenishment material placed on the beach, or material being transported offshore from the beach, is usually lethal unless the animals are able to migrate through the sediment overburden and escape. Laboratory studies have shown that some benthic animals (especially bivalves) can migrate vertically through more than 1 foot of deposited sediment. The ability of benthic animals to survive burial by dredged material will depend not only upon the depth of the sediment, but also upon the length of time the animals are buried, time of year, sediment grain size, quality of the sediment, and other specific requirements of the animals. Therefore, rate of survival will vary from location to location.

(2) Beach nourishment creates new habitat that is uninhabited by benthic animals, except for those that may have survived being pumped to the beach with the dredged material or those that survived by vertical migration through deposited sediments. A beach nourishment operation is generally followed by rapid establishment of new benthic populations. Many of these are opportunistic species that develop large population densities, then decline as other species are recruited which are more adaptable to the new habitat. The time for the resident species to become established is referred to as the recovery time of the nourished area (the time required to approach a stable animal population level). Recovery time varies, depending upon type of recruitment of benthic animals. Those animals that have planktonic larvae or can migrate from nearby areas into the nourished area will establish rapidly, whereas those that spend their entire life cycle within the sediments may be slow in recovering. Once beach restoration ceases, recovery of benthic animals is generally rapid, and complete recovery usually occurs within one or two seasons.

(3) The sediment type used for nourishment and the season of year the nourishment takes place are critical to the recovery rate. If the dredged material is different from the natural beach sediment or contains large quantities of fine material, there may be a major change in beach biota, and it may require a long period of time before local resident populations can be reestablished.

b. Impacts on Offshore Organisms. Potentially, the most serious impact of offshore dredging is the loss or damage to major commercial species of benthic shellfish, seagrass beds, corals, and sea turtles. Damage can be minimized by proper selection of borrow areas, by precisely positioning the dredge to avoid these sensitive resources, and by using dredging equipment that minimizes sedimentation and turbidity, such as a suction dredge.

(1) Benthos.

(a) Repopulation of a dredged area by benthic animals will depend upon the magnitude of the disturbance, the new sediment interface, and the water quality in the borrow pit. Borrow pits will be recolonized by migration of animals from adjacent areas and by larval transport. Stability of the environment and bottom sediment type after dredging are major factors in determining the level and rate of species recolonization. It is extremely important to remember that if bottom sediments are significantly changed from the natural sediments, the reestablished populations may not be of the same magnitude or species composition as those prior to dredging.

(b) Offshore borrow pits that accumulate organic material and acquire high concentrations of hydrogen sulfide and low concentrations of dissolved oxygen in the water are- generally very poor quality aquatic habitats. They also usually take a long time to recolonize by benthic animals, or may never recolonize.

(2) Corals.

(a) The ability of corals to recover from beach nourishment is related to the extent of reef damage. If a reef is heavily damaged by equipment being dragged across the reef, by being-covered with sediments, or by all corals being killed, the reef can take a long time to recover, or it may never recover. It has been shown that corals may recover if the damage is not too extensive. Corals along the Florida Atlantic coast damaged during beach nourishment apparently recovered by 7 years after the dredging operation.

(b) Corals along Florida and Hawaii coasts are susceptible to direct physical damage by dredging and to sedimentation and reduced light unless dredging operations are carefully planned and executed. With proper planning and control, dredging impacts on corals can be minimized. One of the most significant impacts on corals results from dragging of anchors and cables, which collapse the reef and destroy benthic animals. Erosion and scour at the base of the corals in the dredged area also may damage corals. This can result in the corals slumping or tilting, or forming overhangs that tend to break off. Reef coral recovery is very slow.

(3) Fish and motile invertebrates.

(a) The mobility of fish and some invertebrates renders them less vulnerable to the adverse effects of beach nourishment than the nonmotile benthic communities. When disturbed by beach nourishment, motile animals will generally leave the area. Those animals that do not leave or are susceptible to suspended sediments in the water can be killed by coating of their gills, leading to anoxia, or if they spawn in the area the sediments may cover their eggs or delay hatching time of their eggs. Feeding habits also may vary according to length of exposure to suspended sediments. Filter-feeding fish are more vulnerable to siltation than bottom feeders.

(b) Destruction of habitat rather than suspended sediment seems to be a greater potential problem to fish. Those fish which are either closely associated with the beach for some part of their life cycle for spawning (i.e., California grunion) or some burrowing and reef-dwelling species with limited mobility (i.e., the dusky jawfish on the Florida Atlantic coast) are more likely to be adversely affected. Beach nourishment operations at Imperial Beach, California, did not prevent subsequent spawning of the grunion; however, on the Florida Atlantic coast it may have displaced the dusky jawfish.

(c) Loss of benthic animals due to sediment burial may indirectly affect motile animals that prey on them. This was suspected to have occurred following a nourishment project on the North Carolina coast. Nourishment occurring during the peak season of beach animal recruitment delayed population reestablishment for several months. During this period, fish and shellfish that usually feed in the surf zone were not observed. Nourishment may also have had short-term benefits to some fish by suspending additional food materials, and the associated turbidities may have provided protection from predators to some motile animals. Studies have shown that moderate to complete recovery of motile animals will usually occur within less than a year unless a required habitat or food source is permanently lost. Fish have been observed moving into an area within the first day after a disturbance.

(d) Mobile animals will be least affected by borrowing operations because of their ability to avoid a disturbed area. Studies have shown that fish will leave an area of active dredging and return when dredging ceases. Whether fish will continue to use a borrow pit as habitat depends upon water quality in the pit. If the pit accumulates anaerobic sediment that results in poor water quality, fish will avoid the pit. However, fish may be attracted to a dredged area as a result of suspended food and as a haven from the cold surface water during the winter. The sediment plume from the dredge may also provide protection to some motile animals. Total recovery at a dredged site, therefore, is variable and ranges from immediate for some species to a year or more for others, depending upon the nature of the habitat modification.

(4) Sea turtles.

(a) Sea turtles are one of the animals most vulnerable to the effects of beach nourishment on the South Atlantic and Gulf coasts (Figure 9-2). Turtle nesting on the beaches and replenishment operations occasionally conflict in these areas. There is concern that turtle nesting and hatching success may be adversely affected by beach nourishment.

(b) Sand particle size and sand compaction have been found to influence nest site selection by some sea turtles. Aborted nesting attempts (false crawls) have occurred on rebuilt beaches in Florida. The precise effects of beach nourishment on nesting sea turtles have not been documented because of insufficient studies. The present limited data indicate caution should be taken in rebuilding beaches that are known to be major turtle nesting sites. It would be best to avoid turtle nesting beaches from April through November, the period which encompasses all of the sea turtles' nesting and incubation season. Such operations must be closely coordinated with U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service, and state agencies.

(c) Hibernating or aestivating sea turtles have been captured and killed by trawls and dredges. Turtles that are not hibernating or aestivating should be able to avoid a dredge and move back into an area when dredging ceases. If hibernating sea turtles are located, dredging should cease until the operation can be coordinated with FWS.

(5) Seagrass beds. As with corals, caution should be taken to avoid these highly productive areas. Both the actual dredging operation and turbidity caused by adjacent dredging will destroy seagrasses. Seagrasses are usually very slow to recover, if they ever recover. To date, seagrass transplantation has not been refined to a point where a high-percentage survival of transplants and economic feasibility justify efforts to restore large areas of destroyed seagrasses (See Chapter 8). Dredging cautions for corals should also apply for seagrasses.

c. Timing. Timing of the nourishment operation may also be a critical factor in reestablishment of benthic animals. If nourishment occurs during spring and early summer, recruitment of planktonic larvae may be inhibited. High turbidities and unstable substrate are known to preclude larval settlement, thus delaying recovery time of benthic animals. The best time ecologically for beach nourishment and borrowing is during the period of lowest biological activity. This is usually during the winter when there would be minimal effect on the adult and developmental stages of most nearshore and beach animals. Adults have usually migrated out of the area and would be less concentrated in the shallow beach zone, and the nesting and spawning season of beach animals would have passed. Nevertheless, it is still necessary to ensure that no sensitive nonmotile animals are in the area.

d. Dredged Material Substrates. Sediments to be used as material should match the natural beach sediments and should be low in pollutants.

This recommendation is particularly important when maintenance dredged material is used for beach nourishment. Minimum damage to beach animals will occur when clean sand is placed on a sandy substrate, whereas damage to the benthic animals would be great if fine sediments high in organic material are used. Changes in the sand particle size on ocean beaches, should they occur, may also influence site selection and nesting of the threatened and endangered sea turtles.

e. Equipment in Sensitive Areas.

(1) If it can be avoided, the cutterhead on a suction dredge should not be used in the vicinity of live coral reefs or other light-sensitive resources, unless barriers are established to separate the dredging site from them. The suction dredge without a cutterhead is a better choice because siltation is minimized and there is less potential for physical damage to the reef. The dredge should be positioned within the designated borrow area and should not cross a live coral reef, commercial clam bed, or other valuable resources. Cables, anchors, and discharge pipes of a dredge should be positioned in sand or another nonsensitive habitat. Local directions in tidal flow and current should be determined prior to dredging, and the operation adjusted to prevent sediments from crossing live coral reefs or other sensitive resources.

(2) Consideration should be given to shallow dredging over a large area in a low wave energy environment rather than deep dredging which may create a stagnant borrow pit which will require a long time to recover or may never recover. Although ecological damage from dredging the shallow pit would initially be greater, recovery should be faster in the shallow dredged area.

f. Monitoring. Biotic surveys should be made at beach restoration and borrow sites. As an absolute minimum, a preproject baseline survey should be made to identify and locate natural resources, i.e., corals, commercial clam beds, sea turtle nesting beaches, fish spawning areas, and seagrass beds, to aid the planner in avoiding potential damage to these resources.