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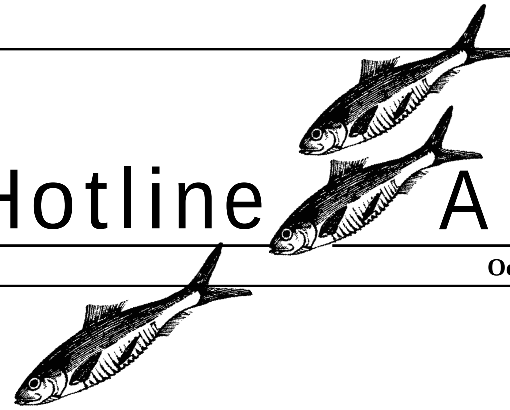

Beach Nourishment: Possible Impacts To Fish and Fish Habitat

by
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Introduction

Many beaches along the east coast of the United States are eroding leading to a loss of habitat for sea turtles, birds, fish, plants, and a host of other organisms that use the beach during some part of their life cycle. Loss of sand can be caused by natural factors such as storms, sea level changes, waves, currents, tides, as well as man-made activities including construction of harbors, groins, jetties, and seawalls; shoreline development; dredging of tidal inlets; damming of rivers; and beach nourishment. Sea level rise is one of the major global concerns that will likely affect coastlines throughout the world in the coming years. Sea level is estimated to rise approximately 20 cm by the year 2050 (IPCC, 1996), which translates to an average of 1 meter of shoreline erosion per year (Leatherman et al., 2000).

There are three types of methods used to address coastal erosion: (1) hard stabilization such as seawalls, breakwaters and groins and jetties, (2) non-structural alternatives such as removal or relocating structures and (3) soft stabilization techniques including beach nourishment, beach bulldozing, and dune creation. Many states have shifted from hard structure approaches to policies that favor soft structures, specifically beach nourishment and beach bulldozing. In fact, beach nourishment has become the preferred course of action to address shoreline erosion in the United States, Australia, and Europe. However, there are still many uncertainties concerning effects to the marine and beach environment. This article focuses on beach nourishment and potential impacts to fish and fish habitat.

Beach Nourishment

Beach nourishment can be defined as "the process of mechanically or hydraulically placing sand directly on an eroding shore to restore or form, and subsequently maintain, an adequate protective or desired recreational beach (USACE, 1984)." Benefits from beach nourishment include 1) a wider recreational beach, 2) protection to shoreline structures, 3) possible beneficial use for dredged material from nearby sources, 4) the ability to switch to other beach management methods in the future (as long as increased coastal development does not preclude this), 5) protect threatened or endangered plants in the dune area and 6) restore habitat for sea turtles, shore birds, and other beach organisms.

Beach nourishment operations involve extracting the sand from source areas called mine sites, transporting it to target beach areas often via dredge pipelines, and redistributing sand at target areas. The most common sources of sand for beach nourishment projects are nearshore ocean waters and offshore ocean waters. These sources are usually the most cost-effective, and in the case of nearby channel dredging, can serve the dual purpose of maintaining the inlet for navigation and nourishing the beach. However, dredged material used for beach nourishment must be evaluated for content of contaminants based on local, state, and federal guidelines. Most east coast states review beach nourishment under general permit regulations. The U.S. Army Corps of Engineers has primary authority to carry out federally authorized beach nourishment.

Potential Impacts

Generally, impacts that can occur at the mine site typically involve the complete removal of physical structures resulting in habitat loss, while impacts at the target site are often the result of burial or heavy siltation. Increased turbidity is likely to occur at both the mine and target sites. Unfortunately, there is a lack of information documenting the effects of these activities on

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fish and fish habitat. However, Nelson (1985) has noted some potential effects, including: 1) altered distribution during nourishment; 2) potential for gill clogging; 3) temporary removal of benthic prey; 4) burial of structures that serve as foraging and shelter sites; and 5) potential burial of demersal fish. Table 1 summarizes potential impacts to fish and other aquatic organisms.

Habitat Removal

Mining involves digging up the bottom to extract sand, resulting in the removal of habitat important to fish, including hardbottom habitat, underwater sand berms and mounds that offer refuge for some fish species. In addition, dredges, discharge pipelines, mooring chains, and other equipment associ-

Table 1. Potential impacts resulting from beach nourishment activities based on monitoring studies and laboratory experiments.

Turbidity/ Sedimentation	Changes in Sediment Characteristics (i.e. higher silt content)	Physical Changes (i.e. creation of pits, removal of ridges, compacted sand at target beach)	Noise / Physical Presence of equipment
Reduced nutritive organic particles in water column (SZ, M)	Altered benthic composition (T, M)	Suffocation upon burial, including benthic infauna (T) and demersal fish (SZ)	Collisions with marine mammals/sea turtles (M)
Suffocation of benthic infauna from silt (SZ, M)	Long-term alterations to sediment (T, M)	Anoxic conditions (SZ, M)	Mortality or interference with movement of beach fauna (T)
Impaired foraging for filter feeding and deposit feeding organisms (SZ, M)	Impaired burrowing ability of invertebrates (T)	Loss of fish habitat, including foraging and shelter sites (SZ, M)	Reduced sea turtle nesting sites (T)
Reduced prey capturing ability for sight dependent predators (SZ, M)	Reduced success of incubating sea turtle eggs (T)	Reduced benthic diversity/composition (M)	Mortality due to entrainment of fish larvae and mobile invertebrates (M)
Decreased microalgal production/mortality (SZ, M)	Decreased feeding efficiency for shorebirds (T)	Decreased primary and secondary production – leads to loss of prey items (T, SZ, M)	Altered distribution of fish (SZ, M)
Unsuitable fish egg spawning and hatching conditions (SZ, M)		Decreased sea turtle nesting sites (T)	Avoidance by shorebirds and destruction of eggs/nesting sites (T)
Egg abrasion and reduced ventilation rates in molluscs (SZ, M)			
Clogging of fish gills (SZ, M)			
Mortality to fish from anoxia (SZ, M)			
Reduced growth and increase calcification rates in coral reefs (SZ, M)			

T = Target Beach
SZ = Surf Zone
M = Mine Site (can be close to shore or in the Exclusive Economic Zone referred to as the EEZ)

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ated with sand mining have also damaged hard bottom areas (Blair et al., 1990). If mining occurs during the spawning season, some species may be unable to leave the area because their larvae are estuarine dependent. Other fish species that are permanent residents may be unable to find other habitat. Fish that prey on exclusively non-motile organisms and fish that are less motile, themselves, are anticipated to suffer the greatest effects from dredging. The degree to which fish that prey on benthic invertebrates are affected depends on the recovery rate of the benthic communities. Very few organisms and little organic matter are left intact when surface sediments are removed during mining (Saloman, 1974; Oliver et al., 1977; Culter and Mahadevan, 1982).

Relic shoals are another important habitat to fish. The term “relic shoal” refers to a shoal that is not dynamic in nature, unlike many shoals that are constantly accreting and diminishing in response to tides and water currents. If relic shoals are removed they will likely not replenish themselves, and the structures will be permanently lost. For fish that rely on relic shoals to optimize feeding along an otherwise featureless substrate, relic shoals provide important physical habitat (Caruso, 2002; Tinsman, 2002). Relic shoals may also be used as navigation points by some fish species (Goodger, 1999). Striped bass, bluefish, scup, summer flounder, and coastal sharks are among the fish species known to use these structures (Caruso, 2002; Tinsman, 2002).

Following dredging, other physical changes to the seafloor can occur as a result of altered waved patterns and sediment transportation including changes in substrate type and composition, surface texture, water circulation, and nutrient distribution. Such changes may reduce the ability of benthic flora and fauna to adapt to the existing conditions and impact the availability of prey and suitable conditions for fish. For example, an increase in fine sediment may exclude some organisms and recruit higher numbers of other organisms (Naqvi and Pullen, 1982), such as replacement of crustaceans by polychaete worms (Johnson, 1982). It is also possible that the resultant mine pit can cause an increase in the depth of the water and reduce the amount of solar energy that reaches the seabed, which has the potential to cause a decrease in primary productivity (USDOI/FWS, 2000). Mined areas can also refill with decomposed organic matter that is silty and anaerobic, hydrogen sulfide levels may increase, and eventually, the area may become anoxic. Such areas may never recover from these dredging events.

Habitat Burial

Fish habitat can also be smothered by sediment. At the mine site, re-suspended sediment can settle out over important fish habitat, especially if the new sediment has more silt and clay. For example, sabellariid worms are common in Delaware Bay building considerable mound-like and tubular aggregations in the nearshore surf zone, sometimes forming distinct reefs. Following beach nourishment, the reefs are less prevalent due to smothering by sand and silt. Since fish use these reef structures for feeding and escaping predation, a reduction in reef area is likely to have an impact on the fish that use this habitat (Tinsman, 2002).

When extracted sand is deposited at the target beach area, physical changes can occur including changes in silt/clay composition. Infilling of sediment high in clay/silt can increase turbidity levels and impact fish. In South Carolina, the effects of increased siltation and smothering from sand movement are considered to have a greater impact on hard bottom habitat than other nearshore habitat (Van Dolah et al., 1994). Some areas have already been lost to the effects of beach nourishment, such as hard bottom habitat off the coast of Wrightsville Beach, NC, which was buried under two to six inches of sand when sand eroded from the nourished beach. These once productive fishing grounds no longer support the fish they once did.

Turbidity

Increased turbidity at the mine site is usually limited to the times of dredging activity. Turbidity at the target beach can last longer, even years. Areas that do not have naturally high turbidity, or beaches that are not typically subjected to storm-related turbidity, may experience greater impacts from beach nourishment-related turbidity, especially if a higher silt/clay content is present in the beach fill (Van Dolah, 2002). Elevated turbidity at both the mine site and target beach may have potential effects to fish species, such as clogging of gills and gill abrasion. Some researchers found that fish subjected to high sedimentation and turbidity have died from anoxia, especially juveniles and small fish (Courtenay et al., 1974; O’Connor et al., 1976). Increased turbidity may impact fish prey; benthic animals may be suffocated from heavy silt loads and filter feeders may have difficulty in locating and capturing food. In addition, for some fish species, especially those that are sight feeders (such as adult winter flounder), it is likely that increased turbidity affects their success rate for capturing prey.

Determining Impact and Recovery

Many factors, physical, biological, and ecological, contribute to the type and severity of the impact and the extent of recovery resulting from beach nourishment activities. However, in some cases, data are lacking or there is conflicting information regarding the degree and extent of impacts and recovery. Unfortunately, impacts to fish and their habitat are still poorly understood and cumulative effects are not adequately addressed in monitoring studies. Monitoring studies are often based on unreplicated field surveys, have not been peer reviewed by third parties, and are not published in scientific journals (Lindeman et al., 2000). More research is needed to address the issue of long-term recovery, especially regarding impacts to all fish stages, fish habitat, prey availability, and effects of turbidity.

For example, information on long-term physical changes at the mine site are not well documented (NRC, 1995), making the task of identifying cumulative effects more difficult when only the immediate short-term changes are identified. Some studies have found the impacts to fish populations to be benign, while other studies have documented increased diversity at the mine site. In

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addition, many studies have concluded that the mine site is fully recovered within one year post-dredging, maintaining that taxonomic diversity and density are often restored, as is the organisms' ability to adapt to their new environment, while others have found that full recovery takes more time (likely beyond one year) for organic matter to accumulate on the substrate and for aerobic conditions to return to normal. Studies of turbidity associated with beach nourishment dredging are limited; most are conducted at the target beach or are generic turbidity studies.

While the importance of hard bottom habitat is well established, there is conflicting information and differing viewpoints on the effects of beach nourishment on species that rely on these areas. Some find displacement of fish short-term and loss of food sources for fish temporary, while others find displacement is permanent (more than 15 months). Recovery of organisms in soft-sediments varies with the season, habitat, and the species' life history characteristics (e.g. Zajac and Whitlach, 1982; Thrush et al., 1996; Shull 1997).

A growing issue of concern is over the frequency that beaches are re-nourished. One study (Leonard et al., 1990) found that 88% of Atlantic coast artificial beaches had to be re-nourished within five years of initial nourishment. Areas that are slow to return to pre-nourishment conditions may never fully recover before the beach is re-nourished again. Long-term monitoring that continues until the site is fully recovered is critical to prevent repeated events from creating cumulative impacts on the environment.

Future Activities

Future beach nourishment activities should monitor the refilling rates of the pits at mine sites following dredging as well as the composition of surface sediments especially with regard to silt and clay content. Studies are needed to determine whether the new post-dredging benthic community has less, more, or equal value as a food source for fish and whether displacement occurs and to what degree this affects demersal fishes (Peterson, 2002). In addition, state and federal agencies may want to identify physical structures that serve as important habitat for migrating and resident fishes in areas where mining is proposed or currently taking place. To minimize impacts, beach nourishment activities could be planned for periods when organisms will least likely be affected for example, by determining seasonality of important organisms such as reproductive period of benthic fauna. Future efforts could continue to experiment with different sand mining techniques, such as extracting thin layers over larger areas, which has been demonstrated to reduce some of the impacts at the mine site.

*Adapted from **Reviewing the Biological Impacts of Beach Nourishment and Outlining Future Research Needs**, by Karen Greene, ASMFC Habitat Management Series #6, 83 pp., available from the Atlantic States Marine Fisheries Commission. For more information, contact Carrie Selberg at the Commission office (202-289-6400).*

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World Summit Agreements on Oceans and Fisheries

In 1992 at the Earth Summit in Rio de Janeiro, the international community adopted Agenda 21 (Chapter 17 of the agenda addresses marine fisheries sustainable development), a global program of action for achieving sustainable development. Ten years later, the World Summit for Sustainable Development (WSSD) was held in Johannesburg, South Africa, to provide an opportunity for governments and organizations to assess the progress made since the Earth Summit, and to develop new partnerships and initiatives to implement Agenda 21.

In August 2002 the World Summit on Sustainable Development (WSSD) brought together tens of thousands of participants, including heads of State and Government, national delegates and leaders from non-governmental organizations (NGOs), businesses and other major groups to focus the world's attention and direct action toward meeting difficult challenges, including improving people's lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services and economic security.

Some of the key outcomes from the summit regarding oceans and fisheries include agreements to:

- Encourage the application by 2010 of the ecosystem approach for the sustainable development of the oceans.
- On an urgent basis and where possible by 2015, maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield.
- Put into effect the FAO international plans of action by the agreed dates:
  - for the management of fishing capacity by 2005; and
  - to prevent, deter and eliminate illegal, unreported and unregulated fishing by 2004.
- Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 .
- Establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment.
- Eliminate subsidies that contribute to illegal, unreported and unregulated fishing and to over-capacity.

For more information on the World Summit on Sustainable Development visit the website www.johannesburgsummit.org.

Sources: NOAA Press Release 9/4/02 (NOAA 2002-117) and website: www.johannesburgsummit.org/html/documents/summit_docs/2009_keyoutcomes_commitments.doc.

First Assessment of U.S. Coral Reefs

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) recently released the first national assessment of U.S. coral reefs. The report, **The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States**, identifies the pressures that pose increasing risks to reefs, assesses the health of reef resources, ranks threats in 13 geographic areas, and details mitigation efforts. Developed by 38 coral reef experts and 79 expert contributors and prepared under the auspices of the U.S. Coral Reef Task Force, the report establishes a baseline that will be used for biennial reports on the health of U.S. coral reefs. In addition, NOAA has also released **A National Coral Reef Strategy**, a report to Congress outlining specific action to address 13 major goals, including continuing mapping and monitoring, to safeguard reefs.

While natural environmental pressures such as temperature, sea-level changes, diseases and storms have shaped coral reefs for at least thousands of years, human-induced pressures are now also taking their toll. Coastal pollution, coastal development and runoff, and destructive fishing practices are among the top-ranked threats. These are followed by ship groundings, diseases, changing climate, trade in coral and live reef species, alien species, marine debris, harmful tourist activity and tropical storms.

Overall, Florida and the U.S. Caribbean were found to be in the poorest condition, mainly because of nearby dense populations and the effects of hurricanes, disease, overfishing and a proliferation of algae. Live coral cover in the Florida Keys has declined 37 percent over the past five years. Of 31 coral reef fishery stocks in federal waters, 23 are overfished in the U.S. Caribbean. Coral disease is especially high in the Caribbean, where over 90 percent of the once abundant longspine sea urchins died in the early 1980s. Vital in keeping coral from being overgrown and killed by algae, they have since recovered to just 10 percent of their original numbers off the coasts of Florida, Puerto Rico and the U.S. Virgin Islands. In 20 years, white-band disease has killed nearly all the elkhorn and staghorn corals off the coasts of St. Croix, Puerto Rico and southeast Florida.

Data and other information derived from NOAA's coral reef efforts are now available at CoRIS, a new Coral Reef Information System Web site that provides a single point of access for nearly 20,000 aerial photos, navigational charts, photo mosaics, monitoring reports, professional exchanges and much more.

The new reports and CoRIS Web site are available at http://www.coralreef.noaa.gov. Digital map products are available on CD-ROM and at http://biogeo.nos.noaa.gov.

Source: NOAA press release, September 26, 2002 (NOAA 2002-125).

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