U.S. Geological Survey and U.S. Fish & Wildlife Service

Report: Impacts of Sediment Removal from and Placement in Coastal Barrier Island Systems

Frequently Asked Questions

Q: Who prepared this report and why was it created?

On June 2, 2021, the U.S. Geological Survey (USGS) published an Open File Report on the impacts of sediment removal from and placement in coastal barrier island systems (OFR 2021-1062). The report was prepared jointly by the USGS and the U.S. Fish and Wildlife Service (FWS) in response to a June 2019 request from the House Committee on Natural Resources that the two agencies evaluate the short- and long-term impacts of sediment removal on areas in and adjacent to the Coastal Barrier Resources System (CBRS). The agencies assembled a team of scientists and landscape managers who reviewed and summarized the scientific literature on how sediment-supply alterations affect physical and ecological processes of coastal barriers and, in turn, how specific species, habitats, and coastal resilience are impacted. The report can be accessed at: https://doi.org/10.3133/ofr20211062.

Q: What is the scope of the report?

This report contains a comprehensive summary of the scientific literature on the physical, biological, and ecological effects of sediment removal and placement in coastal barrier island systems. Specifically, the report presents the consensus findings and relevant knowledge gaps associated with the impacts of sediment removal and placement on: physical barrier island processes and sediment supplies; benthic habitats; fish and other marine species; subaerial beach habitats; and coastal resiliency.

The report identifies the physical and biological data required for assessing and monitoring impacts of sediment management actions in coastal barrier island systems and provides a table of existing USGS data resources for five CBRS areas of interest as identified by FWS (Hereford Inlet, NJ, Carolina Beach, NC, Masonboro Inlet, NC, New River Inlet, NC, and Folly Beach, SC). Assessments of sediment management actions for any particular CBRS units or other site-specific areas were beyond the scope of this report.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers Philadelphia District pumps sand onto Brant Beach, NJ in June of 2013

Q: What is the Coastal Barrier Resources Act?

The Coastal Barrier Resources Act (CBRA) of 1982 originally established the CBRS which now encompasses about 3.5 million acres along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts. The purpose of the law is to protect natural resources, save taxpayer money, and keep people out of harm's way by removing the federal incentive to develop ecologically-sensitive and storm-prone coastal barriers. CBRA prohibits most new federal expenditures and financial assistance for projects and activities within the CBRS, including projects to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area (16 U.S.C. 3504(a)(3)). The law does not restrict the use of private, state, or local funds or limit the issuance of federal permits within the CBRS. FWS is responsible for maintaining the maps that depict the CBRS and consulting with other federal agencies that propose spending funds within the CBRS. Additional information about CBRA is available at: https://www.fws.gov/cbra.

Q: What are coastal barrier island systems?

Barrier islands, and the environments therein, are dynamic systems, responding to wave and tidal processes, sediment supply and disruption, and sea-level change. These islands support a great diversity of plants and animals, including many threatened and endangered species. Historically, coastal barrier island systems were largely sustained by natural sediment exchanges between the inner continental shelf, shoreface, beach, dunes, marsh, and estuary. Today, humans also alter these systems through sediment management, which refers to the removal of sediment from one part of the system (e.g., dredging) for placement in another part of the system (e.g., nourishment). These practices are used for either hazard mitigation (e.g., erosion and flood control) or coastal restoration (e.g., expansion or restoration of beach, dune, and/or marsh habitats). In instances where barrier systems are altered through human intervention, naturally occurring coastal processes can be modified, enhanced, or impeded.

Q: What are the key findings of this report?

An extensive review of the literature for this report found that sediment management actions can have both beneficial and detrimental impacts on coastal species and the physical and ecological resiliency of barrier island systems, depending on where and how they are applied.

The key findings in the report illustrate how some sediment management practices can have negative impacts on seafloor habitats, fish and other marine species, beach and dune habitats, and the coastal sediment supply that maintains barrier island resiliency. For instance, when sediment is removed from one barrier island system and used in a separate system it reduces the amount of sediment for the original island. This may lead to coastal erosion near the removal location or could cause longer-term impacts to the supply of sediments to neighboring barrier islands, all of which may alter the islands' ability to withstand future storms and increases in sea level. This process of removing sediments from an area can also directly and indirectly alter the quality of nearshore seafloor habitats like seagrass beds and fish nurseries that are critical for supporting economic and ecologically important species. Organisms that live in or on the seafloor, which often serve as food sources for many threatened and endangered coastal and marine species, may be directly excavated during dredging activities. Additional impacts to surface-dwelling species, such as manatees and sea turtles, include direct entanglement in or physical strikes from dredging equipment.

The report also highlights some positive impacts of sediment management. For instance, sediment placement can increase feeding areas, viable nesting habitat, and increase nesting success for some coastal wildlife like shorebirds and turtles. However, the timing of nourishment is important, since the addition of sediments to beaches, dunes and marshes could interfere with breeding seasons of certain species. Though beach nourishment can temporarily protect coastal infrastructure and habitats from storm inundation and erosion, it may lead to negative affects at other locations. Beach nourishment can cause detrimental sedimentation on sensitive seafloor habitats and the dredging required to acquire the sediments needed for nourishment can reduce sediment supply to barrier islands, which reduces their ability to keep pace with sea-level rise.

Five topics addressed in the report and associated findings (and knowledge gaps) are:

1. Physical Impacts of Sediment Removal and Placement on Coastal Sediment Supplies

Sediment removal and placement reshapes barrier islands and their adjacent environments by altering: a) wave and current impacts at the shoreline, b) the volume of sediment exchanged via inlets, c) alongshore sediment transport, and/or d) the frequency of sediment exchanges between beaches and back-barrier environments. For example, removal of sediment from any part of the submerged barrier system may alter the position of barrier island shorelines. Over time, placed sediment may be dispersed to other barrier island environments and may cause both physical and ecological benefits, such as increased sediment supply to downdrift beaches and increasing habitat extent. Placement may also result in adverse impacts, such as the alteration of natural sediment exchanges between barrier island environments that decrease habitat suitability.

This review revealed a need for more research and monitoring on the following topics in order to better estimate both beneficial and adverse physical impacts of sediment removal and placement on coastal systems: (1) prior to sediment removal, it is important to establish the range of natural shoreline variability so that after sediment removal, variability in shoreline position can be attributed to sediment supply disruptions; (2) substantial uncertainty surrounds forecasts of the impacts of sediment removal or placement due to the episodic nature of the storms that drive many of the changes and the difficulty in predicting exact magnitudes of storm-related sediment transport; (3) effects of sediment placement on estuarine or back-barrier beaches is less studied than effects on ocean-facing beaches; and (4) more understanding is needed of the barrier-system as a whole, including effects of sediment removal from inlet-associated shoals, tidal flats, and channels on inlet shore-lines and downdrift sediment supply and physical and ecological feedbacks from sediment placement.

2. Impacts of Sediment Removal and Placement on Benthic Habitats and Their Importance

Benthic habitats, and the organisms that live in and on the seabed, are directly and immediately impacted by sediment removal and placement. Changes to water depth, sediment composition, and the hydrodynamic conditions at the seafloor can impact habitat quality for benthic organisms, which are important food resources for shore and waterbirds and other marine species. The physical removal of sediments causes immediate mortality and reduced abundances of benthic organisms. Sediment placement also has immediate impacts to benthic organisms. Whether on the beach or

U.S. Army Corps of Engineers

A mixture of sand and water is pumped onto Rockaway Beach, Queens, NY, June 26, 2014, from an offshore borrow site.

underwater, those buried by placed sediments die, reducing the food supply for shorebirds and surf fish. Further, increased suspended sediment associated with removal or placement can impact nearby sensitive seafloor habitats, such as seagrasses, corals, and hard bottoms. Importantly, recovery of benthic communities is highly variable. In contrast, thin layers of placed sediment have been found to increase vegetation cover and number of benthic organisms in degraded marshes.

The primary knowledge gaps for benthic communities include improving understanding of: (1) how sediment removal and placement affect benthic ecosystem functioning; (2) how efficiently and quickly resident taxa repopulate affected areas, and how less-mobile members of the benthic community repopulate affected areas; and (3) the long-term effects of sediment removal and placement or those that might persist beyond the typical 1-2 year monitoring period, particularly when actions are repeated.

U.S. Fish and Wildlife Service

Loggerhead sea turtle hatchlings at Back Bay National Wildlife Refuge in Virginia

3. Impacts of Sediment Removal and Placement on Fish and Other Marine Species

Although sediment removal and placement occur at specific sites, threats to fish and other marine species emerge from direct entrainment and entanglement of organisms, suspended/settled/contaminated sediment, noise, and net bathymetric change that occur at those sites or beyond. Species vulnerability to sediment management effects depends on an organism's mobility relative to the spatial extent and frequency of the sediment removal or placement activity. Vulnerability is particularly acute when sediment removal and increased suspended sediment overlaps spatially or temporally with sensitive habitats (e.g., coral reefs), migration paths or foraging areas in which individuals congregate, or spawning, nursery, or overwintering habitats. In addition to changes to the physical environment, vulnerability can result from direct interaction with equipment and vessels. Direct dredging impacts include species entanglement in buoys or lines marking projects and physical injury if struck by transiting vessels or impacted by vessel noise. In particular, sea turtles, manatee, and sturgeon are susceptible to vessel collisions, propeller strikes, and/or crushing because they may spend a considerable amount of time at or near the water surface. Sediment placement, particularly that which expands the area of estuarine tidal flats, can increase viable habitat for fish and other estuarine/marine species more so than other "hard engineering" solutions, such as armoring or bulkheading. However, it is unknown whether the benefit of habitat expansion outweighs the burial of benthic food sources on those tidal flats on which fishes and other species depend.

Uncertainties in the sand removal and placement impacts to fish and other marine species are due to lack of species population information and lack of understanding of the interaction of those populations with sediment management activities. Given the wide variation in known responses among fish species and life stages, prevalence of laboratory studies versus field studies, and existing knowledge gaps, additional research is necessary to: (1) characterize population, species, and community-level impacts of sediment removal in situ; (2) quantify fine-scale activity patterns on free-ranging animals using new tools; and (3) assess contaminants in marine sediment deposits to determine the extent to which disturbed sediments release toxins into the environment and food chain.

4. Impacts of Sediment Removal and Placement on Subaerial Beach Habitats

Sandy beaches provide important ecosystem services, including habitat for federally- and state-listed plants and animals, which may be directly or indirectly impacted by sand placement on beaches. Beach nourishment can lead to improved sea turtle and shore/waterbird use by widening severely eroded beaches. However, if sediment placement occurs during the shore/waterbird breeding season, there is potential harm to reproductive success by increasing human disturbance, crushing or burying eggs or unfledged chicks, reducing prey species, and impeding access to back-barrier foraging habitats. The removal of sediment from shoals, mudflats, and sandbars can affect habitats that are vital to overwintering and migrating shore- and waterbirds. Losses in the abundance and diversity of seagrass, macroinvertebrate, and benthic species during both the removal and placement phases of nourishment projects can propagate up through the food web to shore- and waterbirds, resulting in reduced shore- and waterbird populations on nourished beaches throughout the annual cycle. Detrimental effects to shore- and waterbirds through the food web can persist for months to several years. However, the placement of dredged materials can also provide entirely new foraging grounds for these birds where such habitats were lacking due to shoreline erosion.

This review found only a limited num-

ber of studies that evaluated the direct effects of beach nourishment on coastal taxa, and most of these studies focused on sea turtles and shorebirds. The following additional areas of research and monitoring are warranted: (1) the impacts of beach nourishment on plants, insects, and other species; (2) statistically rigorous before-and-after monitoring studies on species' population dynamics; (3) evaluation of the impacts of repeated nourishment cycles; (4) evaluation of the biological effects of construction, disturbance, and other related practices; and (5) evaluation of other beach nourishment-related impacts on sea turtles.

5. Impacts of Sediment Removal and Placement on Coastal Resiliency

Coastal resiliency is defined as the ability of a coastal system to withstand and adapt to perturbations, natural or otherwise. In their natural states, barrier islands are inherently resilient to short- and long-term drivers such as storms and sea-level rise, respectively. During storms, sediment is exchanged between the dunes, beach and shoreface to reduce wave energy. During post-storm periods of recovery, waves and currents return sediment to the beach to increase elevation and width, while winds transport beach sediment to the dunes so that they grow and revegetate. Over longer time scales, barrier islands migrate landward or seaward in response to changes in sea level, constantly changing elevations and widths in balance with sea level through dune overwash, alongshore transport, and marsh accretion. Connectivity through these short- and long-term exchanges of inorganic sediments and organic materials across the barrier island are critical for maintaining the form and function of its ecosystems. As such, it is this natural physical and ecological resilience that has allowed barrier islands to successfully support coastal communities and their economies. Sediment removal and placement can impact short- and long-term coastal resilience. Sediment placement is often, by design, a short-term strategy that can help protect coastal infrastructure and critical habitats from storm inundation. However, sediment removal at one location may cause downdrift shoreline erosion and reduced sediment supply at other locations. These impacts may be exacerbated by sea-level rise. A few studies suggest that nourishment may be helpful in reducing erosion under future sea-level rise; however, artificially high nourished dunes may reduce overwash and deprive back-barrier environments of deposition needed to keep pace with sea-level rise.

Based on the literature reviewed for this report, a number of current knowledge gaps exist on the effects of sand removal and placement on short- and long-term coastal resilience. Observations and modeling can be applied to: (1) studies to assess how past and present nourishment of beach, dune, and shoreface can improve long-term barrier island resilience, especially under future sea-level rise; (2) studies that evaluate the effects of shoreface and profile nourishment in the context of storm protection and short-term coastal resilience; (3) evaluation of the long-term effects of sediment removal from ebb deltas or channel dredging on sediment pathways and erosion and deposition patterns along adjacent shorelines; and (4) analysis of beach nourishment and frequent complementary activities (e.g., berm construction, sand fencing) on ecosystem connectivity over short and long timescales.

Q: What are the next steps with this report?

This report provides a comprehensive summary of the science that can help federal agencies evaluate the possible outcomes of sediment management actions within and adjacent to the CBRS. It can also be used to help inform project stakeholders and state and community coastal planners on the impacts of dredging and beach nourishment on coastal species, habitats, and barrier island resiliency. FWS and USGS plan to review the existing knowledge gaps in the report to help prioritize future research, modeling, and monitoring efforts. Furthermore, efforts will be made to identify best management practices that may ameliorate some of the identified negative impacts associated with sediment removal and placement in coastal barrier systems. Any future studies and collaborations will depend upon availability of resources for such efforts.

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