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Environmental Effects of Dredging

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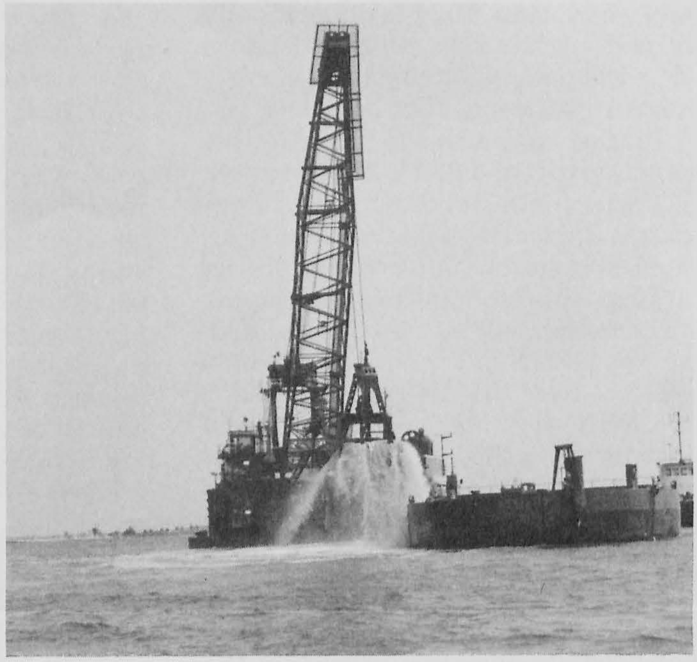

Mechanical dredge *Chicago* deepening the Mobile Bay Ship channel; dredged material is taken offshore to create a stable mound

Creation of Offshore Topographic Features With Dredged Material

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Dredged material has been placed at numerous sites in the offshore waters of the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. Much effort has been invested in monitoring programs to determine the physical and biological consequences of these operations. The typical monitoring program is geared toward detecting detrimental environmental effects that were identified as potential concerns during the planning and site selection process. Seldom has any attention been given to the potential beneficial aspects of offshore disposal, although the Corps of Engineers and other agencies are demonstrating that habitat and biological resource benefits can result from well planned disposal operations. Marsh, mangrove, seagrass, and oyster reef habitat creation or rehabilitation are examples of the types of beneficial-use options being explored for shallow waters. Similar beneficial uses of dredged material in offshore waters present a more formidable challenge.

Dredged material placement can follow either of two basic strategies. For one strategy the long-term disposal site goal is to have the deposited material disperse from the site, and the site selection process emphasizes hydrodynamically active sites. Beneficial effects at the site are limited to short-term phenomena, such as enhanced productivity of benthic organisms. More tangible benefits of placement at dispersive sites fall into the physical realm. For example, when the disposal site is properly situated, sediments transported off site can nourish beaches and alleviate shoreline erosion. The Mobile District and the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES) are currently engaged in such a "feeder berm" project. A second strategy can be applied when the disposal site is depositional in character, and a different spectrum of potential beneficial effects can be conceived. In this case the dredged material is intended to be confined to the disposal site boundaries for an extended period of time. Long-term beneficial effects may thus be considered, but they are limited to the disposal site itself. This article focuses on potential benefits of offshore placement at depositional sites.

Placement of dredged material at a depositional site will change the character of the bottom in several ways. The accumulation of a dredged material overburden will shoal the bottom to some degree based on the volume of disposed material, the mode of disposal (for example, fixed-point release versus scattered release throughout the site), and physical properties of disposed and in situ sediments. Subsidence, compaction, and surficial winnowing of fine-grained sediments are a few examples of physical processes that determine the ultimate character of the dredged material overburden. Continued placement of material at a site will inevitably create a detectable mound, and it is the formation of a mound that presents an opportunity to obtain certain types of resource benefits.

Attraction of many species of fish and shellfish to areas of high vertical relief has been documented, particularly for reef-dwelling species. In most such cases, the bottom relief has been provided by hard substrates such as rock outcrops or artificial structures. This tendency of many species to congregate around a topographic feature has led to the development of artificial reef technologies in support of recreational and commercial fisheries. A major unknown factor in deriving resource benefits with topographic features constructed of dredged material is the relative attractiveness of soft-bottom mounds to selected target species. Historically used offshore disposal sites have gained reputations as productive fishing spots, but these benefits have developed incidentally rather than intentionally and have remained essentially undocumented.

In recent years, as the demand for maintenance and new-work dredging projects has continued unabated and the availability of upland disposal sites has diminished, open-water disposal alternatives have received greater attention. In many regions open-water disposal, especially in estuarine waters, has been opposed, largely due to environmental concerns. In the future, offshore disposal may become one of the few alternatives for large-volume dredging projects. Establishing a better knowledge base for managing long-term sites, including ways to optimize resource utilization of disposal sites, would facilitate planning and coordination of future projects. Changing the negative perceptions of open-water disposal by demonstrating resource benefits would go a long way toward achieving stability and reliability in project scheduling.

Several Corps elements are presently investigating beneficial-use applications of dredged material placement in offshore waters. The New England Division, through the Disposal Area Monitoring System (DAMOS) Program, has developed an extensive physical and biological data base for a number of open-water disposal sites (Figure 1). These sites represent a cross-section of physical conditions; that is, old, historically used sites as well as relatively new sites, comparatively shallow versus deep sites, and sites that have received a range in volume of dredged material. Some resource benefits, such as improved fishing and lobster catches, have been tentatively attributed to several of these sites. With assistance from the WES under funding from the Dredging Operations Technical Support (DOTS) Program, the DAMOS data will be reexamined to look for relationships between physical alterations and biological responses at offshore dredged material mounds. A second effort is underway in the Mobile District. In conjunction with the deepening of the main navigation channel through Mobile Bay, AL, a very large volume of dredged material is being transported offshore to build a massive "stable mound" (Figure 2). In addition to intensive monitoring of physical processes associated with mound construction, the District will, with the assistance of the National Marine Fisher-

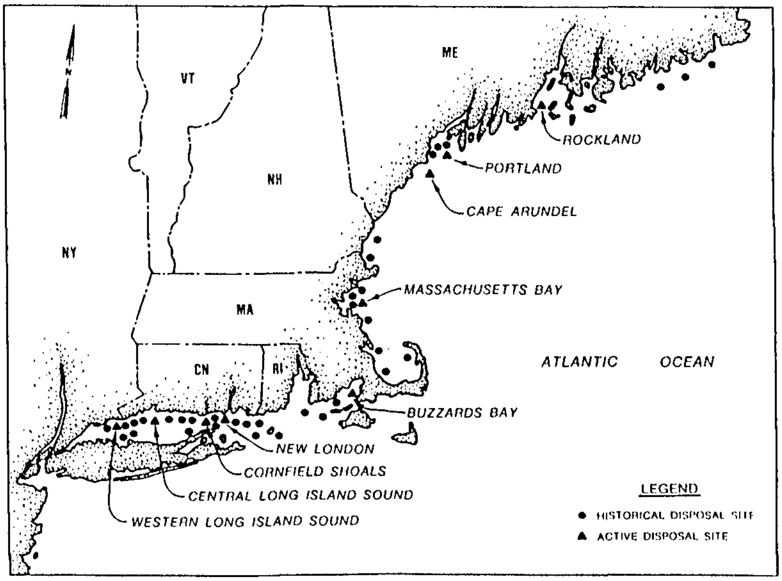

Figure 1. New England Division historical and active dredged material disposal sites

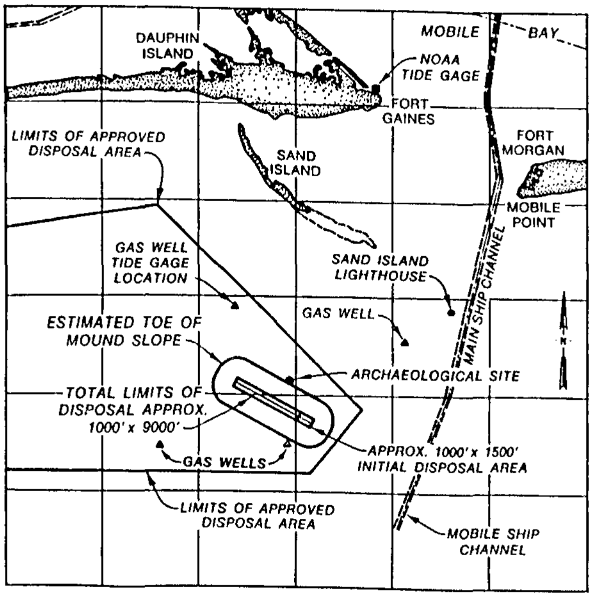

Figure 2. Location of the large-scale mound being constructed by the Mobile District in offshore Alabama waters

ies Service (NMFS) and WES, obtain an assessment of fishery resource impacts at the disposal site. In combination, the above studies will significantly increase the state of knowledge concerning resource benefits attributable to creation of large- or small-scale disposal mounds.

New England Study

Although documentation of enhanced fisheries resources at disposal sites would be informative, understanding the characteristics of a disposal mound that promote favorable use by target resources would be very valuable. Ultimately, a disposal mound could be designed to truly maximize resource benefits. Factors such as orientation of the mound to prevailing water currents, height of the mound in contrast to the surrounding topography, side-slope angle, and configuration of the mound's "footprint" on the bottom are a few examples of potentially important design features. Other factors may interact more subtly to influence use by fishes and shellfishes. For example, the grain-size distribution of the disposed sediments in comparison with the natural bottom may play a role in determining the feeding and shelter-seeking qualities that the mound provides for given faunal assemblages. However, the attraction may not be directly linked to the sediments. For example, eddies created in the flow of waters across the face of a mound may be attractive to fishes that feed on plankton that are swept by and to predacious fishes that feed on the planktivores. These effects have been noted in studies of artificial reefs.

This study seeks to identify key physical parameters of disposal mounds that contribute to their use by biological resources and to use this knowledge to establish an operational framework for future dredging and disposal projects. To establish this framework, the feasibility of constructing mounds of specified designs that would have theoretically optimal resource attributes would be determined. Obviously, dredged material composed of very fine-grained fluid sediments would have more limited side-slope design options than coarser material. Also, the requirements placed on the actual disposal operation in order to create a mound of a particular configuration should be evaluated logistically and economically. The New England study is intended to address both types of questions; that is, what amount of benefit can be derived from a given disposal project, and how can these benefits be imbedded into a routine disposal scenario?

As a subtask of the DAMOS Program, a conceptual approach and study plan to examine fishery resource-disposal mound interactions is being prepared. The study plan will consider target species selection, habitat value estimators, and mound design criteria. Target species selection can be expected to vary among locations based on distributions of fishery resources such as lobster, crabs, or various flounder. Mound designs suitable for lobster may be less suitable for other species. Also, frequency of disturbance as dictated by periodic disposal events may be an important determinant of site use by a given species. For some projects, use by multiple target species could be expected. The study plan will also look at various approaches to documenting fishery benefits, such as catch data, creel surveys, and interviews with commercial fishermen. An initial analysis of the DAMOS data base for compilation of relevant types of information acquired for each disposal site will allow several follow-up steps to be taken. First, gaps in the availability of information (for example, side-scan sonar surveys, precision bathymetry, substrate characterizations, trawl or submersible surveys) will be identified. A subset of disposal sites will then be selected for further study. The large number of historically and currently used sites in the New England Division's jurisdiction enables a number of comparisons to be made, such as between old and new disposal sites, between shallow and deep sites, and between sites with single- or multiple-mound formations. Figure 3 depicts a depth-contour plot of the Central Long Island Sound disposal site that reveals the presence of several mounds of various sizes. Ongoing monitoring work at the selected sites will be supplemented to provide data needed to make meaningful temporal and spatial comparisons.

Once a conceptual approach has been developed, a Corps-sponsored working group consisting of planning and construction/operations personnel from appropriate Districts will be convened. Fisheries experts from other Federal and state agencies and academia will also be invited to participate. With guidance from the working group, the study plan will be refined to channel efforts into the most productive avenues of investigation.

Implementation of the study plan will be phased into future disposal operations on a demonstration basis. The results of these operational tests will then be evaluated. If the results support the supposition that resource benefits can indeed be optimized by "designed" disposal mounds and that these benefits can be accrued without unreasonable modifications to disposal operation, including contracting and scheduling, then this information will be assembled and transferred to Corps field offices.

Gulf of Mexico Study

The "stable mound" construction project being performed by the Mobile District differs substantially from the New England disposal projects. In this instance, a very large quantity of dredged material (about 18.7 million cubic yards) is being placed to create a large-scale mound. Whereas the New England mounds generally represent a 4- to 5-metre vertical change of the preexisting bottom over a several hundred square metre area, the completed Mobile District mound will have approximate dimensions of a 6-metre bottom lift over a 9 million square metre bottom area. The projected side-slopes of the mound will extend outward to cover an area 4,800 metres wide by 12,400 metres long.

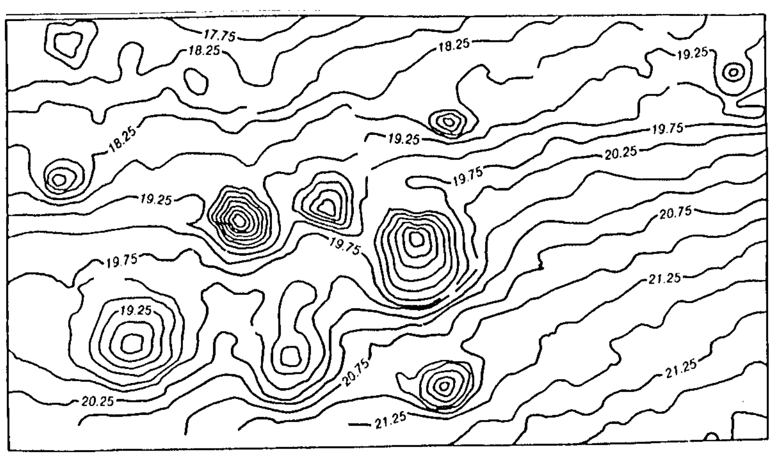

Figure 3. Bathymetric contours (in metres) of the Central Long Island Sound open-water disposal site showing the formation of multiple small-scale mounds scattered throughout the site

An extensive physical and biological monitoring program has been initiated for this placement project. The Mobile District and CERC are jointly evaluating the stability of the mound. Physical monitoring includes areal sediment characterization, sediment coring, wave and current regime measurements, side-scan sonar surveys, subbottom profiling, bathymetric mapping, and sediment profiling imagery. An initial step in the ongoing placement process is the creation of a test mound at the eastern end of the disposal site (Figure 2), where existing bottom depths are approximately 12 to 14 metres. After sufficient material (about 5 million cubic yards) has been placed at the test site to raise the bottom about 6 metres, the disposal discharge zone will be moved to the opposite end of the disposal site and progress southeasterly toward the test mound. This will allow monitoring to proceed early in the construction process and expedite the feedback of information on the behavior of sediments in the test mound. Wave, tide, wind, and barometric pressure instrumentation will record site conditions continuously throughout the monitoring program. All other physical monitoring will be done on a quarterly basis to provide seasonal analyses.

Biological monitoring at the mound construction site will attempt to detect acute changes in benthic, epibenthic, and fish communities. In keeping with the current Memorandum of Agreement between the Corps and the NMFS to determine the feasibility of a nationwide fisheries habitat restoration and creation program, the NMFS will conduct otter trawling, fish trapping, and water sampling within and adjacent to the disposal site on a periodic basis. Determining the effects of mound formation on the distribution and abundances of important recreational and commercial fishery species will be emphasized. Changes in distribution and abundances will be examined with respect to concomitant changes in sediment and current regimes. Because the NMFS has acquired fishery data at stations in the vicinity of the disposal site for a number of years, a comparison of the historical record to postconstruction catches should reveal any significant shifts in epibenthos and fish community structures. Sampling will occur biannually, during warm- and coldwater periods.

The obtained distribution and abundance data may be subjectively interpreted as either detrimental or beneficial effects on the fisheries if the observed changes are subtle. However, if significant increases in the catches of desirable species such as red snapper or grouper are demonstrated to occur, this would indicate the realization of beneficial-use objectives.

The disposal area lies along a pathway that many migratory species such as penaeid shrimp follow into and out of the Mobile Bay estuary. Once completed, the mound can be expected to form an unobstructed trawling alley for commercial fishermen. Heavy fishing pressure at the site may have implications for fisheries resource assessments and for long-term stability of the mound itself. To evaluate fishing pressure, aerial surveys will be conducted to obtain standardized counts of commercial and recreational vessels within and outside of the disposal area boundaries. These efforts will be supported by the WES. Physical disturbance of the mound itself by trawling activities will be evaluated by sediment profiling imagery and opportunistically by diver surveys.

An additional aspect of potential beneficial impacts is that of enhanced benthic production, which can be related to greater availability of food resources for bottom-feeding fishes. To monitor the establishment of benthic infaunal organisms on the mound, to compare mound benthos to that of the surrounding area, and to measure the use of these benthic assemblages by fishes, WES will take quantitative box-cores as well as fish food habits samples along transects across the mound structure and through outlying reference areas.

When completed, the offshore mound monitoring program should provide a relatively comprehensive picture of the environmental consequences of large mound construction. The results should also serve as a field test of the concept of beneficial uses of dredged material in offshore settings.

Summary

Creation of offshore topographic features has been attempted with dredged material in the past (for example, the Norfolk District built an offshore mound in 1982 with maintenance material placed at the Dam Neck disposal site), but has never been adequately documented from a fisheries resource benefits perspective. Cooperative studies by the Corps and other federal agencies will address this issue. If these innovative approaches to offshore disposal operations are successful, they will represent a significant advance in the Corps' ability to fulfill its future dredging mission in an environmentally responsive and productive manner.

Several Corps elements are investigating beneficial-use applications of dredged material placement in open-water areas. Monitoring to document beneficial uses is being performed in open waters of the Atlantic Ocean by the New England Division and the Gulf of Mexico by the Mobile District

ENVIRONMENTAL EFFECTS OF DREDGING

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