

# NON-TECHNICAL SUMMARY

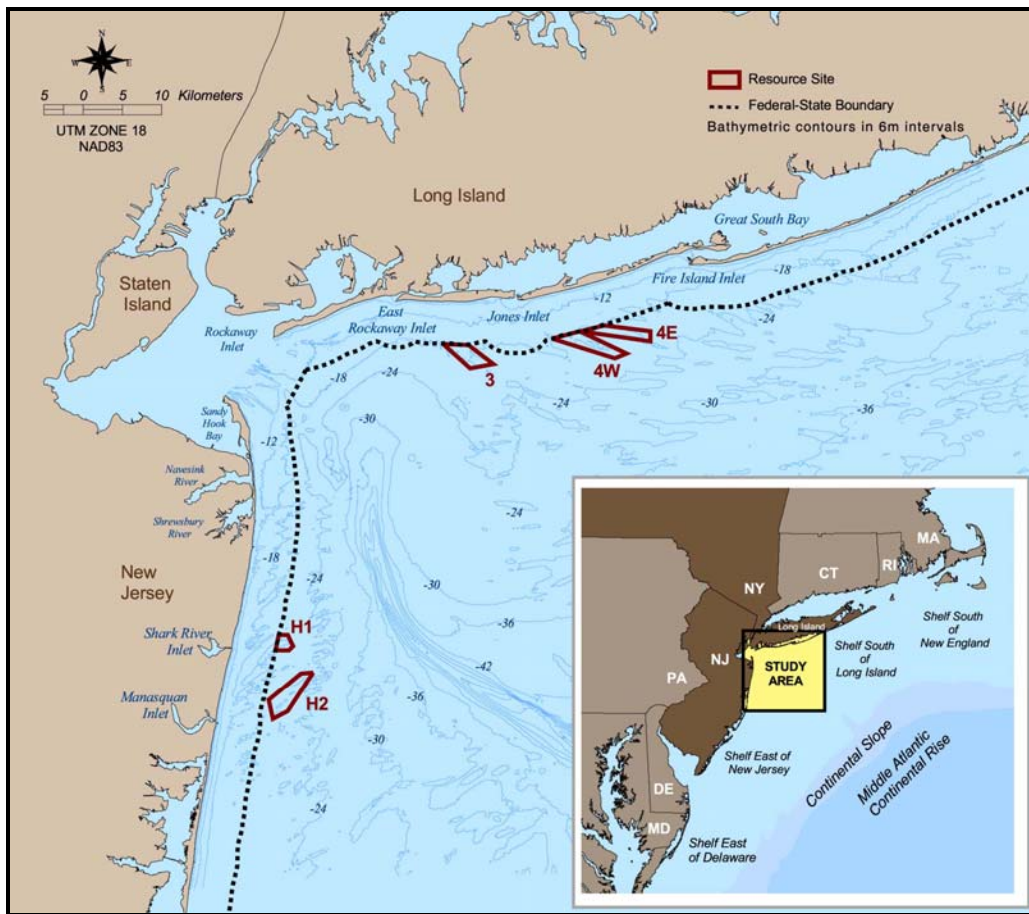
## ENVIRONMENTAL SURVEYS OF POTENTIAL BORROW AREAS OFFSHORE NORTHERN NEW JERSEY AND SOUTHERN NEW YORK AND THE ENVIRONMENTAL IMPLICATIONS OF SAND REMOVAL FOR COASTAL AND BEACH RESTORATION

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## **ENVIRONMENTAL SURVEYS OF POTENTIAL BORROW AREAS OFFSHORE NORTHERN NEW JERSEY AND SOUTHERN NEW YORK AND THE ENVIRONMENTAL IMPLICATIONS OF SAND REMOVAL FOR COASTAL AND BEACH RESTORATION**

In recent years, there has been increasing interest in sand and gravel mining on the Outer Continental Shelf (OCS). The U.S. Department of the Interior, Minerals Management Service (MMS) has responsibilities with respect to potential environmental impacts of sand and gravel mining. Existing regulations governing sand and gravel mining provide a framework for comprehensive environmental protection during operations. Guidelines for protecting the environment stem from a wide variety of laws, including the OCS Lands Act (OCSLA), National Environmental Policy Act (NEPA), Endangered Species Act, Marine Mammal Protection Act, and others. Regulations require activities to be conducted in a manner which prevents or minimizes the likelihood of any occurrences that may cause damage to the environment.

Under the OCSLA, the MMS is required to conduct environmental studies to obtain information useful for decisions related to negotiated agreements and lease activities. As such, the MMS pursues its responsibilities for management of offshore sand and gravel mining by:

- protecting ocean and coastal environments by ensuring that all OCS sand and gravel mining activities are environmentally acceptable;
- ensuring that OCS sand and gravel activities are compatible with other uses of the ocean;
- involving coastal States in sand and gravel mining activities; and
- evaluating the potential of the OCS as a domestic source for sand and gravel resources.

To this end, the MMS initiated environmental studies along the U.S. Atlantic and Gulf coasts to provide information for programmatic marine mining decisions at MMS Headquarters and OCS Regional Offices (follow the link to review progress of the MMS Marine Minerals Program; <http://www.mms.gov/sandandgravel/>). The report discussed in this Non-Technical Summary presents results from one of the environmental studies administered under the MMS Marine Minerals Program. Entitled “Environmental Surveys of Potential Borrow Areas Offshore Northern New Jersey and Southern New York and the Environmental Implications of Sand Removal for Coastal and Beach Restoration”, the Final Report was prepared by Applied Coastal Research and Engineering, Inc. (Applied Coastal) in cooperation with Continental Shelf Associates, Inc. (CSA), Barry A. Vittor & Associates, Inc. (BVA), and Germano & Associates, Inc. under MMS Contract No. 1435-01-01-CT-31118.

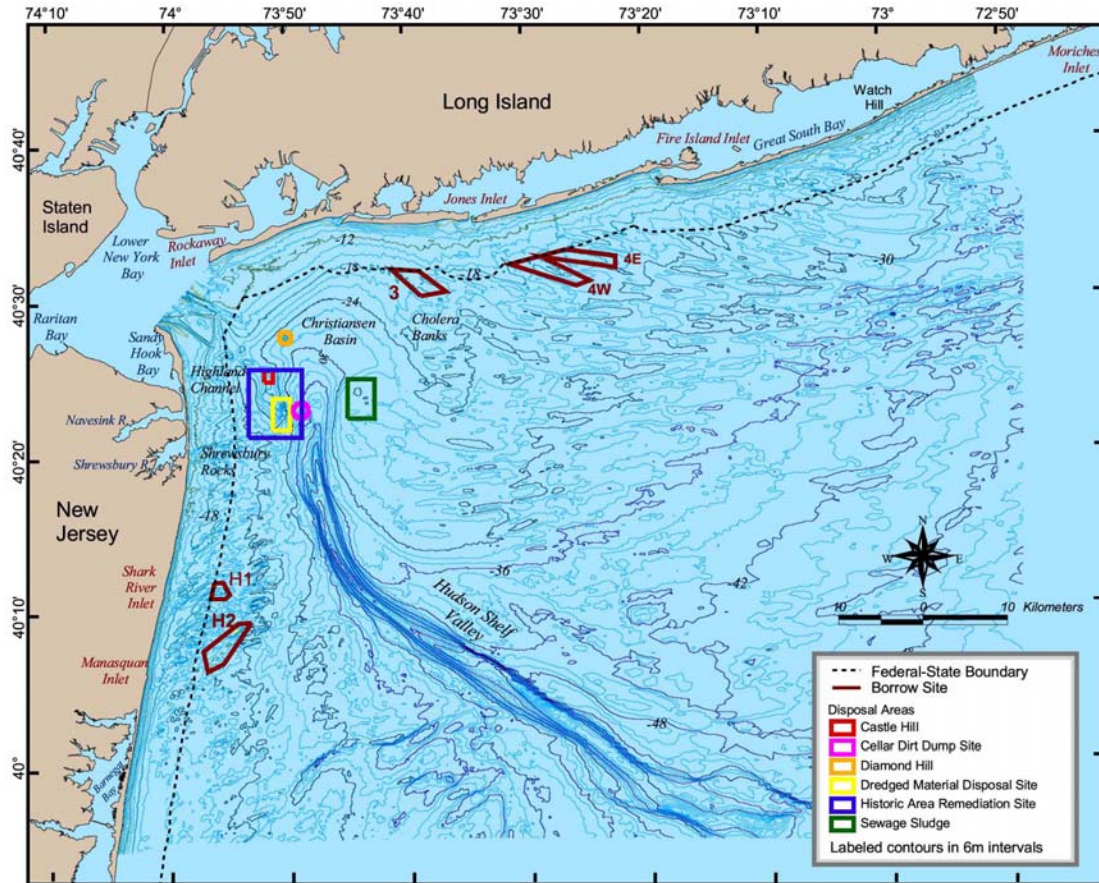
### **BACKGROUND**

The inshore portion of the northern New Jersey and southern New York continental shelf, seaward of the Federal-State OCS boundary and within the Exclusive Economic Zone (EEZ), encompasses the project study area (Figure 1). The project site forms a rectangular area along the two outer coastlines and adjacent continental shelf. It encompasses about 31 mi (50 km) of the northernmost New Jersey coastline from Manasquan Inlet to Sandy Hook and about 68 mi (110 km) of coastline in southwestern Long Island from Rockaway Point to Moriches Inlet (Figure 1). The seaward limit of the study area extends to approximately the 100-ft (30-m) depth contour, a distance of about 6 to 19 mi (10 to 30 km) from the shoreline.



**Figure 1.** Physical setting of the New York and New Jersey coastlines.

The continental shelf within the New Jersey-New York study area is characterized primarily by isolated linear sand shoals and ridges, and localized dredged material disposal mounds (Figure 2). Two sand borrow sites (H1 and H2) in northeastern New Jersey were identified seaward of the Federal-State boundary and between Manasquan and Shark River Inlets. Water depth over the ridges ranged from about 45 to 65 ft (14 to 20 m), and maximum elevation above the surrounding sea floor was about 16 ft (5 m). Linear shoals offshore northern New Jersey typically are separated from the coast by about 3 to 3.5 mi (5 to 6 km), vary in length from 1 to 3.5 mi (2 to 6 km), and have a mean width of about 1000 ft (300 m). All shoals have their long axis oriented east-northeast and have an average angle of about 30° to 85° with the shoreline. Sand borrow sites south of Long Island were characterized as modern sand and gravel ridges by the United State Geological Survey (USGS). Borrow Site 3 exists south of Long Beach Island, encompassing a relatively broad northwest-southeast trending shoal defined by the -62 ft (-19 m contour). Water depth over the shoal ranges from about 55 to 62 ft (17 to 19 m), and maximum elevation above the surrounding sea floor was about 7 ft (2 m). Borrow Sites 4W and 4E exist as two shoreface-attached shoals seaward of the Federal-State boundary and south of Jones Beach. Sand ridges form angles of 30° to 40° with the shoreline and thicken to the east. Shoals in these two areas show increased relief and thus provide greater potential for available sand than at Site 3, with shoal depths ranging from 52 to 66 ft (16 to 20 m). Maximum elevation above the surrounding sea floor was about (13 ft) 4 m.



**Figure 2.** Prominent geomorphic features of the New York Bight continental shelf in relation to potential sand resource areas and offshore disposal sites.

Potential sand excavation quantities were determined for each of the borrow sites using bathymetric data. Excavation depths were determined based on average depth of the ambient shelf surface adjacent to each of the shoals comprising the borrow sites. Using contour elevations of about -62 and -66 ft (-19 and -20 m), shoal volumes were calculated to determine the availability of potential excavation material. Borrow Sites H1 and H2 provided a total volume of about 6,300,000 and 12,400,000 yd<sup>3</sup> (4,800,000 and 9,500,000 m<sup>3</sup>) of sand, respectively. Surface areas associated with excavation volumes were 3,950,000 and 15,670,000 ft<sup>2</sup> (3,300,000 and 13,100,000 m<sup>2</sup>), respectively. Depths associated with shoal features ranged from 45 to 65 ft (14 to 20 m) at Borrow Site H1 and 49 to 65 ft (15 to 20 m) at Borrow Site H2, with shoal depths at Borrow Site H1 generally shallower than those at Borrow Site H2. The majority of the H1 shoal crests were above the -59 ft (-18 m) contour, whereas the shoal comprising Borrow Site H2 maintains only small peaks along the -59 ft (-18 m) contour, with the majority of the shoal ranging from 59 to 65 ft (18 to 20 m) deep. The average thickness of sediment comprising the total excavation volume in H1 is about 5 ft (1.5 m), and the average sand thickness associated with the volume calculated for H2 is 2.3 ft (0.7 m).

For Borrow Sites 3, 4W, and 4E south of Long Island, potential sand volumes were calculated at 14,600,000; 25,900,000; and 21,800,000 yd<sup>3</sup> (11,200,000; 19,800,000; and 16,000,000 m<sup>3</sup>), respectively. Surface areas associated with these volumes were 11,200,000; 14,600,000; and 11,200,000 yd<sup>2</sup> (9,400,000; 12,200,000; and 9,400,000 m<sup>2</sup>), which corresponds to average thicknesses of 3.9, 5.3, and 5.8 ft (1.2, 1.6, and 1.8 m), respectively. Borrow Site 3

is located along the shallowest features in the study area, with the majority of the borrow site located in depths shallower than 59 ft (18 m). Shoals comprising Borrow Sites 4W and 4E have similar depths, and sediment thicknesses along shoals south of Fire Island tend to increase from west to east. As such, Borrow Site 4E maintains the greatest excavation thickness.

Overall, average median grain size for all sites ranged from medium to very coarse sand. Three of the five sites (H2, 4W, and 4E) consisted primarily of medium-grained sand. Borrow Site 3 had the highest average grain size, which was expected due to its location immediately north of Cholera Banks, a very coarse-grained outcrop of old sediment. Borrow Sites 4W and 4E, located to the east of Borrow Site 3, were comprised generally of medium-grained sand. Offshore northeastern New Jersey, Borrow Site H1 was classified as medium- to coarse-grained sand and Borrow Site H2 contained medium sand.

## **PURPOSE**

The primary purpose of the study was to address environmental concerns raised by the potential for dredging OCS sand offshore northeastern New Jersey and southwestern Long Island, and to document the findings in a technical report. Environmental information was collected and compiled to assist the MMS in making future decisions relative to negotiated agreements (non-competitive leases), NEPA documents (Environmental Assessments and Environmental Impact Statements), and other regulatory requirements concerning Federal sand deposits offshore New Jersey and Long Island. Primary environmental concerns focused on physical and biological components of the OCS environment. To this end, the MMS identified five study objectives at the beginning of the project:

### **Physical Objectives**

- *Wave Modifications:* Evaluate potential modifications to waves and currents in the study region due to offshore dredging within potential sand resource areas.
- *Sediment Transport Patterns:* Evaluate impacts of dredging in Federal waters and beach nourishment in terms of potential alterations in sediment transport patterns and sedimentary environments, and impacts to local shoreline processes.

### **Biological Objectives**

- *Benthic Ecological Conditions:* Characterize benthic (bottom) ecological conditions in and around potential sand resource areas identified by the MMS, New Jersey Geological Survey (NJGS), and U.S. Army Corps of Engineers, New York District (USACE-NY).
- *Benthic Infaunal Evaluation:* Evaluate benthic infauna (animals living in the seafloor) resident in potential sand resource areas and assess potential effects of offshore dredging activity on these organisms, including an analysis of recolonization periods and success after dredging activities.
- *Project Scheduling Considerations:* Evaluate times for dredging in the sand resource areas relative to transitory pelagic species (organism that periodically occur in the water column).

In meeting these objectives, the Final Report provides valuable information regarding environmental concerns examined relative to proposed future sand dredging offshore northeastern New Jersey and southwestern Long Island in support of beach replenishment needs. This following summary highlights conclusions of the study relative to project objectives.

## **SIGNIFICANT CONCLUSIONS**

The following discussion provides a summary of results and conclusions regarding the potential environmental effects of sand mining on the OCS for replenishing sand to eroding beaches. Because benthic and pelagic biological characteristics are in part determined by physical processes that vary with location and time throughout the study area, physical processes analyses are summarized first.

### **Spectral Wave Transformation Modeling**

Excavation of borrow sites in the nearshore can affect offshore wave heights and the direction of wave propagation. The existence of offshore topographic relief can cause waves to refract toward the shallow edges of borrow sites. This alteration to the wave field by a borrow site may change local sediment transport rates, where some areas may experience a reduction in transport, while other areas may show an increase. To determine the potential physical impacts associated with dredging borrow sites offshore southwestern Long Island and northeastern New Jersey, spectral wave transformation modeling was used to simulate changing wave patterns because of its ability to propagate individual components of a wave energy distribution (a spectrum) simultaneously across the continental shelf. By simulating several wave components simultaneously, a spectral wave model represents nature more closely. Rather than selecting the most common wave heights and directions as model input, a detailed analysis was conducted to summarize existing wave data into average directions and spectra. Each direction may contain distinct differences in energy and/or directional spectra, and consequently produce varying impacts at borrow locations. Although the interpretation of wave modeling results was relatively straightforward, evaluating the significance of predicted changes for accepting or rejecting a borrow site was more complex.

#### *Offshore Southwestern Long Island*

Linear offshore sand shoals, oriented obliquely to the shoreline in a northwest-southeast direction, are the primary geomorphic features influencing wave propagation offshore southwestern Long Island beaches. Two dominant, relatively long-period wave cases were selected to simulate the impact of dredging on wave transformation across borrow sites. For 4.3 ft (1.3 m), 9.1 sec waves propagating from the east-southeast, shoals encompassed by Borrow Sites 3, 4W, and 4E had the greatest influence on waves in the modeled area; however, effects to waves were relatively small because these shoals are located in approximately 56 to 66 ft (17 to 20 m) water depth. For 5.2 ft (1.6 m), 9.1 sec waves propagating from the southeast, the offshore incident wave angle is more shore-normal, resulting in less change in wave direction as waves approach the shoreline.

Post-dredging wave height changes at Sites 3, 4W, and 4E illustrate the impact of sand extraction at borrow sites, where seafloor topography within each site was lowered to a level not exceeding water depths at the base of the shoals (approximately -66 ft [-20 m]). For 4.3 ft (1.3 m), 9.1 sec waves from the east-southeast, borrow site dredging had no measurable influence on wave propagation over a long section of coastline (>27 mi [44 km]), but changes on the order of 0.4 in (0.01 m) do occur along 12 mi (20 km) of coast in the combined shadow of the three borrow sites. At Site 4E, maximum wave height decrease was approximately 2.0 in (0.05 m), and the maximum increase was 3.9 in (0.10 m) at the landward boundary of the site. At Site 4W, maximum wave height increase was 3.9 in (0.10 m), and maximum wave height decrease was 3.5 in (0.09 m). Seafloor excavation at Site 3 produced smallest wave height changes for borrow sites offshore southwestern Long Island, with a maximum decrease of 2.4 in (0.06 m) and a maximum increase of 1.6 in (0.04 m). Minimal computed changes at Site 3 may be due to the relatively small volume of sand excavated from this site, and because changes in

seafloor elevation for post-dredging conditions were less (approximately 6.6 ft [2 m] change for Site 3, versus 13.1 ft [4 m] for Sites 4W and 4E).

For 5.2 ft (1.6 m), 9.1 sec waves from the southeast, changes in wave field propagation resulting from dredging at the three offshore borrow sites were smaller than those computed for the previous case, even though the wave height for this case is larger. This effect may be due to a combination of incident wave angle and directional orientation of shoals upon which borrow sites are located. For the 4.3-ft (1.3-m) wave case, wave approach angle is oriented closer to the centerline axis of the shoal ridge, which causes slightly more wave energy focusing than the 5.2-ft (1.6-m) case. The wave shadow zone from these three sites affects approximately 28 mi (45 km) of shoreline, but greatest changes are on the order of 0.4 in (0.01 m) and occur within a (2.5 mi) 4 km stretch of shore at the western end of Jones Beach. At Site 4E, maximum wave height changes range from +2.8 to -1.6 in (+0.07 to -0.04 m); at Site 4W, wave height changes are of similar magnitude. For Borrow Site 3, wave height changes are equivalent to the 4.3-ft (1.3-m) wave simulation, with a maximum wave height increase of 1.6 in (0.04 m) and a corresponding decrease of 2.4 in (0.06 m).

#### Offshore Northeastern New Jersey

Potential sand borrow sites offshore northeastern New Jersey are oriented obliquely to the shoreline in a northeast-southwest direction and have minimal influence on wave propagation to the shoreline. Two dominant wave cases were selected to simulate the impact of dredging on wave transformation across borrow sites. For 4.3 ft (1.3 m), 9.1 sec waves propagating from the east, shoals encompassed by Borrow Sites H1 and H2 exhibited minimal wave focusing. The approximate minimum water depths at Sites H1 and H2 are 52 and 56 ft (16 and 17 m), respectively. For the shoal at Site H1, maximum wave height increase was 5.1 in (0.13 m) due to the focusing effect of the sand ridge. For 4.3 ft (1.3 m), 7.7 sec waves propagating from the south-southeast, wave height changes at Sites H1 and H2 are not as pronounced as those for 9.1-sec wave case. The primary reason for this difference is that offshore bathymetry has less effect on wave focusing for shorter peak period incident waves. Closer to shore in shallower water, approaching waves eventually are influenced by the seafloor as they refract to a more shore normal angle.

Post-dredging wave height changes at Sites H1 and H2 simulate the impact of sand extraction at borrow sites, where seafloor topography within each site was lowered to a level not exceeding water depths at the base of the shoals (approximately -66 ft [-20 m]). Wave height differences for the 9.1-sec wave case resulting from numerically excavating Sites H1 and H2 are relatively small and diffuse, and wave height changes at the modeled shoreline are less than 0.4 in (0.01 m). At Sites H1 and H2, maximum changes in wave height are about  $\pm 2.4$  in ( $\pm 0.06$  m).

For the 7.7-sec wave case, wave height changes indicate that borrow sites have an overlapping influence at the shoreline for waves propagating from the SSE. However, calculated wave height changes at the shoreline relative to potential offshore sand dredging are never greater than 0.4 in (0.01 m). Wave height changes at borrow sites are smaller than those for the 9.1-sec wave case due to a shorter wave period. Site H1 exists within the wave shadow zone for Site H2, but wave height changes remain relatively small. Maximum wave height changes are about  $\pm 1.6$  in ( $\pm 0.04$  m) at Site H1 and  $\pm$ in ( $\pm 0.02$  m) at Site H2. Overall, calculated wave height differences between existing and post-dredging conditions are quite small relative to natural wave height variability.

## Circulation and Sediment Transport Dynamics

While no large-scale predictive circulation models were developed to quantify effects of dredging at sand borrow sites, the analysis of current patterns resulting from this study suggests proposed sand mining will have negligible impact on large-scale shelf circulation. The proposed sand mining locations are small relative to the entire shelf area, and it is anticipated that proposed dredging will not remove enough material to significantly alter major seafloor features in the region. Therefore, proposed changes to seafloor features that principally affect circulation patterns will remain relatively unchanged.

Circulation patterns on either side of the Hudson Shelf Valley near potential offshore sand borrow sites documented speed and direction related to current and wind patterns recorded between December 4, 1999 and April 15, 2000. The high-energy environment associated with winter storm events is capable of suspending and transporting sediment and is well suited for determining maximum sediment transport rates for the region. Overall, current meter data compiled for this area generally agrees with regional hydrodynamic modeling results predicted by the U.S. Army Corps of Engineers; bottom currents in the vicinity of offshore borrow sites are driven primarily by winds and influenced by tidal flows. The predominant direction of surface flow within the study area varied from southeast (west of Hudson Shelf Valley) to south-southeast (east of the Hudson Shelf Valley). Surface current magnitudes also were consistent, showing similar maximums, means, and standard deviations. Bottom current measurements illustrated greater variability in direction and magnitude. Offshore northeastern New Jersey, predominant bottom current flow varied from east-southeast to west, while the predominant bottom current flow east of the Hudson Shelf Valley varied from north to south-southeast. Differences in bottom flow may be explained by the presence of the Hudson Shelf Valley, which bisects the continental shelf in this region causing currents to veer to the north as they flow cross contour into the bathometric low from northeast to southwest. Strong northerly flow within the valley prevents currents south and west of this area from flowing to the east-northeast.

The controlling factor for bottom current velocities in the vicinity of proposed sand borrow sites was wind direction and intensity, and local bathometric features controlled current direction. Bottom currents tended to flow parallel to contours causing currents to diverge around localized bathymetric highs and converge near bathymetric lows. In general, bottom flows at the borrow sites offshore southwestern Long Island flowed east-southeast or east and west with deviations caused by wind direction. Maximum bottom current speed was about 1.1 ft/s (35 cm/s) flowing east, with a mean speed of 0.3 ft/s (8 cm/s) flowing southeast. Offshore northeastern New Jersey, bottom currents generally flow north and south along bathymetric contours. Maximum bottom current speed for this area was about 0.85 ft/s (26 cm/s) flowing north, with a mean velocity of 0.2 ft/s (6 cm/s) flowing north. Bottom current speeds at both sites primarily were controlled by wind speeds, and the direction of flow was controlled by local bathymetry.

Because proposed sand mining locations are small relative to the entire shelf area, it is anticipated that proposed dredging will not remove enough material to significantly alter major seafloor features in the region. Therefore, proposed changes to seafloor features that principally affect circulation patterns will remain relatively unchanged.

Three independent sediment transport analyses were completed to evaluate impacts due to offshore sand dredging. First, historical sediment transport trends were quantified to document regional, long-term sediment movement throughout the study area using historical bathymetry data sets. Second, sediment transport patterns at proposed offshore borrow sites were evaluated using wave modeling results and current measurements. Third, nearshore currents and sediment transport were modeled using wave modeling output to document

potential impacts to beach erosion and accretion. All three methods were compared for evaluating consistency of measurements relative to predictions, and potential impacts were identified.

### Historical Sediment Transport Patterns

Regional geomorphic changes between 1873/88 and 1991/97 (southwestern Long Island) and 1836/39 and 1977 (northeastern New Jersey) were analyzed for assessing long-term, net coastal sediment transport dynamics. Although these data did not provide information on potential impacts of sand dredging from proposed borrow sites, they did provide a means of verifying predictive sediment transport models relative to infilling rates at borrow sites and longshore sand transport.

Shoreline position and nearshore bathymetry change documented four important trends relative to study objectives. First, there were three dominant directions of longshore sand transport within the study area. Between Rockaway Point and Moriches Inlet, the dominant direction of transport was east to west. In northern New Jersey, between Sandy Hook and Manasquan, longshore transport from south to north dominated, while south of Manasquan Inlet, the dominant direction was to the south. Along both coasts, the dominant direction of transport was illustrated by barrier island migration and shoreline advance adjacent to inlet jetties. Barrier islands along the south coast of Long Island have historically migrated from east to west, and seaward shoreline advance subsequent to jetty construction has occurred along the east sides of entrances. In northern New Jersey, Sandy Hook spit historically has migrated rapidly to the north, and prior to structural development at Barnegat Inlet, the spit north of the entrance was rapidly migrating to the south. The greatest amount of shoreline change observed for this study was associated with beaches adjacent to entrances, most notably along the leading edge of prograding barrier spits.

Second, the most dynamic features within the study area, in terms of nearshore sediment transport, are migrating barrier island/spit complexes along the northeastern New Jersey and southwestern Long Island coasts, in addition to natural and anthropogenic change along the Hudson River Channel. Areas of significant erosion and accretion are documented between 1927/37 and 1927/97 at Sandy Hook spit, reflecting wave and current dynamics that carry sediment northward and deposit it along the terminal edge of the spit.

Third, alternating bands of erosion and accretion paralleling ridge features illustrated the steady reworking of the shelf surface as sand ridges migrated in the direction of net sediment transport. The process by which this was occurring was relatively consistent across the shelf. At Borrow Site H1, bathymetric comparisons suggested that the borrow site in this region would fill with sand transported from the adjacent seafloor at rates of about 128,000 yd<sup>3</sup>/yr (98,000 m<sup>3</sup>/yr). Areas of erosion and accretion documented between 1927/37 and 1927/97 at Borrow Site 4E illustrated the amount of sediment available for infilling at sites south of Long Island was also about 128,000 yd<sup>3</sup>/yr (98,000 m<sup>3</sup>/yr). Calculations for these two borrow sites were used as indicators of potential infilling rates for all borrow sites within the study area.

Finally, net longshore transport rates determined from seafloor changes in the littoral zone along Sandy Hook spit indicated maximum transport rates near the distal end of the spit, with lower rates to the south. These calculations, along with data published indicate a range in net longshore transport along Sandy Hook from about 292,000 to 500,000 yd<sup>3</sup>/yr (223,000 to 382,000 m<sup>3</sup>/yr). Based on USACE estimates, the direction of net littoral drift along southwestern Long Island beaches is east to west, ranging from 160,000 to 450,000 yd<sup>3</sup>/yr (122,000 to 344,000 m<sup>3</sup>/yr).

### Sediment Transport at Potential Borrow Sites

In addition to predicted modifications to the wave field, potential sand mining at offshore borrow sites resulted in minor changes in sediment transport pathways in and around potential dredging sites. Modifications to bathymetry caused by sand mining only influenced local hydrodynamic and sediment transport processes in the offshore area. Wave height changes at and adjacent to dredged borrow sites experienced minor changes in wave or sediment transport characteristics.

For water depths at the proposed borrow sites, minimal impacts to waves, currents, and regional sediment transport are expected during infilling. Infilling rates computed for each of the five borrow sites offshore northeastern New Jersey and southwestern Long Island represented the total potential sediment transport at each of the sites from the combined influence of wave-induced and ambient bottom currents. These results likely represent average, non-storm conditions for sediment transport at each site. For the five modeled borrow sites, computed transport rates were extremely low, with infilling rates ranging from about 0 to approximately 760 yd<sup>3</sup>/yr (580 m<sup>3</sup>/yr). A number of factors contributed to the low transport rates, including water depth (typically 66 ft [20 m], which reduced the impact of wave-induced currents), relatively short period waves dominating the regional wave climate, absence of storm events in the wave and current data sets that drive sediment transport in this area, coarse grain size of *in situ* materials, and relatively weak ambient shelf currents. Furthermore, potential borrow site excavations consisted of dredging an existing shoal to the same elevation as the surrounding seafloor. Therefore, potential borrow site excavation would primarily flatten the shoal and not create a seafloor depression. Based on extremely low potential transport rates of *in situ* sediment and the geomorphic character of dredged deposits, it is unlikely that any of these borrow sites will reform as shoal deposits in the near future.

### Nearshore Sediment Transport Modeling

Comparisons of average annual sediment transport potential were performed for existing and post-dredging conditions to indicate the relative impact of dredging to longshore sediment transport processes. Mean sediment transport potential calculated for beaches east of Jones Inlet indicate net westerly transport ranging from about 71,000 yd<sup>3</sup>/yr (54,000 m<sup>3</sup>/yr) at Fire Island Inlet to 222,000 yd<sup>3</sup>/yr (170,000 m<sup>3</sup>/yr) at Jones Inlet. Along Long Beach, net westerly transport increased from about 65,000 yd<sup>3</sup>/yr (50,000 m<sup>3</sup>/yr) west of Jones Inlet to a maximum of about 196,000 yd<sup>3</sup>/yr (150,000 m<sup>3</sup>/yr) at the approximate mid-point of the barrier beach, before decreasing to about 115,000 yd<sup>3</sup>/yr (88,000 m<sup>3</sup>/yr) at East Rockaway Inlet.

Mean sediment transport potential along the northeast coast of New Jersey for the modeled 20-year period indicated that dominant transport was net northerly but more bi-directional for shorter term annual results. There was an approximate  $\pm 72,000$  yd<sup>3</sup>/yr ( $\pm 55,000$  m<sup>3</sup>/yr) range in annual net transport rates. Long-term potential transport rates reached a maximum of approximately 39,000 yd<sup>3</sup>/yr (30,000 m<sup>3</sup>/yr) within the modeled study area, and a minimum occurred just north of Shark River Inlet. Results of transport potential calculations indicated that the year with the greatest net southerly transport was 1987, and the year with the greatest northerly directed transport was 1995.

The significance of changes to longshore transport along the modeled shoreline resulting from dredging proposed borrow sites to their maximum design depths was determined using the annual variability in potential transport rates for the 20-yr wave record. Results of the significance analysis for borrow sites offshore southwestern Long Island indicated that the  $\pm 0.5\sigma$  significance envelope increased along Jones Beach from  $\pm 26,000$  yd<sup>3</sup>/yr ( $\pm 20,000$  m<sup>3</sup>/yr) at Fire

Island Inlet to  $\pm 52,000 \text{ yd}^3/\text{yr}$  ( $\pm 40,000 \text{ m}^3/\text{yr}$ ) at Jones Inlet. The significance envelope for Long Beach had a similar range, with a maximum value midway between Jones Inlet and East Rockaway Inlet. Potential dredging impacts to longshore transport rates from excavation at Sites 3, 4W, and 4E are well within the transport significance envelope. As such, proposed dredging at these sites would produce insignificant modifications to coastal processes along this shoreline. Shoreline impacts are negligible due to the relatively deep water at potential borrow sites (19 m for Site 3 and 20 m for Sites 4W and 4E), their distance offshore, and wave climate (dominated by relatively short-period waves).

Results of the impact significance analysis for sites offshore northeastern New Jersey indicated that the  $\pm 0.5\sigma$  significance envelope computed for this area was generally constant at  $\pm 20,000 \text{ yd}^3/\text{yr}$  ( $\pm 15,000 \text{ m}^3/\text{yr}$ ). Impacts from dredging Sites H1 and H2 are well within the significance envelope, and proposed sites would be acceptable under the simulated conditions. Similar to sites offshore Long Island, potential shoreline impacts were negligible due to the relatively deep water at potential borrow sites (66 ft [20 m] for Sites H1 and H2), their distance offshore, and wave climate (dominated by relatively short-period waves).

### **Benthic Environment**

Seafloor organisms surveyed from the New Jersey and New York sand borrow sites consisted of members of the major invertebrate (i.e., animals without a backbone, like worms and clams) and vertebrate (i.e., animals with a backbone, like fishes and whales) groups commonly found in the region of the New York Bight. Numerically dominant infaunal groups included crustaceans (e.g., crabs and shrimps), echinoderms (e.g., sand dollars and sea stars), mollusks (e.g., clams and snails), and polychaetes (e.g., worms), while epifaunal taxa consisted primarily of crabs, shrimps, sand dollars, snails, and squids, all typical components of benthic assemblages in the study area. Similarly, the most abundant bottom dwelling (demersal) fishes collected in trawls within the borrow sites revealed consistency with previous surveys. Fishes such as clearnose skate, northern searobin, scup, and summer flounder were most common during the surveys, and these species consistently are among the most widespread and abundant bottom dwelling taxa in the Bight region.

Field surveys indicated that infaunal distribution and abundance was correlated broadly with sediment grain size. Groups of organisms characterized samples from different sediment types (e.g., sand and gravel). Juvenile surfclams were collected from stations with sand, slightly gravelly sand, and gravelly sand but were not predominantly associated with any particular sedimentary habitat in the borrow sites. Other physical environmental characteristics that normally affect infaunal population distributions, such as water depth, were similar across the study area and therefore did not differentially affect abundance and distribution patterns. In addition to organisms varying relative to sediment type, there were significant time differences in the composition of infaunal assemblages. Just half of all collected taxa were common to both surveys. Temporal patterns of infaunal community indices did not meet expected patterns, possibly due to abnormally high temperatures in the region during the first half of 2002. Despite natural differences in the distribution and abundance of demersal taxa with location and time, results of the 2001-2002 surveys of the New Jersey and New York sand borrow sites generally are consistent with historical demersal survey results in the region.

Infaunal assemblages in the sand borrow sites will be completely destroyed within areas that are dredged; however, these assemblages are expected to recover. The rate of recovery of benthic assemblages after dredging within a borrow site will depend primarily on the depth of sand excavation. Although an excavation with a large surface area would initially affect more infaunal organisms, the recovery process would be quicker than it would be for a smaller, deeper pit. Creation of a steep-sided pit may reduce water flow through such a feature, possibly

resulting in a "dead zone" characterized by fine particles falling to the bottom and little or no oxygen. This scenario would extend the duration of ecological impact beyond that which would occur with a more shallow cut over a much larger area.

Impacts to infauna are expected to be limited relative to the broad shelf area of the New York Bight. Recovery time for any impacts to the benthic environment will vary depending on the organisms affected, seasonal timing of dredging, and type of excavation. Impacts to infauna will affect bottom feeding fishes and epifauna. Based on previous observations, the infaunal community in dredged sites most likely will become reestablished within 2 years, exhibiting levels of infaunal abundance, diversity, and composition comparable to nearby non-dredged areas.

## **Pelagic Environment**

Pelagic invertebrates and fishes live in the water column. These animals were not sampled during the biological field surveys, but their consideration was based on a concern of water column effects related to dredging. The most important pelagic invertebrates in the study area are squids, represented by two species, shortfin and longfin squids. These species occur in the area and were collected in bottom trawls taken during the biological field surveys. Squids could be pulled into the suction field of a hydraulic dredge. In addition, squid eggs are laid in large clusters on the seafloor and could be removed with sediments. Dredging is unlikely to significantly impact squid populations in the vicinity of the sand borrow sites. This excludes the need for an environmental window or specific project scheduling to protect squid resources.

Pelagic fishes in the area include highly migratory species, coastal pelagic species, and anadromous (fishes that migrate from the sea to rivers for spawning) species. Members of all of these groups are managed by Federal or State agencies. Dredging should not present a significant problem for pelagic fishes offshore of New Jersey and New York. Factors related to offshore sand dredging that could be detrimental to pelagic fishes are physical injury (entrainment), attraction, turbidity, and noise. If an environmental window is sought to protect pelagic fishes from dredging impacts, the spring to fall period would encompass the peak seasons for the economically important species. Quantitative data are lacking to support the use of an environmental window to lessen effects on pelagic fishes.

Essential Fish Habitat (EFH) for several fish species (and life stages) overlap the sand borrow sites, but the area encompassed by the sites is very small relative to the known EFH. For this reason, the effect of dredging on EFH for the managed species is expected to be minimal.

The main potential effect of dredging on sea turtles is physical injury or death caused by the suction and/or cutting action of the dredge head. No significant effects on turtles are expected from turbidity or noise. Three sea turtle species that typically occur off New Jersey (loggerhead, green, and Kemp's ridley) are considered to be at risk because of their bottom feeding habits. Loggerheads are the most abundant turtles in the project area, and historically, they have been the species most frequently entrained during hopper dredging. If a hopper dredge is used, then it would be best to avoid the June through November turtle season. However, winter weather off New Jersey make it infeasible to prohibit dredging during these months. If use of a hopper dredge during this season cannot be avoided, then other mitigation and monitoring requirements may be appropriate, such as turtle monitoring and use of a turtle-deflecting draghead. If a cutterhead suction dredge is used, seasonal or other restrictions are considered unnecessary because there is little likelihood of killing or injuring sea turtles.

Marine mammal species occurring commonly on the shelf, such as bottlenose dolphin and common dolphin, may be present year-round but are unlikely to be adversely affected by

dredging due to their agility. Harbor porpoise occurrence is more seasonal, but the likelihood of impact is so low that it does not warrant seasonal restrictions on dredging. Fin and humpback whales would be most likely to occur during winter or spring, and right whales as transients during spring and fall. There is no "resident" population of any of these whales in the study area; rather, they would be temporary inhabitants, or would be transiting the area during seasonal migrations. Generally, the probability of encountering these species in the project area would be lowest during summer. However, due to the low likelihood of impact, seasonal restrictions on dredging probably are not warranted. Instead, measures to minimize possible vessel interactions with these endangered species may be appropriate.

## **SYNTHESIS**

Minimal physical environmental impacts due to potential sand dredging operations have been identified through wave and sediment transport simulations. The significance of changes to longshore transport along the modeled shoreline, resulting from dredging proposed borrow sites to their maximum design depths, was determined by comparing predicted change in transport potential between existing and post-dredging conditions to a transport significance envelope in annual transport along the shoreline. Under representative wave conditions for each of the model grids, it was determined that no significant changes in longshore sediment transport potential would result from modeled borrow site configurations due to the relatively deep water at potential borrow sites, their distance offshore, and wave climate (dominated by relatively short-period waves). However, because minor impacts to wave and sediment transport dynamics and biology at borrow sites may occur under conditions similar to those imposed in the present study, additional data collection and analysis may be required for a specific sand extraction scenario to determine the extent of impacts.

The data collected, analyses performed, and simulations conducted for this study indicate that proposed sand dredging at sites evaluated on the OCS offshore northeastern New Jersey and southwestern Long Island are expected to have minimal environmental impact on fluid and sediment dynamics and biological communities. Short-term impacts to benthic communities are expected due to the physical removal of borrow material, but the potential for significant cumulative benthic impacts is remote. Additionally, no cumulative effects to any of the pelagic groups are expected from potential sand mining operations.

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