Study Title: Design of a Monitoring Protocol/Plan for Environmentally Sound Management and Development of Federal Offshore Borrow Areas Along the United States East and Gulf of Mexico Coasts

Report Title: Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-term Impacts of Offshore Dredging Operations on the Marine Environment

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Sponsoring OCS Region: Headquarters–International Activities and Marine Minerals Division

Applicable Planning Areas: East and Gulf of Mexico Coasts

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Background: The Minerals Management Service (MMS) International Activities and Marine Minerals Division is charged with environmentally responsible management of Federal Outer Continental Shelf (OCS) sand and gravel resources, that is, those resources lying seaward of the State/Federal boundary. These resources must be managed on a long-term, large scale, system-wide basis to ensure that environmental damage will not occur as a result of continual and prolonged use. Sand sources that are to be used repeatedly may require additional biological and physical monitoring to ensure that adverse impacts to the marine and coastal environments do not occur. Therefore, MMS funded this current study to develop biological and physical monitoring templates for the Federal OCS sand resources.

Objectives: The project objectives were to: 1) Develop field monitoring systems to evaluate the physical and biological impacts of using Federal offshore borrow areas on a long-term basis; 2) Examine the feasibility, appropriateness, and desirability of putting these monitoring systems into place and identification of the need for collection of supplemental biological data or physical modeling information in the Federal borrow areas; and 3) Identify the need for and collection of any additional geological/geo-physical data to define available sand supplies for planned projects within the study areas.

Description: This study consisted of a comprehensive literature review to clearly identify the geophysical processes and biological ecosystems that would be affected by OCS sand mining for beach nourishment and habitat protection. The first step was to develop a series of broad scientific questions around which the monitoring program would be designed. Following the completion of the literature review, the project team identified those ecological resources (physical and biological) that would have the greatest potential for being affected by offshore sand mining, both directly and indirectly. Impacts occurring from a one-time dredging event at a given location or as repeated dredging of an area over some time period were included.

Direct physical impacts to seabed characteristics include removal and disturbance of the substrate and exposure of an underlying layer with different characteristics (i.e., grain size,

reduced dissolved oxygen levels, and compaction), and changes in grain size of surficial sediments due to settling of fines from overspill plumes or sediment reworking. Indirect physical impacts include changes related to erosion and deposition. These changes will only be significant where they result in biological impacts. Indirect impacts include changes to the waves within and beyond the borrow area, changes to bed shear stresses and related seabed mobility due to changes to waves, and changes to near bed current velocities driven by tides, wind, and large-scale phenomenon. Based on the literature review, it was determined that, from a purely physical perspective, the only change of consequence is the potential impact of dredging on shoreline change. All other physical changes and impacts caused by dredging are important only if they result in a biological impact, either directly or indirectly. Thus, four physical monitoring and modeling protocols were developed to address these issues:

1. Bathymetric and Substrate Surveys
2. Sediment Sampling and Analysis
3. Wave Monitoring and Modeling
4. Shoreline Monitoring and Modeling

Table 1 is a summary of these four physical monitoring protocols.

For marine biota, the biological communities and associated habitats that were determined as most likely affected by OCS sand dredging were soft substrate benthic communities; nekton; and marine mammals and wildlife. Studies of the recovery of soft substrate benthic communities following dredging have indicated that communities of comparable total abundance and diversity can be expected to re-colonize dredge sites within several years. However, even though these re-colonized communities may be similar in terms of total abundance and species diversity, their taxonomic composition, in terms of dominant species and species abundance, is often very different from pre- to post-dredging. The ecological utilization of ridge/shoal features by fish species as critical habitat for spawning, overwintering, or foraging area is relatively unknown, and should be addressed. However, the greatest potential effect to the fish community utilizing a dredge borrow area is an alteration in trophic energy transfer from the benthos to the fish population. For marine mammals and other marine wildlife such as sea turtles and birds, of the identified direct and indirect impacts, the greatest potential for serious effect is associated with direct collision with the dredge vessel or entrainment in the suction dredge. Thus, two biological monitoring protocols were developed to address these issues:

1. Benthic communities and their trophic relationships to fish
2. Marine mammal and wildlife interactions during dredging

Table 2 is a summary of the biological monitoring protocols.

Costs for implementing the monitoring protocols were estimated for a hypothetical project site off the coast of Maryland and Delaware. Year 1 costs for both physical and biological monitoring programs ranged between $374,160 and $826,800. If the monitoring program was required for a full seven years, total costs were estimated to range between $1,194,800 and $3,429,000.

A key component of any long-term scientific study or monitoring program is the need to adapt the original study design and approach to reflect information and understanding gained from on-going studies during the execution of the program. Thus, it is recommended that the MMS establish a permanent scientific review/advisory board to oversee the implementation and evolution of the OCS sand monitoring program and advise the MMS on the program components. Another key role of the scientific advisory board is to ensure the scientific validity and integrity of the monitoring programs and their findings. Long-term monitoring programs will create extremely large databases of information that must be properly organized and documented with appropriate metadata. Therefore, data management guidelines are recommended that will optimize use of the data for identifying potential long-term impacts and support of decisionmaking.

The report identifies information gaps that will need to be addressed either prior to the implementation of the monitoring program or concurrent with its implementation, including:

1. Identification of procedures to dredge shoal and ridge features that will minimize ecological impacts and/or speed recovery
2. Gaps in baseline data, both biological and geomorphological, at OCS dredging sites
3. Determining the use and role of sand ridges and shoals as potential "essential fish habitat" by migrating or resident fish
4. The potential for benthic biological differences that run longitudinally along the ridge and shoal features that may affect the proposed sampling design and require further stratification
5. Whether the relationship of carbon and nitrogen stable isotopes and trophic level improve the scientific knowledge of how the alteration of organic matter and benthic invertebrate communities affect the population of bottom feeding fish in an anthropogenically disturbed and recovering area of the ocean
6. Identification of strategies to remove sand from a shoal/ridge feature to maximize their use and maintain the integrity of the feature

Because bathymetric highs are the current focus as OCS borrow sites, the report includes a summary of the characteristics of OCS shelf sand ridges and shoals. It is important to note that in the future it is likely that the range of deposit types will be expanded to include paleo-channels, paleo-deltas, and other buried sand deposits. It is has been postulated that while ridges and shoals are more readily (and less costly) to identify in the first place, it is likely that more economic (i.e., larger and closer to shore) and higher quality buried deposits will be discovered within federal waters.

Study Products: Research Planning, Inc., Baird & Associates Ltd., and Applied Marine Sciences, Inc., 2001. Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-term Impacts of Offshore Dredging Operations on the Marine Environment. U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 2001-089, 116pp.

Table 1. Summary of requirements of the physical monitoring protocols.

Protocol	Potential Impact	Objectives	Requirements		Cost/Year
			Monitoring	**Modeling**	
Bathymetry and Substrate	Changes to the morphology and substrate characteristics of the borrow deposit and surrounding area (particularly for ridges and shoals) and potential physical (waves and shoreline change) and biological impacts.	1. Determine the location and quantity of sand removed and change to bathymetry caused by dredging operations. 2. Quantify subsequent changes to bathymetry in the immediate vicinity of the borrow area. 3. Quantify potential changes to the overall borrow deposit feature (e.g. ridge or shoal if one exists)	1. Hydrographic Survey (single beam acoustic) plus Side Scan Sonar: or, 2. Hydrographic Survey with Multibeam technique; or, 3. LIDAR/SHOALS or other methods that are able to achieve specifications and requirements of the Protocol.		$77,500-130,000
Sediment	Changes in sediment texture and total organic content and subsequent biological impacts.	1. Define changes to texture caused by removal, sedimentation and indirect erosion/deposition processes. 2. Potential changes may serve the assessment of changes to morphology of features at the borrow deposit (e.g. ridges and shoals). 3. Determine changes in TOC to assess potential impact to benthic communities.	Collect sand samples at the location of benthic samples and test for grain size distribution (both sieve and hydrometer test or equivalent) and TOC method based on high temperature combustion.		In biological protocol costs

Table 1. Cont.

Protocol	Potential Impact	Objectives	Requirements		Cost/Year
			Monitoring	**Modeling**	
Waves	Change to wave transformation patterns over the dredged area with possible ultimate impact of shoreline change	1. Develop a continuous record of wave conditions starting from first access of borrow deposit. 2. Assess influence of initial changes to bathymetry. 3. Assess influence of subsequent (direct and indirect) changes to bathymetry.	Deepwater wave data through combination of measured directional data and non-directional data and available hindcast data.	Complete nearshore wave transformation modeling to transfer deepwater waves to the borrow deposit, over the borrow deposit and into shore (ultimately for input to the shoreline change model).	$113,000-154,000
Shoreline	Shoreline erosion directly attributable to dredging at the borrow deposit.	1. Document actual shoreline change (regardless of cause). 2. Assess the impact of dredging at the borrow deposit.	1. Beach and Nearshore Profile Surveys twice per year every 300 m. 2. Georegistered aerial photographs and digitized shoreline twice per year.	Apply GENESIS model or equivalent to assess longshore sand transport and related shoreline change with and without project prior to and after dredging commences (comparing to measured change in latter case).	$28,000-51,000

Table 2. Summary of requirements of the biological monitoring.

Protocol	Potential Impact	Objectives & Justifications	Requirements		Cost/Year
			Monitoring	Analysis	
Benthos and Fishes; Trophic Transfer	1. Total removal/loss of infauna and epifauna at borrow site with recolonization by benthic organisms occurring within 1-5 years (possibly longer) to a community with comparable pre-disturbance abundance, diversity and biomass but different species composition and community structure 2. Altered foraging efficiency with resultant effects on individual size and weight. 3. Altered species composition of fish prey base; altered productivity and energy transfer effects on the food chain	• To determine the effects of dredging activities on benthic communities and the transfer of energy from benthic communities to fishes. While overall abundances of benthic organisms have been shown to return to pre-dredging levels in some cases within a year or two after dredging, species composition may be different and the ability of fishes to utilize such altered assemblages for prey is uncertain	1. Collect 0.10 m^2 benthic infauna samples from multiple strata at both impact and reference locations prior to dredging and in years 1, 3, 5 and 7 following dredging. 2. Collect stomachs from numerically dominant or recreationally important species from multiple strata at both impact and reference locations prior to dredging and in years 1, 3,5 and 6 following dredging.	1.a. Infauna taxonomy for comparison with fish gut contents analysis and for determining secondary productivity values. 1.b. Biomass measurements for determining secondary productivity values. 1.c. Carbon and Nitrogen stable isotope measurements of key benthic prey species for fish. 2.a. Fish gut analysis for comparison with infauna taxonomy.2.b. Carbon and nitrogen stable isotope measurements of fish muscle tissue.	1. $110,000-$169,900 2. $105,460-$147,900

Table 2. Cont.

Protocol	Potential Impact	Objectives & Justifications	Requirements		Cost/Year
			Monitoring	Analysis	
Marine Mammals & Wildlife	Injury or death of animal; potential disorientation	1. To obtain site-specific marine wildlife observation and behavior data during OCS dredging events. This information will assist state and federal regulatory agencies in assessing the appropriateness of imposed marine mammal and wildlife protection mitigation requirements and guide any necessary revisions of future mitigation requirements. 2. To obtain and assess marine wildlife stranding data for potential relationships between stranded animals and animals observed during OCS dredging. This information will assist state and federal regulatory agencies in assessing whether there exist any obvious relationships between post-dredging marine wildlife strandings and the OCS dredging event 3. To provide a means for implementing environmental mitigation requirements designed to minimize potential hazardous interactions with marine mammals and protected wildlife during dredging events. (This is the only "operational control" monitoring program element included in the OCS sand dredging protocols.)	1. Collect observation and behavior data on marine mammals and wildlife during OCS dredging events. 2. Collect marine mammal and wildlife stranding data for a 60-day period following dredging operations. 3. Implement imposed environmental mitigation requirements designed to minimize collisions or harmful interactions between marine wildlife and dredging equipment.	1. Compare observation data with stranded animal data and document marine wildlife behavior during dredging events. 2. Compare marine wildlife data with observation data collected during the dredging event as well as with stranding data recorded for comparable time periods during non-dredging years.	No cost estimated