Environmental Studies Program: Ongoing Study

Study Area(s): Gulf of Mexico

Administered By: Marine Minerals Program, Gulf of Mexico Region

Title: Development of a Monitoring Program for Water Quality and Biogeochemical Processes of Louisiana Sediment Borrow Areas (GM-14-03-12)

BOEM Information Need(s) to be Addressed: Alterations to seafloor topography from dredging OCS sediment resources have the potential to affect water quality, sediment biogeochemical processes, and physical oceanographic process. Preliminary results from existing physical processes and geomorphic studies BOEM is conducting at borrow areas suggests that these excavations infill rapidly, so it is assumed that indirect impacts from dredging offshore are temporary (<10 yrs) and localized to the vicinity of the borrow area. However, there are no studies to document the character and magnitude of these temporary alterations to water quality, hydrodynamics, and benthic habitat at borrow areas on the Gulf of Mexico OCS. Moreover, parameters governing borrow area recovery are locally specific, and therefore site-specific conditions must be considered, especially offshore Louisiana where river discharge plays a major role in governing water quality and sediment biogeochemestry. BOEM has invested significant research funds to predict and observe how borrow areas offshore the northern Gulf Coast will recover in terms of geomorphic and sedimentologic evolution (Nairn et al. 2005; 2007; Stone et al., 2009; Xu et al., 2015), however there has been no focused effort by BOEM to validate predictions related to water quality and habitat recovery with empirical data. The existing predictive studies on borrow area physical recovery funded by BOEM have been important for informing management decisions within BOEM (e.g. dredge setback distances from pipelines or potential cultural resources) and during consultations with resource managing agencies (e.g. essential fish habitat consultation with National Marine Fisheries Service), but without understanding the short term and localized effects on habitat and water quality it is not clear if these predictions are accurate and if the attendant mitigations are effective. Results of this study will increase BOEM's and other state and federal natural resource agencies' decision making ability regarding safety and protecting environmental and cultural resources and develop a monitoring protocol for various borrow area scenarios to inform management of OCS mineral resources and associated habitats.

Total BOEM Cost: $579,077 **Total non-Federal (LSU) Match:** $579,124

Period of Performance: FY 2018–2020

Conducting Organization(s): Louisiana State University and Bureau of Ocean Energy Management

LSU Principal Investigator(s): Kehui Xu, Kanchan Maiti, Sibel Bargu, Samuel Bentley, John White, and Zuo Xue

BOEM Contact(s): Michael Miner michael.miner@boem.gov

Description:

Background: Barrier islands are separated from the mainland by estuary, lagoon, or tidal environments. They protect the mainland coast and interior wetlands from meteorological and marine forcings and regulate estuarine physical processes, water quality, and biology. Along the Louisiana coast, a deficit in coastal sand supply is forcing rapid disintegration of barrier islands, compromising stability of estuarine systems and the socioeconomic benefits they provide to the nation. A major component of Louisiana's Coastal Protection and Restoration Master Plan is to restore degraded barrier island systems by introducing new sand to the coastal system from OCS borrow areas. This directly benefits barrier island, estuarine, and wetland habitat and reduces storm risk to coastal infrastructure and communities. However, our knowledge of the impacts of offshore sediment excavation on water quality, biogeochemical processes, and habitat function is rather limited. In recent years, the Louisiana Coastal Protection and Restoration Authority (CPRA) initiated the comprehensive Borrow Area Management and Monitoring (BAMM) Program. This program studied physical evolution and water quality at multiple borrow areas (only one of which was on the OCS) with the intention of providing recommendations on future borrow area location, depth of dredging, and borrow area design. Results from BAMM show that dissolved oxygen levels measured in three (out of six) identified borrow areas decreased due to physical processes interacting with borrow pits, but some oxygen levels fell within a wider regional hypoxic zone or recovered quickly (Sonders et al., 2014). These datasets alone, however, do not explain the driving mechanisms of hypoxia, or provide a defined set of standards for borrow area location determination and design. There is still a lack of Louisiana- or Gulf-wide monitoring protocols for sediment borrow areas and this topic is of interest to CPRA and BOEM.

Objectives:

- document the chemical and biological processes that drive the development of hypoxia locally within two types of dredge pits: one of the sandy shelf (Ship Shoal/Caminada and one on the muddy shelf (Sandy Point);

- Acquire empirical data to validate predictive models;

- Further develop a coupled physical-biogeochemical model on hydrodynamics, water quality, and sediment transport processes; use this model to test the sensitivity of hypoxia to varying dredging depths; quantify the impact of dredge pit to dissolved oxygen and the possible dispersal of pit water to surrounding areas during energetic events;

- Provide recommendations for pit water quality monitoring protocols as well as suggest mitigations for various borrow area types based on measurements.

Hypotheses:

OXYGEN DYNAMICS

Hypothesis 1a. The mud-capped dredge pit at Sandy Point is more prone to develop hypoxic condition than the Caminada sandy pit due to less physical mixing and more available nutrient and organic matter from the river.

Hypothesis 1b. The inside-pit stations have lower dissolved oxygen, higher turbidity and less energetic conditions than these of outside the pits in both Sandy Point and Caminada.

BIOLOGICAL PROCESSES

Hypothesis 2a. At each site, phytoplankton community within the borrow pit are expected to be statistically similar with waters adjacent to the borrow area due to the close proximity; there will be differences between Sandy Point and Caminada due to changes in physical setting and water quality.

Hypothesis 2b. Microphytobenthos and sediment fauna are expected to be statistically different between inside and outside of pit stations as well as between Sandy Point and Caminada due to differences in turbidity, water depth, sedimentation, and water quality.

BIOGEOCHEMICAL PROCESSES

Hypothesis 3a. Higher organic matter accumulation inside the pits will result in increased sediment oxygen demand thereby contributing to the lower oxygen concentration in the water column overlying the pit sediment.

Hypothesis 3b. Higher denitrification rates and sediment-water fluxes of ammonium, phosphate and other redox sensitive elements (Fe, Mn, Pb, V) inside the pit will result in reduced nitrate but elevated ammonium, phosphate and redox elements concentrations in the overlying pit water.

Hypothesis 3c. The rates of organic matter breakdown within pit sediments will be higher than these outside pits due to higher organic matter content in pits.

Hypothesis 3d. Although fine sediments derived from the Mississippi and Atchafalaya Rivers are seasonally present in both study sites, fine sediment will accumulate more rapidly and preferentially in the mud-capped dredge pit than in the sandy locale, owing to the quiescent nature of the mud-capped pit, that forms an excellent natural sediment trap. This accumulation of fine sediments will in turn feed biogeochemical processes that drive oxygen depletion (see 3a-3c).

PIT WATER DISPERSAL AND DREDGING DEPTH TESTS

Hypothesis 4a. During fair-weather condition, low oxygen water is generally trapped inside the pit and its impact to ambient water is limited; During moderate-energy conditions (e.g., cold fronts), low oxygen water might be released from the pit to (and mixes with) the surrounding water. During high-energy condition (e.g., hurricanes), both inside and outside the pit are reoxygenated.

Hypothesis 4b. The probability to develop hypoxia increases with increasing dredging depth. There is a “threshold dredging depth”, deeper than which the hypoxia probability increase quickly.

Methods: A deeper dredge pit on the muddy shelf (Sandy Point dredge pit) will be sampled in spring and summer of Year 1 and a borrow area on the sandier shelf (Ship Shoal) will be sampled in spring and summer of Year 2. At each site samples will be collected in the dredge pit and adjacent to the pit. Water column samples will be collected using regular Niskin bottles from surface, midwater and near bottom depths will be analyzed for dissolved oxygen, salinity, dissolved nutrients (NO_3, PO_4, NH_4, SiO_4 and DOC), plankton communities, and TSS and TVS. Sedimentation processes will be studied using multicores collected inside and outside the pits; water quality and sediment condition will also be investigated using numerical model with inputs from field measurements.

Sediment cores will be collected and sliced at 1 cm interval and analyzed for sedimentation rates (via 7Be, 234Th, and 210Pb geochronology, as appropriate; (O’Connor, 2017), grain size, sediment layering and bioturbation (via X-radiography of cores), as well as organic carbon, total nitrogen and phosphorus content. Water quality and sediment condition will also be investigated using numerical model with inputs from field measurements, tripod time series measurement; the coupled ROMS hydrodynamics, sediment transport and water quality model.

A numerical model will employ field observational data to validate the model for the year 2013 (data from BAMM), 2018 and 2019 (data collected by this project). The model will be run for fair weather, moderate-energy and high-energy conditions to test Hypothesis 4a and using varying depth configurations, for 0 (no pit), 0.2H, 0.4H, 0.6H, 0.8H and H (actual excavated pit) where H is the excavation depth.

Results from the various components of this research and attendant dredge pit physical processes and evolution research will be incorporated to develop a long term monitoring program for a spectrum of dredge pit types in locations typical in the north-central Gulf of Mexico shallow shelf. Key parameters that should be tracked will be identified and a monitoring component will be developed for each.

Current Status: This is year 1 of this project. Field planning and coordination is underway with cruises and deployments planned for May-June 2018

Final Report Due: September 2020

Publications Completed:

Affiliated WWW Sites:

Revised Date: 2/16/2018