ACCESS NUMBER: 30696

STUDY TITLE: Benthic-Pelagic Coupling in the Gulf of Mexico: Implications for the Fate of Organic Matter on the Continental Shelf

REPORT TITLE: Ecosystem Analysis of the Louisiana Bight and Adjacent Shelf Environments, Volume I: The Fate of Organic Matter and Nutrients in the Sediments of the Louisiana Bight and Volume II: Bibliography of Ecological Studies

CONTRACT NUMBER: 14-35-0001-30696

SPONSORING OCS REGION: Gulf of Mexico Region

APPLICABLE PLANNING AREA: Western and Central Gulf of Mexico

FISCAL YEARS OF PROJECT FUNDING: 1994, 1995

COMPLETION DATE OF REPORT: 1 June 1995

COSTS: FY 94: $132,024: FY 95: $67,977: CUMULATIVE PROJECT COSTS: $200,000

PROJECT MANAGER: R. Twilley

AFFILIATION: Department of Biology

ADDRESS: University of Southwestern Louisiana, Lafayette, LA 70504

PRINCIPAL INVESTIGATOR*: B. McKee

KEY WORDS: Western Gulf of Mexico; Central Gulf of Mexico; Texas-Louisiana Shelf; Mississippi River plume; Louisiana Bight; Mississippi Sound; delta; biogeochemistry; benthic-pelagic coupling; organic matter; nutrients; burial; sedimentation; carbon; nitrogen; benthos; ecosystem studies; petroleum impacts; benthic fluxes; nutrient regeneration; benthic respiration

BACKGROUND: One of the major objectives of the ecosystem ecology program at University of Southwestern Louisiana is to understand the fate of nutrients and organic matter in the Mississippi River Plume and adjacent continental shelf. Individual studies indicate that the fate of this organic matter appears to vary, at times fluxing to the sediments and undergoing mineralization or transport, while at other times appearing to be efficiently grazed and remineralization in the water column. Previous studies od deposition suggest that the proximal region of the Mississippi River plume is a zone of extreme input of allochthonous particulate material to the seabed. The coupling of these benthic-pelagic processes is central to understanding the dynamics of the Texas-Louisiana shelf ecosystem. Understanding the natural processes of this shelf ecosystem will lead to better attempts of evaluate human impacts in the region such as oil and gas activities. This is particularly complex given the additional effects of nutrient

enrichment to this OCS region due to inputs from the Mississippi and Atchafalaya Rivers.

OBJECTIVES: One objective of this project was to provide an overview of existing information on the Louisiana-Texas continental shelf ecosystem by developing an annotated bibliography of existing ecological studies in this region of the Gulf of Mexico. In addition, the more complete analysis of existing sediment samples collected on previous studies of the Louisiana Bight provided new information on the role of benthic processes in affecting the fate of carbon and nitrogen in a river dominated shelf ecosystem. This information will contribute to findings from other studies in the central and western OCS regions of the Gulf of Mexico, to understand the coupling of the fifth largest river in the world to coastal margin ecosystems in the Louisiana-Texas region.

DESCRIPTION: Box core samples were collected from 42 stations in Mississippi River plume region of the Louisiana Bight during the LASER 3 cruise in April 1989. Depths of water column ranged from 10 to 110 m and nearly 90 km from the mouth of Southwest Pass of the Mississippi River delta. Large diameter (16.5 cm) subcores were taken from box cores at each sampling station. Sediment subsamples were assayed for ^{210}Pb and ^{234}Th to determine burial (100 yr time scale) and deposition (3 mo time scale) in the dispersal study area. Total carbon and nitrogen were assayed with a LECO Elemental Analyzer. Total phosphorus was determined by dissolving the ashed samples with Hcl and determining PO_4 concentrations. The deposition and accumulation (burial) of carbon, nitrogen and phosphorus in bottom sediments was calculated from the following equation (Hatton et al. 1983): $A = Cd \times R \times D \times 104$ (g m^{-2} yr^{-1}); where A is the rate of nutrient deposition or burial, Cd is the dry mass nutrient concentration, D is bulk density, and R us the sedimentation rate (determined by ^{234}Th or ^{210}Pb).

Intact sediment cores from stations in the shelf were incubated aboard ship under near ambient conditions to determine the exchange of inorganic nitrogen (ammonium, nitrate, nitrite), phosphate, silicate and dissolved oxygen across the sediment-water interface. A flow-through design in which an autoanalyzer pump (Cole Palmer) delivers the experimental solutions from reservoirs at controlled flow rates (typically 4 mL/min) through influent and effluent lines connected to the cores was used during each cruise (Koike and Hattori 1978, Miller-Way and Twilley in press). Pore water nitrogen, phosphate, and silicate concentrations were determined with standard colorimetric techniques (Strickland and Parsons) using an Alpkem RFA/2 autoanalyzer. Total nitrogen and phosphate on water and pore water samples were assayed using persulphate digestion techniques followed by assay of nitrate and phosphate using autoanalyzer techniques.

SIGNIFICANT CONCLUSIONS: Results reveal that approximately 30% of the particulate organic carbon supplied by the Mississippi River to the adjacent shelf is remineralized within 4 months and an additional 40% is remineralized on a decadal time scale. Based on these results, combined with similar information from the Amazon, Changjiang and Huanghe Rivers, we conclude that only 30% of the particulate organic carbon supplied to the ocean by rivers is buried. Our area-weighted estimate of organic

carbon burial in deltaic-shelf sediments is 75 gC m^{-2} yr^{-1} with less than 50% of the organic carbon buried being of terrestrial origin. The resulting gobal estimate for terrigenous POC burial is 0.05 PgC yr^{-1}, representing less than half the value currently used to constrain global CO2 budgets (Sarmiento and Sundquist 1992).

There are distinct spatial and seasonal rates in benthic nutrient regeneration that are strongly linked to the discharge of Mississippi River. Zones of peak nutrient regeneration coincide with areas of high deposition of both terrigenous sediments and in situ primary production. Maximum rates of ammonium regeneration may provide up to 40% of the nitrogen demand by primary producers.

STUDY RESULTS: Chapters in this technical summary describe the accumulation and regeneration of sediment, carbon, nitrogen, and phosphate from the seabed in the plume region of the Louisiana Bight. Strong variation in sedimentation and nutrient accumulation rates in 5417 km^2 plume region of the Louisiana Bight indicate the problem of accurately determining reliable estimates for these processes in river-dominated shelf ecosystems. The area-weighted sedimentation rate was 4,442 g m^{-2} yr^{-1}, carbon accumulation was 64, nitrogen 7.02 and phosphorus 2.89 g m^{-2} yr^{-1}.

Seasonal deposition of allochthonous organic matter during spring provides the predominant mechanism for sustaining peak rates of benthic regeneration in the plume region of the shelf. During April, ammonium regeneration in the plume region (station B50 and C50) may exceed 500 µmol m^{-2} h^{-1}, compared to fluxes of less than 200 µmol m^{-2} h^{-1} during low river discharge in September and October. Further downfield (stations D50 and E50), ammonium regeneration is generally less than 200 µmol m^{-2} h^{-1}. Seasonal differences in benthic regeneration are most evident nearest the mouth of the Mississippi River, while rates are more constant both temporally and spatially in more distant regions. The link between sediment deposition and benthic nutrient regeneration is clearly demonstrated in results of silicate flux at near and far - field stations on the Louisiana Bight. Fluxes of silicate across the sediment-water interface to the water column increase linearly with deposition rates from 0.3 to 2.5 cm /mo, reaching maximum silicate flux rates of 550 µmol m^{-2} h^{-1}. Above a deposition rate of 2.5 cm/mo, silicate flux was lower at less than half the maximum rates. However, there was no clear pattern in ammonium or phosphate regeneration with bulk deposition of sediments in the study area; suggesting that the quality of material must also be evaluated.

Rates of benthic nutrient flux tended to decrease with distance from the riverine source, and exhibited contours of rates similar to patterns of sedimentation and nutrient accumulation. Modeling nutrient fluxes from pore water gradients showed little correlation to the actual measured nutrient flux; however these sediment characteristics do provide explanations for outliers in benthic regeneration rates. Benthic fluxes always showed a higher correlaiton to some qualitative index (input of carbon, nitrogen, phosphorus, or chlorophyll a) of deposition to the seabed than to the quantitative input of sediment. The combination of geochronologies on time scale of months and decades along with repeated measures of benthic nutrient regeneration provide spatial and

temporal resolution of these benthic processes in this river-dominated continental shelf ecosystem.

STUDY PRODUCTS: Twilley, R.R. 1995. Ecosystem Analysis of the Louisiana Bight and Adjacent Shelf Environments. Vol. I. Bibliography of Ecological Studies. OCS study/MMS No. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Regional Office, New Orleans, La.

Twilley, R.R. and B. McKee. 1995. Ecosystem Analysis of the Louisiana Bight and Adjacent Shelf Environments. Vol. II. The Fate of Organic Matter and Nutrients in the Louisiana Bight. OCS study/MMS No. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Regional Office, New Orleans, La.

McKee, B. and R.R. Twilley. The burial and remineralization of terrigenous organic carbon in deltaic-shelf environments. Manuscript submitted to NATURE.

Bourgeois, J. 1994. Patterns of Benthic Nutrient Regeneration on the Louisiana Continental Shelf. Master of Science Thesis, University of Southwestern Louisiana. 73 pp.

*P.I.'s affiliation may be different than that listed for Project Manager.