ACCESS NUMBER: 30470

STUDY TITLE: Gulf of Mexico University Initiative: Studies of Long-Term Effects of Oil and Gas Production

REPORT TITLE: Effects of Bottom Water Hypoxia on the Benthic Communities of the Louisiana Continental Shelf

CONTRACT NUMBER: 14-35-0001-30470

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREA: Central Gulf of Mexico

FISCAL YEAR OF PROJECT FUNDING: 1993

COMPLETION DATE OF REPORT: November 1994

COST: FY 1993: $25,708

CUMULATIVE PROJECT COST: $25,708

PROGRAM MANAGER: Nancy N. Rabalais

AFFILIATION: Louisiana Universities Marine Consortium

ADDRESS: 8124 Hwy. 56, Chauvin, Louisiana 70344

PRINCIPAL INVESTIGATOR: Nancy N. Rabalais

KEY WORDS: Benthos, hypoxia, oxygen depletion, anoxia, Louisiana, hydrograph

BACKGROUND: Natural variation in space and time often complicates assessments of the effects of petroleum production activities on ambient communities in a field setting. A major confounding effect in offshore regions of Louisiana is seasonally intense and widespread hypoxic (dissolved 0_2 < 2 mg/1) bottom waters. Zones of hypoxia may cover up to 16,500 km^2 during mid-summer on the inner continental shelf from the Mississippi River delta to the upper Texas coast. Several studies of the effects of offshore petroleum development have been unable to separate the effects of sediment contamination from oxygen stress because of a lack of knowledge of the natural variability in the system or knowledge of the history of oxygen stress.

OBJECTIVES: We previously examined the multiple effects of production activities and hypoxia at three study sites on the southeastern Louisiana shelf during April-August 1990 (Rabalais et al. 1993). In the present study we focused exclusively on the effects of hypoxia to better define the variability in the benthic community. We examined varying degrees of oxygen stress, and expanded the temporal scale to define the variability in the community over several annual cycles of oxygen stress and benthic community recovery.

DESCRIPTION: The study was conducted within the South Timbalier and West Delta lease blocks. Unocal South Timbalier 53A (= ST53A, UA) is in close proximity to the 1990 instrument mooring (with continuously recording oxygen meter) at Unocal's South Timbalier 53B platform (= ST53B, UB). The instrument mooring was moved to Unocal South Timbalier 53#3 (=

ST53#3) in 1991. Shell's platform West Delta 32E (= WD32E, SH) is located closer to the Mississippi River and 74 km distant from the primary instrument moorings. An oxygen meter was deployed at WD32E during 1990. Standard benthic community studies accompanied by detailed hydrographic measurements and sedimentary characteristics analyses were conducted.

SIGNIFICANT CONCLUSIONS: Benthic communities impacted by severe, persistent and extensive hypoxic bottom waters undergo a predictable sequence of community charges, which, now identified, can provide a general understanding within which to place results from studies of the effects of offshore petroleum development. We were able to document the annual cycle of benthic community responses to varying degrees of oxygen stress because we (1) expanded the temporal scale to monthly sampling over several annual cycles of oxygen stress and benthic community recover, and (2) continuously measured the bottom water oxygen environment. We documented that (1) the larger, mobile fauna usually migrate from hypoxic bottom water, (2) the smaller, less mobile organisms die off in differential patterns depending, in part, on community structure, history of previous stressed, duration and intensity of exposure to oxygen deficient waters, and the physiological capabilities of the fauna, (3) some macroinfauna are physiologically capable of surviving extremely low dissolved oxygen concentrations and form part of the basis for the fall benthic community, (4) additional benthic recruits colonize the area when hypoxia abates, (5) the community is comprised of smaller, shorter-lived, opportunistic individuals and does not develop into a more diverse, longer-lived, potentially deeper-dwelling community, and (6) benthic communities continually exposed to seasonally severe hypoxia are distinguishable from other communities not exposed to such conditions or to ephemeral or less intense oxygen stress.

STUDY RESULTS: The 1990 season of hypoxia at ST53A and ST53B was sever, in that hypoxia occurred early and persistently in the spring, hypoxia was sever in the summer, long periods of anoxia were documented, and the generation of hydrogen sulfide in bottom waters was recorded often. The oxygen record for WD32E showed incursions in and out of hypoxic conditions, with no extremely low levels for prolonged periods. By comparison, hypoxia in the lower water column was patchy and ephemeral in the South Timbalier area in 1991 from mid-May through mid-July, was extensive and severe in Mid-August, and had diminished substantially by mid-September. Sediments in West Delta 32 were predominantly silts (80 to 95%) while those of the South Timbalier area were predominantly silt and sand mixtures of extreme variability.

There were significant decreases in summer and fall of 1990 in species richness and abundance of organisms. Decreases were dramatic at ST53A and ST53B during the period of severe hypoxia/anoxia. The decline in benthic populations was gradual at WD32E throughout the summer and early fall. There was a slight recovery in the benthic community at ST53A and ST53B during October, but the decline in numbers of species and organisms continued at WD32E. Overall, abundance was greater at ST53B int eh spring and early summer. As hypoxia/anoxia set up in the South Timbalier area and benthic populations declined, abundance of organisms became significantly greater at WD32E. As populations continued to decline at WD32E into the fall along with the slight recovery at ST53B, ST53B became the study site with the greatest reductions occurred when bottom water oxygen levels fell below 0.5 mg/1. Oxygen levels seldom approached this level at WD32E, and were never persistently low.

Spring recruitment of 1991 replenished both species and number of individuals at all three sites, but not to the same level as in spring 1990. The timing and magnitude of spring recruitment varied from year to year. During mid-summer 1991, severe hypoxia drastically reduced the

number of species and individuals at ST53B, but not as severely as in 1990. A comparison of the continuous oxygen records for the two years indicated that the number and duration of hypoxic and anoxic events were not as great in 1991 as in 1990. This demonstrates variable responses within degrees of severity of hypoxia, and not just a single response to hypoxic conditions.

Most individuals were distributed within the upper 2 cm of the sediments, especially during peaks in spring recruitment of both years. Individual (low in abundance) were more evenly distributed during mid-summer hypoxia in July-August 1990 and August 1991. Although numbers increased in fall (September-October) of both years, they remained more evenly distributed through the sediments (with a few exceptions) as opposed to close to the sediment surface as in spring.

Benthic biomass trends at West Delta 32E closely paralleled those of abundance data. The relationship of biomass to abundance for South Timbalier 53A and 53B was linear with the exception of the recruitment event for *Paraprionospio pinnatta* and *Mediomastus ambiseta* where the number of individuals increased dramatically, but biomass did not (i.e., smaller recruits).

The hypoxia-affected fauna on the southeastern Louisiana shelf followed many of the predictable patterns of previous studies. They were dominated primarily by polychaetes of smaller individuals, with overall less biomass, especially during the peak of severe hypoxia. Longer-lived, large, higher biomass organisms were virtually absent from the hypoxia-affected study sites.

STUDY PRODUCT: Rabalais, N. N., L. E. Smith, D. E. Harper, Jr., and Dubravko Justic'. 1994. Effects of Bottom Water Hypoxia on Benthic Communities of the Southeastern Louisiana Continental Shelf. OCS Study MMS 94-0054. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana 109 pp.