

**STUDY TITLE:** Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study

**REPORT TITLE:** Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study; Final Report

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**BACKGROUND:** The Deep Gulf of Mexico Benthos (DGoMB) project was initiated in 1999 for the U.S. Department of the Interior's Minerals Management Service. MMS sought to investigate the structure and function of the biota associated with the sea floor in the deep water of the northern Gulf of Mexico. The purpose of the study has been to determine how living resources inhabiting deep-water habitats might be impacted by oil and gas exploration and exploitation. The strategy of the initial stage of the field work was to survey a broad region from which community structure could be determined, and to conduct extensive sampling of physio-chemical variables within both the water column and the sediments of the sea floor.

**OBJECTIVES:** The multi-year project, referred to as Deep Gulf of Mexico Benthos or DGoMB, was designed to provide a better understanding of:

- the present condition of biological communities in the study area,
- the distribution patterns of deep-sea biota,
- the biological and physical processes that control the environmental setting, and
- the effects of these processes on the character of benthic and benthopelagic communities.

The project has emphasized understanding the make-up and variability of soft-bottom biological communities, joined with a secondary effort to characterize the important biological and abiotic processes that sustain or change the observed patterns. The study includes:

- 1) the composition and structure of slope biological communities,
- 2) an inference of the relationship between these communities and local conditions and forcing factors,
- 3) a characterization of the “health” and functioning of deep-sea communities, and
- 4) a comparison of the GoM region with similar oceanic basins.

**DESCRIPTION:** Eight hypotheses were tested on the basis of the initial survey in 2000. Hypotheses related to how the environmental variables control or affect community biomass, standing stocks, diversity and recurrent assemblages of species. The variables tested were depth, location within small (5 to 15 km diameter) basins, canyons, geographic location in the northeast vs. northwestern section of the northern half of the GoM basin, location below steep escarpments, proximity to high vs. low surface water productivity, time (year to year), and association with or close proximity to methane seeps. The null hypotheses were that community structure is not affected by any one or a combination of these variables. Components of the seafloor community sampled included sediment bacteria, small protists and metazoans (meiofauna, > 63 micrometer mesh sieves), small metazoan invertebrates (macrofauna, >300 micrometer mesh sieves), large bottom-dwelling invertebrates (megafauna, > ca. 1 cm diameter), and demersal fishes. Sampling devices used to capture these organisms were a 0.2 m<sup>2</sup> box corer (along with subsampling from within the cores); 40 foot otter trawl, with 2.5 cm stretch mesh net; and sea floor photography. Profiles of water column variables were determined using Conductivity-Temperature-Depth profiling sensors (CTD), and a rosette of sampling bottles for the measurement of standard water-column chemical variables (temperature, salinity, oxygen, suspended organic matter, inorganic nutrients and plant pigments). The sampling crossed the continental margin from depths of 200 m on the upper

continental slope out to 3,750 m on the Sigsbee Abyssal Plain and extended geographically from the Mexican border on the west over to north Florida.

At a limited number (7) of “process” sites, the total suite of measurements was enhanced to allow estimation of the rates of processes related to organic matter cycling. At this subset of locations, community oxygen consumption (SCOC) was measured with three complementary approaches: an autonomous benthic lander with incubation chambers on the sea floor; subcores taken from box cores incubated in the ship’s laboratory; and microelectrode profiles in sediment cores to determine oxygen concentration gradients in surficial sediments. Microbial growth and respiration within repressurized subcores were estimated from uptake rates of tritiated thymidine and turnover of C-14 labeled dissolved organic compounds. The label was followed into the meiofauna to determine the importance of bacteria to the food requirements of the meiofauna. At one site (MT1 in the Mississippi Canyon), size-classes of the dominant macrofaunal species, *Ampelisca mississippiana*, were used to estimate secondary production. A suite of radionuclides was used to estimate rates of sediment mixing, burial and consumption of sedimentary organic carbon.

**SIGNIFICANT CONCLUSIONS:** It was concluded that potential interactions between the biotic communities and oil and gas exploration and exploitation activities, including alterations of resident biotic communities, are expected to be substantially greater on the upper continental slope (down to 2,000 m depth), simply because the standing stocks are so much higher on the upper slope.

On the other hand, the “upper slope” biota may be better adapted to respond to and thus survive alterations in available substrate and organic loading, because of the greater natural environmental variability at those depths than in deeper water. Alternatively, the carbon-based food web models suggest that the introduction of biodegradable organics, whatever the source, could stimulate biomass production in the deep GoM where food supply is limiting.

The general principle has emerged that the biota, in the rather quiescent and benign environment of the deep ocean, is controlled by various sources of organic nourishment, including those introduced by human activities. Supplemental organic carbon would be expected to cause a shift in the location or depths of the biotic zones.

**STUDY RESULTS:** The biota, in terms of standing stocks, biodiversity and species composition, was demonstrated to be a function of the following independent environmental variables:

Standing stocks were inversely related to depth, and the decline was exponential.

Diversity followed a unimodal pattern, with maxima on the mid to upper continental slope at depths of about 1.5 km.

Highest standing stocks were found in the shallow extensions of the DeSoto and Mississippi Canyons.

The Mississippi Canyon head was characterized by low diversity in the macrofauna because of the dominance of the amphipod crustacean *Ampelisca mississippiana*, whereas the DeSoto macrofaunal diversity was relatively high in both standing stocks and diversity measures.

Biomass was directly proportional to surface water phytoplankton pigments, proximity to methane seeps, an east to west gradient, and sediment organic matter (the carbonate-free fraction) concentrations.

On the other hand, there was little or no evidence that the following characteristics affected community structure, including mesoscale "subsurface salt-related" basins on the continental slope, sediment grain size, oxygen concentration, temperature, salinity or chemical contaminants within the sediments.

Stock size and sediment community oxygen consumption (SCOC) decreased exponentially with depth, and this is inferred to be controlled by decreasing food supplies from the surface water or exported offshore to deeper water from the upper depths of the continental slope. Groups of recurrent species occurred in four primary depth zones that lined the basin between isobaths. These zones appear to be related to specific levels of food supply in the form of sedimenting particulate organic matter. Diversity among most groups reached a maximum on the upper continental slope between 1.2 and 1.6 km depth, from which it declined to the abyssal plain. While alpha diversity was lower in the Mississippi Canyon within individual sampling sites, the total number of species was higher in the canyon compared to adjacent transects, due, it is thought, to the canyon's higher physical complexity.

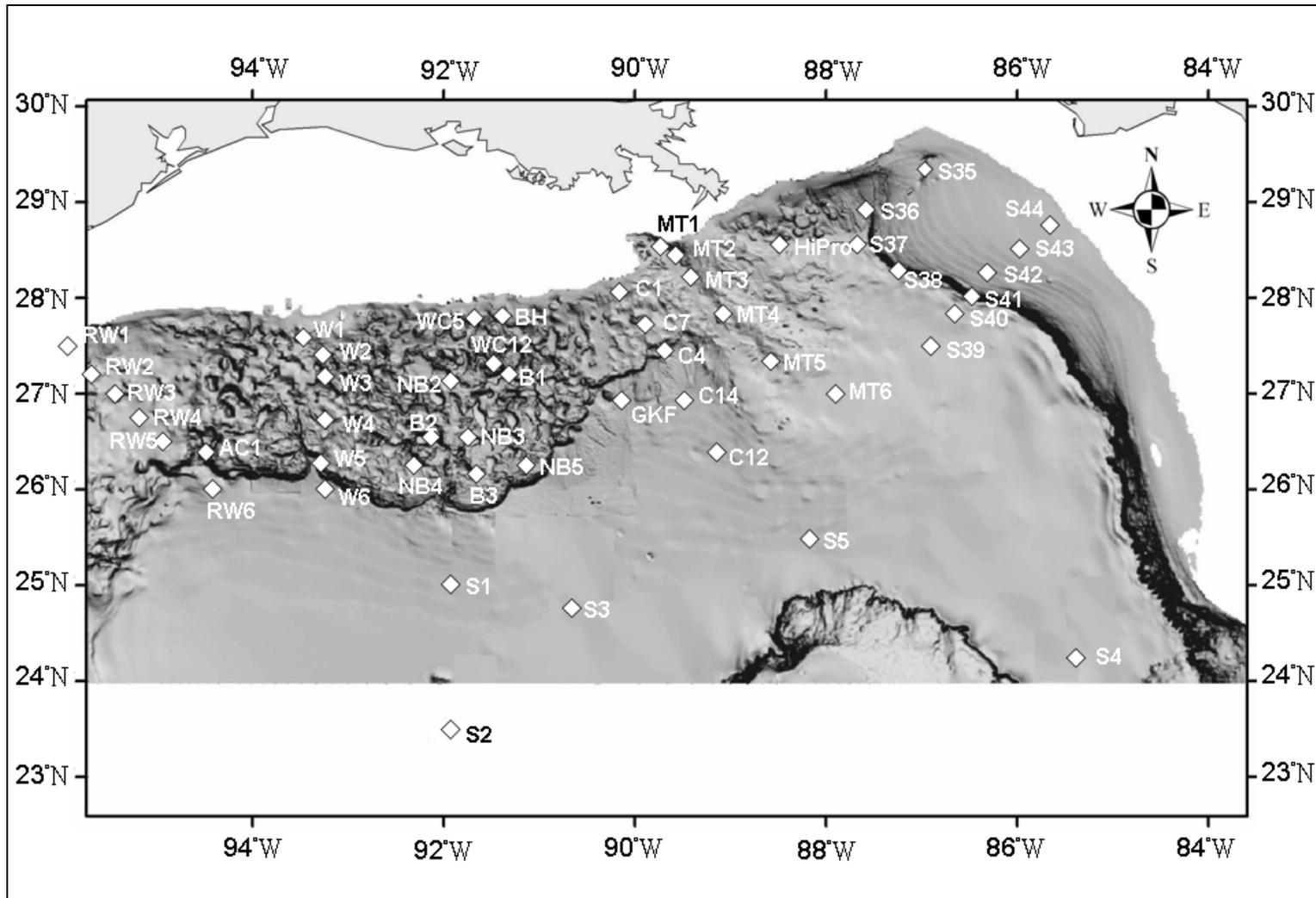
The turnover of organics, estimated from SCOC, was approximately three to ten times lower on the upper slope (500 to 2000 m depth) than on the adjacent continental shelf (10 to 200 m depth), but the upper slope was approximately ten times higher than on the abyssal plain (2 to 7 mg C m<sup>-2</sup> d<sup>-1</sup>). The turnover time of the living carbon pool (the total standing stock of the biota), calculated by dividing the total biomass by the SCOC, was on the order of days to months, whereas the detrital organic carbon turnover time was years.

The standing stock information from each group was assembled into food web budgets for each of the seven sites where SCOC and bacterial metabolism and growth were measured. Rates of respiration, growth, and predation were estimated in units of carbon cycling (mg C m<sup>-2</sup> d<sup>-1</sup>) at presumed steady state for each stock. These budgets illustrated that the stocks of large animals (the megafauna, the fishes, and the macrofauna) decrease more rapidly with depth than the small size groups (meiofauna and bacteria). The detrital carbon was the largest pool in all sediments, but its relative importance increased with depth, suggesting that much of it is unreactive. All of the metazoan stocks declined with water depth in a statistically significant pattern, but the decline in bacteria was not as steep as that of the metazoans, suggesting in the budgets that the role of the bacteria as an intermediary in the food web increases as detrital organic matter becomes less

reactive, or that a large fraction of the bacteria are inactive because of their origins in shallow water, including the surrounding continental margin.

**STUDY PRODUCT:** Rowe, G.T. and M.C. Kennicutt II, eds. 2009. Northern Gulf of Mexico continental slope habitats and benthic ecology study, final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-039. pp. 417

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Study Area – The Northern Gulf of Mexico