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REPORT TITLE: Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring, Final Synthesis Report

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BACKGROUND: The Mississippi/Alabama outer continental shelf (OCS) is an important multiple use area for human commerce, fisheries harvest, recreation, and other activities, including oil and gas exploration and development. Because of the petroleum industry's interest in the area and the potential for environmental impacts, an understanding of hard bottom communities and environmental processes that influence them is critical.

OBJECTIVES: The overall goal of this program was to characterize and monitor biological communities and environmental conditions at carbonate mounds along the Mississippi/Alabama OCS. Specific objectives were as follows: (1) to describe and monitor seasonal and interannual changes in community structure and zonation and relate these to changes in environmental conditions; and (2) to characterize the

geological, chemical, and physical environment of the mounds as an aid in understanding their origin, evolution, present-day dynamics, and long-term fate.

DESCRIPTION: This report summarizes a 4-year program to characterize and monitor carbonate mounds on the Mississippi/Alabama OCS. Nine sites in the Mississippi/Alabama "pinnacle trend" area were selected for monitoring. The sites were sampled intensively during four monitoring cruises over a 2-year period. Moorings with sediment traps, current meters other oceanographic instruments, and settling plates were also deployed at four of the sites. Monitoring program components included geological characterization, sediment dynamics, geochemistry, physical oceanography and hydrography, hard bottom communities, fish communities, microhabitat studies, and epibiont recruitment. A synthesis chapter draws together findings from all program components.

SIGNIFICANT CONCLUSIONS: Hard bottom community development was generally greater on higher relief features, and probably due in part to negative effects of resuspended sediments. A benthic nepheloid layer was present at all sites; it probably reaches all but the tops of the tallest mounds and may affect hard bottom community development. There are east-west patterns in hard bottom communities in the study area, but whether these reflect a direct or indirect influence of the Mississippi River or some other factor is not known. Substrate characteristics influence the distribution and abundance of hard bottom epibiota. Among sites, there was a positive relationship between percentage of emergent hard bottom and biological variables, including biotic cover and numbers of taxa. At a finer scale, relationships between microhabitat factors and hard bottom taxa were documented, including effects of feature morphology, small- and medium-scale roughness, slope, location on feature, and sediment veneer. Stochastic or unexamined processes contribute substantially to distribution patterns of hard bottom biota.

There was little or no evidence of trace metal or petroleum related hydrocarbon contamination at any of the study sites. Relationships among community development, relief, and sediment flux suggest that it would be more detrimental to discharge drilling muds and cuttings on top of large, flat top mounds than to discharge them in low relief areas. Existing lease stipulations focus on avoiding physical damage to hard bottom features but also make it unlikely that drilling discharges could occur near large, high relief mounds. Data collected during this program suggest that recovery of hard bottom communities, following a disturbance, would be slow.

The current meter data indicate a regional flow regime with local variations dependent on topography, rather than a strong east-west or onshore-offshore gradient. Current direction is an important influence on the orientation of filter-feeding sea fans. The distribution of other epifauna on hard bottom features may also be affected by current directions. Existing knowledge of flow over bottom features suggests that different mounds, and different areas within a mound or mound complex, could experience local flow regimes that could affect the exposure of epibiota to sedimentation, erosion, and food flux.

STUDY RESULTS: Four “megasites” (subsets of the study area) contained recognizable carbonate mounds varying in size, number, and morphology. The mounds were classified into several different forms: small, “unit” mounds; composite mounds; irregular mounds; smooth-top mound; and carbonate hard bottoms. Morphologic differences among mounds suggest differences in development. Low, wide carbonate hard bottoms imply slow upward growth over a large area, perhaps indicating stable sea level or slow sea level rise. Tall, steep-sided “pinnacle” mounds suggest rapid growth during faster sea level rise. Widely dispersed, shallower mounds may represent a short period of sea level stabilization in the middle of the deglaciation. Mound growth was probably most intense on the side facing the sea, which is similar to the formation of coral reefs and lends credence to the hypothesis that mounds were formed by biological action in shallow water. Sediments at the monitoring sites are mainly sand, with a small and variable amount of clay. Gravel content is usually highest near mounds, indicating them as a source or suggesting mound proximity as an important factor controlling the presence of organisms. While normal sedimentation is not very active, high-current events cause significant reworking of the sediments.

Little or no evidence of trace metal or petroleum related hydrocarbon contamination was observed in sediments at the study sites. Barium, a tracer of drilling mud discharges, was observed to be at background levels with only a very few samples that might be interpreted as slightly elevated.

Particle flux varied widely in space and time. A benthic nepheloid layer was present at all sites in all casts, though its intensity was variable. Water column profiles indicate a local origin for the nepheloid layer particles. Sediment trap results reflect the influence of resuspension, with fluxes increasing toward the bottom for all moorings and time periods. Average vertical fluxes during non-hurricane periods ranged from 1.5 to 6 g m^{-2} d^{-1} in the traps 15 meters above bottom (mab) and from 6.7 to 29.3 g m^{-2} d^{-1} in the 2.5 mab traps. There was no consistent geographic trend in the sediment trap data set at any given depth level. No seasonal trends were apparent. Extremely high fluxes (4 to 70 times the non-hurricane average) were recorded during a period when Hurricane Georges passed near the study area.

Across the study area the observed flow fields were similar at 16 mab. The most frequent direction octant and the direction of the vector mean current were east at Sites 1 and 9. At Site 4, located farther from shore in deeper water, there was a slight southwesterly bias as compared with the other sites. At all sites, the most frequent speed range was 5 to 10 cm/s, reflecting the normal tidal influence. Strong currents most frequently flowed southwest or west, particularly during Hurricane Georges (maximum of 97 cm/s at Site 1). The near-bottom (4 mab) flow was more site specific. Bottom friction and local topography influenced flow, particularly at Site 1, a large mound that disrupted the downstream flow.

A total of 2,997 random photographs were analyzed for percent cover of hard bottom biota. The 40 taxa with the highest overall cover represented 14 taxon groups. Octocorals were the most diverse group (10 taxa), followed by sponges (6),

ahermatypic corals (4), antipatharians (4), and ectoprocts (4). Ahermatypic corals (e.g., *Rhizopsammia manuelensis*) were the most abundant group. Mean biotic cover (over all taxa and cruises) ranged from 13.5% to 30.6%. Most of the dominant taxa varied with respect to both relief category and region, as well as related environmental variables. The highest abundance was observed at high relief sites, with organisms found primarily on the sides and tops of features. Sediment veneer was also an important influence, especially for medium-high relief taxa. Many taxa were more abundant toward the east (i.e., farther from the Mississippi River), but some taxa increased toward the west. Stochastic or unexamined processes contributed substantially to distribution patterns of hard bottom biota. Fixed quadrat data reveal a dynamic benthic environment, with numerous instances of sediment deposition, and occasional instances of erosion, and organism growth and damage or mortality.

In all, 76 fish taxa representing 33 families were seen. Numbers of fish taxa per cruise varied from 15 to 28. The most frequently occurring fishes were roughtongue bass, short bigeye, bank butterflyfish, red barbier, scorpionfish, and tattler. Streamer basses (e.g., roughtongue bass and red barbier) numerically dominated the mounds. There were no significant differences in numbers of taxa among cruises, sites, or relief categories. Numbers of taxa were not strongly correlated with environmental variables. Frequency of occurrence of 17 common fish taxa was analyzed in relation to habitat characteristics at three scales: large (tens of kilometers to hundreds of meters), meso (tens of meters to 1 m), and small (1 m to centimeters). There were no strong patterns at the large scale. Meso-scale observations showed that some species regularly used portions (tops, sides, bases) of larger features, generally reflecting their feeding behavior. Different fishes were associated with sedimentary vs. hard bottom habitats. Most small species remain near features for shelter from larger groupers, amberjacks, and sharks that patrol the structures. There was considerable overlap in use of the small-scale habitats. Crevices, ledges, and holes were especially important to some fish species.

A microhabitat study focused on orientations of gorgonian colonies at several sites. At every site, gorgonian orientations were non-random, and the results suggest that mean orientations of gorgonians are strongly influenced by mean directional water flow. Deviations from the current meter readings probably indicate local topographic steering that is not captured by moorings located well away from features. Substrate characteristics such as morphology, location on feature, and sediment veneer were also significant factors in determining the abundance of gorgonian and antipatharian colonies.

A recruitment study using settling plates found nine phyla: Rhizopoda, Porifera, Cnidaria, Ectoprocta, Entoprocta, Mollusca, Annelida, Arthropoda, and Chordata. There were significant differences among sites for plates located on the bottom but not for plate's elevated above the bottom. The attached community changed over time. However, just the earliest successional stages of community development were found on the plates, and community structure was different from the surrounding hard bottom

communities. If disturbed, deepwater hard bottom communities could require decades to recover.

STUDY PRODUCT(S): Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group. 1998a. Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Ecosystem Monitoring, Mississippi/Alabama Shelf; First Annual Interim Report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1997-0008 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 97-0037. 133 pp.

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