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KEY WORDS: Central Gulf; Western Gulf; Flower Garden Banks; biology; hydrography; maps; geology; monitoring; coral reef; physical oceanography; sediment; distribution; benthos; hydrocarbons; abundance; seasonality; physiography; faunal zones; geohazards.

BACKGROUND: Due to concerns about possible environmental impacts of oil and gas drilling and production operations on coral reefs and fishing banks in the northwestern Gulf of Mexico, certain restrictive regulations were established for drilling operations in the vicinity of the coral reefs at East and West Flower Garden Banks. As very little was known about the geology and biology of the banks lying in or near lease blocks to be offered for lease on the Gulf of Mexico Outer Continental Shelf (OCS), the Bureau of Land Management (BLM) contracted for what became a series of studies to fill this information gap. From 1974 to 1980, 38 features on the OCS were examined using either precision depth recorder, side-scan sonar, or research submersible. From 1977 to 1980, biological monitoring of the coral reefs of the Flower Garden Banks was undertaken, as well as expanded measurements of turbidity, current velocities, temperature, and salinity in the region of the banks. Discovery of a high salinity brine lake at East Flower Garden Bank and subsequent submersible observations (1977-1980) provided an opportunity for the study of effects of natural brine discharges and the nature of salt tectonism at the bank.

OBJECTIVES: (1) To produce a sediment distribution map for the Flower Garden Banks' region and to examine the relationship of sediment facies to biotic zones; (2) to construct maps identifying faults on the two banks and to interpret the structure of the banks from analyses of side-scan and subbottom data and submersible observations; (3) to prepare a side-scan sonar mosaic for West Flower Garden Bank and a seafloor roughness map for East Flower Garden Bank; (4) to assess the health of biotic communities of the two banks; (5) to develop biotic zonation maps of the banks; (6) to compare results of coral ecological studies at the two banks; (7) to study the hydrographic environment (salinity, temperature, turbidity, and currents) in which the banks exist; (8) to develop an understanding of the dynamics of the nepheloid layer, particularly as it impinges on these shelf-edge banks; (9) to ascertain the nature of the shelf-edge flow, including the driving mechanisms; (10) to determine the significance of petroleum-derived hydrocarbons in samples of organisms and sediment from the Flower Garden Banks; and (11) to characterize and identify possible geohazards of seven selected banks (Bouma, Bright, 18 Fathom, Ewing, Parker, Stetson, and MacNeil) from existing subbottom and side-scan records.

DESCRIPTION: A summary of the descriptive geology of the Flower Garden Banks was compiled from existing data gathered during the 1960s plus those data collected during previous BLM cruises. A compilation of observations gathered from submersible transects across the Flower Garden Banks was utilized to develop a descriptive account of biotic zonations and biotopes. Reef monitoring efforts were directed toward describing and monitoring coral populations above 30 m at the two banks. Stratified random line photo-transects, sclerochronological analysis of cores, seasonal measurements of encrusting coral growth and mortality, and seasonal coral recruitment data were used to evaluate the condition of the reefs.

Vertical profiles of current velocity, conductivity, and temperature were recorded at various locations around each bank during five separate cruises (September 1979 to July 1981). In situ dye emission experiments in the bottom boundary layer were conducted to analyze the flow in the boundary layer and shear stresses under known flow conditions. Twenty samples of the Atlantic thorny oyster, *Spondylus americanus*, and eight surficial sediment samples collected from the Flower Garden Banks were analyzed for high molecular weight hydrocarbons to determine the levels of contamination from petroleum. Geological analyses of the seven banks were accomplished through the interpretation of subbottom and side-scan sonar records. Sediment cores previously collected at Stetson Bank allowed for presentation of sediment distribution data.

SIGNIFICANT CONCLUSIONS: Based on the absence of land-derived sediments and muds on the reefs sampled and the vigorous growth of corals, established drilling restrictions (e.g., shunting of discharges to within 10 m of the bottom) appear to be adequate mitigation measures to protect the reefs from exploration and development activities. Comparisons of biological samples from East and West Flower Garden Banks indicated: (1) the presence of distinct biotic zones whose boundaries were determined by physical parameters; and (2) statistically similar community parameters between the two banks. Oceanographic measurements at the Flower Garden Banks indicated a predominant current flow toward the east, with movement of bottom waters around, not over, the banks. No elevated levels of petroleum hydrocarbons were detected in biota from the banks or within sediments of the area, indicating the absence of major petroleum contamination.

STUDY RESULTS: There were no land-derived muds in the bottom sediments above a depth of 85 m. If the nepheloid layer ever reached the top of the reef, even only occasionally, there would have been evidence of its presence in the bottom sediments. The distribution of sediments around the reef indicated a downslope movement due to gravity. There was no evidence for upslope transport of bottom sediments. The vigorous growth of corals on the living reef, and other reef-building organisms such as coralline algae at depths shallower than 75 m, suggested that the nepheloid layer never envelops the reef. Therefore, the established restrictions on drilling appear to be sufficient to protect the reefs from damage due to drilling activities. The danger of catastrophic collapse of the seafloor both on the hard bottoms of the banks and on the soft bottoms immediately surrounding the banks is very real.

Benthic organisms inhabiting the Flower Garden Banks were stratified into distinct biotic zones, the limits of which seem to be related to substratum type, light penetration, turbidity, sedimentation, and depth. Species diversity, evenness, richess values, and percent live cover of corals at East and West Flower Garden Banks were statistically similar. Recruitment and laterally encrusting growth of corals showed seasonality in rates. Mortality of corals was suggested to progress at greater rates than growth for the same species.

The mean flow on the outer shelf and upper slope in the vicinity of East and West Flower Garden Banks was persistently toward the east. Bottom waters moved around the banks even during major storm events, not up and over the banks. Tides at the shelf edge produced very small amplitude currents most of the year. Bottom boundary layer studies implied that it was only within the lowest 3 m of the bottom that local resuspension due to strong flow events contributed to significant changes in the sediment concentration.

Petroleum contamination in samples of *S. americanus*, if present at all, was at very low levels. Further monitoring would be necessary to determine if the observed petroleum values were the normal ambient values for animals in this area. The distribution of high molecular weight hydrocarbons, total organic carbon, and Delta ^{13}C in the sediment samples did not display patterns consistent with major petroleum contamination. Comparison with previous data indicated that although levels of petroleum-like hydrocarbons may be slowly increasing in the vicinity of the banks, they remain near baseline concentrations as compared to those in other Texas shelf sediments.

Numerous maps and graphic visuals were produced to illustrate the geological structure, physiography and/or sedimentology of the seven selected banks. Most of the banks described are mature salt domes with evidence of numerous faults that displace the seafloor. Evidence of the presence of gas charged sediments was seen in the form of hazy and chaotic reflections on the seismic records and reflections from bubble trains in the water column on some of the banks.

STUDY PRODUCTS: McGrail, D. W., R. Rezak, T. J. Bright, et al. 1982. Environmental Studies at the Flower Gardens and Selected Banks: Northwestern Gulf of Mexico - 1979-1981. A final report to the U.S. Department of the Interior, Bureau of Land Management Gulf of Mexico OCS Office, New Orleans, LA. Vol. I: Executive Summary- NTIS No. PB83-101303; Vol. II: Final Report - NTIS No. PB83-101295. Contract No. AA851-CT0-25. 381 pp.

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