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REPORT TITLE: Canyon and Slope Processes Study.

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KEY WORDS: North Atlantic; Mid-Atlantic; Baltimore Canyon; Lydonia Canyon; physical oceanography; slope; commercial fishing; currents; hydrography; sediment; nutrients; abundance; distribution; infauna; benthos; mitigation; transport; suspended matter; feeding; zooplankton; benthic photographs.

BACKGROUND: The seafloor off the east coast of the United States is incised by large valleys which head on the Atlantic Outer Continental Shelf (OCS) and cut downward across the slope and rise. There are 26 major submarine canyons between Nova Scotia, Canada and Cape Hatteras, North Carolina. These canyons appear to be sites of enhanced biological productivity, with extensive commercial fishing for squid, lobster, and finfishes. Submarine canyons are anticipated sites for exploratory drilling and potential petroleum production wells. Foreseeing a potential conflict between the commercial fishing and petroleum exploration interests, the Bureau of Land Management contracted this study to provide a factual basis for future discussions and regulatory decisions concerning the physical and biological processes operating in submarine canyons and on the slope, and the processes that might transmit the effects of OCS activities to benthic communities.

OBJECTIVES: (1) To characterize the currents and hydrography within submarine canyons and on the slope; (2) To document the along-slope structure of currents and the influence of canyons on slope currents; (3) To characterize the suspended sediment and nutrient exchange between canyons and the adjacent shelf and slope; (4) To determine the abundance and distribution of epifaunal communities in selected canyon and slope areas; (5) To determine the abiotic and biotic processes affecting the distribution and abundance of epifaunal communities; (6) To identify the communities which may be affected by oil and gas operations; and (7) To identify measures for alleviating or eliminating the effects of oil and gas operations on the epifaunal communities.

DESCRIPTION: Five areas were examined during this three-year study. These included Baltimore Canyon in the Mid-Atlantic, Lydonia Canyon in the North Atlantic, and three slope areas of high oil and gas industry interest. The slope areas included an area between Linderkohl and Carteret Canyons, an area between Toms and Meys Canyons (both in the Mid-Atlantic), and an area between Veatch and Hydrographer Canyons in the North Atlantic. Study depths ranged from 100 to 2,000 m. Baltimore

Canyon and the two adjacent Mid-Atlantic slope sites were the scenes of physical oceanographic, sediment transport, nutrient, and zooplankton studies. Megafaunal assemblages were assessed in Lydonia and Baltimore Canyons, and all three slope sites.

SIGNIFICANT CONCLUSIONS: Results of this study showed that megafaunal assemblages in canyons may be substantially different from the surrounding slope area. Submarine canyons provide habitat for a variety of unique taxa and act as refuges for large refuge populations of sessile filter-feeding anemones, corals, and sponges. Growth rates in deepsea organisms are generally slow, and recovery of a submarine canyon megafaunal community from any major environmental impact would be slow. Canyon epifaunal assemblages should be regarded as fragile, compared to those of the shelf and slope. Taxonomic richness was highest in areas of hard substrate whether in canyons, on the shelf, or on the slope.

STUDY RESULTS: Peak bottom current speeds of 106 cm s^{-1} were observed in the axis near the head of the Baltimore Canyon at depths of 275 m. At 594 m, a current of 95 cm s^{-1} was also reported from the axis station. Currents of this magnitude were not anticipated and were greater than any observed on the adjacent shelf-slope area. The highest current speed observed on the shelf itself was 81 cm s^{-1} in 100 m of water just above the canyon heads. Spectral analysis showed the energy of the fluctuating currents to be concentrated in two frequency bands, suggesting a nearly semi-diurnal tidal frequency and the other indicating the existence of an internal or baroclinic tide. The mean current flow near the surface over the slope area and Baltimore Canyon is southwestward paralleling the shoreline at speeds of 10 to 15 cm s^{-1}. Only at depths below 100 m does canyon topography influence shelf current direction. Mean currents along the canyon axis are down canyon from the head to a depth of 400 m and up canyon in the 600- to 1,000-m depth range, forming a zone of convergence between 400 and 500 m. Here water must be carried upward and dispersed along the thermocline, although this is not conclusively demonstrated in the present study. Bottom currents were negligible below 1,000 m.

Resuspension of particulate matter within the canyon occurred predominantly along the canyon axis and at tidal frequencies. Sediment transport generally followed the net transport of the water: on the shelf it was parallel to the coast, southwest along the isobaths; in the canyon it was down canyon from the head to 400 m then strongly up canyon at 600 m; and virtually nonexistent in the 1,000 m range. Seaward transport of particulate matter occurred in the form of turbidity layers which detached and moved outward along density gradients. Transport along the canyon walls and adjacent slope areas was very small compared to the canyon axis.

Surface and near-bottom nutrient concentrations in the Baltimore Canyon area suggest their distribution is influenced primarily by the mean circulation patterns. Surface concentrations of phosphate, silicate, and nitrate varied seasonally as a result of biological activity in the upper water column. Concentrations increased with depth, reaching a maximum from 300 to 600 m at all stations.

Total megafaunal abundance was high along the shelf and upper slope (100 to 600 m), low at mid-slope depths (below 1,400 m), then high again at lower slope depths (below 1,400 m). Five major depth zones with characteristic common taxa were found between 100 and 2,000 m. Depths of transition between these zones varied slightly from area to area. Substantial overlap in taxa between adjacent zones indicated a pattern of gradual species replacement along a depth gradient. In the North Atlantic, faunal densities in Lydonia Canyon were considerably higher than at comparable depths on the shelf and slope. In the Mid-Atlantic, no consistent differences in megafaunal densities between the Baltimore Canyon and adjacent slope areas were detected.

In the Mid-Atlantic, canyon and slope trophic patterns were similar: the shelf and upper slope showed dense populations of filter feeders and/or carnivore/ scavengers; the mid-slope sparce densities of carnivore/scavengers; and the lower slope fairly dense groups of deposit feeders and filter feeders.

Lydonia Canyon showed dense populations of sessile filter feeders at the mid-slope depths because of increased hard substrate in those depth ranges.

Zooplankton biomass was highest at the surface over the shelf and decreased further offshore. Near bottom biomass was also highest at shelf stations. An increased species abundance and biomass was observed in the upper canyon relative to the rest of the canyon. This increase is consistent with observations of increased particle concentrations, nutrient concentrations, epifaunal distribution, and resuspension phenomena from this study.

STUDY PRODUCT(S): Lamont-Doherty Geological Observatory of Columbia University. 1983. Canyon and Slope Processes Study. A final report for the U.S. Department of the Interior, Minerals Management Service Atlantic OCS Office, Vienna, VA. Contract No. 14-12-0001-29178. 541 pp.

Samples collected during this study are archived at the following locations: zooplankton specimens, suspended sediment samples, and photographs are archived at Lamont-Doherty Geological Observatory; geology samples from submersible dives are archived at the U.S. Geological Survey (Woods Hole, Massachusetts) and National Oceanic and Atmospheric Administration (Rockville, Maryland); and voucher specimen collections of anemones are at the Museum of Comparative Zoology (Harvard) and all other epifaunal groups are at the Smithsonian Institution (Washington, D.C.).

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