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STUDY TITLE: Current and Acoustical Measurements Over the Vertical Water Column In-Situ and PIES and Northeastern Gulf of Mexico Physical Oceanography Program: DeSoto Canyon Eddy Intrusion Study

REPORT TITLE: Deepwater Observations in the Northern Gulf of Mexico from In-situ Current Meters and PIES, Final Report, Volume I: Executive Summary and Volume II: Technical Report

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APPLICABLE PLANNING AREA: Central Gulf of Mexico

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KEY WORDS: Gulf of Mexico, DeSoto Canyon, Loop Current, eddies, cyclones, current, topographic Rossby waves, sea surface height, circulation, field measurements, transport, Sigsbee Escarpment, slope.

BACKGROUND: This study was conducted in a deepwater region of significant potential for oil and gas exploration and development. Prior industry current measurements showed that strong current speeds are both possible and occur over a vertical layer that extends from the bottom to a nominal depth of 1000m. The U.S. Department of the Interior requires an environmental characterization of these deepwater potential lease areas for making appropriate management decisions. The present report presents the results of a field measurement and synthesis study conducted by scientists from SAIC and the University of Rhode Island.

OBJECTIVES: *In-situ* current measurements, hydrographic data, satellite altimetry and surface drifters were used to document and characterize dynamic conditions occurring in the upper (above 1000 m) and lower layer (below 1000 m) over a region in the vicinity of the Sigsbee Escarpment. These data were to be used to develop a characterization of the pattern of currents in the lower layer and possible linkages to conditions/processes in the upper layer of the water column. In addition, inverted echo sounders with pressure (PIES) were deployed for six months in conjunction with a full-depth mooring to document full-depth temperature, salinity and velocity profiles.

DESCRIPTION: This study area is located on the far western flank of the DeSoto Canyon at the base of and extending up the Sigsbee Escarpment. Measurements were generally centered about 91°W, 27° 15' N, in water depths that ranged from ≈1500 m on the top of the Escarpment to ≈2100 m away (southeast) from the base of the Escarpment.

In August 1999, two years of field measurements were initiated with various combinations of joint funding by the MMS and BP. Initially, four moorings were deployed. Three were near-bottom moorings that extended approximately 400 m above the local bottom. Each short mooring had current meters at 10, 100 and 400 m above the bottom. One near bottom/short mooring was at the top of the Escarpment; the other two were near the base. Mooring separations were on the order of 20-30 km. A full-depth mooring was deployed near the base of the Escarpment and contained a combination of Acoustic Doppler Current Profilers (ADCPs), thermistors, fixed-level current meters and conductivity/temperature sensors. These were distributed vertically so the resulting observations would document well the vertical differences in currents, temperature and salinity as they varied with time. Between 12 and 18 months, three moorings (two near bottom and one full depth) were maintained, all of which were located at the base of the Escarpment. During months 18-24, these three moorings were supplemented with an additional mooring on the Escarpment but close to one of the longer-term near-bottom moorings. In addition, three Inverted Echo Sounders with Pressure (PIES) were deployed at this time in a triangle about the full-depth mooring. Rotation, deployment and maintenance cruises were conducted semiannually.

For this study, these data were supplemented with satellite altimetry obtained from the web site maintained by the University of Colorado (http://www-ccar.Colorado.EDU/~realtime/gom-real-time_vel/). These daily graphics provided a serially continuous characterization of most major dynamic features in the upper layers (above ≈ 1000 m) of the Gulf of Mexico. Trajectories for surface drifters (drogued at 50 m below the water surface) within Eddy Millennium in the interval of January – July 2001 were purchased from the Horizon Marine, Inc. archive.

SIGNIFICANT CONCLUSIONS: Strong near-bottom currents varied significantly with time and due to position relative to the Escarpment. The lower layer (bottom to ≈1000 m below the water surface) was strongly barotropic so only relatively weak shears occurred. The major variations in deep water currents appear to be driven by topographic Rossby waves that move through the study area in long duration wave trains that were separated by intervals of relative quiescence (noticeably lower current velocities). These trains of waves and associated higher velocities could persist for intervals ranging from two to six months.

STUDY RESULTS: Good data return resulted in long, generally unbroken time series that provided a basis for an excellent documentation of dynamic conditions and processes within and proximate to the study area. Measurements provided excellent characterization of the two-layer structure of the current field in the deeper Gulf of Mexico. In this study area, the upper layer was strongly affected by Loop Current eddies, cyclonic eddies and cyclonic boundary eddies that occur on the Loop Current and on Loop Current eddies. The migrating eddy fields were a major cause of the time varying velocity and temperature field. In the lower layer (depths > ≈ 1000 m), current shear was often relatively weak such that in 2000 m water depths, this lower layer moved almost as a “slab”. The higher speed events that occur in this lower layer were periodic (8-12 day periods are common), and these periodic velocity signals could persist over intervals ranging from two to six months, based on the two years of measurements taken in this study. The deep currents were such that the highest current speeds occurred near the bottom (bottom intensified). Highest measured currents were approximately 95 cm/s (≈ 2 knots) at 100 m above the bottom, and 75 cm/s at 10 m above the local bottom. Currents above 50 cm/s were relatively common with the passage of trains of waves. If, as these data seem to show, these trains of periodic current variations are due to passage of topographic Rossby waves, their source region is probably relatively close to the measurement sites and at these short periods do not appear to propagate into the western Gulf basin.

The preliminary examination of PIES and associated GEM methodology, showed this technology provided a very good method for estimating time series of vertical temperature and salinity profiles. These combine to estimate accurately the profile of geostrophic current vectors. Measured reference current velocities near the seabed were used to convert the shear profile to an absolute velocity profile that agreed well with the measured profile. Similarly, the PIES-based estimates of temperature and salinity time series agreed well with the measured values.

STUDY PRODUCT(S): Hamilton, P., K. Donohue, J.J. Singer, and E. Waddell,. Deepwater Observations in the Northern Gulf of Mexico from In-situ Current Meters and PIES, Final Report, Volume I: Executive Summary. OCS Study MMS 2003-048. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 21 pp.

Hamilton, P., K. Donohue, J.J. Singer, and E. Waddell,. Deepwater Observations in the Northern Gulf of Mexico from In-situ Current Meters and PIES, Final Report, Volume II: Technical Report. OCS Study MMS 2003-049. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 103 pp.

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