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SPONSORING OCS REGION: Gulf of Mexico

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CUMULATIVE PROJECT COST: $5,499,579

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KEY WORDS: Eastern Gulf; Central Gulf; Western Gulf; Florida; Louisiana; Texas; physical oceanography; Loop Current; currents; satellite imagery; hydrography; survey; shipboard observations; nutrients; West Florida Shelf; slope; shelf; eddy; wind forcing; seasonality; upwelling; tidal currents

BACKGROUND: In 1982, the U.S. Department of the Interior initiated a multi-year investigation of physical oceanographic conditions related to or resulting from deep circulation patterns in the Gulf of Mexico. During the first two study years, measurements and interpretation focused on the eastern Gulf of Mexico with emphasis on the Loop Current and its interaction with the adjacent west Florida shelf and slope. The present report describes data collected during the first two years.

OBJECTIVES: (1) To describe Gulf of Mexico circulation and to provide data to be used in concurrent numerical modeling studies.

DESCRIPTION: During the two-year study period, data necessary to describe Loop Current behavior and associated circulation patterns were obtained from Lagrangian drifters, satellite thermal imagery, regional shipboard hydrographic surveys, moored

current meters, and ships-of-opportunity. Four drifting spar buoys equipped with position transmitting instrumentation were used to track rings. One buoy was fitted with 9 thermistors attached to a line at depths of 5, 10, 25, 50, 75, 100, 150, 175, and 200 m. Satellite imagery was used to define the spatial extent and time dependent characteristics of the Loop Current boundary and related features. Infrared imagery was obtained from National Oceanic and Atmospheric Administration and Geostationary Operational Environmental Satellites equipped with advanced very high resolution and visible-infrared spin-scan radiometers, respectively. Hydrographic sampling was conducted during four cruises. Cruises were planned according to satellite imagery and sea surface temperature maps to allow samples to be taken within or following particular Loop Current events. Data collection during the cruises included conductivity, temperature, and depth measured by a conductivity-temperature-depth instrument deployed with a rosette water sampler. Water samples were analyzed for chlorophyll, nutrients, and oxygen using standard methods. An expendable bathythermograph was used for temperature profiling. Vertical profiles of horizontal currents were obtained using a hull mounted acoustic doppler current profiler. Moored current meters were used to measure temperature, subsurface currents, and pressure. Current meter data were collected from three general areas during this study including the west Florida, Louisiana, and south Texas outer continental shelf (OCS). Five tautline moorings were deployed along a heading perpendicular to the west Florida shelf in water depths ranging from 50 to 3,275 m, while one was placed 167 km north on the 180-m isobath. The Louisiana mooring was deployed in 81 m of water immediately south of Conoco's platform SP-55A. Near bottom currents on the South Texas OCS were monitored for 145 days in the summer, fall, and early winter of 1984 using current meters deployed in water depths of 12, 18, 34, 74, and 140 m.

SIGNIFICANT CONCLUSIONS: Rings (eddies) followed similar paths across the Gulf and exhibited similar behavior, suggesting some common underlying mechanism. The circulation regime offshore southwest Florida was found to be complex, involving offshore forcing and wind forcing. Hydrographic surveys revealed subregional scale dynamic features and regional scale synoptic conditions. High frequency tidal and inertial currents, which contributed greatly to west Florida shelf current variability, showed considerable seasonal variability. Averages of these measurements appeared stable after two study years.

STUDY RESULTS: Lagrangian drifters revealed the paths, translation velocities, local vorticity, and horizontal deformation rates for three large anticyclonic Gulf of Mexico rings. The paths taken by the rings were nearly identical. Trajectories indicated a ring life span of approximately 9 to 13 months with persistence off the Mexican coast of 3 to 5 months. The fourth drifter, not seeded in a ring, demonstrated strong anticyclonic motion. Satellite imagery provided information on average dimensions, speeds, and trajectories. Translation velocities determined from imagery ranged from 2 to 5 km day^{-1} with a diameter ranging from 150 to 200 km. Oscillation ranged from 1 to 8 km day^{-1} on the average at periods of 40 to 100 days. Sea surface temperature maps showed an approximate 50% reduction in surface area of the eddies in the first 150 days and a 70% reduction in 300 days.

Hydrographic cruises provided information on conditions in proximity to the Loop Current boundary as well as surface and subsurface calibration data for satellite thermal imagery. Higher speed currents were located in a 100 to 150-km near-surface band which was just inside the Loop Current frontal boundary. Maximum speeds near or at the surface decreased by approximately 50% or more in the upper 250 m. Acoustic doppler current profiles indicated that a very sharp shear occurred in the Loop Current along-front velocity component. Cold pockets associated with the Loop Current eastern boundary could extend to considerable depths and isotherm doming was evident at over 500 m. Upwelling of nutrient-rich water from the slope onto the west Florida shelf was documented. Temperature, salinity, and nutrient profiles were similar to those found within the Gulf Stream. Seasonal thermal stratification was also evident with vertical stratification during summer months and vertically well mixed shelf water with stronger horizontal gradients during winter.

Shelf currents were found to be coherent with prevailing wind patterns. Between 40 and 60% of the variability was in the higher frequency band (3 to 40 h). The diurnal-semidiurnal tide had little effect on the current field. The maximum measured wind-induced currents were at mid-shelf and decreased offshore. When the Loop Current penetrated the shelf, it completely dominated velocity and temperature fields. Also, when the Loop Current was adjacent to the slope, cold-core boundary perturbations had considerable effect on circulation.

STUDY PRODUCT: Science Applications International Corporation. 1986. Gulf of Mexico Physical Oceanography Program Final Report: Years 1 and 2. Vol. I, Executive Summary. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. NTIS No. PB87-107405. MMS Report 85-0093. Contract No. 14-12-0001-29158. 21 pp.

Science Applications International Corporation. 1986. Gulf of Mexico Physical Oceanography Program Final Report: Years 1 and 2. Vol. II, Technical Report. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. NTIS No. PB87-107413. MMS Report 85-0094. Contract No. 14-12-0001-29158. 406 pp.

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