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STUDY TITLE: MAFLA OCS Hydrographic Study

REPORT TITLE: Compilation and Summation of Historical and Existing Physical Oceanographic Data from the Eastern Gulf of Mexico

CONTRACT NUMBER: BLM: 08550-CT4-16

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KEY WORDS: Eastern Gulf; Central Gulf; Mississippi; Alabama; Florida; baseline; physical oceanography; hydrography; Loop Current; fish; spawning; meteorology; seasonality

BACKGROUND: A consortium of oceanographers was contracted by the Bureau of Land Management to summarize available information concerning the physical oceanography of the Mississippi-Alabama-Florida (MAFLA) shelf region. The resulting synthesis was to guide future biological, chemical, geological, and physical oceanographic studies targeted for the MAFLA region prior to oil and gas exploration activities.

OBJECTIVES: (1) To assemble the historical and contemporary physical and associated meteorological data of the northeastern Gulf of Mexico for submission to the National Oceanographic Data Center (NODC); (2) to construct a zero-order synthesis of oceanographic conditions in the northeastern Gulf and have them graphically displayed; (3) to describe the general circulation and oceanographic conditions of the northeastern Gulf continental shelf and in the Loop Current of the deeper Gulf areas; (4) to describe qualitatively the interaction between the shelf circulation of the northeastern Gulf and

the Loop Current; (5) to describe the seasonal distribution of the fish spawning intensity and zooplankton productivity on the West Florida Shelf and relate these to temperature and salinity data; (6) to develop a first-order understanding of the trajectory of a pollutant in the northeastern Gulf; and (7) to provide recommendations on sampling locations for future biological, chemical, geological, and physical oceanographic investigations.

DESCRIPTION: Data assembled and synthesized for this report relied on archived and recently entered hydrographic data (e.g., salinity, temperature, depth) from NODC files. This information was obtained with expendable bathythermographs, mechanical bathythermographs, salinity-temperature-depth hydrocasts, current meters, and cyclesonde meters. Data sets were generated from the general region bounded by 21 to 30°N Lat and 81 to 90°W Long. NODC established a separate file for MAFLA data. At the request of individual investigators, analyses and graphic displays were produced. Climatic information was provided by the National Climatic Center.

From 1972 to 1974, ichthyoplankton and zooplankton were sampled with paired 60-cm Bongo net plankton samplers. Stations were spaced 24 or 48 km apart on a grid from Dry Tortugas to Cape San Blas and from the 10- to 200-m isobaths at the shelf edge.

SIGNIFICANT CONCLUSIONS: Primary motion inducing forces on the West Florida Shelf were atmospheric disturbances and the Loop Current. Summer or winter tradewinds coupled with tropical cyclones, cold fronts, warm fronts, and hurricanes induce compensatory mass water movements. Primary Loop Current effects include: momentum and water mass transfer from the Loop Current to the shelf; direct incursions of the Loop Current onto the shelf; incursions of Loop Current related eddies, and their associated eddies, onto the shelf; and fluxes of mass from the shelf to the deep basin instigated by Loop Current features.

Three control volumes should be considered for an appropriate sampling grid from which to gather data to be used in forecasting, monitoring, and numerical modeling: the immediate vicinity of a drilling unit, the continental shelf from the Mississippi Delta to the Florida Keys, and the deep basin waters of the eastern Gulf of Mexico. For the first two control volumes, transhelf spacing of current meter moorings should be 25 km, and alongshelf spacing of moorings should be 100 km. A surface current meter should be attached directly to the drilling unit. For the shelf volume, additional meters should be deployed at the shelf break. Monitoring for the deep basin should employ satellite altimeter, satellite imagery, satellite film loops, and moored buoys with thermistor chains, tide gauges, and hydrographic sections.

Process-oriented studies for the shelf should include surface and bottom mixed layer dynamics during strong meteorological events, surface gravity wave dynamics during strong meteorological events, dispersal of surface and subsurface materials, and bottom sediment transport dynamics. Suggested deep basin studies were mainly of Loop Current dynamics. Particular areas that might receive attention included De Soto Canyon, Cape San Blas, and the shelf break.

STUDY RESULTS: Meteorologically, there are two distinct seasons in the eastern Gulf of Mexico: winter and summer. Primary atmospheric disturbances during winter months are cold fronts, warm fronts, stationary fronts, and occluded fronts. Cold fronts, most prevalent during winter, move southeast at an average speed of 15 to 20 kn and affect shelf circulation during their passage. Summer atmospheric conditions are primarily affected by the Bermuda-Azores high pressure ridge; however, tropical waves and tropical cyclones also occur that exert pronounced effects on hydrographic conditions. Cumulative river runoff, another hydrographic feature in the MAFLA area, was 18,784 $m^3 s^{-1}$ or 60 x 10^{10} $m^3 yr^{-1}$. The Mississippi River contributes 72% of the total discharge to the MAFLA area. Tidal and inertial motions produce particle orbits with a radius on the order of several kilometers and an orbital period on the order of 12 to 28 h. Such particle motions are likely to play a significant role in horizontal dispersion. Two water masses, the Subtropical Underwater and the Antarctic Intermediate Water, were traversed by the Loop Current in deep basin waters of the eastern Gulf of Mexico. Water mass properties, salinity, temperature, and dissolved oxygen increased in variability with distance from the core of this current. Based on available data, an annual cycle of the Loop Current was proposed. A spring intrusion of the Loop Current was followed by maximum penetration in summer. An anticyclonic eddy then separates from the main flow. During fall, the Loop recedes and with minimum intrusion occurs during winter. Temporal variability of this cycle was unknown, but was believed to be substantial. Detached eddies and the Loop Current often flow directly onto the shelf, usually during summer, and considerably influence shelf circulation. Mean current flow on the shelf usually parallels local depth contours, although near-surface currents on the outer shelf often flow perpendicular to depth contours. This indicates the presence of surface currents and undercurrents operating within the system. Low frequency components, with periods of 5 to 20 days, are important contributors to shelf circulation patterns. Low frequency components were 50 cm s^{-1} as opposed to 10 cm s^{-1} for tidally induced flows. On a time scale of several days to a week, the advective flow field is dominated by low frequency fluctuations. Thermal stratification on the shelf intensified in a shoreward direction during summer. In winter, shelf waters were well mixed vertically, mainly due to atmospheric (wind) forcing. A 25-m thermocline advances shore from January-February to May-June, and moves seaward in August. Lowest average surface salinities (21 ppt) of shelf waters were recorded during March, and lowest bottom salinities never dropped below 30 ppt at any time. Seasonal cycles in surface salinities were associated with riverine discharges.

Many of these circulation characteristics were responsible for the observed distribution of zooplankton and ichthyoplankton. Mean zooplankton volumes ranged from 69.1 to 287.8 ml 1,000 m^{-3}. Mean fish egg abundances ranged from 163.1 to 927.1 under 10 m^2 of sea surface. Mean larval fish abundances were 55.3 to 825.4 under 10 m^2 of sea surface. Zooplankton, fish eggs, and fish larvae had standing crop values that peaked during summer and dropped during winter. Generally, zooplankton and ichthyoplankton were concentrated in the northern half of the study area, but pooled means did not differ greatly between sectors. Seasonal abundance patterns of fish eggs and larvae were more pronounced within the 50-m isobath. In general, correlations among biological variables (concentrations of organisms) and other environmental variables (temperature

and salinity) were not apparent. A biological phenomenon known as red tide is dependent on circulation pattern and is due to massive blooms of the dinoflagellate *Gymnodinium breve*. The actual triggering mechanisms for these blooms are unknown, but ambient currents are important in transporting the red tide and determining subsequent effects.

STUDY PRODUCTS: State University System of Florida, Institute of Oceanography. 1975. Compilation and Summation of Historical and Existing Physical Oceanographic Data from the Eastern Gulf of Mexico. A report for the U.S. Department of the Interior, Bureau of Land Management Gulf of Mexico OCS Office, New Orleans, LA. NTIS No. PB80-190168. Contract No. 08550-CT4-16. 97 pp. + app.

*P.I.'s affiliation may be different than that listed for Project Manager.