

STUDY TITLE: Northeastern Gulf of Mexico Physical Oceanography Program: Chemical Oceanography and Hydrography Study

REPORT TITLE: Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study: Synthesis Report

CONTRACT NUMBER(S): 1435-01-97-CT-30851

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREA(S): Central and Eastern Gulf of Mexico

FISCAL YEAR(S) OF PROJECT FUNDING: 1998, 1999, 2000, and 2001

COMPLETION DATE OF REPORT: January 2002

COST(S): FY 1998 \$654,969; FY 1999 \$700,571; FY 2000 \$733,077; FY 2001 \$224,761; CUMULATIVE PROJECT COST: \$2,313,378

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KEY WORDS: Physical oceanography, Gulf of Mexico, Mississippi-Alabama shelf, west Florida shelf, circulation, hydrography, Loop Current, eddies, temperature, salinity, nutrients, dissolved oxygen, particulate matter, pigments.

BACKGROUND: The Minerals Management Service (MMS) Gulf of Mexico Outer Continental Shelf Region sponsored a workshop on 5-7 April 1994 in Tallahassee, FL, to assess the knowledge of the circulation over the shelf and slope of the northeastern Gulf of Mexico and to provide recommendations on studies needed to fill gaps in knowledge. MMS then designed the Northeastern Gulf of Mexico Physical Oceanography Program (NEGOM). This summary presents the main results of the NEGOM Chemical Oceanography and Hydrography Study.

OBJECTIVES: (1) To develop and conduct an effective and efficient oceanographic experimental design of research cruises over the NEGOM region at spatial and temporal scales sufficient to resolve seasonal variations of chemical oceanography and hydrographic properties. (2) To collect the ancillary data necessary to complement and

analyze the data collected under objective 1. (3) To analyze the data to describe the vertical and horizontal spatial distributions and temporal variations of properties and the chemical, physical, or biological processes that contribute to the observed distributions.

DESCRIPTION: The study area is bounded by 89°W on the west, the 10-m isobath inshore, 27.5°N on the southeast, and the 1000-m isobath offshore. Nine oceanographic research cruises were conducted aboard the *R/V Gyre* over three field years from November 1997 to August 2000. During each field year, one cruise was conducted in spring (April/May), summer (July/August), and fall (November) seasons. Continuous profiles were made of temperature, salinity, pressure, light transmission, fluorescence, and downwelling irradiance using a Sea-Bird 911*plus* CTD system. A total of 883 CTD stations were occupied. Discrete water samples were drawn at each CTD station for analyses of dissolved oxygen, nutrients (nitrate, phosphate, silicate, nitrite, ammonium, and urea), pigments, particulate matter, and particulate organic carbon. Four to twelve discrete samples per station were taken, totaling in excess of 8000 oxygen and nutrient samples, 1500 pigment and particulate matter (PM) samples, and 1000 particulate organic carbon (POC) samples. Over 800 expendable bathythermograph measurements were made. Acoustic Doppler current profiler (ADCP) observations, using a 150 kHz ADCP, and underway flow-through measurements of near-surface temperature, salinity, and fluorescence were made continuously along track. Nearly 1000 near-surface chlorophyll samples were taken to calibrate the underway, near-surface fluorescence data for determination of calculated chlorophyll. Data from a 38 kHz ADCP were collected on three surveys. Ancillary data sets, such as river discharge, sea surface height fields from satellite altimeter, and meteorological measurements, were assembled to support the data analysis and interpretation.

SIGNIFICANT CONCLUSIONS: A general conclusion of this study is that interannual variability overshadows seasonal signals. This is due to a number of factors. First, the offshore circulation, consisting of both cyclonic and anticyclonic eddies as well as the Loop Current and filaments thereof, is very energetic, highly variable, and greatly affects the shelf circulation, particularly over the Mississippi-Alabama shelf and near DeSoto Canyon. These features are not seasonal or deterministic in occurrence. Second, although there is a clear seasonal pattern in the climatological winds over the study area, the observations show there is much interannual variability. Moreover, the variability in direction from downcoast to upcoast occurs with greater frequency than in the northwestern Gulf shelves, leading to rapid shifts in direction of the wind-driven coastal current. Thus, the seasonal cycle of wind forcing over the inner shelf is neither so strong nor so regular as that needed to ensure a strongly seasonal coastal current regime. Finally, the discharge of rivers to this area follows a complicated pattern, particularly as compared to the northwestern Gulf shelves. The dominant river is the Mississippi and its discharge is often carried eastward along the outer continental shelf or over the slope, leading to a pattern of decreasing offshore salinity over the mid to outer shelf and consequent buoyancy effects. These factors also influence the distributions of water properties and chemical parameters, such as salinity, dissolved

oxygen, nutrients, light transmission, particulate matter, particulate organic carbon, chlorophyll *a*, and other pigments.

STUDY RESULTS: Realizing the large interannual variability and the fact that only three realizations of the circulation for each season were available, space-time patterns over the area nevertheless were sought. Key results regarding the circulation are: (1) offshore circulation features appear to account for about three-quarters of the variance of the near-surface circulation of the study area, (2) nearshore currents may be driven by local/regional winds. However, the wind regime in the study area is quite variable on both short and interannual time scales, rendering climatological predictions of diminished value. Only some ten percent of the variance of the near-surface circulation observed during the NEGOM study showed a seasonal pattern associated with the wind regime, (3) about 15% of the variability of near-surface circulation in the study region is associated mainly with currents over the inner shelf and may be attributed to the effects of local winds and river discharge, and (4) variability in both circulation and property distributions is judged considerably greater in the western than eastern study region.

Dissolved oxygen patterns near surface reflected the relationship of enhanced oxygen solubility with decreasing temperature and salinity. The effect of river discharge, with its lower salinity, was to enhance the oxygen concentrations in the surface waters. At most stations with high chlorophyll *a*, water samples were highly supersaturated in oxygen, illustrating the potential effect of primary production on dissolved oxygen concentrations. Bottom dissolved oxygen concentrations were greatest in fall and lowest in summer. No hypoxic conditions were observed during the cruises, but very low concentrations were observed at a few stations over the inner shelf during two spring and two summer cruises. Results showed that, regardless of season, nutrient concentrations in the photic zone were elevated in areas of enhanced river water influence and of uplift of density surfaces by dynamic processes, such as the presence of cyclones near the shelf edge, divergence between cyclone-anticyclone pairs, and wind or bottom-induced upwelling. Oxygen and nutrient concentrations were examined on density surfaces corresponding to water masses found in the Gulf. No relative dissolved oxygen maximum associated with 18°C Sargasso Sea Water was found. A relative oxygen minimum associated with Tropical Atlantic Central Water near 425 m and a relative nutrient maxima (nitrate, phosphate) associated with Antarctic Intermediate Water near 750 m were observed.

Cruise average water column PM mass was lower over the eastern shelf (east of 87°W) than the western shelf. Similarly, the cruise average percent of PM per unit surface area contained in bottom nepheloid layers over the shelf was much lower and less variable over the eastern than western shelf. This is evidence for the effects of the Mississippi and other rivers on PM and light transmission, as well as suggestive of more re-suspension on the western shelf. PM values showed lower mean near-surface concentrations in fall and most variability in spring. Near-bottom means were similar for the three seasons, although the smallest variability was observed in summer. Highest POC levels in all seasons generally were associated with high PM plumes near river mouths. Near-surface POCs were greater and evidenced more variability than sub-

surface concentrations. Indicative of phytoplankton productivity in the photic zone and remineralization of organic carbon in the water column, the quantity of POC accounting for PM was more variable near surface than within the water column. Near-bottom particulates also may have a contribution from re-suspended sediments relatively poor in organic carbon.

As determined from pigment data, the four major algal groups present in the NEGOM area were prymnesiophytes, prochlorophytes, pelagophytes, and cyanobacteria, although locally high abundances of other groups were detected. Prymnesiophytes were the dominant group on each cruise, accounting for between 31% and 46% of the chlorophyll present at the deep chlorophyll maximum (DCM). Prochlorophytes, pelagophytes, and cyanobacteria were the second most abundant groups in the DCM on four, three, and two cruises, respectively, accounting for 13-23%, 6-18%, and 0-21% of the chlorophyll *a*. High concentrations of chlorophyll *a* were found in areas influenced by discharges of the Mississippi and Apalachicola rivers. For the study region as a whole, the average surface and DCM chlorophyll concentrations were lower in boreal fall-winter (November–March) than boreal spring-summer (April–October); the opposite relationship would be expected for offshore Gulf waters. This was a consequence of (1) the fact that most stations were over the shelf rather than offshore, (2) summer entrainment and transport offshore of low-salinity Mississippi River water with enhanced nutrient levels, and (3) the presence of various offshore eddies that contributed enhanced nutrient levels to the photic zone during summer by uplift of density surfaces. As expected, however, average surface chlorophyll *a* values in waters of depth greater than 400 m were several times higher in fall than in spring.

STUDY PRODUCT(S): Jochens, Ann E., Steven F. DiMarco, Worth D. Nowlin, Jr., Robert O. Reid, and Mahlon C. Kennicutt II. 2002. Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study: Synthesis Report. OCS Study MMS 2002-055. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 570 pp.

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