Program Summary of the
Northeastern Gulf of Mexico Physical Oceanography Program (NEGOM):
Chemical Oceanography and Hydrography Study

Background

We will study the hydrography and chemical oceanography of a region of the northeastern Gulf of Mexico bounded by 27.5N, 89W, the 10-m isobath and the 1000-m isobath.

The principal forcing functions for the circulation and distributions of chemical and hydrographic variables in the region are: wind stress, the Loop Current and derived circulation phenomena, river discharge, and air-sea exchanges other than wind stress.

The inner shelf flow is likely wind-driven, with contributions due to buoyancy forcing by river discharge. Documentation and synthesis of winds for the Gulf of Mexico are given in Florida A&M University (1988). We will examine forcing from wind stress fields obtained from NOAA and the U.S. Navy, and we may produce analyzed wind fields directly from the observations.

The Loop Current (LC) is the major dynamic, circulation feature in the Gulf of Mexico. Once or twice annually (on average), it sheds anticyclonic, mesoscale current rings with potential lifetimes longer than one year; these rings typically migrate to the western Gulf and spawn cyclonic rings during interaction with one another or the continental slope. The LC sometimes extends well into the northern part of the eastern Gulf. Filaments from the LC are not uncommon in the NE Gulf of Mexico (NEGOM).

Satellite images gathered during MAMES (MS-AL Marine Ecosystem Study,1987-89) show that LC filaments and plumes extending northward are frequent and persistent on the slope and shelf region of the NEGOM. Their pathways are not restricted to the axis of DeSoto Canyon; filaments meander hundreds of kilometers northward from the main body of the LC. The extent of northward penetration by the LC does not reliably indicate the potential for intrusions reaching the shelf/slope of the NEGOM; filaments readily traverse considerable distances.

MAMES results and analyses as presented by Brooks et al. (OCS Study MMS 91-0063, 1991) provide first estimates for use in the design of this work. Conclusions of this earlier study for the region west of DeSoto Canyon are: a) LC-derived intrusions strongly modulate the stochastically wind- forced shelf circulation; b) LC-derived intrusions appear to displace shelf water masses, but do not impart significant kinetic energy to the shelf circulation; c) LC-derived intrusions are observed on the shelf/slope about 44% of the time; d) at the 430-m isobath, monthly mean currents are usually northeastward at the surface, while mean bottom currents are persistently to the southwest; e) the cross-shelf length scale of motion is between 30 km and 70 km; and f) LC-derived intrusions onto the MS-AL shelf have a width scale of 30-45 km, typical of the baroclinic radius of deformation.

The major river system influencing the Gulf of Mexico is the Mississippi- Atchafalaya. It is believed that approximately 50% of the Mississippi River discharge flows eastward to influence the study region, but that most of the Atchafalaya's discharge flows onto the Texas-Louisiana shelf. We know, however, that under some wind conditions a larger fraction of the discharge of this system spreads eastward to influence the study region (e.g., Walker et al., EOS Trans AGU, 75: 404-409, 1994), though this has not been observed/studied in any detail. Another major river is the Apalachicola River that discharges directly onto the study region through four passes between barrier islands and is the source of a pool of fresh water found occasionally on this shelf (Ichiye et al., 1973). Discharge of the Mobile River System (principally the Tombigbee and Alabama rivers) is the largest east of the Mississippi River and also is know to affect the study region (Brooks et al., 1991).

Key science questions to address in this study fall into several categories:

Water Masses: What water masses are present in the study region? How do they vary spatially and seasonally?

Circulation: What is the mean regional circulation and property patterns in the study region? What are their seasonal variabilities?

Scales: What are the horizontal scales of circulation and physical and chemical property distributions in the study region? What are the horizontal and vertical scales of currents and properties associated with LC features?

Distributions: What are the vertical distributions of physical and chemical properties? What is the water column structure, including stratification, mixing, stability and presence of thermoclines, haloclines, and pycnoclines? How often do LC features affect the property distributions over the upper slope and shelf? Are there strong shelf fronts? What is the distribution of hypoxia in the study region, how does it vary and what are its causes? What is the vertical attenuation of light over the region, and its temporal variability? What are the temporal and spatial distributions of nepheloid layers present? What are their sources and sinks?

Budgets: What are the heat content, freshwater fraction, nutrient loads, organic carbon content, and suspended particulate matter amounts over the shelf in the study region? How do they change with time; what are the principal causes of such variations (identify sources, sinks, and advective and mixing processes)?

Forcing: What is the influence of fresh water from the river discharge on the circulation, stratification, and distribution of properties of the study region? What is the influence of wind stress -- mean, seasonal, and episodic atmospheric events? What is the contribution of off-shelf circulation features? How often are LC-derived features advected into the region? Are the frequency and extent of LC-derived features on the slope of the study region correlated with the configuration and strength of the LC? Do intrusions significantly alter the potential and kinetic energy of the region? What are the contributions of air-sea fluxes and surface waves? What are the relative contributions of these forcing functions?

Study Objectives

(1) During nine cruises distributed seasonally over a three-year period, measurements will be made to characterize the spatial distributions over the upper slope and shelf of the northeastern Gulf of Mexico of key physical, chemical, and biological variables (see list that follows in the "Field Work" section). These observations will be taken so as to resolve the energetic spatial scales of variability and describe the temporal changes with season over the observation period.

(2) To collect the ancillary data needed to complement and analyze the measurements collected in objective 1. These will include river discharge rates, meteorological information, information related to the Loop Current and its associated intrusions and eddies, and information characterizing other fronts in

the region.. Much of this will come from other ongoing programs, including the DeSoto Canyon Study, the nine transects of the MMS so-called Eastern Planning Area that are being run by R/V Oregon-II and R/V Gyre 1996-1997 in support of GulfCet-2, and the Northern Gulf of Mexico Coastal and Marine Ecosystems Program: Ecosystem Monitoring, Mississippi- Alabama Shelf (e.g., river discharge, meteorological information, and satellite) will come from operational, government monitoring/analysis systems. The needed data also include historical data sets of the variables measured in this study and forcing functions.

(3) To use the new measurements and ancillary data to prepare descriptions of the spatial and temporal variability of the observed variables during the observation period; to prepare shelf-wide budgets of heat, freshwater, organic carbon, suspended particulate matter, and nutrients for each cruise and their variation; and to make interpretations of the phenomena and processes responsible for these scales, distributions and budgets.

(4) To provide a milieu in which graduate students and scientists involved with this study can use the assembled data sets to investigate the circulation and property distributions of the NEGOM. We hope to use this opportunity to educate several Ph.D. scientists, who will, in the process, become familiar with MMS activities and needs.

Field Work

On each of nine cruises we propose to occupy approximately 96 chemical/ hydrographic stations for continuous vertical profiles of conductivity, temperature, pressure, light transmission, optical backscatter, and light penetration, as well as bottle samples for dissolved oxygen, nutrients (phosphate, silicate, nitrate and nitrite), phytoplankton pigments, particulate organic carbon, suspended particulate matter, and salinity. Sampling will be from the surface layer to within a few meters of the bottom.

Additionally, approximately 77 XBT drops will be made between these CTD/rosette stations enhancing cross-shelf resolution to about 10 km. Underway surface samples for salt will be taken at locations over the inner shelf to assist with tracking the distribution of river discharge. We will deploy 10 additional XBTs along the outer (1000 m) track lines connecting the cross-shelf sampling lines. These temperature profiles with T-S relations will yield geopotential anomaly estimates at these locations, and we will use both the temperature and geopotential anomaly information to study small along-shelf scales. About another dozen XBTs per cruise will be available to better define observed features.

We will perform all reduction (i.e., quality assurance/quality control) necessary to secure the highest possible quality data and metadata -- ensuring that data are well calibrated, free of spurious signals, in acceptable formats, and easy to use. This will begin with "quick look" analyses of data while at sea to detect real and potential problems at the earliest opportunity, thus, ensuring that the maximum quantity of usable data are obtained-a first step in quality assurance.

Integration of Water Column Chemistry and Particulate Studies

Water chemistry and particulate studies of the NEGOM program will produce vertical profiles and sections as appropriate. Simple correlations, principle component analysis, univariate analysis, and multivariate analysis will be used to determine interactions between various properties as appropriate and feasible within time and budget constraints. However, the primary product is a description of spatial and temporal variability in property distributions, an evaluation of property distributions with regard to physical processes, and an evaluation of the biogeochemical processes influencing water column chemical properties in the study area.