ACCESS NUMBER: 29034

STUDY TITLE: BLM/NDBO Cooperative Drifting Buoy Program

REPORT TITLE: Analysis of Drifter Dispersion by Rings

CONTRACT NUMBERS: BLM: IA2-34; MMS: 14-12-0001-29034

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREAS: Central Gulf of Mexico; Western Gulf of Mexico

FISCAL YEARS OF PROJECT FUNDING: 1982

COMPLETION DATE OF REPORT: 1983

COSTS: FY 1982: $117,945

CUMULATIVE PROJECT COST: $117,945

PROJECT MANAGERS: E. Kerut

AFFILIATION: National Oceanic and Atmospheric Administration

ADDRESS: National Data Buoy Office, Stennis Space Center (formerly NSTL), Mississippi 39529

PRINCIPAL INVESTIGATORS*: A. Kirwan, J. Lewis, R. Whittaker

KEY WORDS: Central Gulf; Western Gulf; physical oceanography; Loop Current; drifters; meteorology; trajectory; warm core ring; dispersion; Gulf of Mexico Region

BACKGROUND: The presence of warm core rings associated with major current systems within the Gulf of Mexico has been recognized for many years. Subsequent to their discovery, the analysis and characterization of warm core rings has been undertaken for numerous reasons, including a general interest in delineating the movement and longevity of these oceanographic phenomena, as well as an interest in determining their potential transport capabilities. The deployment and subsequent tracking of drifters or oceanic buoys can result in the acquisition of a considerable amount of information on the currents and horizontal velocity gradients existing within a ring. These physical features are important considerations in the design of buoy array dispersion measurement studies (e.g., open ocean, climate related programs). Such information is also critical to future management decisions which pertain to oil and gas leasing activities.

OBJECTIVES: (1) To analyze the existing drifter (i.e., buoy) data as a means of providing selection criteria for the future design of such arrays, as well as to test the feasibility of using buoys as a tool for measuring ocean current kinematics and dynamics.

ACCESS NUMBER: 29034

DESCRIPTION: In November 1980, the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Office (NDBO) deployed three experimental drifters (also termed "TzD buoys") in the Gulf of Mexico at approximately 24°30'N Lat and 92°00'W Long, within the bounds of a warm core ring shed by the Loop Current. The purpose of the deployment was to determine the equipment's operational effectiveness for gathering near real-time meteorological and oceanographic information from the data-sparse region of Campeche Bay. The three drifters provided data until 17 April 1981 when one of the drifters exited the ring. At that time, the ring was centered off the coast of Mexico, at approximately 22°30'N Lat and 96°00'W Long. A second drifter exited the ring in May 1981, while the third drifter continued to track the ring until 15 June 1981. As part of this study, the data collected during this period were assimilated into a format suitable for data processing and analysis. Using these data, a computer program was developed to describe the differential kinematic properties (DKP) of the data set. Dynamical analyses were also performed to describe dispersion of the drifter array by ring shears and translation as well as dynamical balance in the warm core ring.

During the course of the project, an unexpected high frequency component was found in the velocity records which complicated calculations of the DKP as well as dynamical calculations. To alleviate this problem, additional techniques were developed to remove the high frequency fluctuations from the buoy velocity records. This involved cross-spectral and rotary spectral analysis of the velocity records. Based on this analysis, a low pass filter was developed to remove 10-20 cm/s fluctuations with time scales of 24 hours or less from the buoy velocity records.

SIGNIFICANT CONCLUSIONS: Motions within a ring did not separate drifters. Therefore, under those circumstances where a drifter array has a scale less than that of the ring, the drifter array will not be dispersed if deployed within the ring. The separation of elements of a drifter is the result of translations by different rings. As a result, it was recommended that drifter arrays need not be smaller than the typical ring size. There was general agreement between the three drifters in the array on rotation rate, ring translations, ring orientation, and the DKP. This suggests that one drifter, if carefully seeded in the ring, will suffice to determine these characteristics. One drifter is not able to determine ring size, however. Therefore, in the Gulf of Mexico, it was recommended that ship of opportunity or aerial expendable bathythermograph (AXBT) surveys be made of the ring to determine absolute size. Substantial spectral analysis and filtering were required to recover the DKP from the drifter velocities. Of all the DKP, the vorticity was the most important. There was insignificant separation of the drifters in regards to shear and normal deformation and divergence. As the ring moved across the Gulf of Mexico, there was substantial modification to the ring's size and shape, even in deep water. This was reflected in a general increase in area and development of an east-west orientation. Typical ring translation velocities were on the order of 5 cm/s with swirl velocities of 50 cm/s.

STUDY RESULTS: The first drifter left the ring about 17 April 1981, followed by a second drifter during the first week of May 1981. The third drifter stayed with the ring until 15 June 1981. The loss of drifters from the ring was attributed to the ring's movement into shallower water and its subsequent interaction with bottom topography. This interaction dissipated the ring's energy and altered its shape. However, prior to this period, the drifter paths traversed the same general region of the Gulf of Mexico and there was no permanent separation of the drifters. The ring itself had an average period of rotation of just less than 15 days.

Three important features were noted in the records of absolute drifter velocities. The first feature was the large velocities associated with motion of the ring, with component speeds on the order of 50 cm/s. The second feature was the periodic nature exhibited in the east and north components of the velocity (i.e., u and v signals, respectively) in the drifters. This arose from the anti-cyclonic motion of the drifters in the ring. The third recognized feature was the presence of high frequency noise in the records, measured at 10-20 cm/s with periods less than 24 hours. Velocity observations of such magnitude have not been previously recorded from the Gulf of Mexico. Since the primary interest of this study effort was the low frequency motion associated with the ring (e.g., amplitudes of ≈50 cm/s; periods of ≈2 weeks), a determination of the cause of the noise was necessary in order to filter it from the records. Standard filtering was used to remove the high frequency fluctuations which were determined to be caused by meteorological conditions and tides.

Data from all three drifters indicated a westward translation of the ring of between 5 and 10 cm/s for almost the entire period. Swirl velocities were on the order of 40 cm/s with peak values approaching 75 cm/s. Swirl velocities increased during the late December/mid-January period, coincident with an increase in the size of the ring.

Of all the DKP, vorticity was the most important being typically 5-10 times as large as the other DKP. Shear and normal deformation rates seemed to produce geometric changes in the ring and appeared to have a reduced effect on the frequency of ring rotation. Horizontal divergences appeared to have less of a role than the other DKP measured.

All three drifters persistently indicated an elliptical ring in contrast to theoretical models which assume circular rings. The drifters also indicated an east/west orientation of ±30°. The agreement in drifter data indicated that one drifter could suffice for determining ring orientation. However, use of a single drifter would not be sufficient to determine ring dimensions.

During the course of the deployment, drifter data indicated that the lengths of both the major and minor axes of the ring increased. This was consistent with the concept that there is divergence in an anticyclonic ring. The ring began with a path radius of about 40 km, increasing in January to a size where the major and minor axes measured 160 km and 60 km, respectively.

STUDY PRODUCTS: Kirwan, A. D., J. K. Lewis, and R. E. Whittaker. 1983. Analysis of Drifter Dispersion by Rings. A final report by the National Data Buoy Office, National Oceanic and Atmospheric Administration and Science Applications, Inc. for the U.S.

ACCESS NUMBER: 29034

Department of the Interior, Minerals Management Service Gulf of Mexico OCS Office, Metairie, LA. NTIS No. PB84-113349. Contract No. 14-12-0001-29034. vii + 113 pp.

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