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STUDY TITLE: Deepwater Currents at 92° W Longitude

REPORT TITLE: Full Water Column Currents near the Sigsbee Escarpment (91-92º W Longitude) and Relationships with the Loop Current and Associated Warm and Cold-Core Eddies

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BACKGROUND: As industry migrates towards deep water exploration, the need to characterize the deep water environments of the Gulf of Mexico (GOM) has become increasingly important. LSU researchers were funded to characterize surface to bottom current variability on the plateau in ~2200 m of water (above the Sigsbee Escarpment) and later at the base of the Sigsbee Escarpment in ~3000 m of water during the period February 2000 through June 2004. A major focus was also placed on understanding the links between strong currents (surface, bottom, and surface to bottom) and surface forcing events.

OBJECTIVES:

(1) To assess whether these new measurements at single, full water column moorings support the hypothesis that topographic Rossby waves influence near-

bottom currents on the plateau and at the base of the Sigsbee Escarpment.

(2) To quantify current variability (speed, direction, energy, coherence, energy density frequency) from surface to bottom on both the plateau and the continental rise near 26º N, 91-92º W.

(3) To investigate the forcing mechanisms for the strongest currents at all levels of the water column.

(4) To assess the relationship between strong currents and major surface forcing such as Loop Current intrusions, growth and proximity of warm core anticyclonic eddies, cold core cyclonic eddies and Loop Current frontal eddies.

DESCRIPTION: LSU deployed four full water column moorings in the Gulf of Mexico starting in February of 2000 and removed the last mooring in June 2004. These moorings were designed to measure current, along with temperature, salinity, and pressure at various depths throughout the water column. The first two moorings, Deployment 1 and 2 were located on top of the Sigsbee Escarpment in approximately 2200 m of water. These two mooring were combined together, to form a single time series. The last two moorings, Deployment 3 and 4 were positioned at the base of the Sigsbee escarpment in approximately 3000 m of water.

Characterization of the long term currents above and below the Sigsbee Escarpment was one of the main objectives of this project. This characterization was carried out by using multiple methods of spectral analysis, wavelet analysis along with basic statistical analyses.

Another major component of this study was the analysis of the surface variability in the GOM. This included but was not limited to the Loop Current, Loop Current warm core eddies, and Loop Current frontal eddy cyclones, as well as additional mesoscale cyclonic and anticyclonic eddies. GOES-8 and GOES-12 sea surface temperature (SST) imagery as well as chlorophyll *a* estimates from Oceansat-1 OCM were used extensively in the analysis. Sea surface height (SSH) data were often integrated with the SST data to better resolve ocean features of interest.

SIGNIFICANT CONCLUSIONS: Using GOES night-time SST/SSH composite images, along with current and temperature measurements, the eight strongest current events were identified in each of the three records. Strongest surface currents occurred when the Loop Current (LC), or Loop Current eddies (both anticyclonic and cyclonic) flowed near or over the mooring. Of the 24 events investigated in detail, 4 of the events showed surface to bottom coherence in flow which corresponded with the intensification of a Loop Current frontal eddy (LCFE) cyclone in close proximity to the mooring. The GOES SST data were essential in resolving day to day changes in position and motion of the surface flow features, whereas the sea surface height data gave an indication of the intensity of the features and pre-existing conditions. Wavelet Hovmöller diagrams showed a 15-25 day broadband signal during three of these full water column events.

In each of these three events, the moorings were located between the LC and a LCFE. A fourth mooring, which was not part of this study, showed a similar 15-25 day signal, when that mooring was located between a LCFE and the Loop Current. Bottom currents flowed to the southwest at 20-30 cm/s during these events. Relatively strong bottom currents to the northeast occurred when a large warm core anticyclonic LC eddy (ring) passed south of the mooring.

STUDY RESULTS: In Deployments 1 and 2, the mooring was resting on the plateau well above the top of the escarpment, and the bottom currents paralleled the escarpment. Four LC warm core eddies resulted in strong flow at the mooring. In general, a two layer flow system was observed, with the exception of a surface to bottom event in late February/early March 2001, when a LCFE intensified near the mooring. Variance ellipses in the bottom half of the mooring showed little variation in the principal angle, reinforcing the affects of the isobaths on the bottom. Bottom currents (1000-2200m) generally flowed northeast or southwest in line with the escarpment. Mean and maximum bottom currents were 4.73 cm/s at a depth of 2010 m and 36 cm/s at 1461 m. Multiple methods of spectral analysis showed signals in the 40-50 day signals near the surface with wavelet analysis showing the 50 day signal to be near the beginning of the time series. A strong 25.9 hour signal was seen in the 500 m to 800 m depths. This signal was most likely tidal. At depths greater than 1000 m, this signal was masked by surrounding noise and not seen in the spectral analysis. The bottom 1000 m showed coherence in both strong and weak spectral signals. A strong coherent signal was seen in the 22-24 day period, with a weak 13-16 day period, near the bottom. Wavelet analysis showed this 22-24 day signal to be in the last 3 months of this time series. Cross spectral analysis revealed little signal correlation between the surface signals and the bottom signals. Evidence for topographic Rossby waves in deployment 1 and 2 mooring was inconclusive.

Deployment 3 was positioned east of Deployment 1 and 2, and situated at the base of the Sigsbee Escarpment in 3000 m of water. During this deployment, an abnormal northwestward intrusion of the LC occurred in January 2002 and in February/March 2002, two warm core eddies (P and Q) detached from the LC in very close proximity to the mooring. Maximum currents of 133 cm/s were experienced at 50 m during this event. In addition, two coherent surface to bottom flow events were identified which corresponded to the intensification of LCFE's over the mooring site. These surface events are believed to have triggered 2-3 day pulsed current events to the southwest throughout the water column. In general, variance ellipses in the bottom 1500 m paralleled the isobaths, with the mean flow up and across the escarpment. This cross isobathic flow also shows up in the mean statistics where a significant northerly component is seen at all levels. Strongest northeastward flowing currents occurred when the center of LC warm core eddies passed south of the mooring. A strong 17 day signal was identified near the surface in 50 m of water. Wavelet analysis showed this signal occurred in late February 2002 during the LCFE intensification event. Spectral analysis also showed a strong 14-15 signal during the second half of the deployment. Mean and maximum near bottom currents were 11.6 cm/s at 2128 m and 37.4 cm/s at 2978 m.

Deployment 4 was positioned in 3028 m of water, slightly west of Deployment 3 also at the base of the Sigsbee Escarpment. The principal axis of the variance ellipses paralleled the escarpment. The mean current flow below 1000 m was across the escarpment isobaths. This was similar to what was seen in Deployment 3. Cross-spectral analysis showed a coherent surface and depth signal near 30 days. Wavelet analysis showed coherent surface to depth energy in the 20-30 day periods near the end of July 2004, which corresponded to the mooring being between the LC and a LCFE. Currents were slightly weaker, overall in this deployment. This can be explained in part as the surface currents were measured at 70 m not 50 m. Mean and maximum near bottom currents were 11.5 cm/s at 2628 m and 40.3 cm/s at 2178 m.

STUDY PRODUCTS: McKone, Kevin, Nan D. Walker and Eddie Weeks, 2007. Full water column currents near the Sigsbee Escarpment (91-92 W) and relationships with the Loop Current and associated warm and cold-core eddies, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-056. 107 pp.

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