Abstract: Full water column, current profile data are collected in approximately 1300m of water at Green Canyon block 645 in the Gulf of Mexico. The seabed-mounted 75kHz Acoustic Doppler Current Profiler has recorded and displayed profiles in near real time at 20-minute intervals continuously (without a single failure) from June 2005 to the present day. Data were collected during Hurricanes Gustav, Ike, Katrina, Rita, and Wilma, various Loop Current eddies, and the demise of the Deepwater Horizon. These data indicate the existence of a complex structure in the near-seabed region. In addition to near-inertial currents generated by surface wind events, the data show current speeds exceeding 25 cm/s at intervals of approximately 20 days and three instances of currents exceeding 35 cm/s at 1,200m depth.

Background: Full water column, current profile data are collected in approximately 1,300m of water at Green Canyon block 645 in the Gulf of Mexico (GoM) at National Data Buoy Center (NDBC) Station 42370. The seabed-mounted 75kHz Acoustic Doppler Current Profiler (ADCP) has recorded and displayed profiles in near real time at 20-minute intervals continuously (without a single failure) from June 2005 to the present day. Data were collected during Hurricanes Gustav, Ike, Katrina, Rita, and Wilma, various Loop Current Eddies, and the demise of the Deepwater Horizon. These data indicate the existence of a complex structure in the near-seabed region and show current speeds exceeding 25 cm/s with periodicities of approximately 20 days. There are also signatures of wind-generated, near-inertial currents and three instances of higher speed currents (>35 cm/s). Background currents in the lower layers are typically less than 5.5 cm/s.

Observations (Hamilton, 1990; Hamilton and Lugo-Fernandez, 2001; Hamilton, 2007) suggest the hypothesis that deep sources of energy in the GoM can be accounted for by Topographic Rossby Waves (TRWs). Major sources of energy in the GoM include the
fluctuations of the Loop Current and the shedding of the large anti-cyclonic eddies (or warm-core rings). The northward Loop Current excursions into the eastern Gulf generate TRWs that propagate into the western Gulf. Loop Current Eddies may also generate deepwater disturbances and involve propagating Rossby waves.

Near-inertial oscillations are common features observed in the shelf seas. These oscillations are seen as clockwise rotating, near circular horizontal currents in the northern hemisphere, with frequencies above the local inertial frequency. Near-inertial currents are common in the shelf region in the northern GoM (DiMarco et al., 2000). They are surface intensified with rotary spectral energy peaks at near-inertial frequency. For the measurements at the latitude of GC645, the inertial frequency is 26.08 hours.

The purpose of this paper is to present current measurements obtained from NDBC station 42370 in the north-central portion of the GoM and the preliminary findings of Rossby wave signatures and inertial motions observed in the region.

**Technical Details:** National Data Buoy Center Station 42370 is a Production Drilling and Quarters Truss Spar permanently moored in 1,325m of water in Green Canyon block 645, 150mi South of New Orleans, Louisiana.

Recognizing the need for accurate current data in the field, the operator of the Spar installed real-time, full water column current profiling instrumentation in 2005. The instrumentation reporting to the NDBC website comprises a 38khz ADCP deployed from the surface and a 75kHz ADCP deployed on the seabed in a stainless steel frame.

The 38kHz ADCP measures ensembles every 20 minutes from the near surface (60m) to 990m and transmits the data to NDBC. The 75kHz ADCP also measures ensembles at 20-minute intervals from the seabed (1,300m) to 700m. As a result of the ranges achieved by both instruments, an overlap of approximately 300m enables the comparison of data quality from both instruments.

This study focuses on the data obtained from the 75kHz ADCP deployed on the seabed. The seabed-mounted ADCP has transmitted data every 20 minutes without any failure or down time since May 6, 2005. The success of the system can be attributed to the integration of the instrumentation from the seafloor to the surface. Power is provided from the surface (a distance of approximately 2,000m) through an umbilical utilizing ROV wet mateable hybrid (copper and fiber) connectors and frame-mounted subsea electronic converters.

**Data Analysis:** According to the Horizon Marine website (www.horizonmarine.com) that tracks Loop Eddy generation, a total of 12 Loop Eddies detached from the Loop Current between May 2005 and May 2010. Each Loop intrusion into the eastern GoM and Eddy detachment is associated with the generation of periodic oscillations, or TRWs, that travel westward along the continental slope in the northern Gulf. An example of TRW-influenced near-bottom current response to Loop Current intrusion and Loop Eddy detachment is shown in Fig 1.

![Fig 1. Current speeds at 1,000m responding to Eddy Yankee, which separated between time stamps 4000 and 6000. The vertical axis is cm/s and the horizontal axis represents data sample number between May and December 2009.](image)

Spectral analysis of the time series of current speeds at 1,000m and 1,200m using a Fast Fourier Transform (FFT) technique results in a power spectrum that indicates the dominant frequencies in that time series. A 40-hour filter is applied to the time domain data before the FFT results in a smoothed power spectrum. The full and smoothed
power spectra at 1,200m for the period of May 2005 through May 2010 is presented in Fig. 2.

Fig. 2. Five-year power spectrum at 1,200m.

Salient features of the power spectrum at 1,200m (Fig. 2) include a distinct peak at 0.90 cpd, corresponding to 26.67 hours. The shift from the expected inertial frequency of 26.08 hours is due to other currents present in the region. Power associated with the lower frequency peak at 0.06 cpd, or 16.7 days, is an order of magnitude larger than that at the near-inertial band at this depth.

The full and smoothed power spectra at 1,000m are shown in Fig. 3. In addition to the peak in the TRW band, two distinct peaks are observed at near-inertial frequencies.

Fig. 3. Five-year power spectrum at 1,000m.

Near-bottom currents in excess of 35 cm/s were observed three times during the 5-year period studied. The first maximum speed event occurred on 11 August 2006 (35.9 cm/s at 1,200m) and was related to the passage of Eddy Yankee. Full water column current profile data show currents in the upper 150m towards the north-northeast at more than 0.5 m/s and towards the northeast between 150 and 450m at 0.3 to 0.5 m/s. A Naval Research Laboratory (NRL) Sea Surface Height (SSH) map of the GoM suggests that the northwest extent of Eddy Yankee passed over GC645. Currents at 1,200m were in the opposite direction.

A second maximum speed event associated with the passage of Eddy Albert occurred at 1,000m on 20 December 2007 (31.9 cm/s) and at 1,200m (38.9 cm/s) on 21 December 2007. The maximum speeds at the two depths were separated by a matter of hours. Currents at 1,000m were northward, while the currents at 1,200m and below were southward. The NRL SSH map shows Eddy Albert in the region, but it appears to be south of GC645.

A third maximum speed event occurred 10 March 2009 and was related to the passage of Eddy Darwin. Speeds at 1,200m of 38.7 cm/s were associated with several hours of offshore currents from 1,150 to 1,250m depth. The NRL SSH map shows the northern edge of Eddy Darwin over GC645.

Eddy Ekman formed during June/July 2009 and detached from the Loop Current around 30 July. The Loop Current remained in the southeastern GoM after Eddy Darwin separated in late December 2008. Throughout the early part of 2009, the Loop Current pulsed farther into the eastern portion of the Gulf until late May 2009, when it began “pinching off.” The process continued until a cyclonic eddy moved in from the east and completed the separation between 10 and 20 July 2009. Currents at NDBC Station 42370 exhibited a cyclic response to the detachment of Eddy Ekman, but the response differs at 1,000 and 1,200m. At 1,000m, the response is regular with a period of approximately 20 days. The currents at 1,200m are stronger with a similar frequency, but also much noisier.

Conclusions: Five years of near-bottom ADCP data collected from the northern Gulf of Mexico in block GC645 have been analyzed. The power spectra for 1,000 and 1,200m depths reveal significant peaks at near-inertial
frequencies (near 28.06 hours) and at lower frequencies associated with TRWs (10 to 100 days). While the 1,200m spectra exhibits a single peak near the inertial frequency, the 1,000m spectra shows peaks at two distinct frequencies. The energy in the near inertial peaks at 1,000m is greater than the peak at 1,200m, indicating more energy in this band. At the deeper site, 1,200m, the energy in the TRW frequency band is greater than at 1,000m.

Topographic Rossby Wave impact on near-bottom currents is shown for four Loop Eddy detachments during the period from May 2005 through May 2010. Loop Current and Loop Eddy positions from a Naval analysis utilizing altimetry in a numerical model show the time series of each detachment. Currents in excess of 35cm/s were detected as Loop Eddies Yankee, Albert, and Darwin passed just south of the GC 645 site. Current directions at 1,200m were opposite the direction of flow in the upper layers of the ocean associated with the Loop Eddies, suggesting bottom flow response to surface flow.

Loop Eddy Ekman detached from the Loop Current in July 2009. Both the time series and the power spectra for the time period indicate a strong response in the TRW band, with frequencies at 17.4 and 20.2 days dominating.

This document demonstrates that real-time data collected for operational purposes can be used as research data to look at different oceanographic phenomena. It also suggests that a seabed mounted network of observing systems interfaced to oil and gas communication networks could play a role in a Gulf of Mexico Ocean Observing System.

References:

