Oil and Gas Platform Ocean Current Profile Data

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Abstract - **Approximately forty deep water oil production platforms and drilling rigs continue to provide real-time current profile data to NOAA's National Data Buoy Center (NDBC). NDBC receives and quality controls the data and transmits it over the Global Telecommunications System. NDBC stores the raw binary current profile data where it can be extracted by private concerns in order to forecast the Loop Current and Loop eddies for oil and transportation concerns in the Gulf of Mexico. After quality control, NDBC also stores the processed data.**

In addition to aiding the oil and gas industry to understand and design for the forces in the water column generated by strong currents in the Gulf of Mexico, the three years of ocean profile data show a number of oceanographic phenomena. The high currents of the Loop Current that extend to several hundred meters are present and generally impact several oil platforms as it moves into the northern Gulf of Mexico. Cyclonic loop eddies exhibit many of the same characteristics of the Loop Current, but move into the western Gulf of Mexico as currents diminish. Five day plots of the current profiles show the passage of eddies. Evidence of tidal currents modifying unidirectional currents are also present. Inertial currents generated by wind events are omnipresent and propagate throughout the water column in all regions of the Gulf. The current profiles from delayed-mode, bottom-mounted profilers show that inertial currents reach great depths. Statistical analyses of these data verify the existence of the currents.

I. INTRODUCTION

The Minerals Management Service (MMS) requires that deep water oil drilling and production platforms in the northern Gulf of Mexico collect and provide current profile data to the National Data Buoy Center (NDBC). Oil companies collect current profile data using Teledyne RD Instruments, Inc. (TRDI) Acoustic Doppler Current Profilers (ADCPs), when drilling wells or operating production platforms in water greater than 400 meters deep. They are required to collect the data at 20 minute intervals and transmit the data via FTP to NDBC. NDBC processes, quality controls, and displays the resulting currents on the NDBC website. A committee of oil company, industry, and government representatives determined an approach that includes both individual bin (depth level) and profile algorithms. NDBC implemented quality control algorithms agreed upon by industry and the government. The resulting imagery and data, including quality control flags, are available on the publicly available NDBC website.

II. ENVIRONMENT

The structure of the Loop Current and associated Loop and cyclonic eddies is presented in fig. 1. The Loop current enters the Gulf of Mexico through the Yucatan Straits, turns back toward the south at approximately 25oN, and exits through the Florida Straits to form the core of the Gulf Stream. Ref. [1] shows data from a mooring in this region with currents at 60 meters depth that exceed 170 cm/s. Currents in the lower layer, below 1550 meters, exceed 50 cm/s. A strong Loop Current Eddy, recently detached from the Loop Current, is centered at 26.5oN 89.5oW. An older detached Loop Current Eddy is centered in the western Gulf of Mexico. The shedding process is related to cyclonic eddies that rotate clockwise around the Loop Current. These and other cyclonic eddies are also found throughout the Gulf of Mexico. Oil and gas platforms have begun drilling in deeper waters of the Gulf of Mexico (fig. 2) and have moved into region of high currents associated with the Loop Current and its associated eddies. Exploration, installation, and production activities are impacted by the currents. The location of drilling rigs and platforms may move, structural bending and stress on platform components may occur, excessive riser angles may result, and costly damage can be inflicted. Diving and remotely operated vehicle operations, pipe laying, and anchoring operations are more difficult as a result of the high currents [2].

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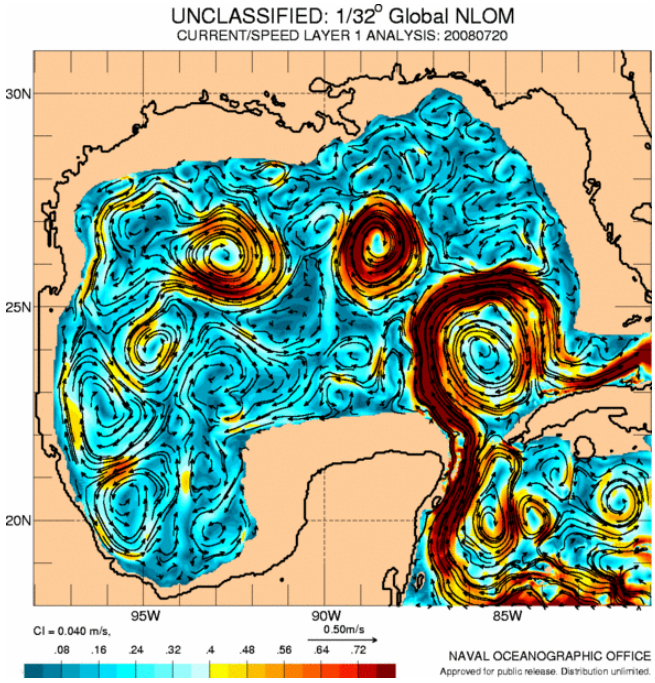

Fig. 1. 20 July 2008 Gulf of Mexico NLOM surface current output.

Approximately seventy production platforms and drilling rigs in the northern Gulf of Mexico have provided data to NDBC during the three years since the beginning of this program. An example of the distribution of platforms is shown in fig. 2. Most of the sites are located on the outer continental shelf and slope of the northern Gulf of Mexico, stretching from Alaminos Canyon off Texas to Vioska Knoll, south of Mississippi. As many as 48 stations have simultaneously provided data to NDBC.

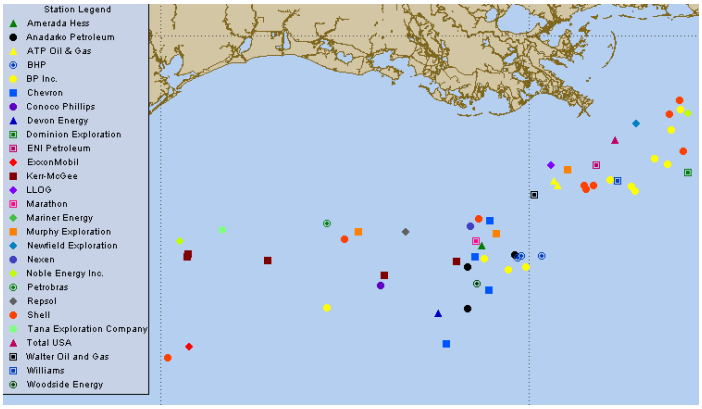

Fig. 2. Oil and gas platforms and rigs reporting data to NDBC.

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Access to all of the data transmitted to NDBC is unlimited. The raw, binary data may be FTP'd from NDBC and quality control algorithms applied as desired. The quality controlled data may also be extracted from NDBC. Alternatively, hourly data are transmitted via the Global Telecommunications System to the world. These in-situ current profiles may be assimilated into numerical models, used to develop nowcasts, or used to verify model runs.

III. LOOP CURRENT

The location of the Loop Current within the Gulf of Mexico is shown in a composite sea surface temperature image (fig. 3) for early May 2005. At this time, the Loop Current had progressed far into the Gulf of Mexico and into area offshore of Louisiana, where the oil and gas industry have a number of production platform and drilling rigs. ADCP current profile data from four platforms show the ocean dynamics associated with the image of the Loop Current (fig. 4). The first plot of five days of current vectors for the Brutus platform in the Green Canyon region west of the Loop Current shows very low current velocities. Currents are toward the north-northwest at drilling rig Nautilus indicating that this is the western side of the Loop Current and inflow is represented. The drilling rig Jim Thompson is north-northeast of Nautilus and the eastward currents indicate flow across the northern extent of the Loop Current. Currents toward the east-southeast at production platform Ursa, indicate that this is the location of the northeastern edge of the Loop Current.

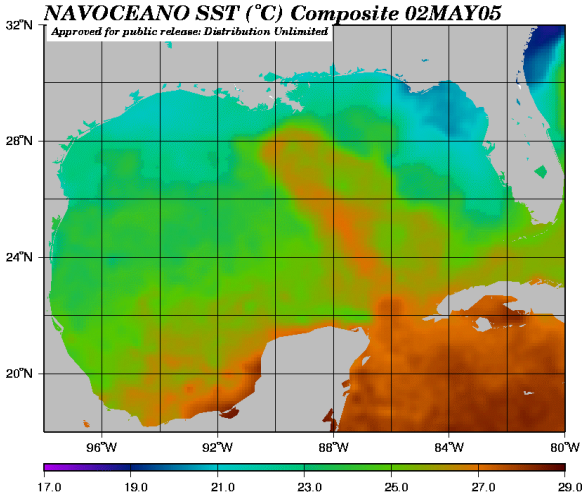

Fig. 3. 20 July 2008 Gulf of Mexico NLOM surface current output.

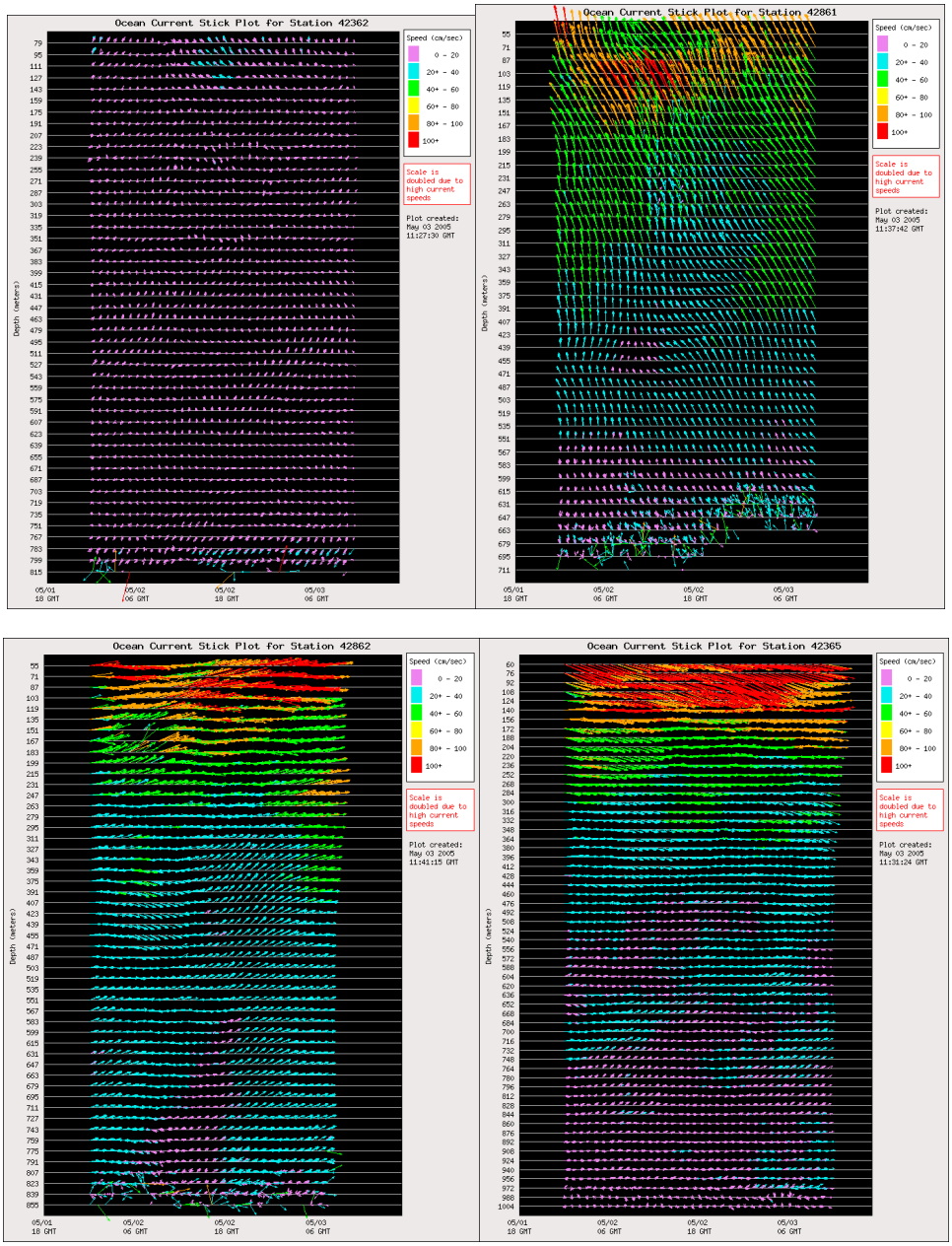

Fig. 4. May 2005 stick plots from platforms, Brutus (upper left panel), Nautilus (upper right panel), Jim Thompson (lower left panel), and Ursa (lower right panel)

IV. Loop Current and Cyclonic Eddies

Two Colorado Center for Astrodynamics Research (CCAR) plots of surface currents in the Gulf of Mexico (fig. 5) show the detachment of a Loop Current Eddy during a three-week period in July 2008. An older Loop Eddy to the west has been moved farther westward and two paired eddies north of the new Loop Eddy have been generated in response to the event. The action of two cyclonic eddies, one west and one east of the Loop Current appear to have played a role in the detachment of the eddy.

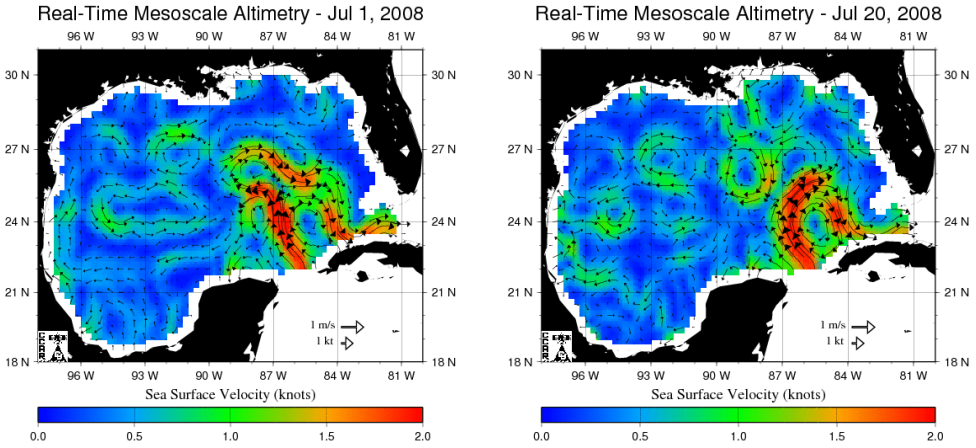

Fig. 5. The detachment of a Loop Eddy during July 2008 from the Colorado Center for Astrodynamics Research (CCAR) Gulf of Mexico Near Real-Time Altimeter Data Viewer, sponsored by the University of Colorado, Bolder.

Three oil and gas platforms that provide ADCP data to NDBC are located in or adjacent to the older detached Loop Eddy in the Western Gulf of Mexico. The MODU Lorris Bouzigard is on the northwest edge of the Loop Eddy and exhibits currents towards the northwest (fig. 6). To the southeast is the Magnolia production platform, where currents on the northeast edge of the Loop Eddy flow south-southeastward (fig. 6). To the southwest of Magnolia is the MODU Discoverer Spirit, where the currents on the southeastern edge of the Loop Eddy are flowing southward (fig. 7). The drilling rig Ocean America is southwest of Lorris Bouzigard and shows evidence of an eddy passing the rig at depths of 200 to 700 meters depth (fig.7).

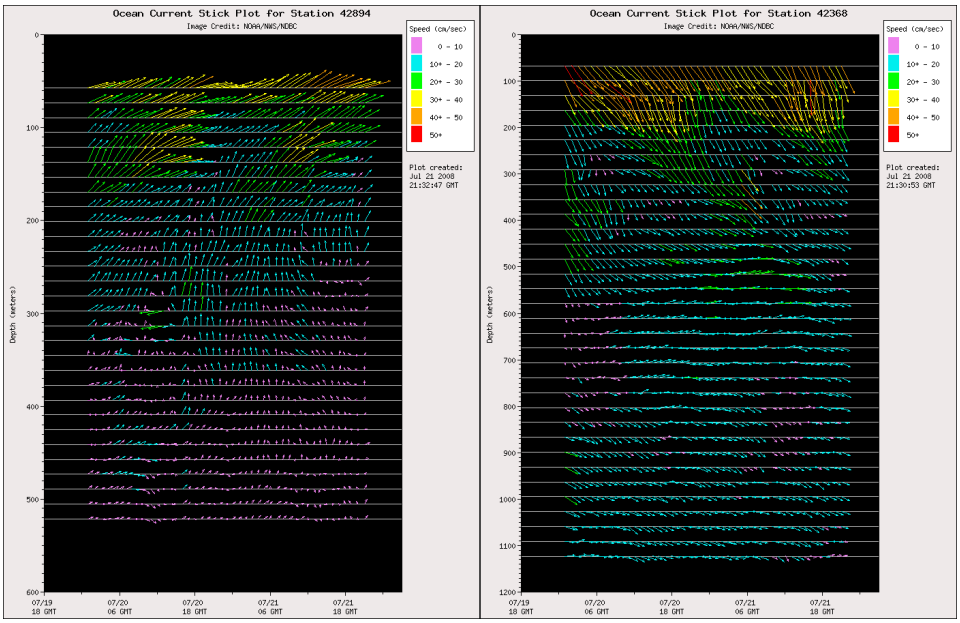

Fig. 6. Stick plots for the drilling rig Lorris Bouzigard (Left panel) showing flow around the northwest edge and the Magnolia platform (right panel) showing flow around northeast edge of detached Loop eddy in the Western Gulf of Mexico.

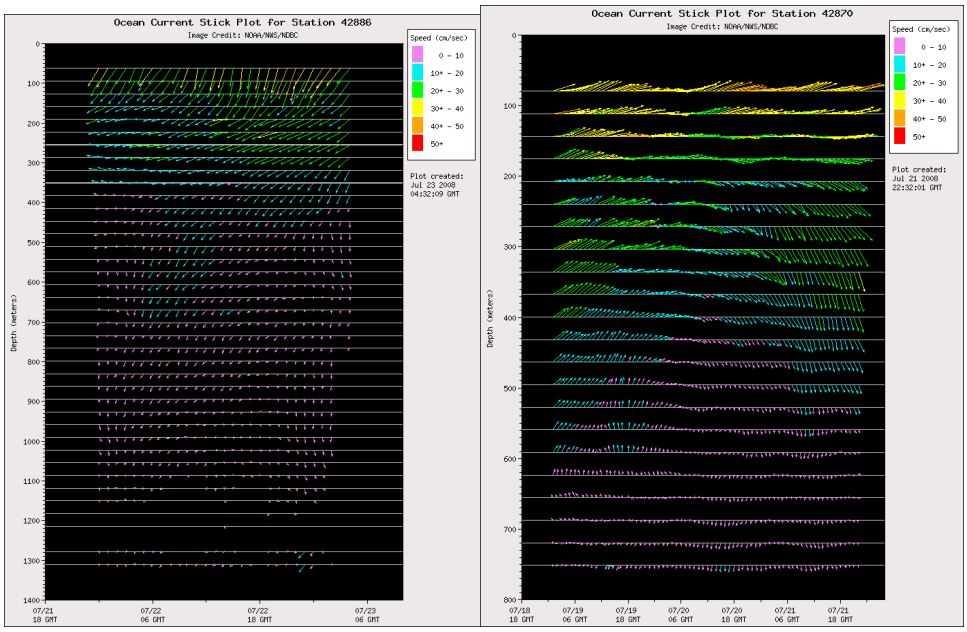

Fig. 7. Stick plots showing flow around southeast edge of detached Loop eddy from the MODU Discoverer Spirit (left panel) and current direction and speed at the Drilling Rig Ocean America on the northern edge of the eddy as the eddy passes (right panel).

Two platforms that transmitted data to NDBC during this period show evidence of being in the newly detached Loop Eddy. The ADCP data from the drillship Development Driller II (fig. 8) suggest that the northwest edge of the Loop Eddy is encroaching on the location. Currents are to the north-northeast and gaining strength as the Loop Eddy nears. Currents at the nearby Neptune production platform are similar to those at Development Driller II.

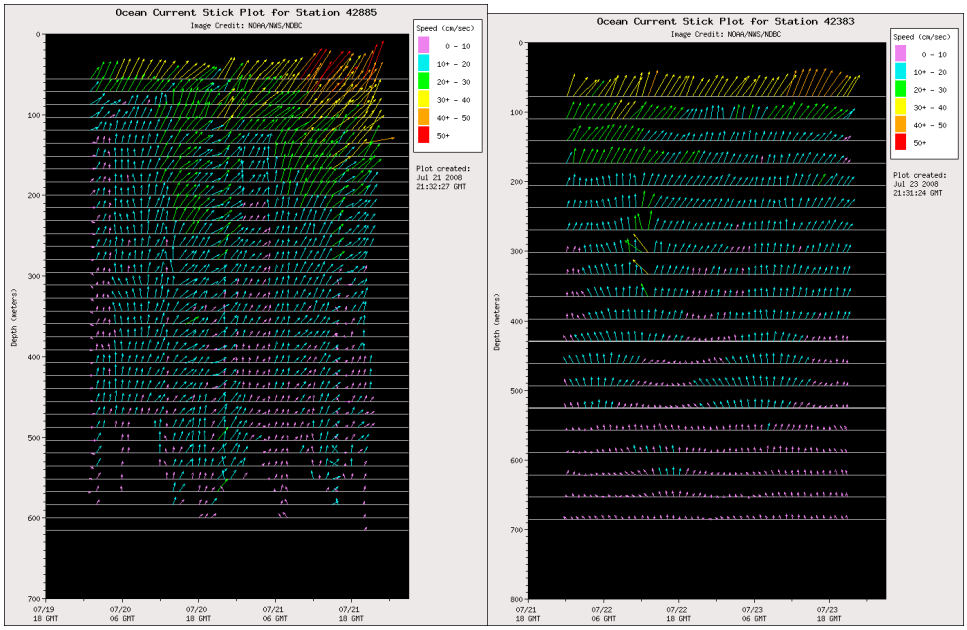

Fig. 8. Stick plots for the Development Driller II (left panel) and Neptune (right panel) drilling rigs showing flow to the north-northeast along the eastern edge of the newest Loop Eddy.

A cyclonic eddy appears to have been generated between the Loop Eddy and the Mississippi Delta region. Fig. 9 clearly shows this feature. Two production platforms, Genesis and Horn Mountain, provide data that support the flow around the cyclonic eddy. The Genesis platform on the western margin supports the idea of southward flow along the western side of the cyclonic eddy. North-northwestward currents at Horn Mountain at 40 cm/s suggest the northward flow along the eastern side of the cyclone.

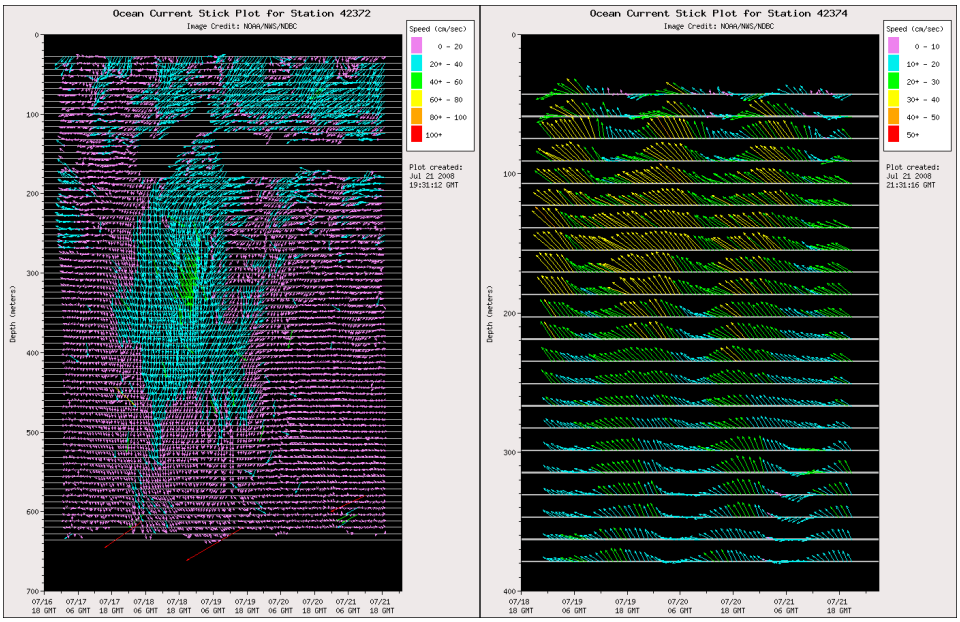

Fig. 9. Stick plots showing pulse of 40-60 cm/s water at 300 meter depth at Platform Genesis (left panel) and Inertial flow superimposed on flow around a cyclone at the Horn Mountain Platform (right panel).

The drilling rig, Cajun Express (fig. 10), shows flow to the south-southwest on the western side of a cyclonic eddy apparently trapped between the two Loop Current eddies.

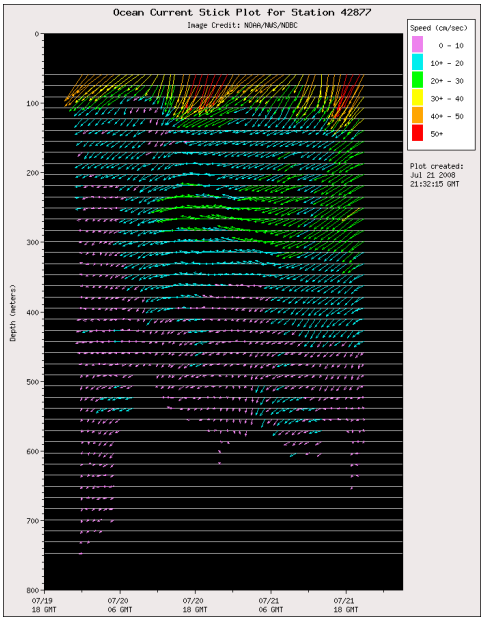

Fig. 10. Stick plot showing currents at the Cajun Express drilling rig.

IV. BOTTOM CURRENTS

The Na Kika platform southeast of the Mississippi Delta was less than 100 km to the right of the track of Hurricane Katrina as it approached Louisiana on 28 August 2005. A bottom-mounted ADCP had been deployed near Na Kika to collect bottom current profile data. The data were processed and quality controlled at NDBC following recovery of the sensor. Analysis of the data [3] shows that the bottom currents at Na Kika, which normally range from 0 to 5 cm/s, were impacted by Hurricane Katarina. The currents at 1900 meters depth responded within 12 hours to the passage of the storm. Maximum currents recorded at the site exceeded 30 cm/s (fig. 11). Currents remained above the background 5 cm/s for approximately 12 days. Analysis of the Na Kika bottom current data set also revealed responses of the data to Hurricanes Rita (maximum speeds greater than 20 cm/s and impact for 21 days) and Wilma (maximum speeds greater than 20 cm/s and impact for 13 days) during 2005.

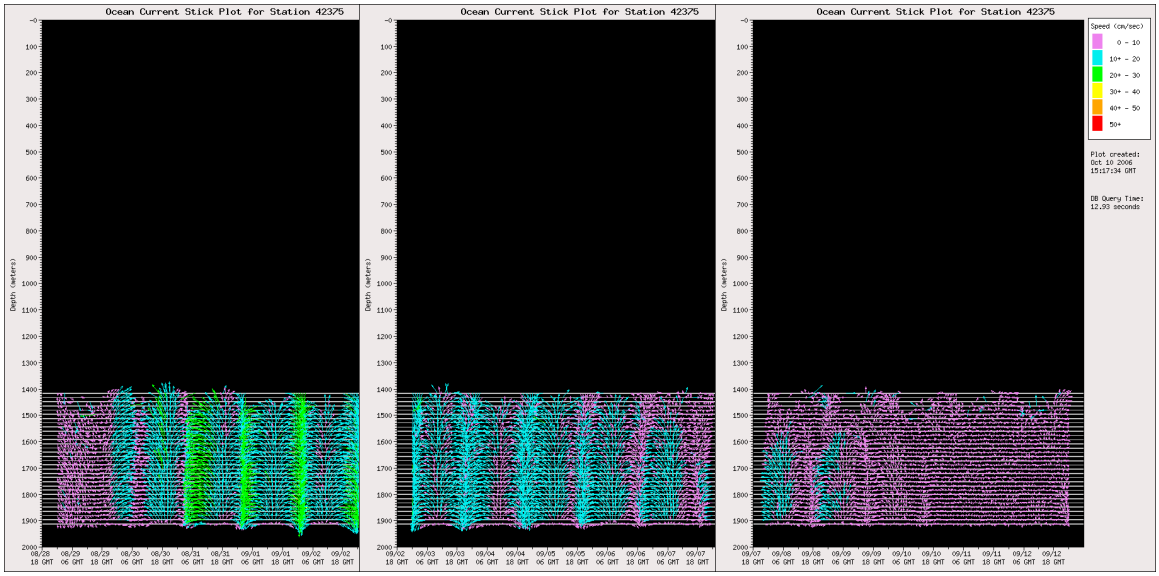

Fig. 11. Bottom currents from Na Kika platform following Hurricane Katrina passage, August-September 2005.

V. CONCLUSIONS

High current areas in the northern Gulf of Mexico associated with the Loop Current and associated Loop and cyclonic eddoes are important to oil exploration, platform installation, and production activities. High currents cause shifts in locations of platforms, structural bending of platform components, stress, and excessive riser angles and may inflict costly damage [2]. Additionally, diving, remotely operated vehicles operations, pipe laying, and anchoring operations are more difficult and often impossible in high current areas.

Current profile data collected by oil and gas companies at drilling rigs and production platforms in the northern Gulf of Mexico in response to the MMS NTL of 2005 were intended to address these issues. Additionally, the data have been used by commercial and academic entities to generate nowcasts to initialize models, update models though assimilation, and verify and validate model output. In this paper, the current profiles reveal flow in the Loop Current, in newly detached and older Loop Current eddies, in cyclonic eddies that translate clockwise around the Loop Current, and in near-bottom waters in response to catastrophic events such as hurricanes.

In a summary of model efforts in the Gulf of Mexico, ref. [4] notes that there are similarities in model behavior for the Loop Current eddy shedding process, eddy propagation following detachment, and the propagation of deep cyclones. Future work will include simulations of Topographic Rossby Waves, deep currents, eddy-shelf/slope interactions, frontal eddies, and eddy-shedding dynamics. The data collected by

the drilling interests in the northern Gulf of Mexico since early 2005 as mandated by MMS are available from NDBC for model validation and verification and other investigations at www.ndbc.noaa.gov.

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