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Life and Times of Eddy Zorro: A Review of the 2007 Gulf of Mexico Loop Current Activity

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Abstract

The Loop Current and its associated anticyclonic eddies have been familiar impediments to deepwater operations in the Gulf of Mexico. At the start of 2007, the Loop Current was located well south of deepwater lease areas and all was quiet across the northern Gulf of Mexico. In March of 2007, the Loop Current advanced rapidly north of 28°00'N, engulfing most of Lloyd Ridge and entering into southern DeSoto Canyon. In early April, a new Loop Current Eddy (LCE) named "Zorro" was shed. Eddy Zorro exhibited maximum currents in excess of 4 knots and remained in the northern Gulf for over five months. It impacted operations in Mississippi Canyon, Atwater Valley, Green Canyon, DeSoto Canyon, Ewing Bank, and Lloyd Ridge. In early June, Eddy Zorro pushed further north than any previous Loop Current event observed in the history of the Eddy Watch program. It extended north to 29°15'N, covered Viosca Knoll, and even reached into the South Pass lease area. Eddy Zorro's death was unusual as well as it was completely absorbed by the Loop Current instead of assuming the traditional southwesterly migration into the western Gulf.

Introduction

For over six months in 2007, the Loop Current and Eddy Zorro complicated offshore drilling and construction activities in the central Gulf of Mexico. This major anticyclone (warm core ring) was unique in many respects. While forming from the Loop Current, it advanced north across active lease blocks at a rate nearly triple the typical progression rate of eddies observed over the past several decades. Zorro also extended farther north than any previously observed eddy, impacting shallow shelf operations in South Pass off the Mississippi Delta. Zorro exhibited maximum currents as high as 4.3 knots even after separating from the Loop Current. The eddy separated and reattached to the Loop Current three times over a period of nearly four months. One of the attachments was unique as a band of water extended from around the Loop's eastern front, snagging the eddy. Zorro's center of circulation migrated more slowly and over the shortest distance than any eddy previously observed. It was also the only major eddy known to disappear and be totally absorbed by the Loop Current.

The Loop Current, anticyclonic (warm core) eddies like Eddy Zorro, and cyclonic (cold core) eddies are common phenomena in the Gulf of Mexico. When these features enter areas of active offshore exploration, installation, and production, they often have a significant impact on operations. Three to four knot currents associated with the Loop and eddies can shift rigs off position, cause structural bending, stress and excessive riser angle, and inflict other costly damage. Anchoring operations, anchor cable tension, and load distribution can be impaired. Diving, ROV operations, and pipelaying are often impossible. Downtime can last for weeks as currents interfere with sensitive operations.

This paper will describe Zorro's rapid northerly extension into areas never before impacted by strong currents, the numerous separations and reattachments, intensity, the atypical migration, its impact on operations, and the ultimate absorption and recession from active lease areas.

Data Sources and Methodology

The primary source of data regarding currents in the Gulf of Mexico is the Far Horizon Drifter (FHD), an air-deployable satellite transmitter platform. Fourteen of these were strategically deployed in and around the Loop Current as Zorro developed, 62 were deployed in and around Eddy Zorro between 02 April and 17 August, and 6 more were placed in and along the perimeter of the Loop Current the end of August. Drogued to remain with the current and having negligible

windage, the FHD yields valuable information on frontal locations, configuration, orientation of major and minor axes, angular rotation, migration speed and direction, and current velocities. Satellite sea surface temperature (SST) images, Airborne eXpendable BathyThermographs (AXBTs), MODIS ocean color images, Acoustic Dopplar Current Profiler (ADCP) measurements from platforms and survey vessels, and altimetry were also analyzed in the identification and analysis of both the Loop Current and Eddy Zorro.

Discussion

The year started out quietly. **Figure 1** from Horizon's 02 January Eddy Watch update shows the Loop Current south of Lloyd Ridge (LL) and Yankee Eddy (2006) migrating safely south of activity in Walker Ridge (WR) and Keathley Canyon (KC). At the end of month, the Loop nudged LL, but it did not pose an immediate threat to operations in the central Gulf lease areas. Throughout February a cyclonic eddy (counterclockwise circulation) situated north of the Loop prohibited its advance north. In early March, the cyclone exited LL and the Loop surged north 30 n.mi. to 27°30'N in LL.

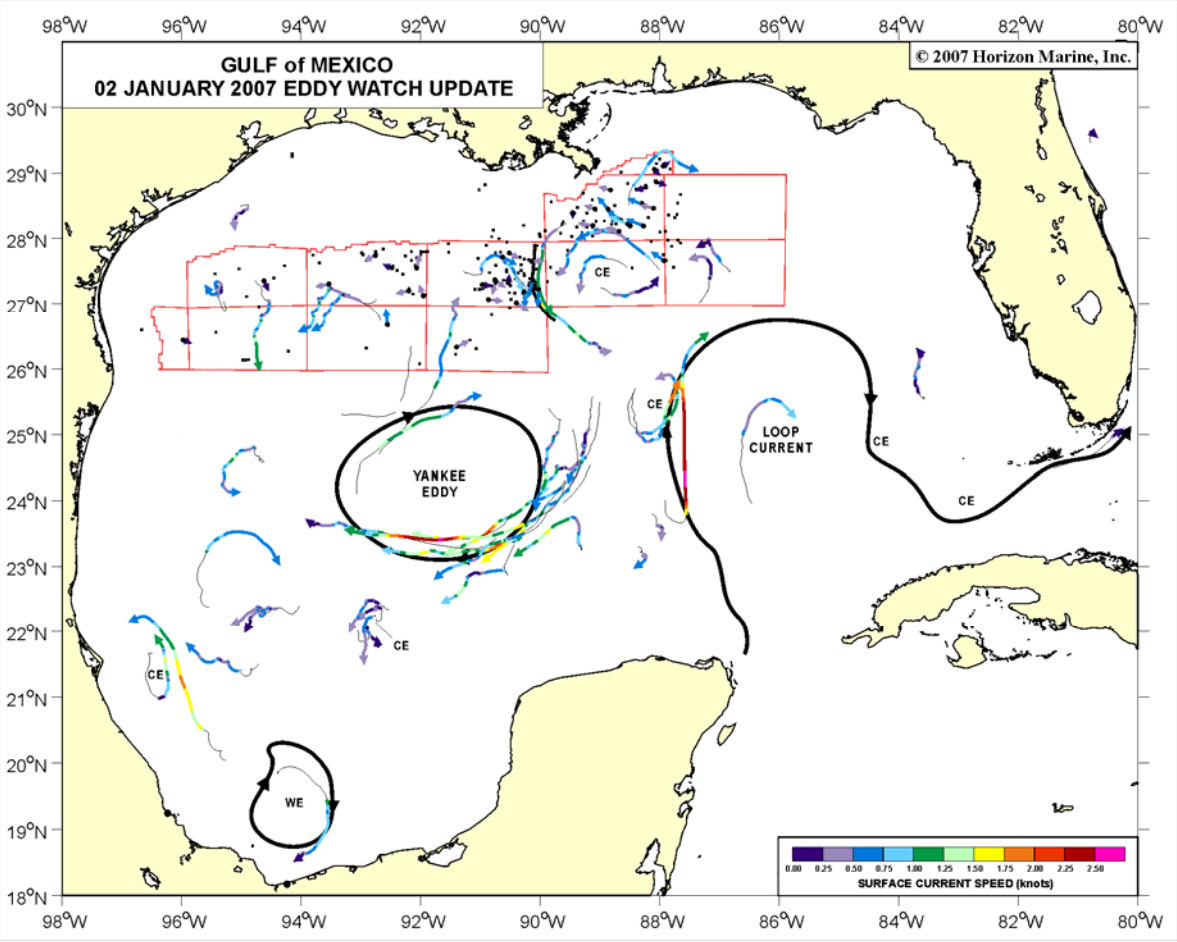

Figure 1. Conditions across the Gulf of Mexico on 02 January 2007.

A "Loop Current Alert" was issued on 08 March as 3 knot currents lay merely 30 n.mi. south of Mississippi Canyon (MC) and DeSoto Canyon (DC). Over the next two weeks, the Loop surged another 64 n.mi. north to 28°36'N in western DC, carrying the northwestern front and 3 knot currents into southeastern MC. This represents a northerly translation of 94 n.mi., or nearly 4.5 n.mi./day over a period of only three weeks, three times the average progression rate observed in previous eddies (see **Figure 2**). By the end of March, 3.3 knot currents impacted southeastern MC, currents over 4 knots were observed in northwestern LL, and there were several signs that a new eddy was forming. First, a vigorous cyclone had begun intruding into the Loop's eastern front, constricting the flow between the northern and southern halves of the Loop. Secondly, and as a result of the restricted flow, a closed circulation developed north of 25°00'N.

In early April, the developing eddy was named "Eddy Zorro". Four knot currents were observed in western LL, and Zorro covered the entire lease area as it advanced to 28°46'N in DC. Operations in LL, DC, southeastern MC, and eastern Atwater Valley (AT) all felt the impact of the powerful new eddy. Zorro's clockwise rotation and the deep intrusion of the eastern cyclone resulted in Zorro separating from the Loop Current on 20 April.

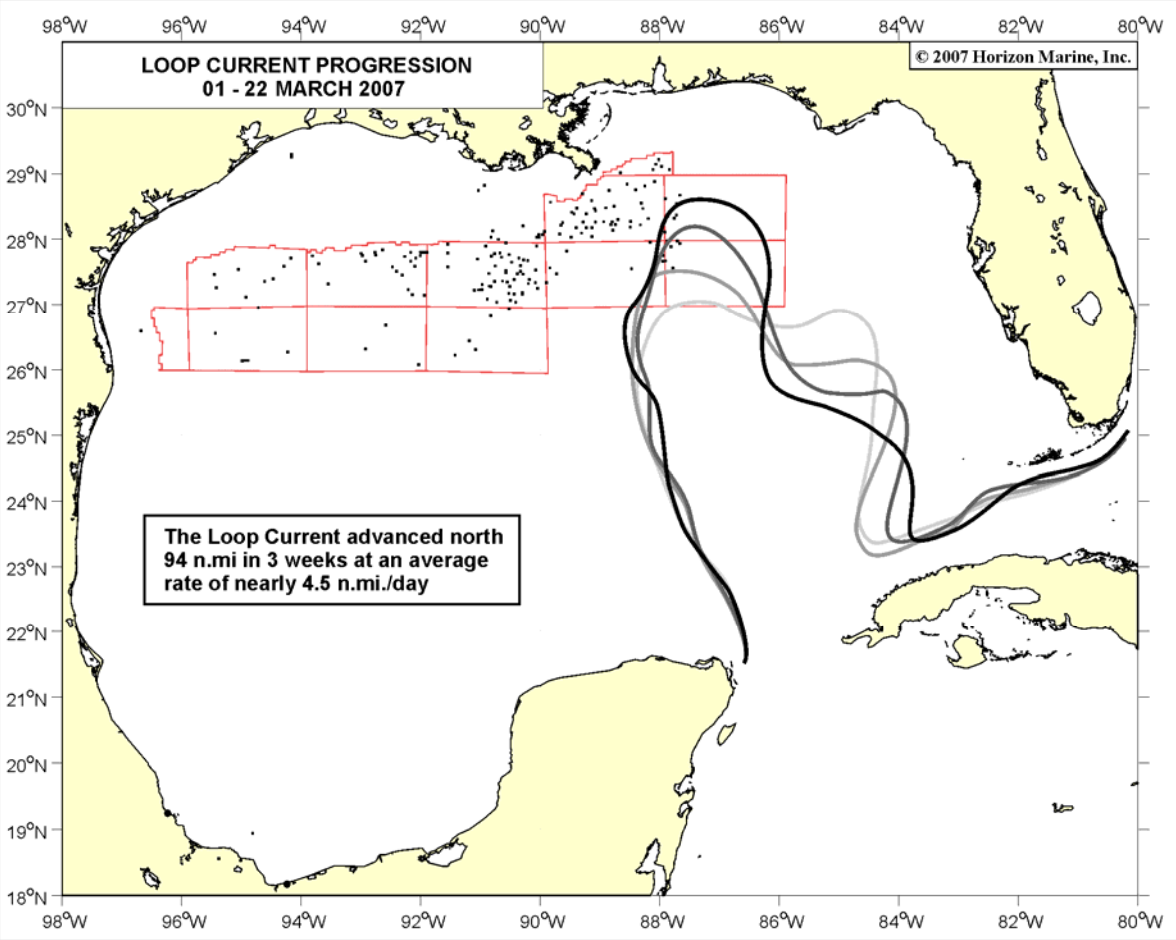

Figure 2. Rapid Loop Current progression over a period of 3 weeks in March 2007.

The Loop/eddy not only progressed more rapidly than any feature monitored since the mid 1980s, but it advanced farther north than any event observed during this period. Two knot currents were reported on 02 June in shallow shelf water in the South Pass (SP) lease area off the Mississippi Delta. **Figure 3** shows the eddy impacting SP 72 where water depths reach only 250 feet. The eddy continued to push north and by 11 June reached 29°37'N (see **Figure 4**). Zorro remained north of 29°00'N for ten days until 14 June when it retreated south out of Viosca Knoll (VK).

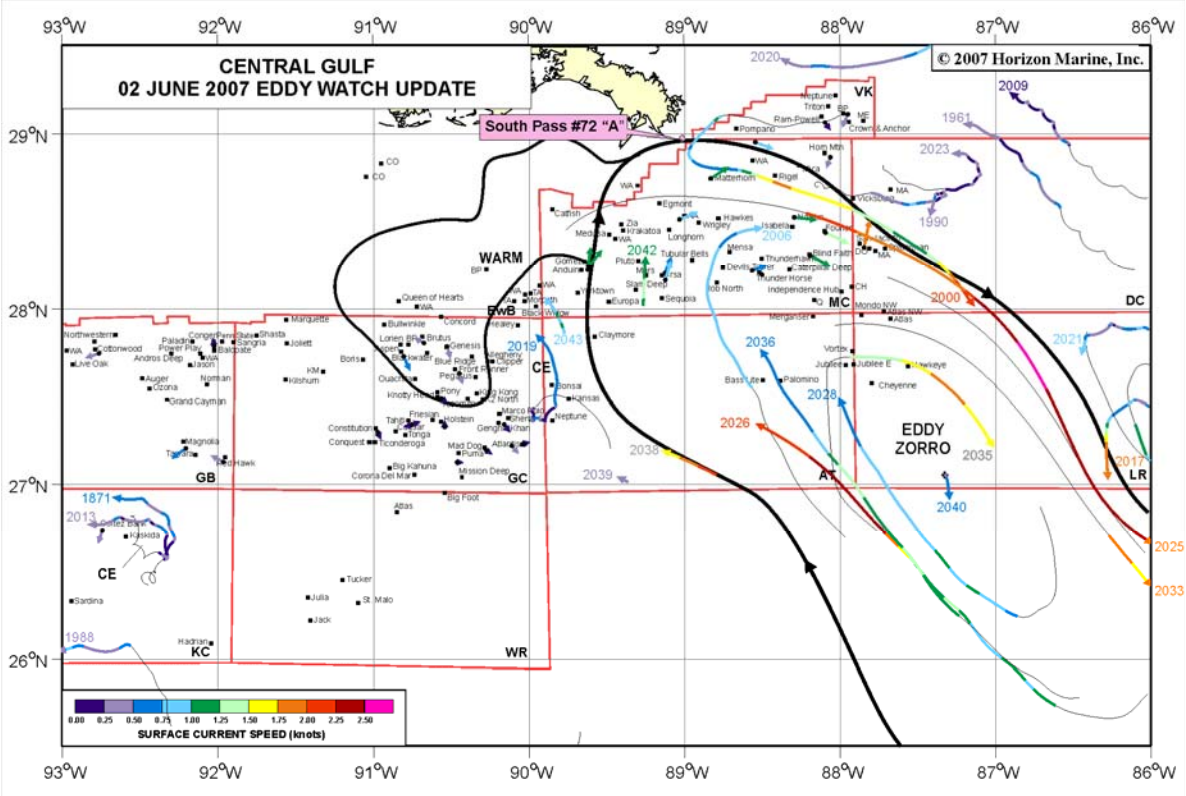

Figure 3. Eddy Zorro and two knot currents extend into shallow shelf water in SP 72.

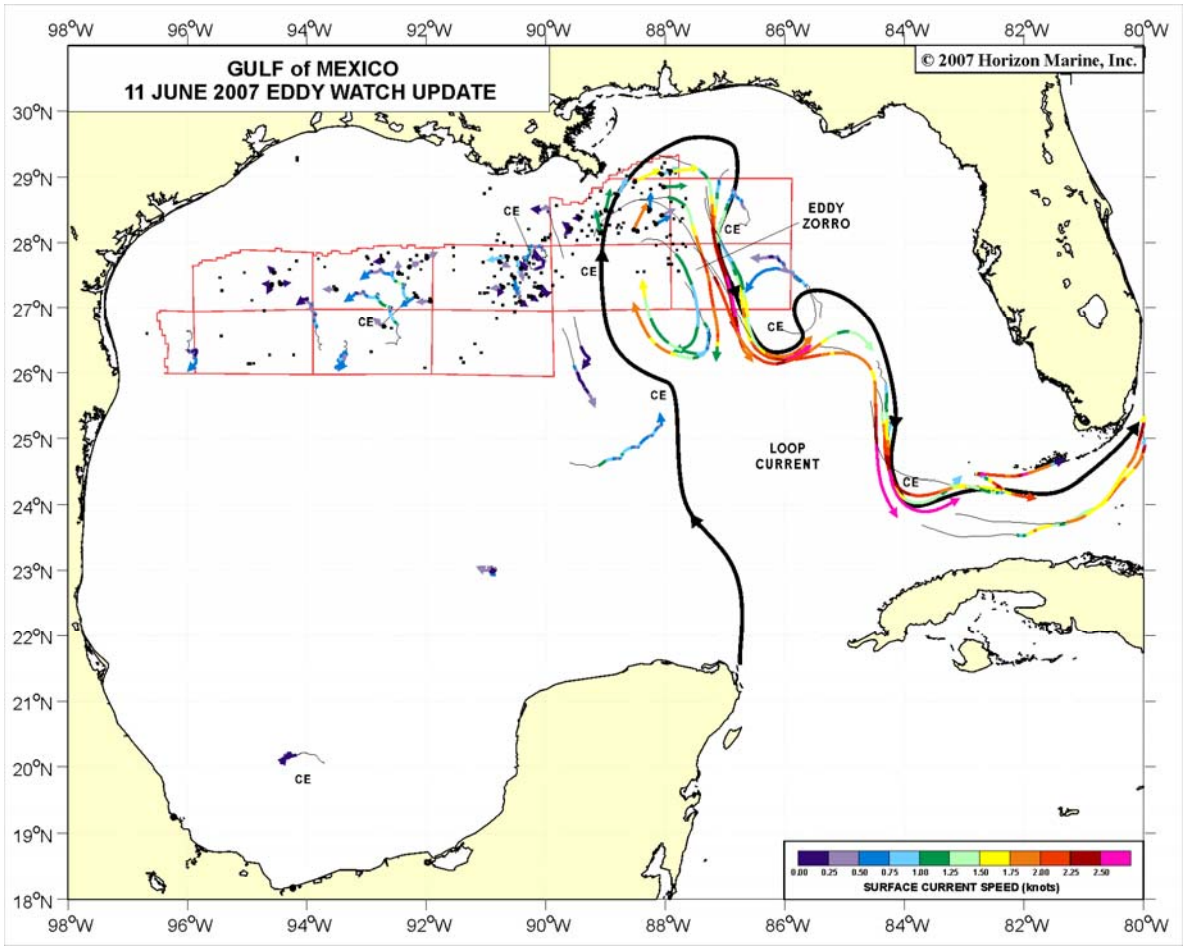

Figure 4. Eddy Zorro extends to 29°37'N.

Eddy Zorro rotated clockwise over the next several months, remaining east of 90°00'W and alternately reattaching and separating from the Loop Current. Three separations and reattachments were documented between 20 April and 06 August 2007. These are listed in the following table:

Event	Date	Separation Period (weeks)	Maximum Radius (n.mi.)	Maximum Latitude
Initial separation	20 April 2007	4	116	28°37'N
Reattachment	15 May 2007		94	28°42'N
Second separation	21 June 2007	1	102	28°54'N
Reattachment*	28 June 2007		100	28°42'N
Third separation	02 July 2007	4	102	28°37'N
Reattachment	06 August 2007		80	28°35'N

Table 1. A compilation of Eddy Zorro separation and reattachment events derived from Horizon Marine's 2007 Eddy Watch reports.

Repeated reattachments to the Loop Current held Eddy Zorro over the central Gulf lease areas throughout the summer of 2007. The 28 June reattachment was unusual as a long filament extended from the Loop Current's northeastern front around and approximately 60 n.mi. north of the Loop then snagged Zorro's southeastern front (**Figure 5**).

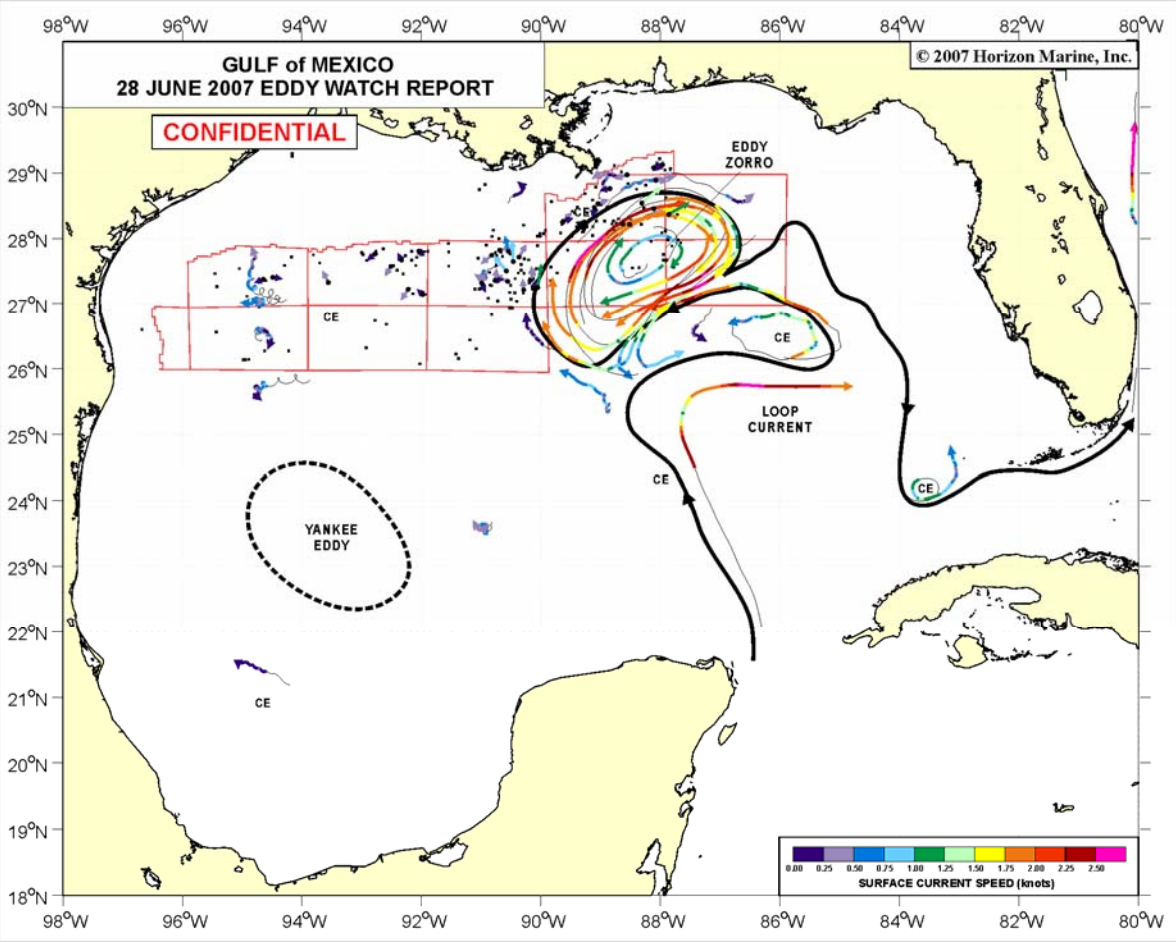

Figure 5. Unusual eastern Loop Current attachment.

The center of circulation, placed at 27°28'N, 86°46'W on 05 April, migrated only 124 n.mi. west-northwest to 27°37'N, 89°05'W on 20 August, a translation of an average 1.1 n.mi. per day - less than half the migration speed observed during eddy events over the past several decades. While stalled over this region, Zorro adversely impacted numerous installation and drilling sites in the central lease areas. **Figure 6** below illustrates the duration of impact at the following selected sites: Atlantis (GC 743), Cheyenne (LL 399), Independence Hub (MC 920), Neptune (AT 574), Thunder Horse (MC #822), and Spiderman (DC 620).

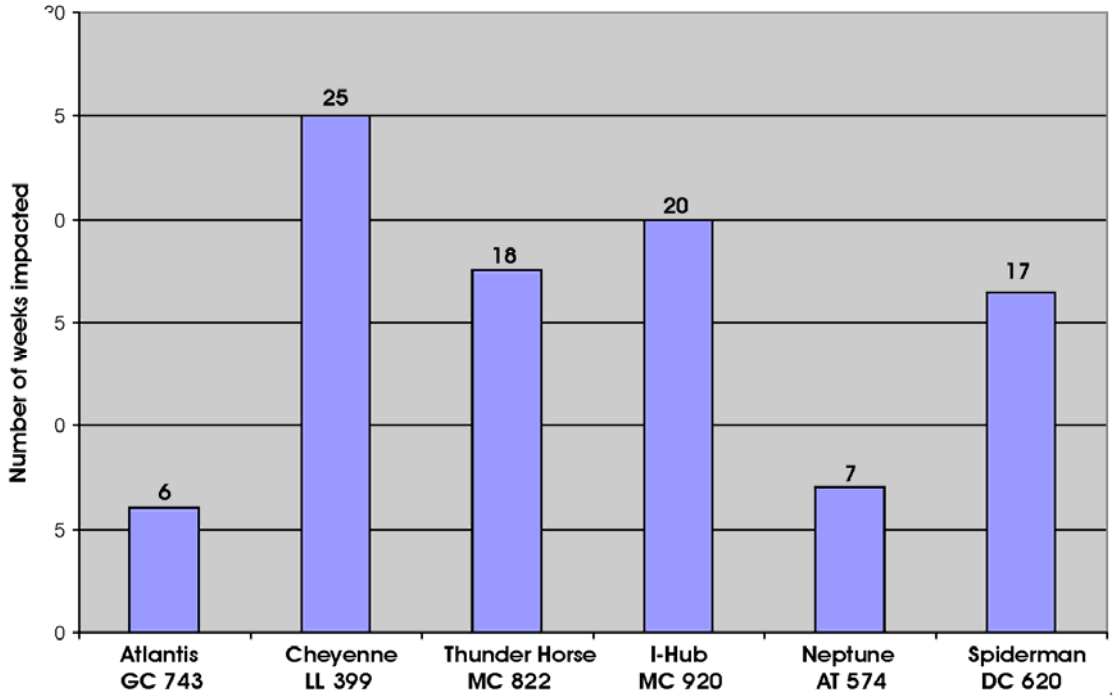

Figure 6. Eddy Zorro's duration of impact (shown in weeks) at selected sites in GC, LL, MC, AT, and DC.

Zorro also sustained intense currents longer than most eddies observed due to its repeated interaction with the Loop Current. **Figure 7** shows 4.3 knot currents observed shortly following separation along the northwestern front adjacent to a cyclone.

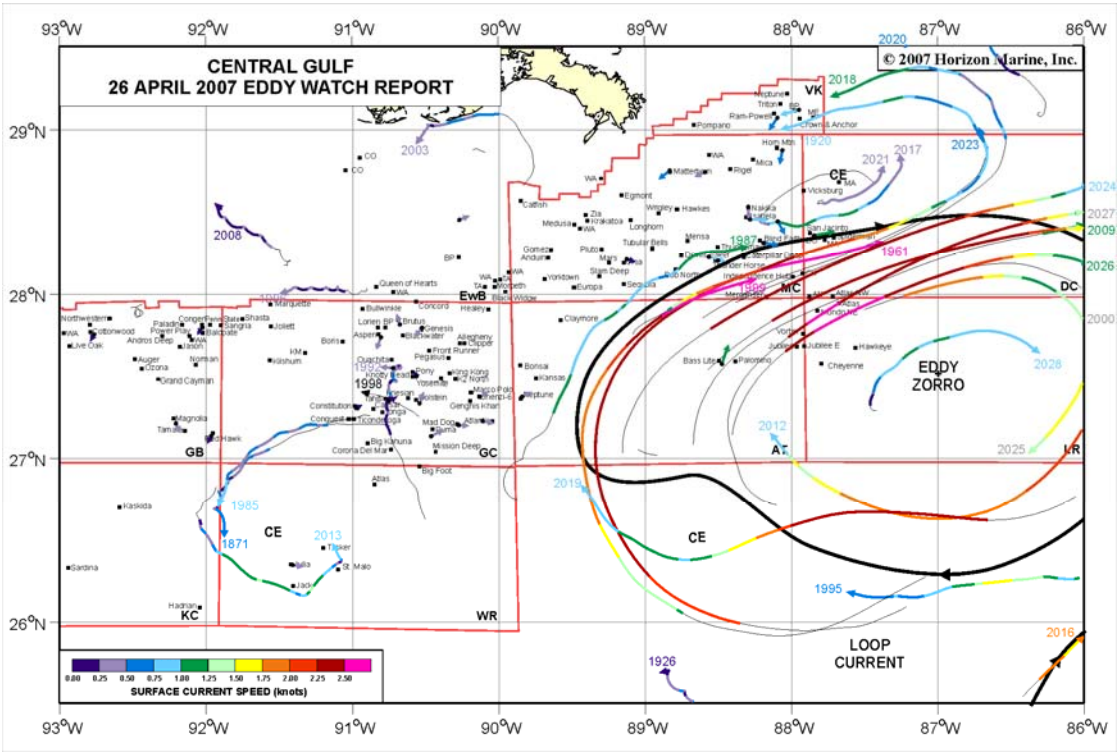

Figure 7. Observed currents reached 4.3 knots on 26 April 2007 shortly after Zorro's initial separation from the Loop Current.

These observations were consistent with Horizon's Eddy Forecast model (**Figure 8**) which indicates strongest currents are found where anticyclones and cyclones abut each other. The Eddy Forecast System (EFS) uses an existing high-performance, high-resolution ocean model for the prediction component but also a completely unique, feature-based initialization component. The essential underlying idea of a feature initialization approach is to extend real-time information with a historical knowledge of the typical structure and evolution patterns of LCEs [Robinson and Gangopadhyay, 1997]. This is analogous to "vortex bogusing" used so successfully in hurricane forecasting. This initialization procedure allows the use of all available oceanographic data, not just satellite altimetry.

In late June, 3 knot currents were still observed along Zorro's northwestern front which, at that time, had migrated into central MC. **Figure 9**, a FAST Eddy survey transect through the northwestern front on 24 June, confirms the intensity of currents still observed two months after Zorro's initial separation from the Loop Current.

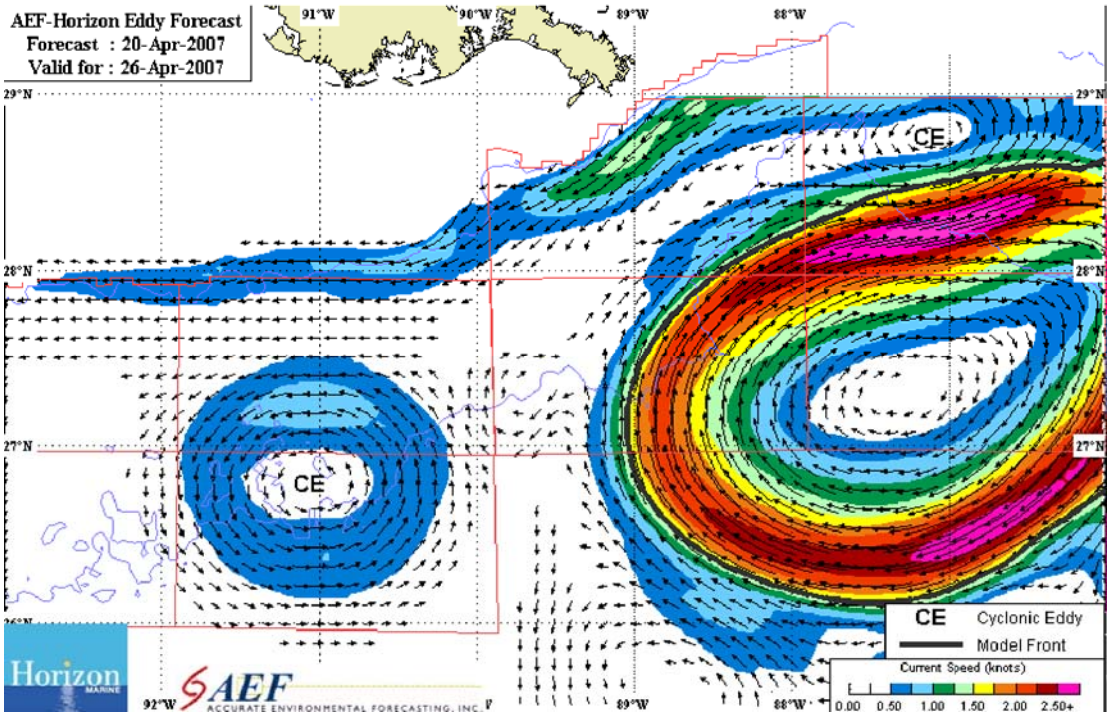

Figure 8. Eddy Forecast model output for 26 April 2007 showing strongest currents along the northwestern front adjacent to a cyclonic eddy.

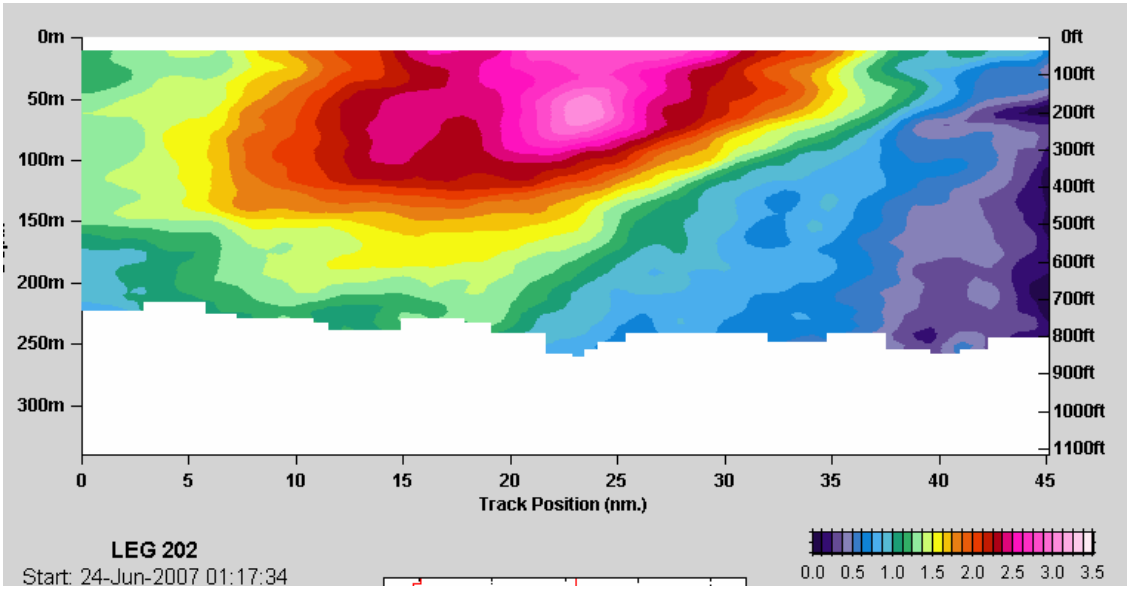

Figure 9. FAST Eddy 24 June transect through Eddy Zorro's northwestern front. ADCP data courtesy of Anadarko.

On 16 August, as Zorro extended west to 90°45'W, its westernmost advance, the Loop Current secured a firm hold on the eddy. In less than one week, the connection between the two features steadily widened and Zorro lost its eddy structure and closed circulation. The Eddy Forecast model initialized on 20 August predicted that the Loop Current would absorb the eddy before the end of the month. On 22 August, the eddy/Loop exhibited over 2 knots in western MC along the northern front and 3.1 knots in AT and LL along the northeastern front as Loop water again re-energized the five-month-old eddy. By 27 August, strong currents retreated from Ewing Bank (EW) and GC, and by 01 September, all traces of Zorro were absorbed and the Loop Current lay south of 28°00'N (see **Figure 10**). Never before have we observed the rapid and total absorption of a major anticyclonic eddy in the Gulf of Mexico.

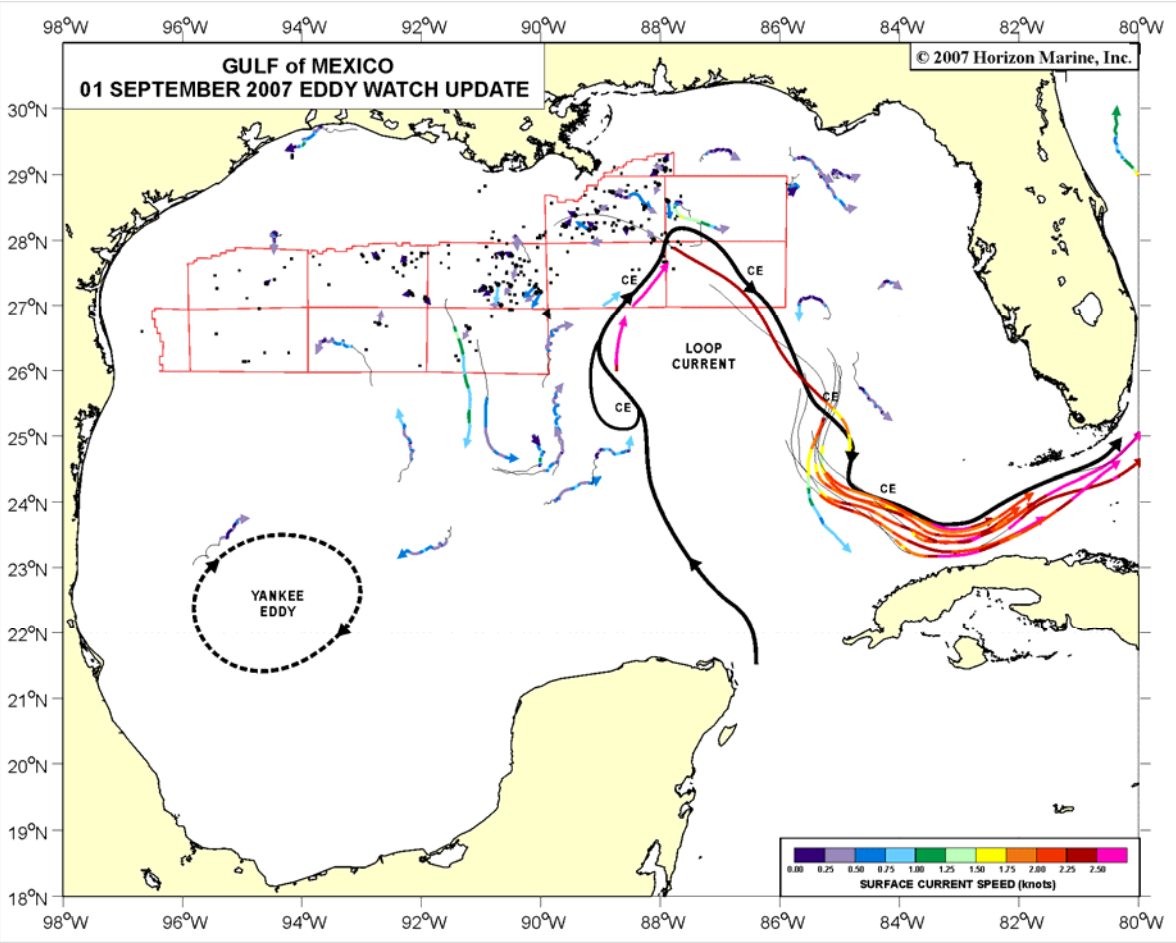

Figure 10. Conditions across the Gulf of Mexico on 01 September 2007.

Conclusion and Summary

The goal of this paper was to review the 2007 Gulf of Mexico Loop Current activity and, in doing so, describe one of the most unique eddies monitored and forecasted over the past several decades. When compared historically to over 50 eddies observed during this period, Zorro was one of the most intense, extended the farthest north, separated and reattached more often, and was the only eddy to be absorbed completely by the Loop Current. It was also one of only eight eddies that have lingered for an extended period of time over active sites in the central Gulf lease areas. This lingering and subsequent prolonged impact of Eddy Zorro on offshore operations is consistent with a recent trend in Loop Current activity observed over the past five years. Beginning with Eddy Sargassum (2003), the trend has been that eddies forming from the Loop Current are not separating and migrating away from the central Gulf as rapidly as observed in previous years. **Table 2**, below, shows the duration of these recent phenomena.

Event	Year	Number of Weeks Impacted
Eddy Sargassum	2003	32
Eddy Ulysses	2004	17
Eddy Vortex	2005	36
Eddy Walker	2205 – 2006	9
Xtreme Eddy	2006	22
Yankee Eddy	2006	22
Eddy Zorro	2007	28

Table 2. Five-year trend of Loop Current and eddy activity over active sites in DC, LL, MC, AT, EW, GC, and WR.

Operational interest in the Loop Current and associated eddies has enabled daily monitoring and forecasting of the phenomena with more sophisticated tools than in the past. Tools such as the scores of drifting buoys, rig- and vessel-mounted ADCPs, satellite remote sensing, and the development of an accurately initialized dynamical forecast model have enhanced the ability to monitor and forecast the energetic oceanographic features in the Gulf of Mexico. Utilizing these tools and methods, we observed and forecasted the “Life and Times of Eddy Zorro”, an atypical event in the Gulf in 2007. Zorro advanced more rapidly and farther north than any eddy observed prior to 2007. It separated and reattached to the Loop three times, exhibited strong shelf currents, was completely absorbed by the Loop, and retreated rapidly from active lease areas. The lessons learned, alliances formed, and technologies utilized during the 2007 Eddy Zorro event will assist in monitoring and forecasting future eddies in the Gulf of Mexico.

References

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Robinson, A. and A. Gangopadhyay, 1997: Circulation and dynamics of the western North Atlantic; part II: Dynamics of meanders and rings, Journal of Atmospheric and Oceanic Technology. 14(6), 1333-1351.