EddyNet: A Measurement Program for Collecting Real-Time Current Profiles from the Gulf of Mexico

Steven P. Anderson
Horizon Marine, Inc.
15 Creek Road
Marion, MA 02738
(508) 748-1860
steveanderson@horizonmarine.com

Cortis K. Cooper
ChevronTexaco, Exploration & Production Technology Co.
6001 Bollinger Canyon Rd, L-4240
San Ramon, CA 94583

David B. Driver
BP America Inc.
P.O. Box 3092
Houston, TX 77253-3092

Jan van Smirren
Fugro GEOS Inc.
6100 Hillcroft (77081)
PO Box 740010
Houston, TX 77274

Abstract—This paper describes the development and implementation of a measurement network that provides real-time ocean current profiles collected from drilling rigs, oceanographic survey vessels, and production facilities located in the Gulf of Mexico. The Eddy Joint Industry Project developed the program, named EddyNet. This real-time network of observations improves the ability to analyze ocean currents in the Gulf of Mexico and ultimately to support the operational needs of deepwater hydrocarbon exploration and production. In addition, EddyNet provides a centralized oceanographic database that can be used to develop environmental design criteria.

I. Introduction

Deepwater exploration and production of oil and gas is a complex endeavor that requires extensive planning and mitigation of risks to achieve success. One of the most productive deepwater regions is the Gulf of Mexico. It is also a region where deepwater fields are collocated with regions of strong ocean currents especially those associated with the Loop Current and its anticyclonic eddies. A good understanding of these currents is crucial to safe operations and design.

Eddy Joint Industry Project (EJIP) is a collaborative program, supported by several companies, that strives to effectively utilize limited resources to better observe and understand the powerful currents found in the deepwater Gulf. This paper reports on a recent EJIP initiative to develop a real-time measurement network that ties together current profile information collected by sites around the Gulf and makes the data readily available to operators and forecasters.

II. Background

The Loop Current (LC) is an energetic current of warm water that enters the Gulf of Mexico through the Yucatan Strait then loops around and exits the Gulf through the Florida Strait. Its position and strength change over time. Once or twice a year, the LC extends far north, and the loop becomes so tight that it becomes a closed circulation, forming an anticyclonic ring or eddy. Like the LC, these Loop Current eddies (LCE) also have strong currents, but unlike the LC, they are not constrained to the eastern Gulf. Instead, they are free to move west and north where they often interfere with deepwater hydrocarbon exploration and production operations in the northern and western Gulf. Oil industry activity in the Gulf continues to expand into deeper

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water. As it does, it is increasingly exposed to the Loop Current and associated eddies.

Offshore operators in the Gulf often rely on a commercial program called "Eddy Watch" to obtain operational monitoring and tracking of the LC and LCE. This program, run by Horizon Marine, relies on data from air-deployed drifting buoys combined with remote sensing and a few field observations to track LC and LCE fronts and regions of strong currents. However, this system is somewhat limited because it provides regional scale analyses and tracks only surface currents (Figure 1). Historical data and experience have shown that LC and LCE current profiles can vary substantially and this has a major effect on the forces imposed on the rigs. In addition, strong mid-water current events of unknown origin have been observed. These have little or no direct surface signature so are often undetected by the standard Eddy Watch measurement devices.

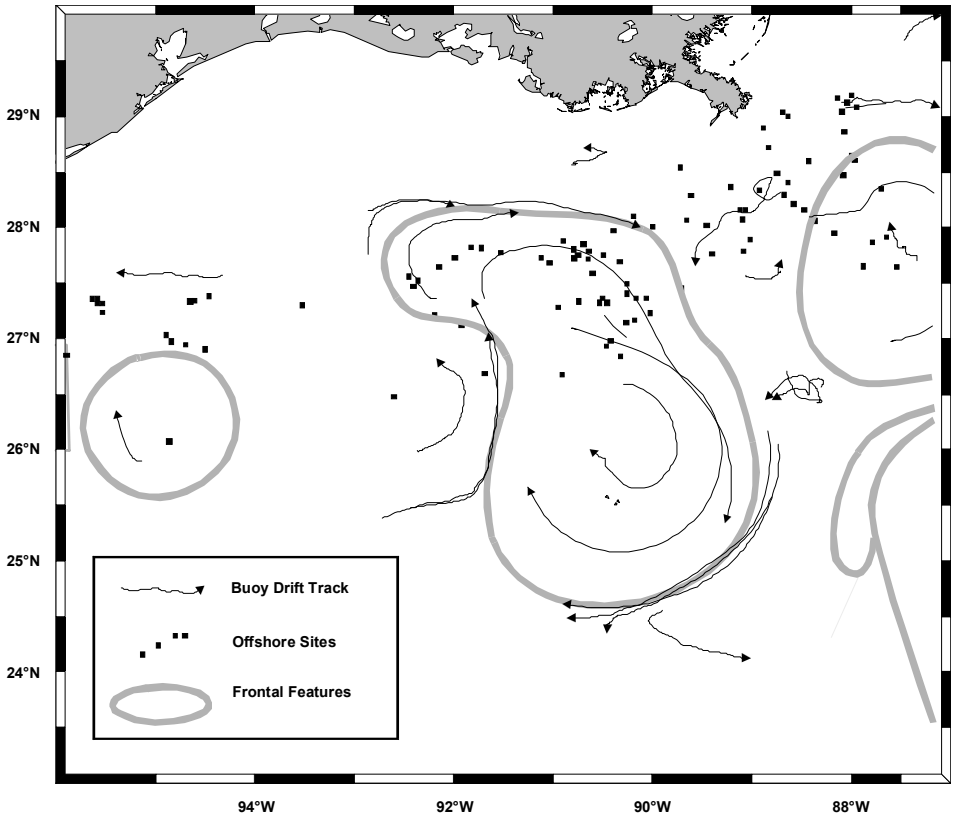
Operators also use Acoustic Doppler Current Profilers (ADCPs) deployed on their drillships and platforms to monitor ocean current profiles locally. In addition, survey vessels are sometimes equipped with ADCPs to monitor regions of strong currents "upstream" of a rig during critical operations. While some manual real-time data sharing of these data is occurring, it is not consistent nor efficient. Finally, much of the data is lost after the operational value has been extracted despite the fact that the data is often useful for later design of production facilities.

In summary, EddyNet was designed to integrate existing ADCPs into a network that could be accessed in real-time with the goal of

1. improving LC and LCE monitoring and forecasting for engineering operations,
2. documenting other potentially strong current events,
3. archiving data so it is not lost and is ready for comprehensive re-analysis,
4. providing real-time surface currents in support of oil spill tracking and search and rescue operations.

EddyNet consists of an offshore component that is located

Figure 1. A chart showing the location of Millennium Eddy on 24 March 2001. Also shown are the seven-day buoy tracks and locations of active or planned offshore exploration and production sites.



at each offshore data collection site and an onshore component that collects and manages the data collection and distribution.

III. Offshore Component

The offshore component of EddyNet includes the Real-Time ADCP (RTADCP) software developed specifically for EddyNet. RTADCP accesses data from the ADCP at user-defined intervals, adds additional information (such as site name, water depth, and position), and formats the data into RD Instruments Broadband ADCP file format. RTADCP then transmits the data files to the onshore EddyNet server through existing Internet connections or a stand-alone Iridium satellite data services link (Figure 2).

The first requirement for RTADCP was to assure that the new software did not noticeably alter the existing ADCP monitoring system. The operators wanted to be sure the ADCP systems continued to be reliable and accessible to individuals in the field. Thus, RTADCP is configured to acquire the raw ADCP data on a secondary computer, either from a serial data stream or from network file sharing, leaving the existing computer system and software intact.

To monitor serial data, a serial port splitter is used to allow a second computer running RTADCP to listen to the serial data stream coming directly from the ADCP to the primary ADCP control/display computer. Serial data can also be transmitted using RDI Transect software that is configured with the "ensemble-out" function to send data out through a second serial port on the primary ADCP control computer to a second computer with the RTADCP software.

Alternately, RTADCP can be configured to monitor raw ADCP binary files through network file sharing. In this case, the primary ADCP control computer is configured to share the directory containing the ADCP data files being collected. RTADCP is then configured to monitor this directory remotely and check for new ensembles at user defined intervals. (Note that this configuration is not possible if the primary control computer is operating in a DOS environment.)

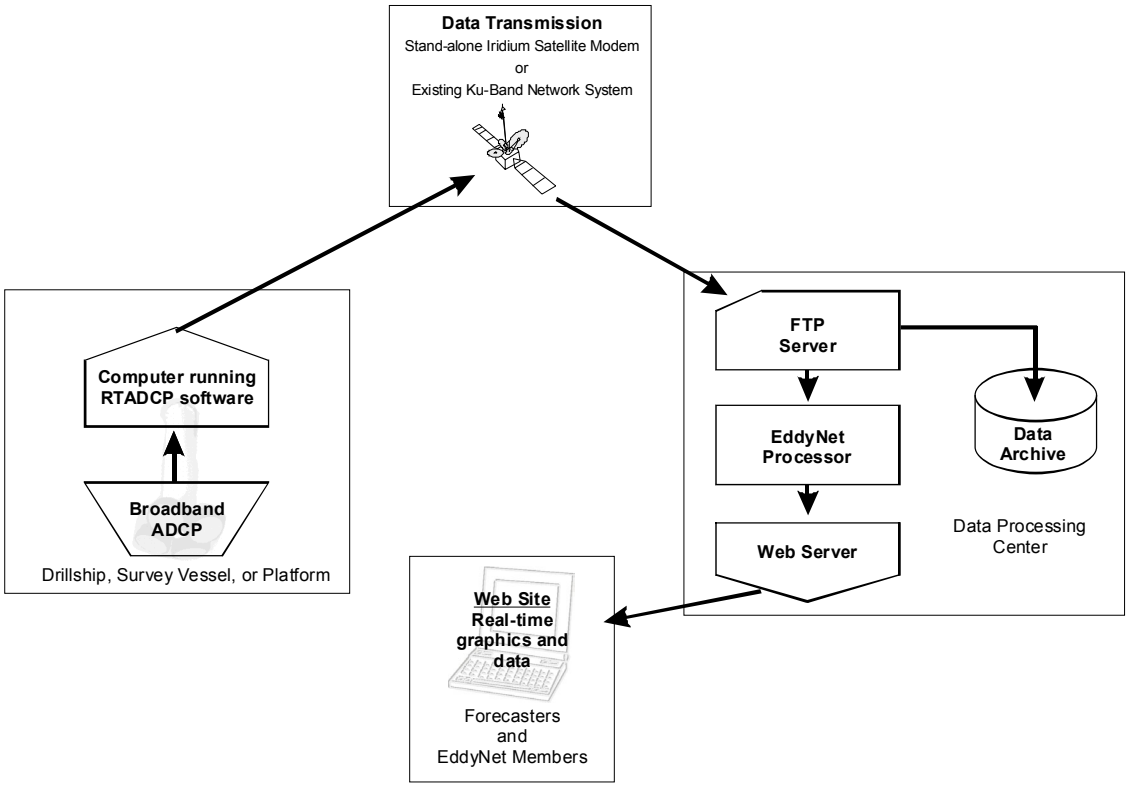


Figure 2. Flow diagram showing integration of EddyNet offshore and onshore components.

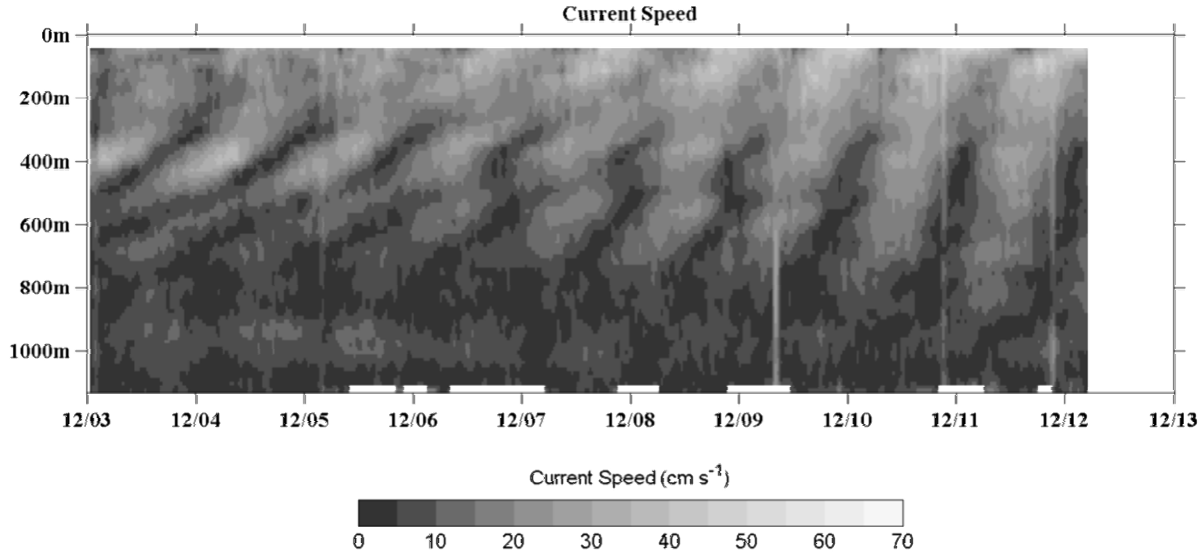


Figure 3. Example of ADCP data from RDI 38 kHz ADCP operated by BP America Inc. and deployed on the Transocean Discoverer Enterprise.

The second requirement for RTADCP was to use a data format that included site-specific meta-data while maintaining compatibility with existing RDI data analysis software. The decision was made to use the RDI Broadband data format for the ensemble data where each ensemble includes a header, a fixed leader, a variable leader, and velocity profile data as described in the RDI Technical Manual [1]. RTADCP then creates EddyNet specific leader data that is appended to each ensemble. The EddyNet leader block includes ancillary data including the location of measurements, the type of instrument, the platform name, the operator's name, the water depth, and the time zone used for time stamping. A unique leader block ID number identifies the EddyNet leader block. In this configuration, existing RDI software is able to display the current profile data in EddyNet data files; however, it will ignore information within the EddyNet leader block.

After acquiring and reformatting the original data, the RTADCP software transmits that data to the server located onshore. Many of the offshore drillships and platforms have dedicated communications systems. RTADCP can use these network systems to deliver the data through the Internet using an ftp client. However, there are situations when this network does not exist or is unavailable due to network security reasons. In this case, there are two options for data telemetry. If a Ku-band satellite communications systems is in operation at the remote site but not directly available to the ADCP system, it may be possible to fit an additional card into the communications multiplexer and transmit ADCP data over an independent network. In the case where existing networks are unavailable, an Iridium Satellite LLC data transmission system can be used. The Iridium system uses a Motorola 9500 Portable Phone, Motorola 9570 Portable Dock, and a data kit. Data is transmitted using either dial-up or Iridium direct Internet services.

IV. Onshore Component

The onshore component of EddyNet includes the software, hardware, and network resources required to acquire, archive, analyze, visualize, and distribute the real-time data. It also includes the EddyNet program administration and accounting.

The EddyNet server continuously receives and archives data from the offshore sites. Most of the data is received directly through the Internet using a file transmission protocol (ftp) server. The EddyNet ftp server is located at an Internet data processing center that provides 24-hour support and server redundancy. Throughout the day, the EddyNet server copies new data files to an offsite data archive and to the EddyNet processing computer.

The EddyNet processor performs preliminary automated quality control on the incoming data. The processor sends out email alerts to the EddyNet administrator and the operator if incoming data fails Q/C or no real-time data is received from a specific site. The EddyNet processor also provides secure website access to real-time current profiles with links to both raw data and graphical data displays from each site. Finally,

the EddyNet processor calculates daily averaged surface currents from each site for use by eddy forecasting services.

EddyNet participants provide either data from their own measurement systems or pay a subscription fee. Participants can access this data through the website as often as they like. At the end of each month, the EddyNet Administrator saves all the archived data from that month to CDROM. A copy of the archived data is mailed to each of the EddyNet participants. The EddyNet Administrator also collects funds from subscription members and forecasters and redistributes the funds to the data members to help pay for ADCP operation and communication costs.

V. Program Implementation

The development of the onshore and offshore components occurred during the first quarter of 2002. The first site came online with real-time data transmission in May 2002 and was operated by Marathon Oil Company. The ADCP was deployed in the East Break lease area onboard Noble Corporation's a semi-submersible rig named Amos Runner. This system utilized Iridium communications and an RDI 75kHz ADCP.

ChevronTexaco brought online the second and third EddyNet sites during the summer. The ADCPs were located on their Genesis site in the Green Canyon lease area and onboard the Transocean Discoverer Deep Seas drillship operating in Atwater Valley and Green Canyon. In the fall, BP America starting sending data from an RDI 38 kHz ADCP on the Transocean Discoverer Enterprise drillship operating in Mississippi Canyon. All of these systems utilize existing communications networks.

Forecasters are now making regular use of EddyNet ADCP data to help with LC and LCE tracking. The Mineral Management Service has joined EddyNet as a subscription member and is using some of the archived data to help develop deepwater oil spill models.

Figure 3 shows an example of the ADCP data collected on the Discoverer Enterprise by BP America. The site uses a 38 kHz ADCP. The figure shows nine days of data and the shading indicates current speed with lighter shades corresponding to higher speeds. Reliable current profiles extend down below 800 m. Apparent in the data is the upward phase propagation of near-inertial waves in a downward propagating wave group.

V. Conclusions

The whole system has proven to be reliable, and over 16 months of ADCP data were collected during 2002. There were very few problems encountered with the system during the first months of operation. The major hurdle for operators has been working with their Information Technology department to receive permission to connect to the company networks and to transmit data from the offshore sites. The number of participants is expected to increase during the coming year. A real demonstration of the value of EddyNet will come during the first half of 2003 when the next major Loop Current Eddy is forecast to reach the northern Gulf.

Acknowledgements

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[1] RD Instruments, “Workhorse Commands and Output Data Format,” 2001.