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Offshore Engineer

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Real-time ocean current data from 3000m and beyond

Drilling operations increasingly make use of real-time profiles of ocean currents throughout the water column. Until now those profiles have been restricted to water ranges of around 1000m. However, following trials in the Gulf of Mexico, ocean current data will soon be obtained in depths to 3000m and beyond, as discussed in this article by **Michael Vogel** of Shell Global Solutions (US) and **Darryl Symonds** of San Diego-based RD Instruments.

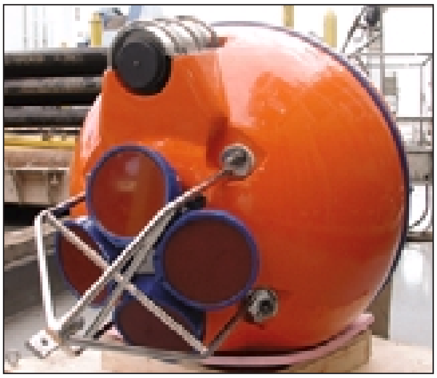
Information from real-time current profiles displayed in the control room of a drilling rig supports a wide range of operational decision-making processes. They include: rig orientation; riser and tubular deployment and recovery; ROV operations; and support vessel station-keeping.

In the Gulf of Mexico in particular, large eddies break off of the Loop Current. These eddies can spawn currents of more than three knots and extend hundreds of metres below the surface. Current profile data have proved particularly useful in warning of these high currents, thus enabling operations to be performed safely and for as long as possible. This information on currents is also archived and is used to influence field development engineering decisions and the design of structures. The measurements also help improve our general understanding of ocean processes.

The instrument used to obtain these measurements in support of offshore operations is the Acoustic Doppler Current Profiler (ADCP). This technology was invented in the early 1980s by RD Instruments Inc, of San Diego, CA. The company now has thousands of systems at work worldwide in a wide range of operations, from measuring flow in rivers at depths of just 0.3m, to deep ocean research.

In order to obtain current profiles throughout the water column in depths greater than 1000m, Shell Global Solutions (US), RD Instruments and other manufacturers developed a real-time system which includes a rig-mounted ADCP 'looking' down through the water column, and a bottom-mounted ADCP 'looking' up. The rig-mounted ADCP feeds data directly to a computer aboard the rig. The bottom-mounted system collects ADCP data and transmits it to the surface in real time via an acoustic modem.

The obvious question here is: 'Why not make a single profiler capable of profiling for 2000m?' This would avoid the need for multiple instruments, the logistical problems of installing a system on the seabed, and the technical challenges of telemetering the data through the water column.



The one-metre diameter sphere with the embedded RDI ADCP and (at top) the Linkquest acoustic modem

The answer here is 'backscatter'. ADCPs work by transmitting sound into the water and receiving reflected sound from suspended particles, plankton, air bubbles and the like. The frequency shift (Doppler shift) between the transmitted sound and received echoes is used to compute the velocities of the particles and thus the velocity of the water in which they are suspended. Thus, the performance of the ADCP is contingent upon the level of backscatter available within the water column.

Towards the surface, backscatter tends to be plentiful, providing sufficient reflections for the ADCP to operate at maximum efficiency; however the deeper you go in the ocean, the less backscattering occurs. This substantially limits the range of any current profiler, and effectively prevents it from collecting a 2000m profile.

To overcome this, recent validation trials have proven that by mounting the ADCP on the sea floor facing upwards, it points into the area of the stronger backscatter, thus dramatically improving the range that would otherwise be obtained by a downward-facing instrument deployed at the same depth. Incorporating acoustic modems to transmit bi-directional data in real time has a further advantage in that it allows real time manipulation – and hence enhancement – of the ADCP's performance.

The upward looking, real-time current measuring system with anchor weight and instrumented buoy.

Armed with this information, Shell Global Solutions (US) and RD Instruments, working in co-operation with Floatation Technologies, Linkquest, and Evans-Hamilton, set about designing a downward/upward-looking system for offshore operations.

A validation test for this configuration was performed in the Gulf of Mexico, where Shell Oil was drilling from the Transocean Sedco Forex *Deepwater Nautilus* semi-submersible in 1574m water depth. The rig was already fitted with an RDI 75kHz Vessel Mounted (VM) downward-looking ADCP mounted in the rig's port pontoon some 9m below the surface. This current profiler provided real time data for the top 600 – 800m of water.

An RDI Workhorse Long Ranger 75kHz ADCP was chosen as the bottom-mounted, upward-looking instrument. The main reason for the choice was that this instrument has the longest profiling range, up to 600m, of any self-contained current profiler available. It can operate in depths to 1500m for up to one year.

Shell Global Solutions (US) had previously tested the Linkquest acoustic modems on a moored platform in 1000m water depth and had obtained 100% data transfer and reliability. For this project, the company chose the Linkquest model UWM4000 for its 3000m range and ability to transmit data at speeds up to 9600 bits per second. Data was transmitted from the seafloor instrumentation to the radio room on *Deepwater Nautilus* via an identical acoustic modem hung from the rig, just below the surface.

The Long Ranger ADCP, Linkquest acoustic modem and batteries were fitted in a

1m diameter buoy, custom-designed and manufactured by Floatation Technologies. The buoy had a 270kg anchor weight, which was three times the positive buoyancy of the system and which was included to keep the entire assembly from 'walking' in strong currents.

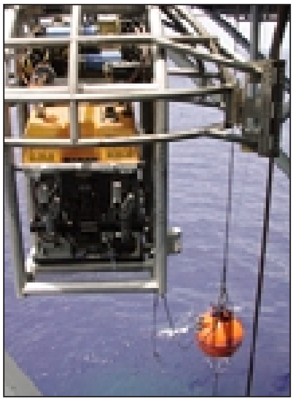
The assembly was placed on the ocean floor near *Deepwater Nautilus* by the rig's onboard Oceaneering ROV, with the buoy some six metres above its anchor weight. Using the ROV for deployment and recovery was ideal, as the system could be placed in a very specific manner out of the way of the platform. The actual deployment and recovery could be tied to normal ROV inspection work on the platform, thus limiting extra duty for ROV operations.

The validation trials were successful. The rig-mounted, downward-looking ADCP achieved a range of 633m – slightly over what had been predicted. The surprise came with the seafloor-mounted, upward-looking Long Ranger instrument. Here, the expected range was 614m, but the Long Ranger consistently turned in far longer ranges – an average of 700m, with a maximum range of 969m. These long ranges meant that the data returns from the two instruments were overlapping by about 50m at the end of each of their two ranges, thus making it possible to create a profile of the entire water column.

This operation provided the perfect opportunity to assess the performance of the seafloor-mounted Long Ranger ADCP. The upper part of the profile was well known because the rig-mounted instrument had been measuring currents for some weeks and the Oceaneering ROV had also been gathering data. Currents near the surface were known to be around 500mm/s and then decreasing to 200-250mm/s below 400m.

Over a 1500m profile of current magnitude and direction, there was very good agreement with the overlapped data from the two instruments. This in turn agreed well with the expected velocities in the profile.

The official report on the trial stated that the 'information gave confidence that the extended range of the [seafloor-mounted] Long Ranger allowed for the collection of accurate water currents'.



For the record, the currents measured at depths below 900m matched the expected values of less than 100mm/s up to 500m from the seafloor, increasing to no more than 250mm/s at around 1000m off the bottom. However, there was a surprise in that during a period of seven days, currents between 100-300m off the bottom increased to 250mm/s with peaks approaching 500mm/s. It is precisely these types of features that are important to offshore drilling decisions, and attests to why full ocean current profiles are required.

The Linkquest modems played a key role in the trials. Not only did they provide the ability to acoustically transmit data to the surface, but also provided the ability to communicate with the seafloor system in real-time. On-site personnel were able to change operating parameters to see instantly how these would affect the overall performance of the system.

An interesting lesson was that the acoustic modems produced harmonics that interfered with the returned signals from the seafloor mounted Long Ranger ADCP and contaminated the data. From this we learned that the Long Ranger must be set up in such a way that it is not actively pinging while the acoustic modems are transferring data. A simple set up change, and this is easily accomplished.

This offshore validation proved that the effects of diminishing backscatter levels in deeper water can be overcome, and full column current profiling data can be obtained by overlapping the data collected from an upward looking ADCP and a downward looking ADCP. This is a significant advancement in light of the increasing trend toward deepwater offshore exploration and development, and the importance of real-time current data in operational decision-making.

Furthermore, the Floatation Technologies buoy design and Linkquest acoustic modems have proven acceptable in this configuration, allowing for full column current profile data via wireless real-time bi-directional data communication, thus enabling critical real-time decision making to take place.

Since the time of this experiment, Shell Global Solutions (US) has purchased a complete system configuration rated for 3000m operation, which it plans to deploy in the spring of 2002. OE

The Oceaneering ROV, with its tether management system, dives from *Deepwater Nautilus* to place the upward-looking current monitoring system on the seafloor in 1574m water depth in the Gulf of Mexico.

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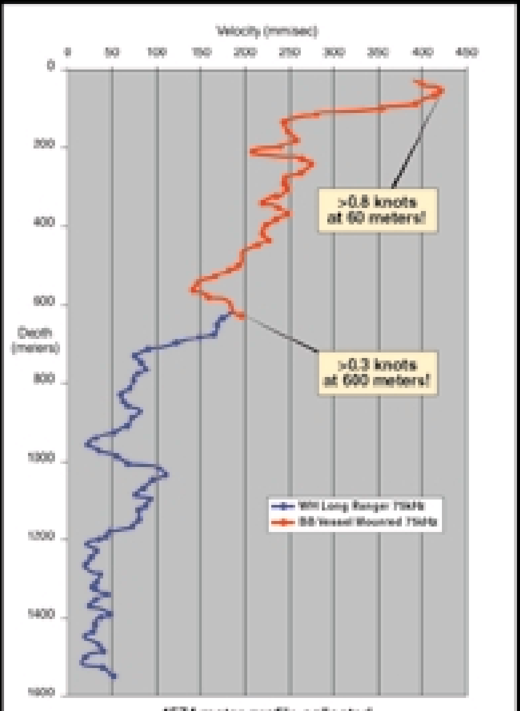

1574 meter profile collected in the Gulf of Mexico

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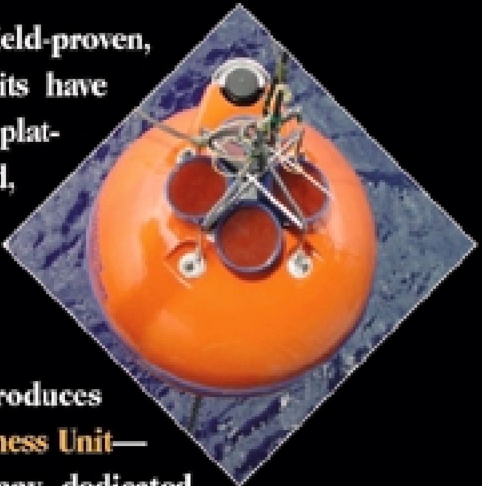

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