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Oceanographic edition

Photo credit: Dr. Andreas Muenchow Associate Professor University of Delaware

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The Lead

Data Collection and Processing

Teledyne Answers the Call of the Running Tide

Working together, leading oceanographic companies strive to create an integrated customer experience

By Peter Spain Ph.D., Teledyne RD Instruments

Introduction

Fifty years ago, the digital wave arrived. Surfing on it was the modern era of measuring the ocean. Within a couple of decades, the new industry consisted of many small companies; most specialized in a particular instrument. Recently, with the graying of these pioneers, the oceanographic industry has consolidated.

Like listening to a jazz band, superior customer experiences will arise from Teledyne Marine's elements working together

Teledyne Marine is a prime example of this consolidation. It is a collective of 23 leading-edge marine companies assembled by Teledyne Technologies Inc. Each company is not only a leader in its niche, but remains committed to its technical heritage. Each provides premium products backed by reliable support.

What advantages does this consolidation offer to customers? Consider the sound of a jazz band. The ensemble can create distinct listening experiences that are not available from individual musicians;likewise, the companies of Teledyne Marine work together to provide new customer experiences.

Teledyne Marine employs over 2000 team members who work within 41 manufacturing and service centers worldwide. The individual companies share their relationships and talents, thus offering more diverse technology development and greater worldwide support.

In this way, Teledyne Marine can offer an unmatched range of solutions, while each of its brandsbecome more relevant and valuable to an expanded range of customers.

Spectrum of Marine Solutions

For this edition, we will address oceanographic markets served by Teledyne Marine. However, the following is a list of the broader vertical markets that Teledyne Marine serves:

Oceanographic: *ocean observatories, deepwater surveys, wreck survey and salvage, and biological observation*

Hydrography/Navigation: port and harbor surveying, dredge guidance and monitoring, navigation aids, and hazard detection

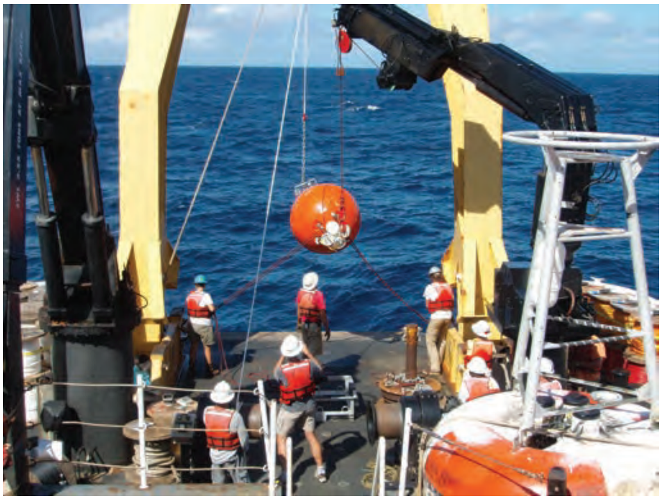

Fig.1. Teledyne RDInstruments' 75 kHz Long Ranger ADCP deployment (Rick Cole, RDSEA International)

Water Resources/Civil Engineering: *river and stream monitoring, bridge and dam inspection, and environmental monitoring*

Energy: *visually inspecting pipelines and managing other undersea assets; verifying and controlling flow to reduce risks and improve reliability in deepwater operating conditions*

Defense and Security: *shallow-water security applications such as terrain mapping, diver detection, search and rescue, visual inspection, powering systems, and reliably returning data to shore*

Ocean Observatories

The Ocean Observatories Initiative (OOI) is a thrust to deliver cutting-edge oceanic data for a generation. Funded by the National Science Foundation, this effort aims for scientists to maintain a persistent presence in the ocean and to develop new scientists from our school age children.

About 40 percent of the world's population lives within 100 km of the coast. And for this growing population, the ocean bears commerce and supplies food and energy. Better managing of coastal resources will stem from learning more about the complexity of the coastal ocean, including human influences.

Fig.2. Teledyne Webb Research's APEX drifting profiler used to measure subsurface currents and profiles of temperature and salinity.

Teledyne Marine's brands have been key suppliers to these ocean observatories. The scope of products includes sensors and gliders as well as infrastructure for underwater networks.

OOI comprises an integrated system deployed in seven focal regions. These include coastal and global sites from deep sea to near-shore coastal ocean. OOI's charter is to examine ocean features and processes on wide-ranging scales in both space and time. The program measures many and varied oceanic properties from the air-sea interface to the seabed. Its toolkit includes a huge collection of sensor systems.

Several overarching science themes motivate this effort. Among them is to examine the complex role played by the ocean and its circulating waters in the dynamic climate system. Another is to learn more about how this large-scale feedback loop alters the earth's myriad ecosystems.

More than 50 ADCPs (Acoustic Doppler Current Profilers) and DVLs (Doppler Velocity Logs)from Teledyne RDI have been supplied. ADCPs equip each of the seven OOI nodes. These devices remotely measure ocean currents at many depths. At the four global sites, 75 kHz ADCPs measure long ranges in the deep sea. A similar number of higher frequency ADCPs are measuring currents at sites across the US continental shelf.

More than 60 gliders from Teledyne Webb Research support OOI. They include both coastal and deep options. Coastal variants dive and rise through the upper 200 m, whereas the deep variety reach to 1000 m. Installed on these Webb Research gliders are Teledyne RDI's Explorer ADCPs. These devices contribute to navigating and measuring water currents. Working around the Pioneer Array offNew England are a couple of AUVs. These too carry DVLs from Teledyne RDI.

A key technological step in OOI is its networked system. Underpinning this setup are power, data, and communication capabilities from Teledyne Marine. Data collected at the nodes can be stored at sea or transmitted in real-time to shore. These links contain connectors, cables, and fiber optic assembly solutions from Teledyne ODI. Many of the sensors include integrated connectors from Teledyne Impulse.

Many of OOI's nodes also use deep-sea flotation in mooring lines. Teledyne Benthos supplies evacuated glass spheres for these applications. At some sites, acoustic modems from Teledyne Benthos provide a key link in sending data ashore. Their acoustic messages are picked up by Teledyne Webb

Fig.3. Teledyne Webb Research's Slocum glider combines wings and buoyant motion to propel itself along its trackline.

Photo Credit: Ben Alsup

Fig.4. Teledyne RDI's Workhorse Citadel CTD recovered for in-field cleaning

Research gliders that act as gateway communication tools. In other coastal nodes, gliders routinely transit the region. They can deliver control data to the system.

Observing Global Circulation

For 16 years, the Argo global array of 4000 free-drifting profiling floats has been continuously measuring the upper 2000 m of the ocean worldwide. The ensemble data set is valuable for studying climate and ocean processes. Many of these are the Autonomous Profiling Explorer (APEX) floats. Since 1982, Teledyne Webb Research has delivered over 6,500 profiling floats to the Argo network.

Unlike surface drifters or deep RAFOS floats, APEX floats make continual vertical cycles while they drift around the ocean. They measure temperature and salinity at many depths. Some custom variants also measure profiles of water current velocity. Others collect data on ocean biology and chemistry.

To support the unprecedented goals of Argo, developers of the APEX floats had to address several challenges. These were the need to be energy efficient, reliable and low cost. A more recent goal was to work at much greater depth. In 2013, an APEX float descended to 6,000 m in the Puerto Rico trench. One day later the float resurfaced from the deep dive; it sent back its data via satellite.

Measuring Near-Surface Waters

During the last two decades, observing the upper ocean has become the domain of gliders. Prominent among these devices is Teledyne Marine's Slocum Glider. Since 2002, Teledyne Webb Research has supplied over 550 gliders. Typical dimensions are 2.2 m length and 60 kg weight.

For a mission, a Slocum glider flies a programmed trackline. Physical water properties like temperature and salinity are routinely measured. Gliders have also observed chlorophyll, sediment, harmful algal blooms, and even resolved internal waves. During the Macondo oil spill in 2010 (Gulf of Mexico), gliders collected subsurface data to support response work.

Slocum gliders can operate in deep water or closer to the surface. One example was the Scarlet Knight glider that crossed the Atlantic in 2009; it glided to 200 m depth. A pressure sensor controls the end of a dive.

Photo Credit: Ocean Net Consulting and Environmental Systems SL

Fig.5. Teledyne RDI ADCP installed for seabed deployment

Like the APEX floats, gliders make clever use of changing buoyancy; wings fly the sinking / rising vehicle horizontally. Gliders can be equipped with a range of Teledyne Marine sensors. Examples include CTD, optical, biological, and environmental instruments. Slocum gliders can also be fitted with an integrated ADCP.

China's Western Pacific Ocean System

Changes in the Western Pacific Ocean are linked to major meteorological events. Examples include the East Asia summer monsoon and El Niño. To learn more about these links, the Western Pacific Ocean System (WPOS) is underway. This large Chinese research program will include scientists from several nations.

WPOS aims to reveal a more complete view of the ocean currents in this region. The findings will be particularly valuable to climate modelers.

More than two dozen moorings, distributed among six arrays, are off the Philippines and Indonesia. The arrays will record ocean currents in water depths to 6,000 m. Each mooring includes Teledyne RDI's 75 kHz Long Ranger ADCP, as well as extra Workhorse ADCPs ranging from 150 to 600 kHz.

Research cruises will complement the moorings. Teledyne RDI's 38 kHz shipboard ADCP will collect transects of deep profiles of ocean currents.

Of particular interest are two major oceanic features: Kuroshio Current and Indo-Pacific Warm Pool. The dominant current in the Western Pacific is the Kuroshio. It provides an important conveyor not only for shipping and physical properties but for nutrients flowing into China's coastal waters. The latter affects plankton blooms and fisheries.

For its part, the extensive Warm Pool of surface water is warmer than any other open ocean on Earth. The Pool pushes heat and moisture high into the atmosphere. This feature seems associated with persistent atmospheric responses. WPOS will look at movement, temperature and nutrient load of various currents that circulate through the Warm Pool.

To avoid disrupted surface observations due to theft and vandalism of buoys, WPOS will rely on the global Argo network of floats. Many of these are APEX profiling floats supplied by Teledyne Webb Research. During their drift, these floats record regular vertical profiles of temperature and salinity to 2,000 m.

Real-time, Moored Deep Water Current Profiles

Within the Gulf of Mexico, there are two types of strong, localized water currents. These are the Loop Current and the eddies that it spawns. Both current types are tracked vigilantly. This monitoring aims to protect vulnerable drilling risers that hang below drilling vessels. Strong currents can cause high drag forces to act on these risers. Such forces can cause the risers to fail, resulting in significant damage and operating delays.

With this in mind, the U.S. Bureau of Ocean Energy Management (formerly, Mineral Management Service) requires the collecting of current profiles around deep water oil platforms in the Gulf of Mexico. Moreover, the data has to be monitored and posted on a website for archiving every three months or sooner. Running data cables can be problematic around working platforms. So this schedule left operators with two options. At 3-month intervals, they could service internal recording devices, or they could use a real-time communications link.

For profiling currents from moorings in these deep waters, the Long Ranger ADCP from Teledyne RD Instruments is the established choice. In upper waters, the profiling range of this device is nominally 600 m. Much farther ranges appear in deeper, cold waters. To span 1700 m water columns, a couple of Long Ranger ADCPs each watch part of the water column - looking upward from seabed and mid-water depths.

The ADCPs collect data for at least one year. One operator devised a cost-effective approach to meet the reporting schedule. They opted for real-time wireless communication of the ADCP data. Acoustic telemetry modems from Teledyne Benthos were selected. These modems are uniquely addressable, which simplified communicating with two ADCPs. From each ADCP, one averaged velocity profile was sent every 20 minutes. This message comprised about 1200 bytes of data.

Two moorings were deployed. One on the seabed held batteries for two years of operation. The mid-water mooring held the ADCP in a syntactic foam float. It held batteries for one year's work.

Wave Monitoring

Using a bottom-mounted ADCP for measuring waves, rather than a surface buoy, can have key advantages. These were appreciated by The Australian Institute of Marine Science (AIMS) when they installed a Wave Monitoring System at the entrance to Darwin Harbour.

Mounted on the bed, the equipment was safe from damage due to collisions by shipping. Also AIMS avoided frequent maintenance trips to remove fouling by tropical birds. Both had been problems while using wave buoys.

The system comprised a 600 kHz Teledyne RDI ADCP equipped with NEMO waves for in-situ processing. The ADCP profiled currents and processed directional wave spectra simultaneously. To enable real time viewing of the data, AIMS sent data through water via a Teledyne Benthos ATM916 acoustic modem.

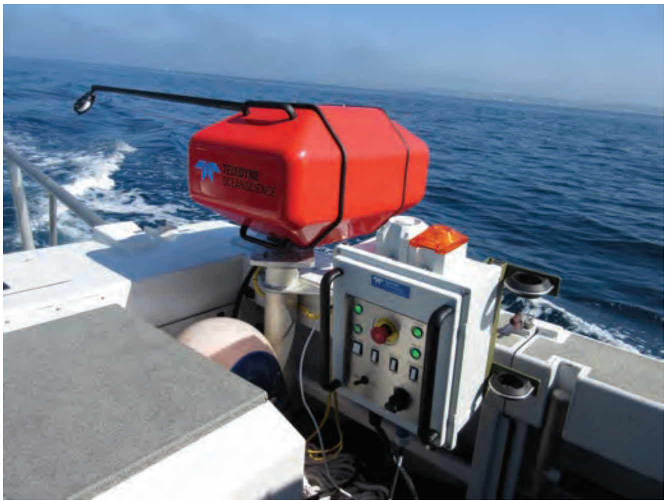

Fig.6. Teledyne Oceanscience rapid CAST underway SV probe allows for underway sound velocity measurements

These data assist the Darwin Port Corporation in navigating of Panamax and LNG bulk carriers as well as other vessels. Similarly, access to the general public aids recreational boating and trip planning. Future uses will include accurate modeling and prediction of under keel clearance.

Water Properties

Key indicators of ocean conditions are temperature, salinity, density and speed of sound. They come from in-situ measurements of electrical conductivity, temperature, and depth (CTD). Uses for these data span traditional hydrographic to environmental and fisheries.

Teledyne RD Instruments and Teledyne Oceanscience supply CTD products. Often CTDs descend in rosettes lowered from stationary ships; others ride in moving vehicles. An interesting hybrid is Oceanscience's rapid CAST Underway CTD profiling system. It allows the CTD to descend while the vessel is moving thereby reducing project time. One survey of New Zealand's Fjordland made more than 400 CTD casts using the underway method. The operator saved 7 working days.

Fixed Ocean Platforms

For much of two decades, ocean engineers struggled to design reliable deep-sea moorings. A key innovation was the means to spread buoyancy thru the length of the mooring line. In many modern designs, glass flotation spheres from Teledyne Benthos serve that purpose. They provide positive buoyancy to keep tension on lines as long as 6000 m. Then, after the mooring releases, these glass floats bring instruments back to the surface. Installed in a plastic casing, each float consists of two glass hemispheres held together with a vacuum.

Another important design element is the acoustic release that initiates mooring recovery. Benthos offers a selection of these releases that not only address deep and shallow water needs but various acoustic options.

In shallower depths, the measurement range of an ADCP can cover the water column. Moorings are not needed. In this case, a well-designed seabed frame is key to making and recovering high-quality data.Bottom-mounted frames from Teledyne Oceanscience carry ADCPs, transponders, cameras, and CTDs. Some frames also come equipped with a pop-up buoy to simplify retrieval.

For working on uneven bottom terrain, frames that hold a gimbal-mounting are sometimes required. And in places where fishermen drag a trawl net, prudent operators prefer a snag-resistant design.

Connections and Data/Power Transmission

Oceanographic equipment needs robust and reliable connections. Several Teledyne Marine companies supply these needs. Among them are ODI, DGO, Impulse, and Storm Cable.

Teledyne ODI supplies electrical and fiber optic interconnect systems that withstand full ocean pressure. Their wet-mateable connectors service both data signaling and high-power needs. Variants include electrical, fiber optic, and underwater Ethernet connectors. As well there are hybrid products and companion dry-mate styles. These rugged components work in deep and harsh environments and can be mated wet, at pressure to allow for modular construction, expansion and upgrade opportunities.

Teledyne DGO designs specialized connection systems for challenging media where high differential pressure solutions are required. These include subsea oil wells and submarine hulls. DGO supplied hull penetrators and feedthrough systems for deep-sea submersibles like Alvin and Nautile.

Teledyne Impulse products span miniature sizes to ROV requirements and even larger. The company has created many innovative solutions for subsea interconnect.

Teledyne Storm Cable is a vertically integrated manufacturer of cable and cable assemblies. Many components, materials and capabilities are combined to create application specific cable construction products and assemblies for harsh environments.

Additional Resources

Teledyne Technologies Inc. has some additional resources for complex aspects of marine applications. Teledyne Scientific provides advanced research and development expertise for applications in extreme environments. A Subsea materials database is being established to qualify a number of materials systems for long operational life performance in the deep ocean. To date over 200 materials systems have been qualified through over 30,000 individual tests.

The Teledyne Oil & Gas Technology Development Center works on longevity challenges for offshore and marine technologies to develop new bespoke technology solutions to resolve complex subsea application challenges. Teledyne Engineered Solutions deliver integrated system solutions for large defense and commercial programs.

Fig.7. Teledyne Benthos's acoustic releases await deployment together with deep-sea glass spheres encased in yellow hard hats

Looking Ahead

The companies of Teledyne Marine are hard at work to provide a new customer experience. Each can tap into Teledyne-wide resources. Thus, they can supply new tools and expertise to help customers resolve complex challenges. Further, management foresees a coordinated approach to systems reliability. Test plans and results will show how an assemblage of Teledyne products operate as a system.

Customers will have a streamlined and simplified experience compared to working with multiple vendors. There will be a single focus for point of origin, terms and conditions, and warranty and the opportunity to manage a single purchase order across multiple product brands. As another benefit, Teledyne Marine anticipates clients will see fewer compatibility issues. Operating as experts in their core technologies, the individual field sales/business development teams and the technical field teams are being trained to recognize applications where the expanded Teledyne Marine solutions set can add value to our customers for bundled and integrated solutions. These field teams can bring in subject matter experts as needed and will act as true consultative technical sales resources.

In short, Teledyne Marine expects customers will see advantages in not only less time and cost of doing business but reduced risk - technical and performance.

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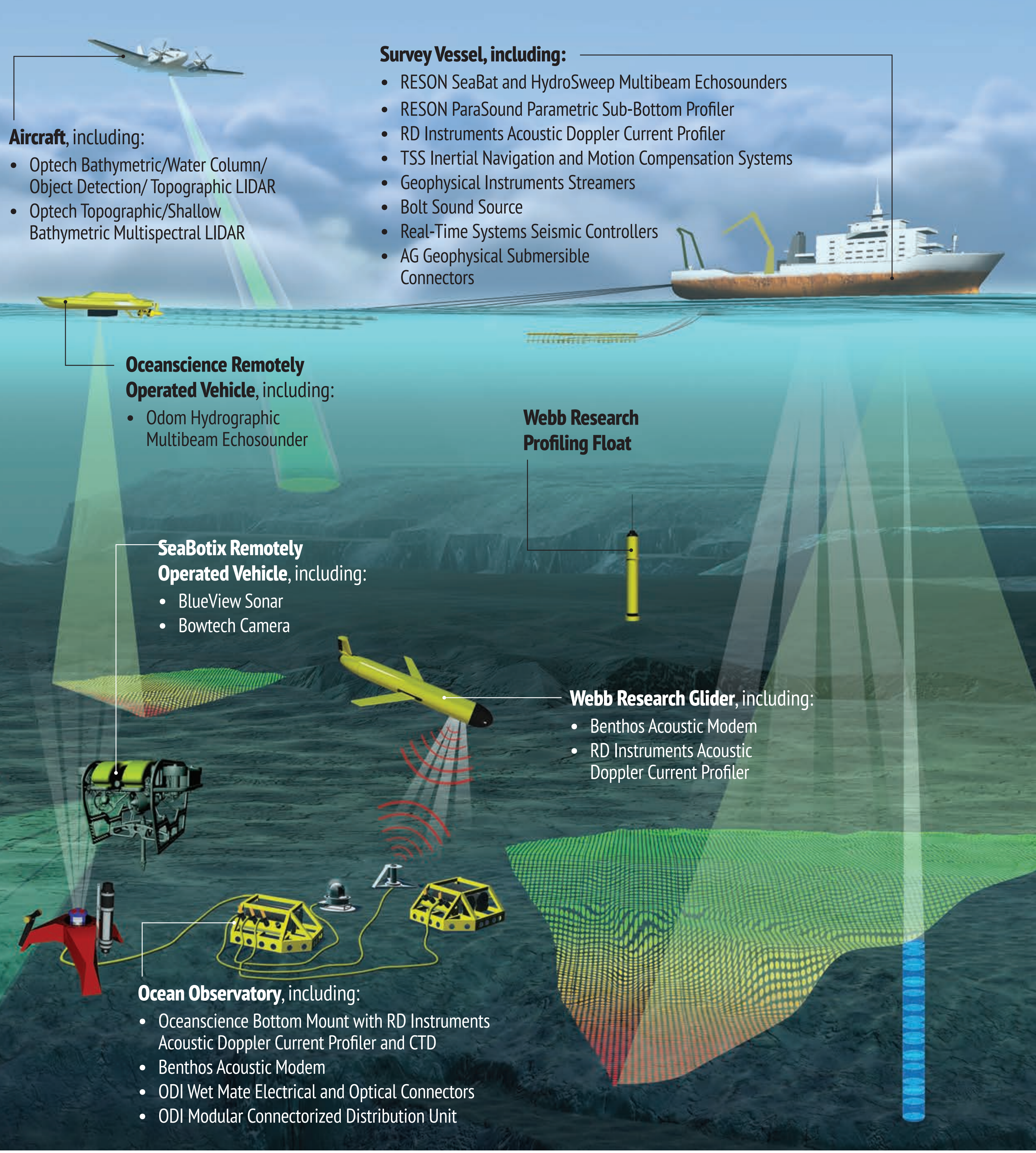

TELEDYNE MARINE

Everywhereyoulook™

BAS monitoring waters under largest ice shelf in Antarctica

By: Margaret McKerron

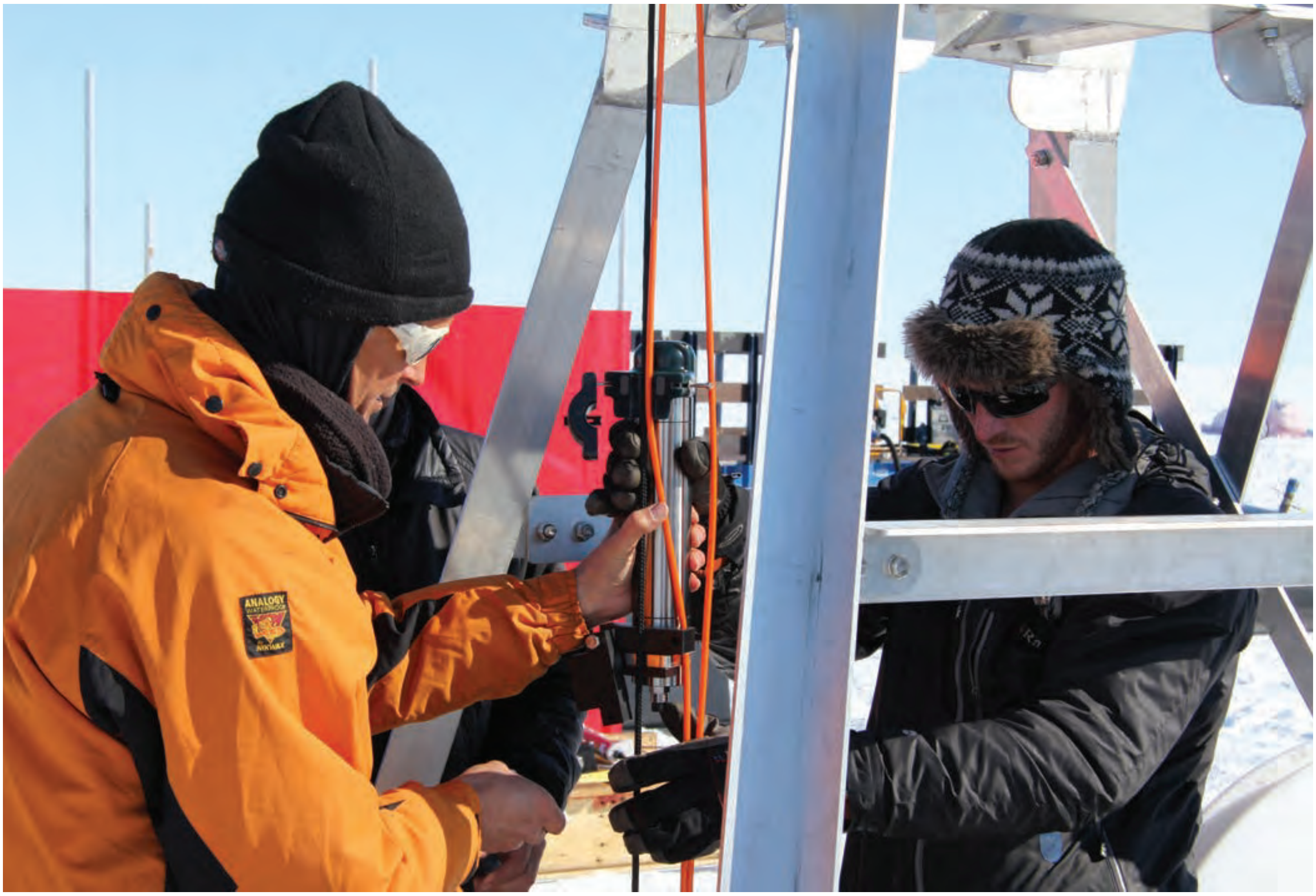

Photo credit: Keith Makinson

Keith Nicholls and Phil Stevens lower an RBRduo C.T used to monitor salinity levels below the Filchner-Ronne Ice Shelf in Antarctica.

It was 1914 when the famed British explorer Sir Ernest Shackleton advertised for crew to attempt the first trans-continental crossing of Antarctica. “Small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful,” he wrote.

A hundred years later, some things haven’t changed—and many things have. In spite of its bitter cold and long months of darkness, Antarctica still possesses a certain intrigue for scientists around the world. It still pushes personal limits and technological boundaries. As it has become a focal point for global climate change discussions, one thing that has changed is the growing interest in exploring and understanding what is happening in the frigid waters below the surface of its great ice shelves.

Oceanographer and drilling engineer Dr. Keith Makinson was one of a seven-member crew from the British Antarctic Survey (BAS) and University of Bergen (Norway) who travelled to the Filchner-Ronne Ice Shelf in Antarctica in 2014. Their crew was responsible for drilling through over three-quarters of a kilometer of ice to access the ocean and deploy a suite of instruments designed for long-term monitoring.

“By ice volume, the Filchner-Ronne Ice Shelf is the largest ice shelf in Antarctica,” Makinson said. Covering an area of

450,000 km2, it is nearly the size of France floating on the ocean. For the scientific community, it is an important indicator for the health of Antarctica and oceans around the world.

The Filchner-Ronne Ice Shelf

From where icebergs break off to the southern grounding lines, the ice thickness ranges from 300m to 2,000m. "Any waters flowing underneath the ice shelf are cooled and freshened by the meltwater," Makinson said. Tidal and buoyant forcing drives circulation, while the ice shelf melts at a rate of about 4,000 tonnes per second.

"[These water masses] outflow as very cold, dense water that makes its way across to the continental shelf break, then dives down into the deep ocean of the Weddell Sea – and ultimately becomes Antarctic Bottom Water, which is a water mass that is one of the most extensive in the world." This cold, dense water mass is found in the deepest parts of many of the world's oceans – even north of the equator.

To monitor water masses flowing underneath the ice shelf, the team revisited a site previously drilled in 1998-9, called Site 5. "This site is of key interest because many of the water masses that enter at the ice front are funnelled by this site," Makinson shared. Setting up a monitoring station allows BAS and Norwegian colleagues to monitor how these different water masses evolve from season to season and sense longer-period signals.

Antarctic research is not an easy undertaking. "Things have become a little more routine over the years, but it's still quite a major effort for us from the planning stage to the final execution and the deployment of instruments."

Usually the team plans at least two years in advance of deployment, with drilling equipment and fuel shipped to Antarctica at least a year before the team's arrival. Flying the team from Rothera Research Station to Site 5 (1500km away), transporting equipment, and drilling fuel requires a staggering amount of fuel. But it's only one of many complications involved in the remote, frigid conditions.

Equipment failure and frozen pipes are another concern. Work needs to be done quickly, because the access hole drilled to the ocean refreezes at a rate of approximately half a centimetre to two centimeters per hour. "There's always the constant worry that instruments might freeze to the side wall, losing both the equipment and use of the hole," Makinson said.

Hot water drilling

To drill the access hole to the ocean, BAS used a specially-designed hot water drill that melts the ice. The drill pumps water through a series of heaters at a rate of 110 litres per minute. These heaters raise the temperature of the water up to a blistering 88ºC. To create the 30cm diameter ocean access hole, the hot water is pumped down a hose to the drilling nozzle. At about 85m below the surface, the team creates a cavity so that water can be pumped back to the surface, reheated and recirculated through the drill, enabling drilling to continue through the ice shelf.

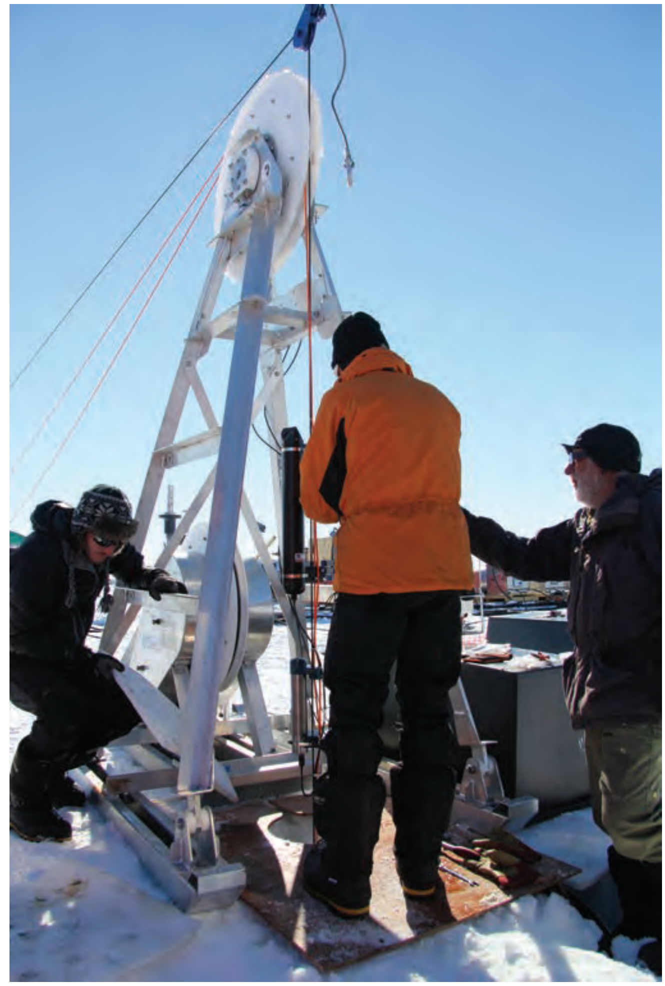

Photo credit: Keith Makinson

The ice melts at a rate of about 4,000 tonnes per second.

At Site 5, the ice shelf was about 770m thick – a depth greater than the height of the CN Tower (Toronto, 553m) and just less than the height of Burj Khalifa (Dubai, 828m), the tallest freestanding building in the world. With a drilling rate of 1.2 to 1.6m/min, it took about ten hours to reach the ocean.

A special drill brush 1m in diameter is used to enlarge the hole at the baseof the ice shelf to prevent snagging of equipment on recovery into the hole. "We'd get started at 8 o'clock in the morning," Makinson recalled. "Hopefully, the drilling would be finished about twelve hours later with hole through to the ocean, and then we'd spend the night doing CTD profiles, collecting sediment cores, and some water samples."

"Happiness is probably at the point at which you have the ocean mooring in the water and you've got that first communication back to say, 'Yes, I'm working. I'm sending you data,'" Makinson said.

"Prior to that, it's actually knowing that you have made the connection to the ocean – collecting that first CTD data, looking at that first profile coming in, because you know that's data you've now got. At the end of the day, no-one can take that data away from you. Even if the instrument does not come


Photo credit: Svein Østerhus

Keith Nicholls attaching the thermistor cable to the main mooring cables.

back for some reason, you've got that data."

Below the surface

In the morning, BAS lowered oceanographic instruments into the water below the ice surface to measure parameters including temperature, conductivity, depth, water speed and direction, and dissolved oxygen. At Site 5b, one of the three sites drilled, they installed a custom-made RBR thermistor string.

One engineer at RBR recalled the order. "It was the longest thermistor string we'd ever made – 400m long," he said. The thermistor string had 24 temperature-measuring nodes, each calibrated to an accuracy of ±0.005°C. Makinson said, "By having the thermistor cable in particular, you've got a high density of measurements through the water column. They're very good at telling you what proportion of water masses you have."

In Site 5a and Site 5c, BAS researchers deployed equipment that will help scientists better understand how water masses flow below the ice shelf—and how much the ice shelf is melting. To measure how water moves at different depths through the water column, the researchers deployed four Nortek Aquadopps.

Several different kinds of instruments were used to obtain measurements of salinity below the ice surface, a measurement derived from conductivity (C) and temperature (T) and sometimes plotted against depth (D). These instruments included four high-accuracy RBR*duo* C.Ts and one RBR*concerto* C.T.D. Each instrument along the "mooring line" was installed with an RBR subsurface modem (SSM) that enables data to be communicated from the ocean back to the surface.

In a conventional Mooring Line Modem (MLM) deployment, a head end modem (HEM) is mounted on a buoy to transmit data from instruments below the water's surface. A special, jacketed steel mooring line anchors the buoy and instruments are mounted on it at desired depths. Magnetic coupling between the SSM and the mooring line at each node allows information to be transmitted via the mooring line to the HEM. To complete the electrical circuit, the plastic jacket is stripped at the ends of the cable and the surrounding water finishes the circuit.

When it comes to researching in Antarctica, though, things are seldom conventional. Because the ice freezes up around the mooring line, the MLM system was customized so that that it did not rely on water to complete the electric circuit. RBR engineers also had to ensure the HEM could withstand the surface air temperatures of Antarctica.

"What temperature does that have to work in?" an RBR engineer remembered asking. The reply? "Well, it's going to be in a box that warms up to -40° C."

A decade of data

With the ice refrozen around the mooring line, the instruments at Site 5 will never be recovered. For engineers, this presents another unusual case: how to maximize the value out of instruments that will never be redeployed. BAS' objective was to create a monitoring station to be operational for ten years.

"From past experiences, as long as you have the battery power, then it normally works pretty well. The particular battery chemistry of the lithiums that we use has served us well in the past. Because the instruments draw such low current, then [the operational lifespan of the instruments] is almost as long as the battery life," Makinson explained.

So far, the data has been coming through just fine. Makinson is hopeful that the deployment at Site 5 will become one of a small network of operational moorings beneath the Filchner Ice Shelf, so that researchers can get a broader picture of what's happening below the ice surface.

To the east, BAS currently has another project funded by the Natural Environment Research Council, which focuses on ice streams flowing into the Filchner Ice Shelf. This season, they were also collaborating with the Alfred Wegener Institute (Germany), successfully drilling another four holes to the south. Next season, there are more plans to drill to the north with teams from Germany and Norway. These future deployments won't necessarily last ten years, but hopefully they will provide enough data to understand more about waters below the Filchner Ice Shelf.


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Photo credit: Svein Østerhus

The suite of instruments during final field testing before being deployed beneath the Filchner-Ronne Ice Shelf.

The project outlined above was supported by the Natural Environment Research Council and the University of Bergen.

RBR creates instruments to measure the blue planet. From the ocean abyss to the polar ice cap, our sensors track water parameters – temperature, depth, salinity, dissolved gases, pH, and many others. With design and manufacturing centrally located in Ottawa, our team works in a fast-paced, dynamic atmosphere to serve customers from all corners of the globe.

Antarctica:
The approximate location of Site 5 is indicated by theorange circle. Future sites are planned to the South-East and North on Filchner Ice Shelf.

