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March 2018

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Volume 61 Number 2

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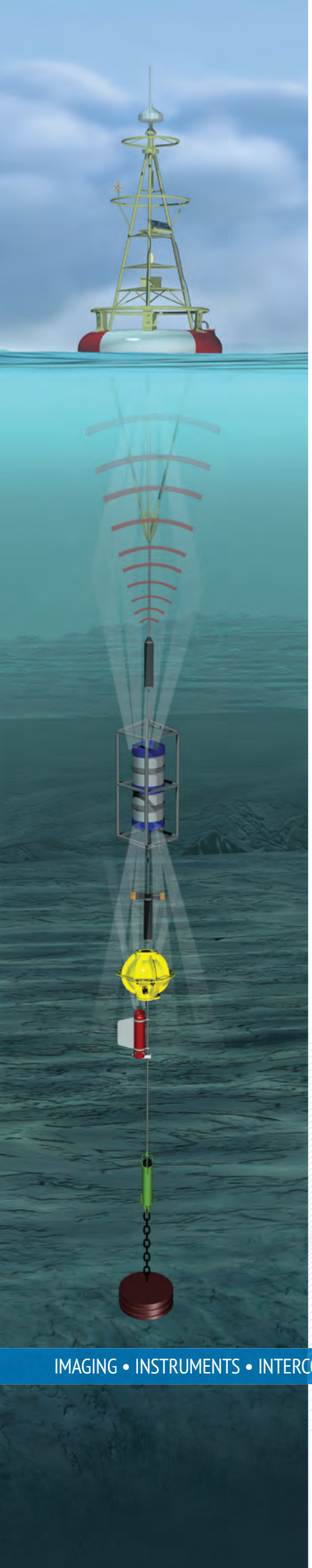

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March 2018
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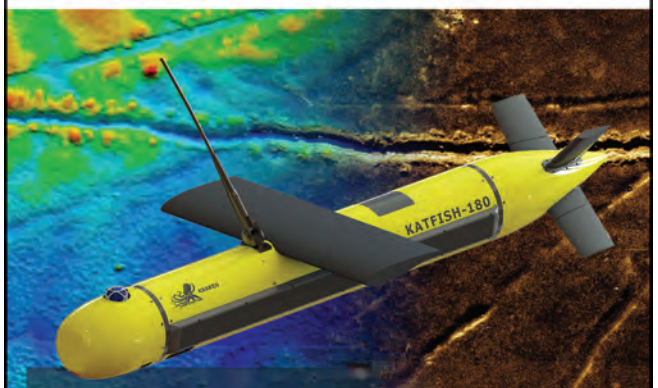

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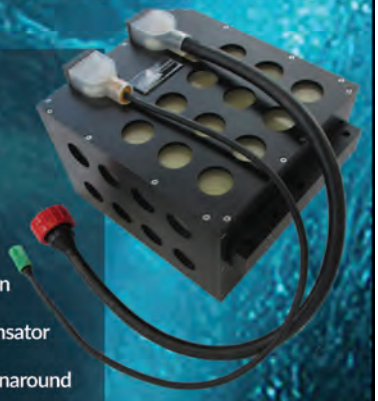

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Credit: University of Washington, NSF-001/ROPOS VISIONS '15 expedition

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Editorial

Gregory R. Trauthwein
Associate Publisher & Editor
Email: trauthwein@marinelink.com

Steaming toward another Oceanology International in London, I am seeing a palpable sense of recovery in many sector of the subsea industry. While the future of oil and gas production in the offshore sector remains a question mark, oil majors have seemingly come to grips with the 'new norm' in oil pricing, which at press time was hovering around $60 per barrel. When the price was double more than four years ago, money was seemingly no object, and the projects and requisite budgets were only described as big and bigger. Today the oil companies are focused on smaller expenditure, shorter term projects, and interestingly are more focused than ever on utilizing technology to keep long-term costs in check. So the ability to gather, decipher, disseminate and efficiently use information emanating from the oceans is at a premium, a trend that bodes well for anyone reading these pages.

Acceleration of programs on the defense side of the business are another matter. It was about five years ago when I attended a dinner at the home of then U.S. Navy CNO Gary Roughead, a dinner and discussion on unmanned underwater systems that included the heads of nearly every subsea robotics company. It was at that dinner that the CNO clearly stressed the Navy's need for these technology leaders to step up the effort, effectively allowing the Navy to leverage robotics and autonomy in the subsea space as it was being leveraged in the air and on the land.

Fast track five years and the plan is clearly coming to fruition. Earlier this year in Washington, DC I attended the Surface Navy Association's annual conference and exhibition, and much to my surprise, despite the word "SURFACE" in the name, there was a large contingency of subsea technology companies exhibiting the latest subsea vehicles and systems to safely and efficiently help the U.S. Navy extend its reach and accomplish its missions. Combined with the current administration's plans to invest in defense systems, the long-term prognosis for defense is decidedly positive.

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Haun

Coley

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People & Companies

Photo courtesy of Martin Klein

Obituary

Edward P. Curley Jr.

Edward P. Curley, Jr, 79, died on February 3, 2018 after a long illness. Born in 1938 to Edward Sr. and Theresa (Savio) Curley, after graduating from Yale in 1960, Ed worked at Clevite Transistor in what was the beginning of the semiconductor age. As a talented engineer he moved onto EG&G where he was an apprentice under **Harold Doc Edgerton** (the inventor of the strobe light and innovator of modern sonar technology). It was during this period that Ed and Wendy married and moved to a small house in Hamilton. Ed left EG&G to start EPC Labs, which he built into a successful international business, selling advanced sonar plotters.

Ed is survived by his three sons, **Michael Curley** and his fiance, Maureen Kieran, **Ted Curley** and his wife, Carrie, **John Curley** and his wife, Sheri and seven grandchildren, Daniel, Samantha, Madison, Erin, Aidan, Jack and Mike. He also leaves behind beloved in-laws, cousins and nieces in the Shaw and Harris families.

This was edited from Edward P. Curley Jr.'s obituary published in The Hamilton Chronicle

Interventek

Bruce Stuart

Interventek Appoints Stuart

Interventek Subsea Engineering appointed Bruce Stuart to the role of Sales and Business Development Director. Stuart brings more than 30 years of commercial leadership experience and operational knowledge of the oil and gas industry. Bruce joins Interventek from Proserv where he was VP Business Development Subsea, having previously held a seven year tenure at FMC Technologies, responsible for UK and Canada sales and marketing for their subsea products and systems.

Ocean Infinity Buys 9th HUGIN

Ocean Infinity, the U.S. company currently searching for missing Malaysian Airlines flight MH370, said it has grown its fleet of 6,000 meter rated Kongsberg HUGIN autonomous underwater vehicles (AUV). The latest purchased HUGIN vehicle, Ocean Infinity's ninth, will be specifically configured to conduct under-ice surveys and features Kongsberg's Highly Integrated Synthetic Aperture Sonar (HISAS).

Other sensors include a Kongsberg EM2040 multibeam echosounder installed in an upward facing modular payload section for surveying the underside of the ice, as well as an up-

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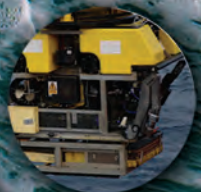

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People & Companies

Ocean Infinity

Ocean Infinity buys its ninth HUGIN AUV

MacArtney

Pile Dwellings

ward looking Doppler Velocity Log (DVL) installed in the same section to aid under-ice navigation.

EIVA Expands in Brazil

EIVA expands its activities in Latin America with a dedicated business development team located in São Paulo, Brazil. The new Brazilian team will be headed by Antonio Felipe Silva, who brings with him 13 years of experience in the offshore industry.

He started his career as an remotely operated vehicle (ROV) support technician and quickly moved on to more sales- and management-focused positions, which also included collaboration with EIVA in more recent years.

Ocean Microstructure Glider Workshop Announced

Rockland Scientific and the Bermuda Institute of Ocean Sciences announced a specialized training program for Rockland turbulence measurement systems that are integrated with ocean gliders. Ocean Microstructure Glider (OMG) 2018 will be hosted by the Mid-Atlantic Glider Initiative & Collaboration (MAGIC) at the Bermuda Institute of Ocean Sciences St. Georges, Bermuda from May 28 to June 1.

Contact **Jeremy@rocklandscientific.com** for more information and to register.

University of Vienna Acquires New Multibeam Equipment

A project to create 3D models of pile dwellings in Austrian lakes thousands of years ago has resulted in the acquisition by the University of Vienna of an innovative multibeam solution supplied by MacArtney.

The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology is a research institute dedicated to the development of new techniques and methodological concepts for landscape archaeology. Its research program combines geophysics, aerial imaging, computer science and geomatics to develop efficient and universally applicable approaches for non-destructive detection, documentation, visualization, analysis and interpretation of archaeological landscapes.

Prior to placing the order for multibeam equipment, scientists of the Institute were attending a demonstration introducing them to the products in question and to their properties and features.

The presenters were hydrographers from MacArtney's German subsidiary who actually did the installations and preparations for the equipment.

The overall purpose of the multibeam solution is to create 3D model areas of former – now completely sub-merged – pile dwellings in Austrian lakes in order to document how some of our ancestors lived 5,000 years ago.

The scope of supply features a Teledyne SeaBat T50-P multibeam sonar, data acquisition software QPS QINSy, data processing software (BeamworX AutoClean/AutoPatch and QPS Fledermaus), training, and installation. Also supplied was the GNSS System Septentrio AsteRx-U UHF in combination with an ALTUS NR2 base station and the INS Sensor SBG Apogee-E to get a high precise position.

To guarantee a reliable and accurate speed of sound measurement, MacArtney said it chose the Valeport products SWIFT and UltraSV.

Deep Sea Mooring Wins Quadrant Contract

Deep Sea Mooring (DSM), a Vryhof company, secured a contract with Quadrant Energy to provide turnkey pre-lay mooring solutions to the Transocean GSF Development Driller 1 semisubmersible drilling rig offshore Australia. The deal – a continuation of previous work for Quadrant Energy – begins in March 2018.

The GSF Development Driller 1 rig was built in 2005 and is a sixth generation semi-submersible with a maximum water depth of 7,500 feet and drilling depth of 37,500 feet.

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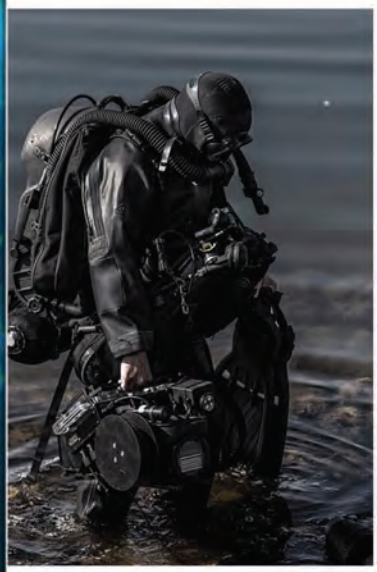

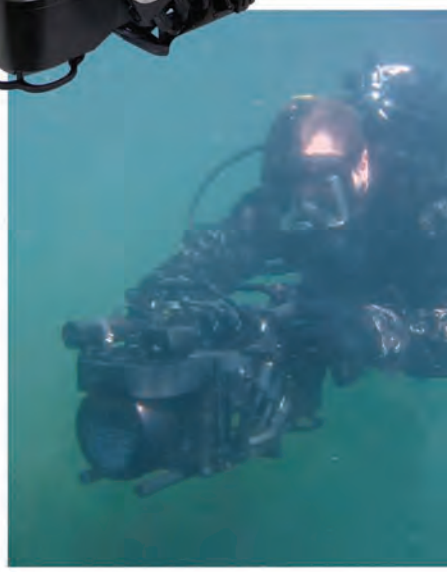

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Submarine Power Cables Protection: Requirements for a Sustainable Project

By Ralitsa Peycheva

Submarine power cables are largely deployed in various offshore renewable energy sources such as wind, wave and tidal installations to transfer power to shore, but also in oil and gas platforms and ocean science observatories. They ensure the power supply to remote areas and by connecting regional electrical transmissions enable global energy trading.

The growing importance of the marine renewable energy sector and the word's focus on environmental issues have made submarine power cables an infrastructure of critical importance. Most efficient and reliable installation and protection methods are the main concern of engineers and manufacturers.

Basic Characteristics

There are two basic types of submarine power cables: the HVAC (high voltage, alternating current), limited by transmission distance to less than 80 km but much more cost efficient than the HDVC (high voltage, direct current) for longer distances and for interconnections. The alternating current is transmitted down each of three conductors while the direct current down a primary conductor and requires another conductor or an anode/cathode for the return path. The choice of the cable depends on the route length, voltage, transmission capacity and grid characteristics.

Submarine power cables can reach up to 1,500 mm in diameter depending on current-carrying capacity and amount of armor protection and up to 140 kg/m depending upon type. The amount of armor depends on manufacturer and seabed conditions. The stronger the waves and the currents, the more armor is needed.

Protecting Submarine Power Cables

The most important reason for protecting submarine power cables is obviously the fact that submarine power cables supply energy to remote areas or ensure reliable telecommunications. Having them damaged has a direct impact on people's lives.

Furthermore, installation, maintenance and repair of submarine power cables is costly. Damages during installation can manifest themselves immediately or even years later. Once installed, cables are at risk of damage by fishing trawlers and ship's anchors. It is crucial that the cable laying route is carefully surveyed and selected for minimized environmental impact and maximized cable protection. Undersea cables are subject to damage when not properly installed and not properly protected.

The repair of a damaged submarine power cable is a laborious and expensive process and may last from weeks to many months, depending on damage level, location of the fault and the availability of the ship. During this time the supply of essential services over a wide area will be interrupted. Cable joining experts are bringing the damaged cable to the surface and are adding a piece of stock cable into the original cable to connect both ends.

Submarine power cables require as well regular maintenance in order to prevent deterioration. This is a costly and challenging activity performed by specialized vessels and it depends heavily on the weather and sea conditions. However, if a cable is proven reliably protected, maintenance can be scheduled differently and interventions minimized.

Conventional Techniques for Protection

Most of the submarine power cables today are laid in shallow waters less than 500m depth and are usually buried. For cables in sand areas deeper trenches should be considered. Cable burial delivers reliable protection but it remains a complex technique that may locally disrupt the seabed and form turbid water.

In areas where burial is not possible, the decision for the most appropriate technique is taken based on the surface, installation possibilities and the length and the primary functionality of the cable. Other common practices include

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concrete mattresses, rock trenching and articulated pipes. However, all existing conventional methods show some disadvantages at certain point, usually in terms of corrosion, cost-efficiency, bending radius, design or fatigue of the electrical conductors.

Aware of the criticality and the importance of this matter, marine renewable energy professionals welcome any new decision that can improve the current situation and deliver reliable submarine cable protection.

An Innovative Solution

A European leader in the manufacture of cast iron counterweights for a wide range of industries, the French foundry FMGC, the casting subsidiary of Farinia Group, decided to diversify its offering and apply its expertise in innovative ballast solutions to the Marine Renewable Energy Sector. The idea for the cast iron protecting and ballasting shells was born out of the need of the sector to deploy a solution with:

- high level of reliability
- good abrasion and corrosion resistance
- minimized environmental impact
- resistance to withstand laying and embedment stresses

In 2014, FMGC has launched an R&D project in partnership with Innosea and Gem to answer the specific expectations of the Marine Renewable Energy industry. The aim of the project was to develop a full range of articulated cast iron shells that protect, ballast and stabilize subsea conducts (cables, pipes, etc) and semiautomatic installation equipment.

The primary goal of the protecting and ballasting shells is to significantly reduce the cost of the electrical connection for MRE solutions and through it, to reduce the cost of the kWh.

After several months, the IBOCS consortium designed, manufactured and tested its first shells in February 2015. 40 m of cast iron shells (réf : IBS-70-88) around a 69 mm in diameter electrical cable have been installed near Ushant in the Fromveur, one of the most powerful stream of Europe. Subject to the specific site conditions and the very bad weather (strong storms and tides) the cast iron shells have fully ensured the stability and protection of the electrical cable.

FMGC have then supplied 200m of shells to protect the cable of the tidal turbine Sabella D10, which have been successfully installed in June 2015.

Since then, the company has supplied many shells to different MRE keyplayers and energy companies. The solution

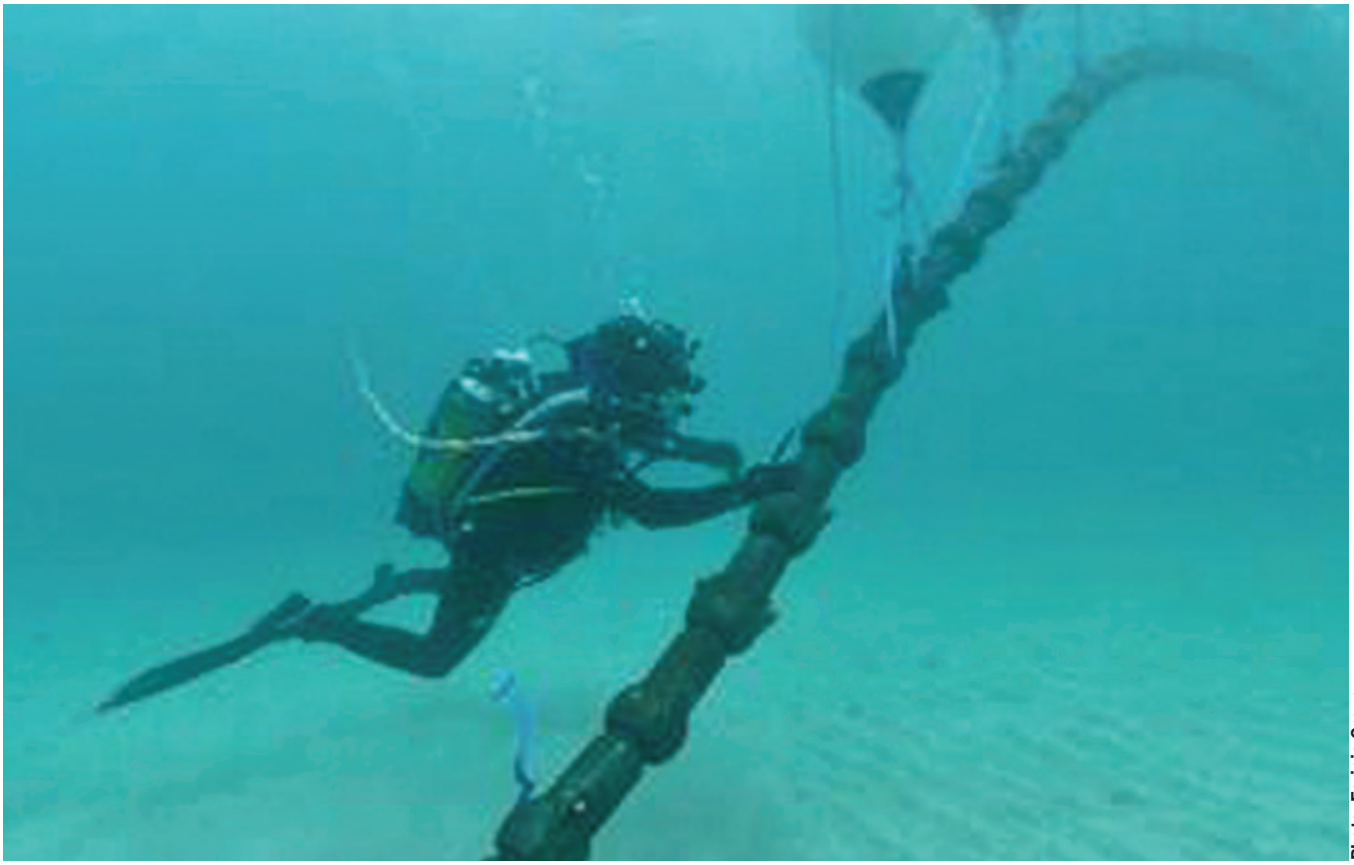


Photo: Farinia Group

can be customized according to the project and the customer's design requirements.

Why Cast Iron?

Cast Iron has numerous proven advantages for diverse MRE solutions. It is denser than concrete and cast iron corrosion (around 0.25 millimeter per year) is harmless for marine environment due to the low quantities of waste leached. Cast iron is a recyclable material and enables the customized manufacturing of complex parts with high resistance and good machinability.

The Advantages of the Protecting and Ballasting Shells at a Glance:

- Sufficient weight to stabilize the cables
- A hydrodynamic design
- An increase of the bend radius to match that of the cable and the undersea relief
- A transfer of tensile forces during the installation of the cable
- Sufficient mass for the entire duration of the immersion period (20 years minimum)
- A simple, robust and economical design

During installation the cast iron shells:

- Provide extra support for handling or semi-automation to increase the speed of installation
- Minimize the difficulty level of handling
- Improve workplace safety
- Decrease installation costs

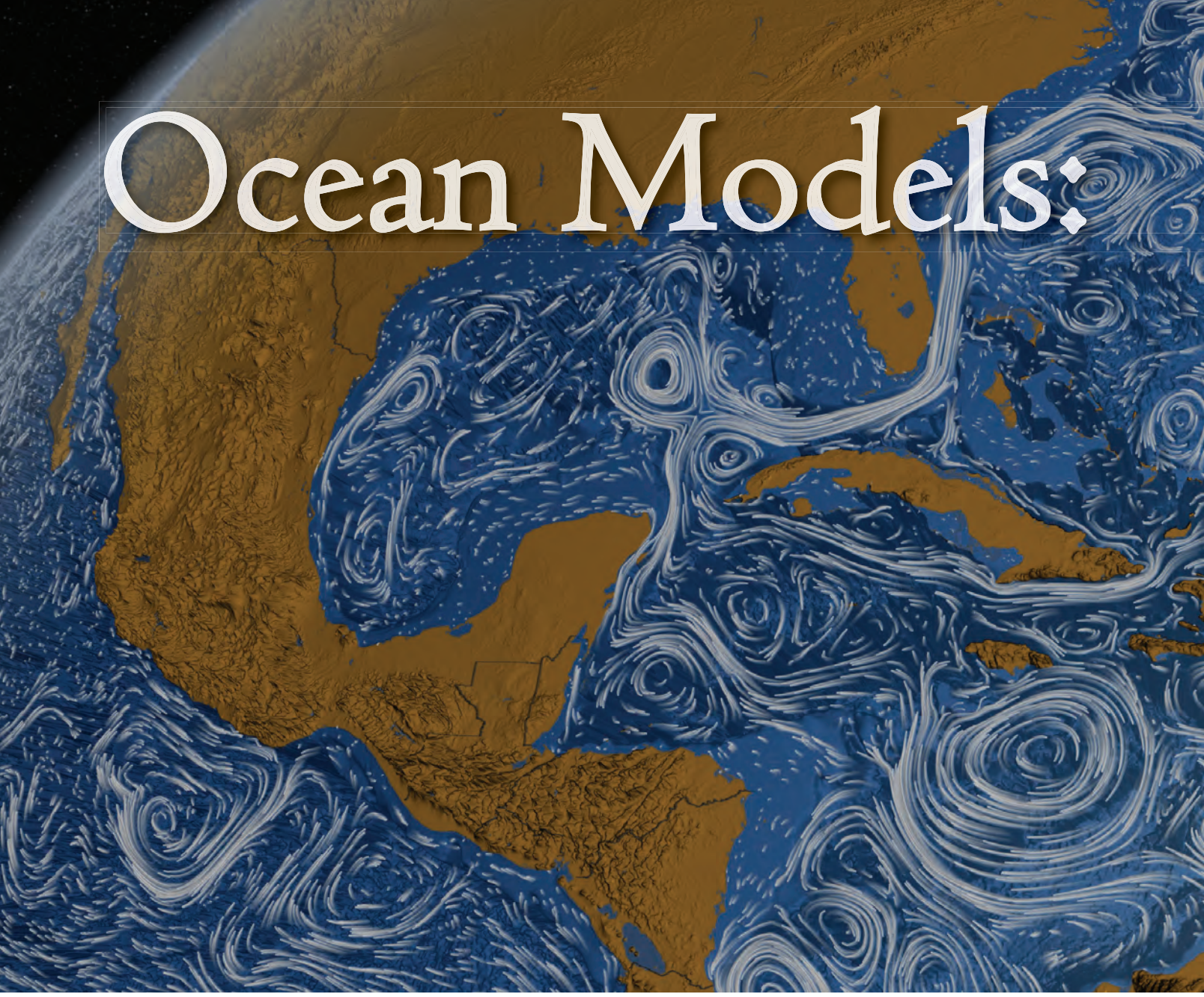
The continuously growing importance of the MRE sector but also the word's need for reliable telecommunications has made submarine power cables infrastructure elements of critical importance. Moreover, climate change may affect marine activities as fishing and expose cables to more natural hazards.

Submarine power cables require a solid investment to be built, installed, maintained, if necessary repaired and are expected to ensure on the long term the transfer of electricity. Better the protection of the cables, less the unexpected cost for repair. To adapt to the high and constantly changing expectations of the sector and to the challenging terrain conditions manufacturers must provide innovative and reliable solutions. Submarine power cables should withstand harsh conditions and environments with limited possibilities of intervention in case of a failure.

The protecting and ballasting shells provide most reliable and robust submarine power cable protection by resisting high impact, abrasion and corrosion. The product is very flexible can be tailored to different types of cables, different weight and different seabed conditions.

Photo: Farinia Group

Ocean Models:



During the 1970s, the first global ocean models emerged at research centers across the U.S. Back then, their construction was basic by modern standards, but like the models of today the researchers creating them aimed to simulate the world's oceans by coding the mathematical equations of fluid motion on a sphere. Those efforts made use of the most sophisticated computing power available at the time, but realistic simulations of the ocean were years away.

Today, things have moved along.

Ocean modelers are much closer to simulating accurate representations of the real ocean, and over the past few decades their models have become incredibly realistic, with applications ranging from weather and wave forecasting, to climate and palaeoclimate research, and not least, the search for missing aircraft.

At the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, Dr. Jonathan Durgadoo has been working with ocean models for almost 10 years. In that time he has witnessed a trend toward increasing realism in the models that he uses.

"By realistic we mean the ability for models to simulate processes in the ocean that are observed and known," he says. "As computers get faster, more oceanic processes that occur at different scales can be included. And as we understand more and more about ocean processes, we can begin to think of ways to include them in our models."

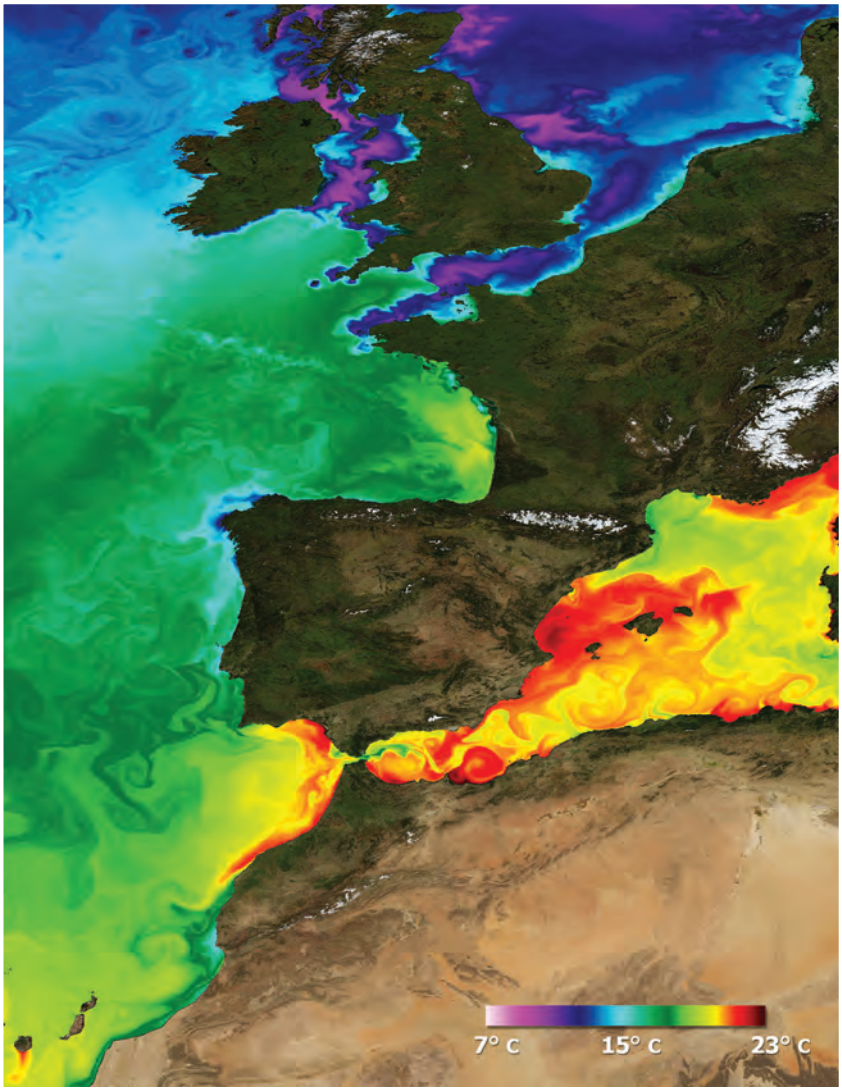
In particular, ocean models have become more realistic in recent years because of their ability to resolve eddies. Eddies are

The Evolution

By Conor Purcell

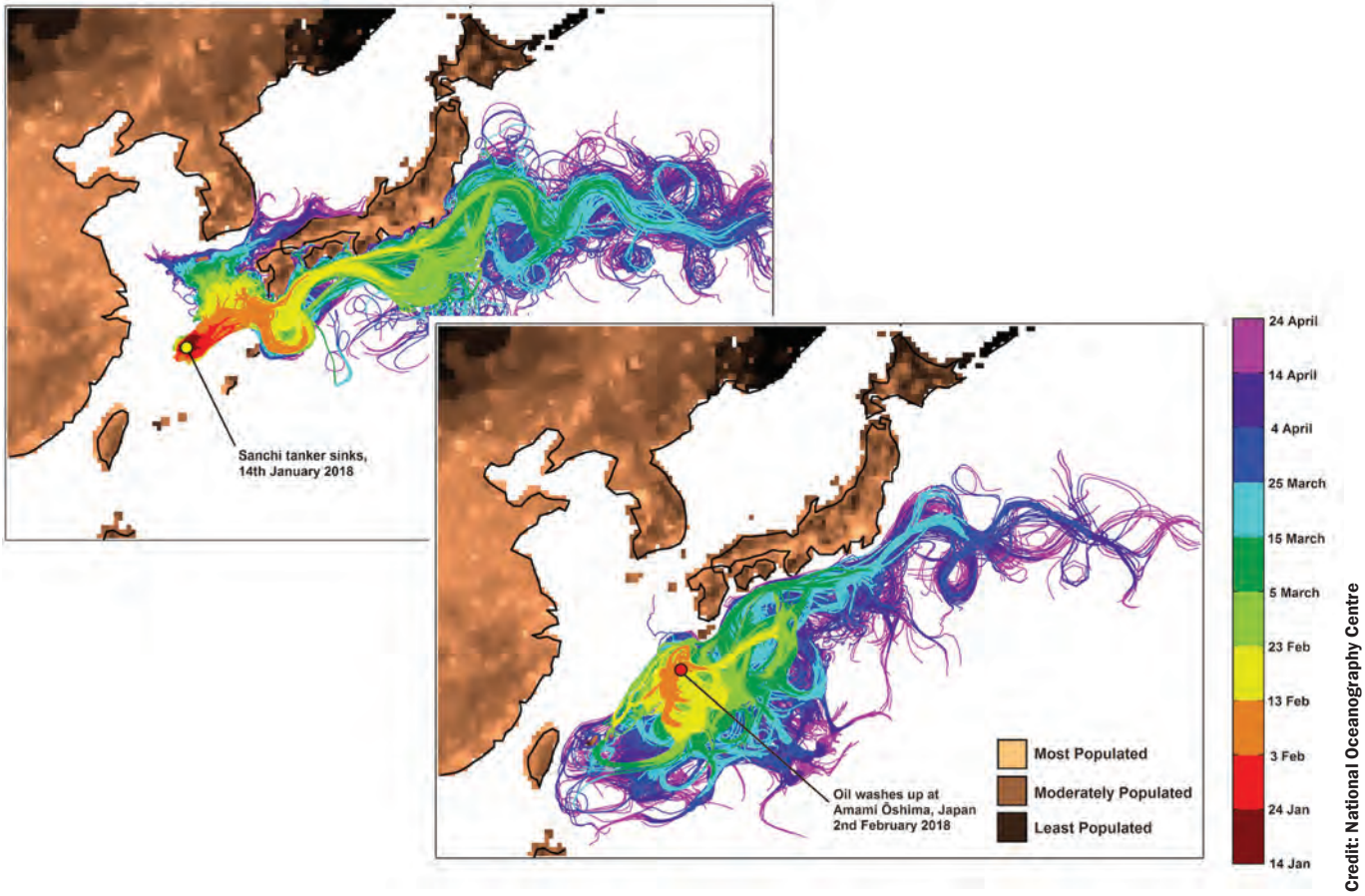
NASA/Goddard Space Flight Center Scientific Visualization Studio

Above:
Ocean surface currents around the world.



Credit: Mercator Océan

Right:
A snapshot of surface temperature modeled in the North Atlantic.



This shows the trajectories of virtual oil particles released from (a) the final resting site of the Sanchi (top-left; 14 January 2018 release) and (b) the vicinity of Amami-Oshima Island (bottom-right; 2 February 2018 release). For both panels, the colors indicate when particles are projected to reach particular areas, from deep red for mid-January, through to magenta for mid-April. For the initial release from the resting site of the Sanchi, particles were found to enter the Kuroshio Current, and to reach both the north and south coasts of Japan, including the Greater Tokyo Area. From this new release near Amami-Oshima, particles both travel along the south coast of Japan as before, but additionally are transported southwest around the Ryukyu Island chain towards Taiwan. The land mask colors indicate human habitation, with lighter colors marking areas with high population density.

mesoscale swirling features which are caused by turbulence in the ocean. Over the past decade or so, as computational power and data storage has increased exponentially, eddy resolving ocean models have become more widespread.

Durgadoo explains that in ocean modeling, size matters. "Oceanographers generally speak of scales in space and time," he says. "Spatially, processes in the ocean occur at scales ranging from millimeters to thousands of kilometers, and temporarily up to several centuries."

The word mesoscale refers to structures on the order of tens to hundreds of miles. These structures, which include eddies, play many different functions in the ocean. For example, eddies capture water masses at certain locations and transport them to another, and can also trap nutrient rich water which locally promotes biological activity. So, in order for ocean models to achieve realism at these scales, eddies and other structures need to be represented.

"This is not to say that models that do not simulate these structures are useless," adds Durgadoo. "One must understand and appreciate the usefulness of models within their limits."

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The problem with model resolution

Modeling the global ocean is inherently difficult. Throughout the history of ocean model development, from the earliest models using very basic computing products by modern standards, through to the modern state-of-the-art 'million-lines-of-code' behemoths, researchers have struggled to deal with issues of resolution i.e. the geographical scale at which a model runs - where the smaller your grid resolution is, the better your representation of the ocean.

According to Professor Sergey Danilov, who works on ocean model development at the Climate Dynamics Division of the Alfred Wegener Institute, Bremerhaven, Germany, the main challenge has always been to make the models reproduce the water mass characteristics and circulation that we observe in the real ocean.

"Motions at small spatial and temporal scales cannot be modeled and are therefore parameterized," he says. "This creates errors, which can accumulate over time. So, modelers try to reduce these by increasing resolution, improving the fidelity of parameterizations, or improving numerical algorithms."

This sentiment is echoed in former MIT oceanographer Carl Wunsch's book *Modern Observational Physical Oceanography*, where the author explains that no model has perfect resolution. This means that some processes are always omitted – an obstacle that nature does not face. "The user must determine whether the omission of those processes is important," writes Wunsch. "Even were it possible to perfectly numerically represent the assumed equations, errors always exist in computer codes."

The search for MH370

Nevertheless, scientists who specialize in ocean model development have made massive strides in their quest for perfection. When a flaperon (part of a plane wing) from missing Malaysian airlines flight MH370 turned up on La Réunion Island in the Indian Ocean in July 2015, Dr. Durgadoo and his colleagues had a brilliant idea. By using their state-of-the-art ocean model, they reasoned that it should be possible to help find out where the plane had crashed.

"The mere fact that debris belonging to MH370 had been found on beaches of the Indian Ocean suggested that they floated for months on the ocean surface," he says. "In theory, given the right information, trajectories could be simulated in the hope to locate the flaperon's possible start position, and hence shed some light on the location of the demised aircraft."

And that's exactly what they did. By using their model and back tracking the debris using a method called Lagrangian analysis, the researchers were able to estimate the location of the plane. Durgadoo described the process in a 2016 article. "The idea was that we could use an ocean model to track the flaperon back in time to establish the flight's crash location. But the ocean is a chaotic place; it makes no sense to simulate the path of a single 'virtual flaperon' backward in time. Therefore a 'strength in numbers' strategy is what we used when we placed close to five million virtual model flaperons around La Réunion Island during the model month of July 2015."

And their results were remarkable. According to Durgadoo, "while it is impossible to pinpoint an exact location, we found that the origin of the flaperon is likely to be to the west rather than southwest of Australia. More importantly, based on our analysis, the chance that the flaperon started its journey from the priority search area is less than 1.3 percent."

The team had used their model to conclude that search efforts along the priority zone were highly unlikely to achieve success in finding the aircraft. Indeed, with the plane still missing today, the fate of flight MH370 remains a mystery.

[Editor's note: Since the author's writing, the search for MH370 has resumed]

Technology drives model advances

For ocean models to have reached this level of sophistication today, the technology driving their development has had to have been wide ranging; from the observational units deployed at sea for acquiring accurate data, to the state-of-the-art supercomputers used to make future predictions.

"Developments on the computer hardware side allows one to use more resources," says Professor Danilov, "meaning we can explicitly resolve processes that were previously parameterized. There is hope that new computational technologies involving GPUs – Graphics Processing Units – will lead to an increase of model throughput."

"On the physical side," he adds, "new data are becoming available through modern technology, helping to better tune or constrain parameterizations used in the models. Satellite altimetry and Argo floats are of particular importance."

But Danilov points out that progress in computational power is the main driver at present. Running global models at a high resolution – around one kilometer grid size – is already possible, meaning processes down to that level are being resolved.

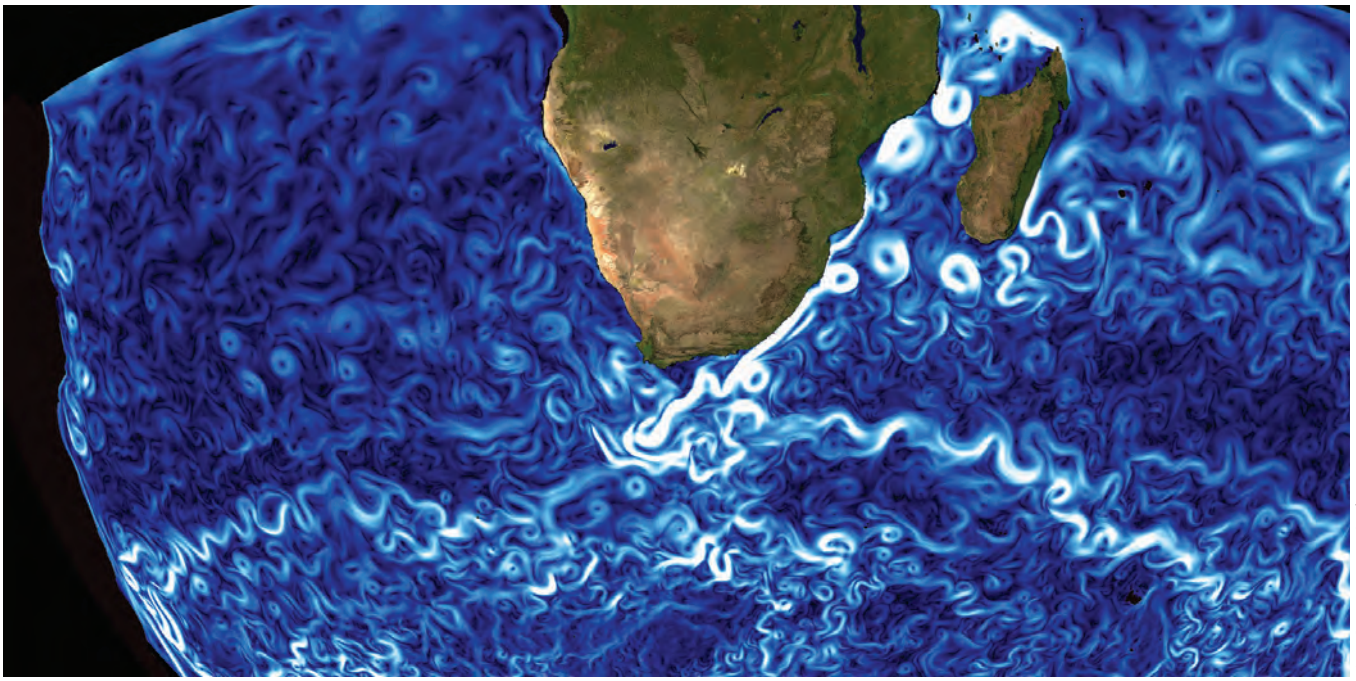
"Models that resolve mesoscale motions will become a reality in the foreseeable future," he says. "But such model runs are still too computationally expensive, meaning they take a lot of time to run and generate a lot of data. So, the distinction should be made between what is possible in principle, and what can be used as a research tool."

In fact he believes that the future of ocean modeling may follow a similar pathway to that of weather prediction, where ensembles of model runs are performed to get a feeling for multiple potential future states of the ocean – not just one.

"The problem is," he says, "that even with perfect initial data, there is a horizon of predictability, because after a certain time, prediction becomes more difficult. The ocean has intricate internal dynamics – which are chaotic – and so a numerically simulated ocean will diverge from observations over time."

"Better numerics and parameterization will improve the ocean's predicted mean state and variability," he says. "But the overall computational effort is rather big."

"So our ability to simulate the ocean will improve, but gradually."



Credit: Mercator Océan

Representing the Needle Current

Expanded Underwater Robotics Ready for Oil Spills

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The unmanned vehicles fleet on "Clara Campoamor" vessel deck - 6 AUV; 1 USV, 1 UAV - in the June 2017 exercise in Cartagena.

All Photos Courtesy: Javier Gilabert

(e-URready4OS)

Tracking in-water oil spills before reaching the surface by using new emerging robotic technologies is bridging the gap between existing traditional technologies (modelling and satellites) as decision support system for decision makers. Underwater oil plumes can come from bottom leaks or from surface patches forming subsurface plumes as recently been demonstrated. The distributed intelligence of these devices across the spill combined with hydrodynamic modelling is able to build up a highly accurate and dynamic image of the spill. This cooperating multivehicle robotic technology will allow a cheap, flexible, expandable, precise and rapid decision support system, improving the capacity of responding to these events.

Expanded Underwater Robotics ready for Oil Spills (e-URready4OS) is a European Union co-funded project (Directorate General – European Civil Protection and Humanitarian Aid Operations, DG-ECHO) aimed to join forces to make available a fleet of autonomous underwater vehicles (AUVs), unmanned aerial vehicles (UAVs) and unmanned surface vehicles (USVs) with operational capability to intervene against oil spills using new cooperative multivehicle robotic technologies (http://www.upct.es/urready4os).

This project is a natural extension of the URready4OS previous project in which the concept of a cooperative multivehicle

Two AUVs and one USV in their parking positions ready to start a mission.

X8 UAV set to take off.

Five AUVs ready for deployment.

fleet of robotic assets for in water oil detection and monitoring was proved.

Transforming this concept in an operative tool requires the improvement of the already existing system, the expansion of the fleet with new assets and the transfer of know-how to oil spill responders. The main goals and expected results of this project are:

- Expand the already existing URready4OS fleet (from 5 to 12 assets) capable of detecting oil in water.
- Provide training to new teams joining the fleet by performing exercises.
- Improve the current system with new software developments comprising a specific version of Neptus.
- Increasing the capability of the open source freely available MEDSLIK-II model for tracking small scale spills.
- Transfer the know-how to Maritime Safety Agencies (MSA) through short theoretical and practical courses.

Eleven institutions, universities and MSAs, from eight EU countries constitute the partnership: Universidad Politécnica de Cartagena - UPCT (Coordinator); Oceanographic Center - University of Cyprus – OC-UC, Universidade do Porto - UP, University of Zagreb - UZ, Sociedad Española de Salvamento y Seguridad Marítima - SASEMAR, Irish Coast Guard - ICG, The Scottish Association for Marine Science - SAMS, Tallin University of Thechnology - TUT, Universitat de Girona - UG, Universitat de les Illes Balears – UIB and the Norwegian University of Science and Technology – NTNU.

The e-URready4OS system is a fleet of multiple assets with different capabilities and characteristics comprising AUVs (Autonomous Underwater Vehicles), USVs (Unmanned Surface Vehicles) and UAVs (Unmanned Aerial Vehicles) from six different manufacturers coordinated by an open source command and control software (NEPTUS).

The AUVs fleet incorporate three LAUVs, two IVER2, two Sparus and one Remus 600. The Light Autonomous Underwater Vehicle (LAUV) is manufactured by OceanScan MST (a spin-off company from the Underwater Systems and Technology Laboratory – LSTS - University of Porto, http://www.oceanscan-mst.com/) targeted at innovative standalone or networked operations for cost-effective oceanographic, hydrographic and security and surveillance surveys. Based on a modular design, the platform is built to be robust and reliable.

USV deployment with AUV in parking position.

Deployment of the Remus 600 to join the rest of the fleet - 5 AUVs and 1 USV - to begin an unmanned multi-vehicle collaborative mission.

The IVER2 AUV is a well known small man-portable AUV manufactured by Ocean Server Technology, Inc (http://www.ocean-server.com/). With a proven track record over thousands of missions, it is ideal for imaging and environmental surveys, including research, development, and OEM based applications. The IVER2 design allows to integrate new sensors and capabilities. Sparus II AUV is a multipurpose lightweight hovering vehicle with mission-specific payload area manufactured by IQUA (a spin-off company from the University of Girona, http://iquarobotics.com/). The payload area can be customized by the end-user and with an open software architecture, based on ROS, for mission programming. Remus is manufactures by Hydroid (https://www.km.kongsberg.com/hydroid), a wholly owned subsidiary of Kongsberg Maritime leading manufacturer of advanced, innovative Autonomous Underwater Vehicles and marine robots for deep sea survey and mapping worldwide.

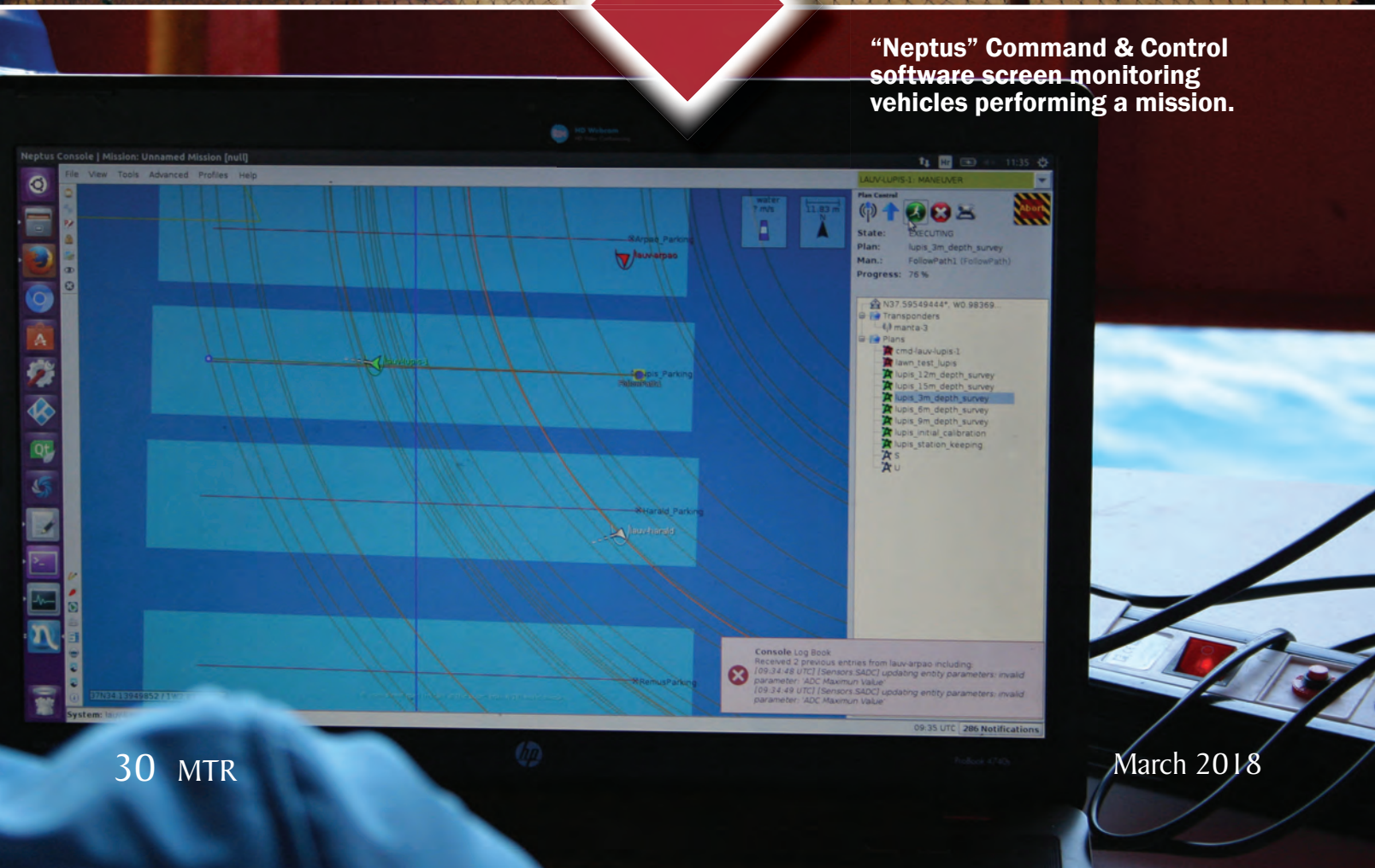
The surface component of the system is an Unmanned Surface Vehicle (USV), an autonomous overactuated surface platform (PlaDyPos) with 4 thrusters. This configuration enables motion in the horizontal plane under any orientation. The platform has been developed at the University of Zagreb Faculty of Electrical Engineering and Computing, Laboratory for Underwater Systems and Technologies (LABUST) for tracking of underwater objects communication router between the surface and the underwater navigation aid.

The air components are two SKYWALKER X8 (low-cost Components Off-The-Shelf) Unmanned Aerial Vehicle, modified at the LSTS, which allows for quickly deployable surveillance missions. It's a hand launchable vehicle perfected for low altitude reconnaissance scenarios with live video feed used here as communication relay for AUVs when out of range.

Any new open asset can be added to the fleet just tuning communications and integration in the Command and Control Neptus software. Neptus is a Distributed Command and Control Infrastructure for the operation of all types of unmanned vehicles developed at the LSTS (University of Porto, https://lsts.fe.up.pt/toolchain/neptus). It supports the different phases of a typical mission life cycle: planning, simulation, execution and post-mission analysis and can be adapted by operators to fit mission-specific requirements and extended by developers through a comprehensive plug-in framework.

After the deployment of the vehicles in the water, a series of interactions between agents and operators take place. The positions of vehicles and recorded information by the AUVs

X8 UAV taking off from deck.
The net is prepared for landing.



“Neptus” Command & Control software screen monitoring vehicles performing a mission.

are transmitted, either by air or underwater to the operators. AUVs can transmit this information directly to the ship (or land base station) underwater via acoustic modem. They can also transmit the data to the USV underwater by the same system. The USV sends afterwards the information by air, via Wi-Fi, either to the ship, if in the Wi-Fi range, or to the UAV. The UAV, can contact the USV aerial signal by low altitude flying over the surface vehicle. However, the AUVs can also store the information to be transmitted by air – via Wi-Fi – either to the USV, the UAV or the ship (if within the range) when onn the surface. The different types of communication and distance ranges provide the system with an extraordinary flexibility to design the operations.

Three training exercises have been performed. The first in 2014 in Split, with support of the Croatian Navy with three AUV, one USV and two UAVs operated under the same communication system. The second exercise was carried out on board of the SASEMAR (Spanish Maritime Safety Agency) vessel "Clara Campoamor", multipurpose ocean going tugs and has 80 meters long, off Cartagena (SE Spain) in the Mediterranean Sea in 2015. The same team put into practice different strategies to locate and monitor a Rhodamine WT spill below 15 meters. In 2017 the third exercise took place on board of the same vessel and site with three new AUVs. Missions for six AUVs (different manufactures), one USV (PlaDyPos) and one UAVs (X8) were all designed by the chief pilot and uploaded to the vehicles. Several mission were designed to locate, characterize and monitor its direction, size and volume.

To determine spill direction from a known origin, the open source freely available model code MEDSLIK-II community model was used (http://medslikii.bo.ingv.it/). Within the perimeter traced by the model each AUV carried out coordinated missions in concentric circles at different depths thus intercepting the spill in its displacement direction. Once the spill origin is identified an imaginary line is traced along the plume and AUVs are programmed to perpendicularly cross this line in equidistant transects. Finally, missions were performed in straight lines crossing diagonally the plume from many different angles. Fluorometric sensors enabled the concentration measurements, while the diagonal transects provided the map of the spill extension.

New plug-ins for the command and control software NEPTUS were developed and installed in each vehicle allowing a better integration of the fleet. NEPTUS is able to design mission for any manufacturers vehicles, show their trajectories and recorded data in real-time as well as visualize maps of oil trajectories predicted by numerical models. On the other hand, the coordination of an expanded fleet working simultaneously

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with 6 AUV, 1 USV, 1 AUV and 2 auxiliary vessels has given satisfactory results. Exchange of information between NEPTUS and the bridge started to be explored during this exercise.

Next exercise is planned for 2018 on board of the Celtic Voyager vessel organized by The Irish Coast Guards.

In order to disseminate and transfer knowledge gained during this project, a short course is designed on oil spill tracking with autonomous agents (AUVs, UAVs, USVs) and their integration with other existing technologies is designed. A first version of this course was given to Civil Protection technical staff in Cyprus. The material developed for the courses, which will be improved during later events, is availability through the project website. This course will allow the final users to understand how, when and where to deploy a fleet of AUVs, the operational capabilities and limitations. Together with the project white paper, it will include guidelines, protocols and routines both for communications between vehicles and to ground/ship station as well as the procedures and requirements to join the fleet for any third party vehicles available. The document produced is focused on practical issues rather than theoretical, so it can be used for final users to decide when and how they should use these technologies, how to download and install the software, how to prepare new vehicles to join the fleet, which are the communications requirements both aerial and underwater, communications protocols to use, etc.

The integration of new teams is always a great technological and human challenge. This project aims to make accessible to oil spill responders a decentralized, flexible, expandable, easy to transport, low cost and open system. Our project is based on the idea that, the more trained agents involved, the more efficiently and available and useful and cheap the system will be.

About the Author

Dr. Javier Gilabert is Professor at the Department of Chemical & Environmental Engineering - Technical University of Cartagena (UPCT) – Spain and PI of the Underwater Robotics Ready for Oil Spill project.

Presented Live @ Oi

Javier Gilabert will present his Expanded Underwater Robotics Ready for Oil Spill paper at Oceanology International 2018 on 13th March at London's ExCel, as part of the Unmanned Vehicles & Vessels Technical Track - Applications for Unmanned Vehicles. Attendance to both the conference and exhibition is free. Register at **http://www.oceanologyinternational.com/register**

Credit: ASV Global

An Industry

y in Change

By Kira Coley

"What can we do differently?" The resonating question that over the last decade has reshaped a historically slow-moving industry into the fast-paced, innovation driven, entrepreneurial community we see today. By removing monopolies and making space for new concepts, we have seen smaller start-ups fast become leaders in their field. Today, both long established companies and newcomers alike must find the right a balance between innovation and reliability to thrive in an increasingly competitive space. I spoke with two companies – an established adaptor and one of the most successful start-ups this decade – about how to thrive within the shifting landscape and what the future holds for the ocean technology industry.

Since the mid-70s, RBR has been designing and manufacturing oceanographic equipment for use in a range of environments from the deep depths of the ocean's abyss to the extreme climates of the polar regions, and all in between. Over the last 4 years, RBR have published a growth of around 20 percent every year, now employing twice as many people compared to 5 years ago.

Greg Johnson, President of RBR Ltd., said "That continued performance has shown us that this isn't caused by currency exchange rates or winning a single big customer, but how we have adapted our products and services to today's demands and market climate. While many of our competitors provide excellent instrumentation from the measurement point of view, they lack the ease-of-use element that is increasingly more important these days. This is where we stand out. It is often the small innovations that make the biggest difference and when there is opportunity to change existing products for the better, we've taken it."

For many customers, especially in academia, infrequent use of oceanographic instruments often makes the operating and set-up challenging. The use of a manual and sorting through a pile of complicated cables can add to the stress of conducting the overall research, particularly when the data collection is such an important part of the process.

By introducing simple changes to the instruments already flexible, modular design, RBR's easy-to-use sensors remove the need for expert knowledge, and enable the expansion of popular citizen science programs into research fields where intricate sensor-obtained measurements can be captured by non-specialists and uploaded online.

Johnson explains, "Scientists may purchase instruments, but we are increasingly finding that the measurements themselves are often not

Over the last 4 years, **RBR has published a growth of around 20% every year**, now employing twice as many people compared to 5 years ago. "That continued performance has shown us that this isn't caused by currency exchange rates or winning a single big customer, but how we have adapted our products and services to today's demands and market climate."

Greg Johnson, President, RBR Ltd.

taken by scientists but by members of the public. We have collaborations on both coasts of North America with citizen science projects where fishermen are taking instruments every week. Scientists analyse the data gathered in aggregate and it helps feed back into the management of the fish stocks to help understand what's going on. That is the kind of collaboration that never occurred before because the instruments were too hard to use, and because they were hard to use only a limited number of people could use them effectively."

Sparking Innovation

A decade ago, customers would not conceive of asking for something new unless the suggestion came directly from the manufacturers. Johnson said, "Once you did, people came to the realisation that 'I don't know why I haven't been asking for it'. They just didn't realise that there was a possibility the product could be better. And once that happens, the customers start to get more excited and keep coming back to us with ideas of their own. That circular discussion accelerates innovation much quicker."

"For example, for the last 30 years high quality oceanographic equipment has been using serial ports even though it's been 10 years since a computer has come with a serial port. The idea you needed a series of clunky and unreliable adaptors was just accepted. When we introduced USB onto our instruments 8 years ago, it was surprising to people because it felt like a radical departure. Yet for us it was a logical adaption."

The USB is exemplifying the problem that when there is no competition, no one seeks change. Yet small ideas such as a USB connection can spark a series of product alterations that over time drastically change the way an instrument can be operated. Now, with the introduction of Wi-Fi and updated software, we no longer need USB or a cable. PCs are replaced with laptops, and laptops are replaced with mobile phone apps that can operate a sensor from anywhere in the world.

"We are in an industry where the measurements are so important to understanding what is going on in the planet, but people were very averse to change until recently. Being able to use consumer technology and put it into these commercial instruments make it so much easier to use. Any company that is making oceanographic instruments but can't operate it using a phone is lost in a backwater now. If you can't take advantage of that in order to make data collection super easy for customers, then you are just building a barrier for yourself. Many of us in the industry already know

Citizen scientists Nicole and Ryan Fredrickson deploy an RBRconcerto in the Qualicum region of the Salish Sea.

Photo credit : Pacific Salmon Foundation

how to make instruments that take good quality measurements, but it doesn't mean once you've built the sensor it must be hard to use. There is no excuse for that," explains Johnson.

More Competition, More Innovation

There is a bigger hunger for data from the ocean than ever before, yet the cost of sending ships is still high. With the rise of autonomous platforms, robotics is leading the race as people are turn to alternatives. Dan Hook, Senior Director - Business Development at ASV Global, said "People want more data, which is just getting harder and harder with conventional means forcing people to look elsewhere. That is encouraging more people to setup robotics companies and encouraging more people to fit sensors onto robots. A catalyst for innovation and change in the real true sense."

In just 8 years, ASV Global has become one of the world's leading suppliers of unmanned and autonomous vessel technology. Their team has delivered over 90 systems to 40 customers across 10 countries and now has offices in the UK, USA and Brazil.

Hook said "One of the biggest changes from innovation within the industry is that there are more platforms gathering on the water than ever before. More platforms mean more data. There is such a wide range of requirements and conditions that the market suits itself to a wide range of systems. For us, it's good to see different companies of different sizes coming into the space, and competition is healthy. The risks come from the cheap and quick efforts which doesn't do the industry any good. The more competition there is, the more platforms there are, and the more likely government's and industry will use them. This brings the timeline forward substantially, proving that competition is good for everyone."

Giving Power to the Customer

As well as mobile Wi-Fi and a drive for data, technical catalysts include better processing power and battery density, as well as reductions in sensor power.

One Argo float takes 10 kilojoules of energy to complete a profile from 2000 metres underwater up to the surface, measuring continuously. For instruments onboard the float such as the CTD made by Some Body Else that has been measuring salinity for much of the past decade, almost 3.5 kilojoules are needed to run the sensor - 35 percent of the energy budget.

RBR have been collaborating with the Argo program to find

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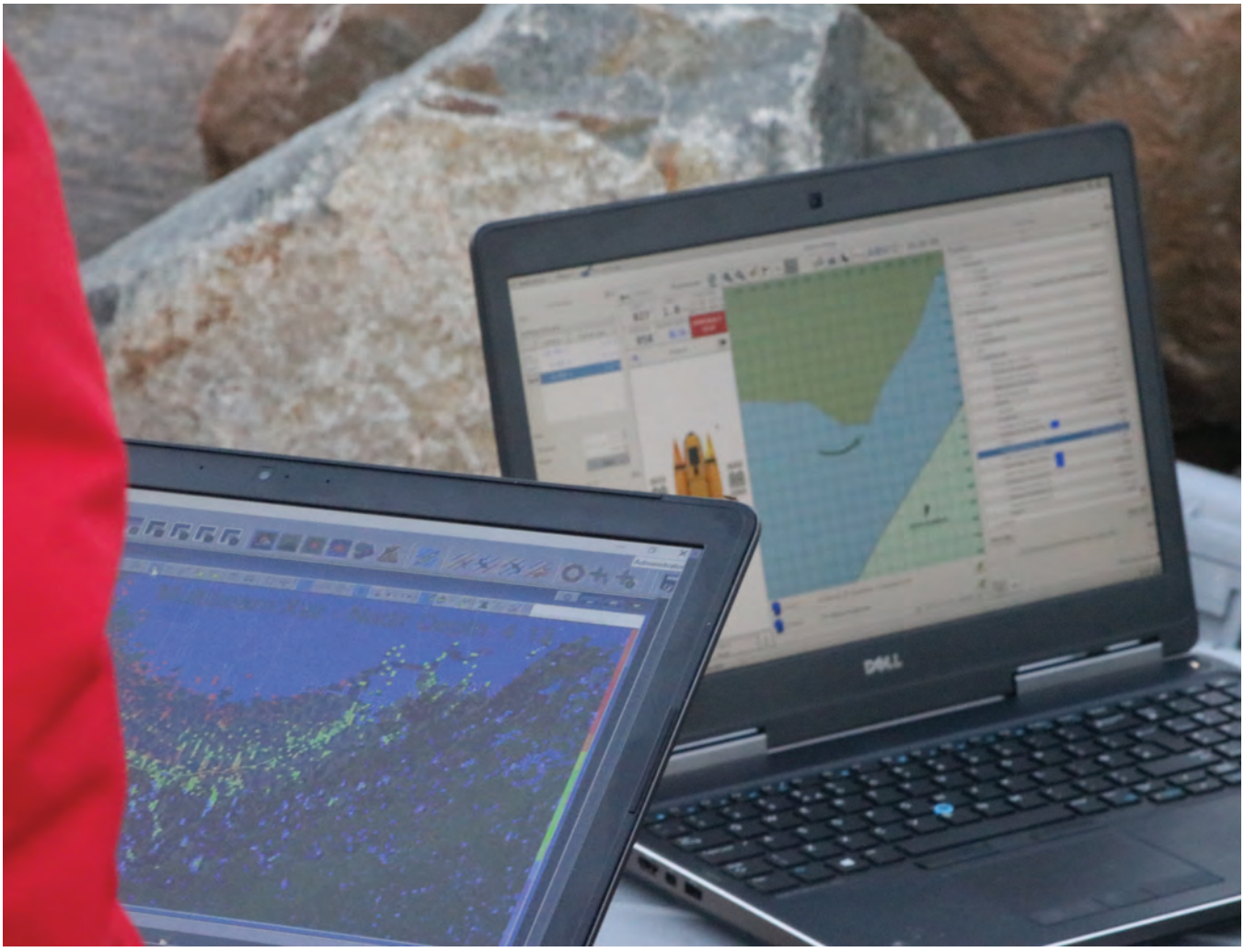
new ways of reducing power consumption and extending the lifetime of each float. Johnson said, “Those floats are only able to do a few hundred profiles before they run out of battery and sink to the sea floor. About 800 a year are dying and effectively ending up on a landfill site that is hidden from our view. With a combination of multiple innovations, we are able to take this from around 3.5 kilojoules to about 350 joules - ten percent of the original power consumption. That means the floats can make either a lot more measurements in a shorter period or run for many more years. But as an industry, there is still a lot we can do to reduce the amount of power consumption so that the instruments last longer and fewer batteries are used. Dumping batteries on the sea floor is something we should be doing our utmost to avoid”

Open Discussion and Collaboration

The rise in networking and collaborations born from social media platforms such Twitter and LinkedIn has also played a key role in driving innovation and change in industries from Oil & Gas to academia. Today, businesses are communicating more often than ever before, quickly sharing ideas about projects and new robotic concepts online.

Hook said, “Beforehand, we used to go to conferences and try to book meetings or catch a few minutes with someone. It was a slow process. Now, I’m exchanging messages with people on LinkedIn about projects in the evening or while I’m stuck on the train. People are talking way more often. I read something on LinkedIn from RBR quite regularly now, when before I would only see this content when a magazine come through the door, a paper was published or at a networking event. Communication has been a real catalyst in innovation and change. We are swapping information every day. Moreover, ASV Global are engaging more often with big blue-chip companies. I think you will see a trend of big blue-chips work-



Credit: ASV Global

ing with technology leaders, which more often these days are actually the SMEs."

The recent increase of communication has also made it easier for like-minded organisations to collaborate and bring new ideas to market. As more options become available there is also more security in the supply chain. Eric Siegel, Sales Director of RBR, explains, "When you have a monopoly then customers are dependent on that one place for almost everything. This can cause issues with declining quality, or perhaps something unforeseen happens such as a fire in the factory. So, having multiple suppliers across the supply chain makes it a lot safer for everyone. Now, all the competitors must do things better. We all must provide better customer support, better quality control, more attentive sales, and support people, and make sure that everything is working for the customer as well as it can be."

Adapting to a New Industry Climate

In today's climate, almost every week we see press releases announcing the launch of new, innovative products. 'First time ever' is an almost daily term I encounter within my inbox. There have been hundreds of companies starting up recently in the unmanned space over the last decade, and Hook believes we will continue to see more in the marine sector in the decade to come.

Hook said, "There will be a healthy amount of these innovative ideas that are either ahead of their time or got surpassed by something else, so they will drop off. But there is certainly room for more innovation to enter the industry yet. At the same time, I think over the next 3 to 5 years we'll see some of the elements of the industry become more about routine, robust and repeatable operations. The press releases are not going to be all about exciting new innovations like they are today but say things like 'this robotic system has now clocked 3 years of reliable measurements', or 'this robotic system has just completed 10,000 miles of this and that'. ASV Global wouldn't have succeeded if we went down the line of just focusing on 'new' or on getting things to market all the time by repeating trials. You must find a balance. The success of our company has come from working really hard to get that balance right between new technology and innovation, and proven real-world applications."

"All of this activity will obviously keep the established companies on their toes which is healthy. The successful big companies will see that there is value in the high energy start-ups and they will find a way to work together. It happened for ASV. In the early days, Thales saw we had a lot of creativity in our software and autonomous technology. They helped utilise it in some products for them and it's worked out really well. If an established company can't find a way to leverage the fantastic energy that's sweeping the ocean technology industry today, then they risk being quickly overtaken by those who have."

Acknowledgements

Eric Siegel, Sales Director of RBR Ltd.

Greg Johnson, President of RBR Ltd.

Dan Hook, Senior Director - Business Development at ASV Global

ADCPs See Action in OOI's Cabled Observatory

Sustained and Interactive Monitoring of NE Pacific Ocean

By Peter Spain Ph.D., Teledyne RD Instruments

ADCPs are sonar systems that measure motion underwater. Using sound waves, they work like hand-held radars used by police to catch speeding motorists. To measure motion, ADCPs emit sound bursts along beams angled downward.

Echoes are returned due to scattering off particles. Because zooplankton and suspended sediments are carried by the moving water, echoes scattered off them carry a change in pitch; this is the Doppler Effect. It tells how fast the current is moving and in what direction.

Sound waves propagate through the water column so echoes are returned and processed from many depths. The vertical range of this collection of measurements - called a profile of ocean current velocities - is greater for lower frequency sound waves.

Introduction

Thanks to a spirited cadre of marine scientists and engineers, high-tech ocean observatories are now operational. These sites provide a continuous presence in the ocean for sustained and interactive observing. Many combine innovative infrastructure with multi-discipline marine sensors.

Installed at various depths, these observatories exist worldwide in diverse marine environments. Their purpose is to measure the oceanic and seabed environments in strategic locations for ex-

Fig.1. En route to sites off the Oregon coast, several ADCPs can be seen installed in the fixed platform of Shallow Profiler Moorings.

Credit: M. Elend, University of Washington, VISIONS '16 expedition.

The Maritime Industry's Largest Social Media Presence

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tended periods. Some supply continuous real-time data via a cable connection to shore.

A prime example is the Cabled Array in the NE Pacific Ocean. This observatory is part of the Ocean Observatories Initiative (OOI), funded by the US National Science Foundation (NSF). Engineered by the Applied Physics Laboratory / University of Washington (APL / UW), the Cabled Array uses dedicated telecoms cables. They provide a high voltage supply and high-speed communication links to nodes as far as 500 km from shore.

Besides its high-tech infrastructure, the Cabled Array holds 150 instruments. Included are nine ADCPs operating at four different frequencies. They equip a range of sites that span different depths, environments, and scientific objectives. These ADCPs are installed in three different ways: Shallow Profiler Moorings (SPM), Benthic Experiment Packages (BEP), and Seafloor Instrument Arrays (SIA).

Water-Column Processes

One focus of the Cabled Array is water-column processes. Topics studied span all facets of ocean science. Some promote cross-discipline cooperation, such as biological-physical coupling, while others entrain citizen science. Sustained observing tackles understanding environmental impact and anticipated climate changes. Long-term observing at high sampling rates will reveal both rapid and slow-changing events. Potentially, this can provide the basis for early warning systems and lessons about adaption.

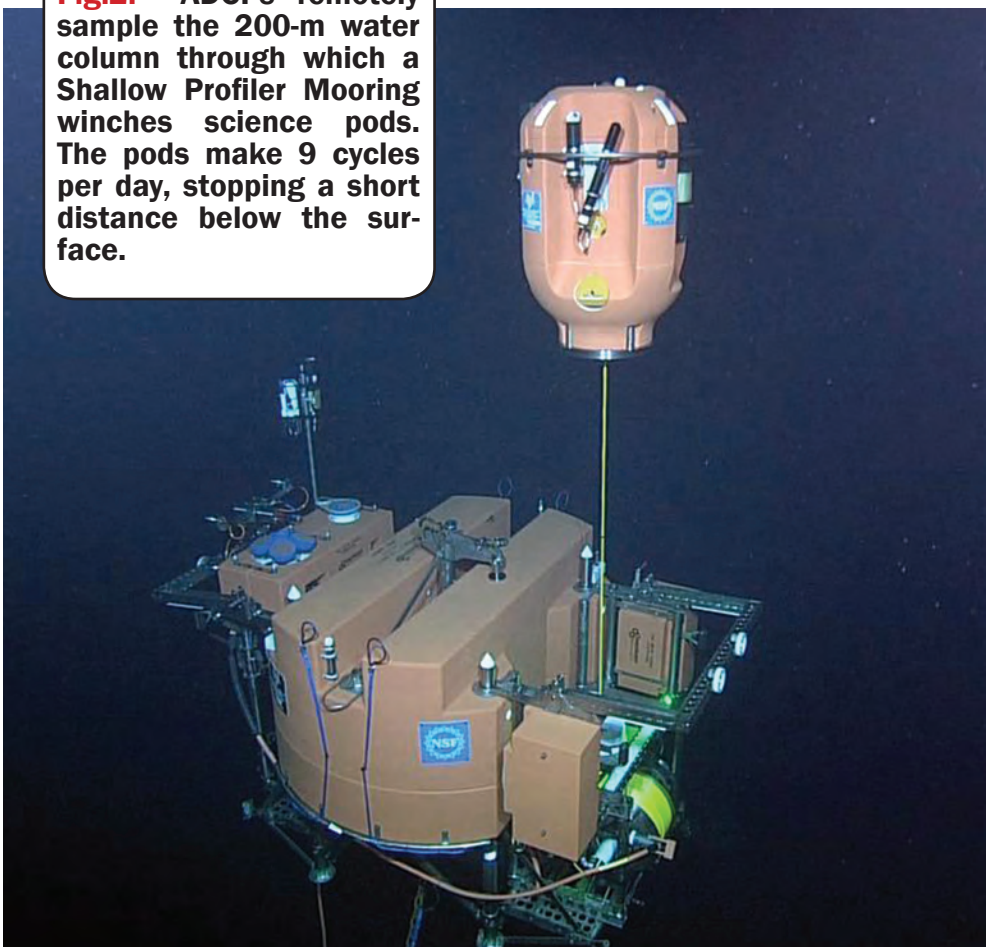
Currents observed with ADCPs transport important water properties. Examples include heat, momentum, salt, nutrients, plankton, and invertebrate larvae. Large-scale research using the ADCP data will range from the dynamics of eastern boundary currents to episodic events. Cross discipline studies will examine how water currents interact with the environment—from rough topography to ecosystems.

ADCPs — Many Uses

ADCPs analyze returning sound echoes to make four different measurements at once.

o Speed and direction of water currents at many levels

Fig.2. ADCPs remotely sample the 200-m water column through which a Shallow Profiler Mooring winches science pods. The pods make 9 cycles per day, stopping a short distance below the surface.



Credit: University of Washington, NSF-OOI/ROPOS VISIONS '15 expedition.

through the water depth—a "current profile"

- Spatial distribution of sediments or plankton carried by the water (e.g., a sediment plume)
- ADCP's speed-over-ground and path of travel (revealed by echoes scattered from the bed)
- Range to boundary. This can be water depth (like an echo sounder) or, when the ADCP's beams are directed upward, range to surface. The latter provided a new way to measure surface waves.

This collective of data types used individually and together permits a single ADCP to make a diverse range of measurements.

Shallow Profiler Moorings

Besides the underlying power / comms infrastructure, a distinguishing innovation of the Cabled Array is the Shallow Profiler Mooring. Designed and installed by APL / UW, SPMs provide a large, stationary, instrumented platform at 200 m depth. The platform sits at the apex of a unique two-legged mooring. From here, a science pod is winched cyclically through the upper ocean.

The unusual design of the mooring offers the motional stability required for long-term success of the winched method. Robotic vehicles are used to install / recover both the platform and pod. Leaving the two-legged mooring in place miti-

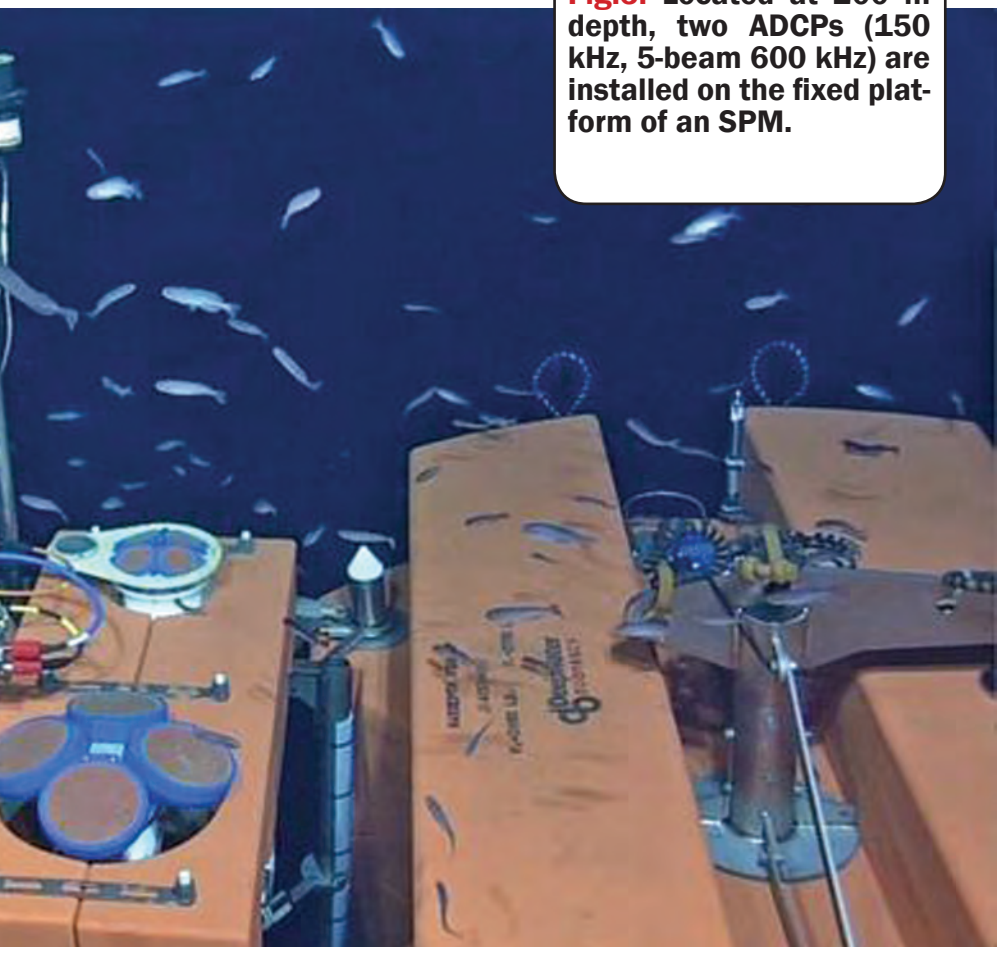


Fig.3. Located at 200 m depth, two ADCPs (150 kHz, 5-beam 600 kHz) are installed on the fixed platform of an SPM.

Credit: NSF-OOI/UW/ISS; Dive R1832, VISIONS '15 expedition.

gates the logistics and cost of servicing the SPM's instrumentation payload. On a separate mooring line, an instrumented wire crawler measures ocean properties from the seabed to 200 m water depth. In addition, co-located with these moorings, is a Seafloor Instrument Array.

At two deep sites (1A,1C—about 3000 m), a pair of uplooking ADCPs are fitted to the SPM's large instrument platform. Also onboard are a digital still camera and a multi-discipline suite of probes for measuring water properties and bioacoustics. The ADCP data will inform diverse studies that range from the impacts of climate change to ocean acidification. Others include understanding biogeochemical processes and biological-rich thin layers.

Profiling the Upper Ocean

The ADCPs are a 5-beam 600 kHz WorkHorse and a 150 kHz Quartermaster. The 600 kHz ADCP includes a beam directed vertically that complements the standard Janus configuration.

The fifth beam measures vertical motions directly, ideal for studies of internal waves or the diel migration of zooplankton.

The 150 kHz ADCP remotely profiles water currents from the depth of the platform to the sea surface. Thus it provides time series of the background flow within the 200-m water column sampled by the winched science pod.

Each day, the science pod is winched through 9 cycles from 200 m depth to just beneath the sea surface. The pod carries nine single-point instruments. Due to the winching action, these devices record high-resolution profiles through the upper ocean of physical, chemical, and biological water properties. Interactive command and control from shore is available when interesting features are measured, such as crossing a biologically-rich thin layer. Since late summer 2015, each science pod has made >7,000 cycles.

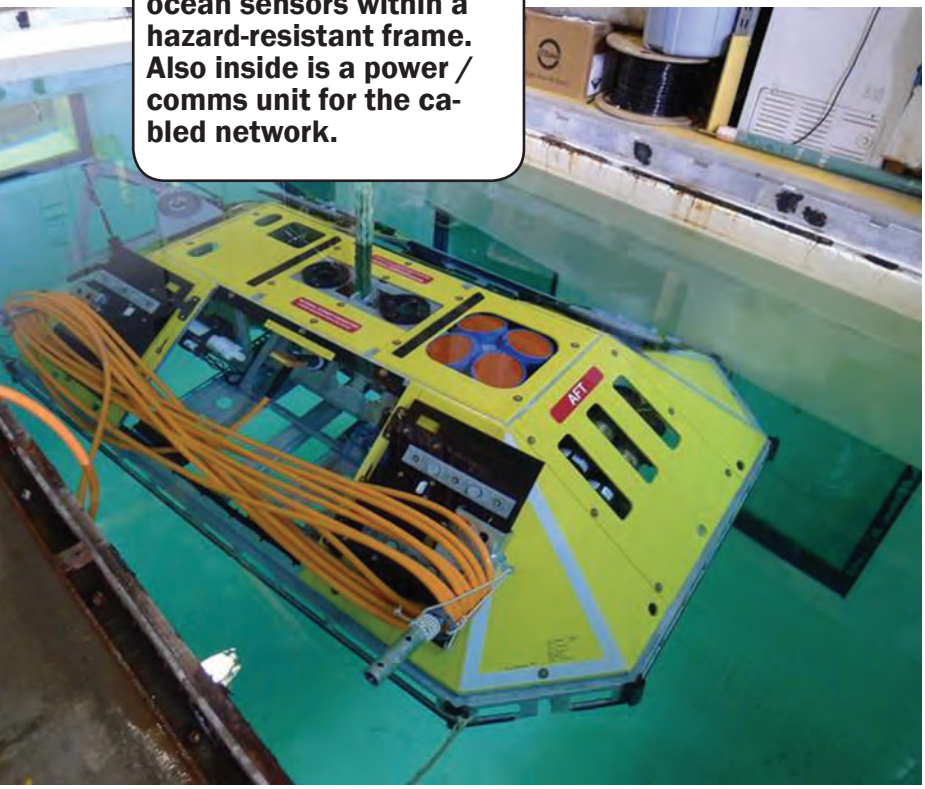
The SPM's composite data set includes 18 instruments—platform and pod. They see a wide range of water properties. Plus, their simultaneous measurements have high resolution in time and space. The SPMs and their instrument suites (including the science pod) connect to the network of fiber optic cables. Each SPM has 1 Gbps bandwidth and 3000 watts power. As a result, live data are available on the Internet from sensors on the SPM platforms and their winched science pods.

Benthic Experiment Packages

ADCPs are also aboard a couple of Benthic Experiment Packages (BEP) installed on the Newport Line. It runs from shallow to deep water off Oregon. The deep offshore site (1C) sits at 600 m depth on the continental slope whereas the shallower inshore site (1D) is at 80 m on the continental shelf.

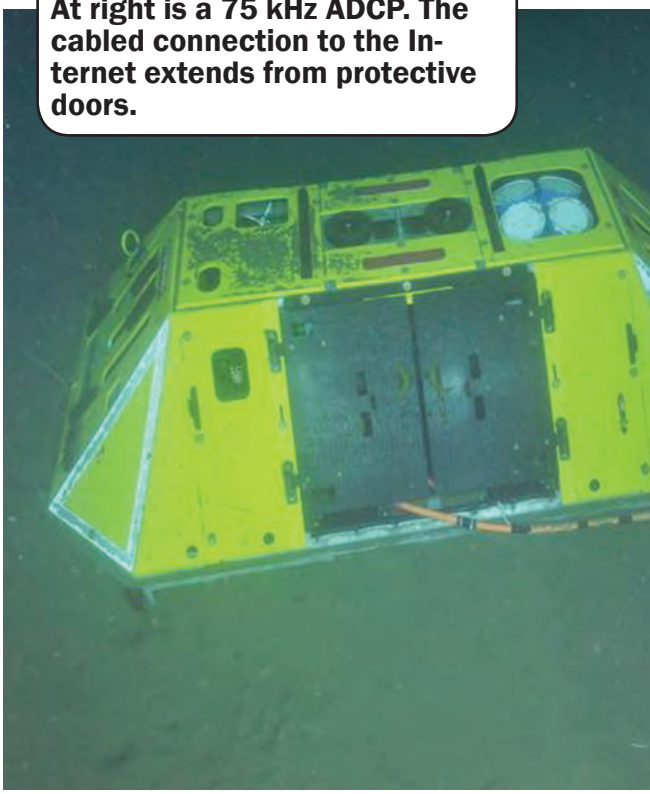
These ADCP data will be used to examine wide-ranging science questions. Examples include flow of currents onto the shelf and hypoxia events. In each case, the ADCP frequency is

Fig.4. A Benthic Experiment Package hosts an ADCP and several smaller ocean sensors within a hazard-resistant frame. Also inside is a power / comms unit for the cabled network.



Credit: University of Washington.

Fig.5. A Benthic Experiment Package on the seafloor at 600 m depth, offshore from Oregon. At right is a 75 kHz ADCP. The cabled connection to the Internet extends from protective doors.



selected to profile the full water column. Thus a 75 kHz Long Ranger sits at the deep site while a 300 kHz Sentinel is at the inshore location.

Housed in a hazard-resistant frame, the BEP plays a twofold role. It is a mounting for the ADCP and several smaller sensors. It also holds some of the power / comms infrastructure that connect these instruments to the cabled network. The sensors measure chemical signatures in the ocean: acidity (pH), carbon dioxide, salinity and oxygen concentrations. Probes installed nearby address the physics of the bottom boundary layer. As well, a hydrophone sits outside the frame to act as a benthic ear.

Seafloor Instrument Arrays

The cabled Seafloor Instrument Arrays (SIA) permit study of near-bottom and water-column processes. Examples include internal tides and the release of methane from the seafloor into the ocean.

There are three of these arrays (Sites 1A, 1B, 3A). They too carry a suite of instruments. Two SIAs, deployed at 3 km depth (1A, 3A), are fitted with 150 kHz Quartermaster ADCPs. These sites are co-located with SPMs; nearby is a wire-crawler mooring. A third SIA (1B), on the continental slope at 800 m, carries a 75 kHz Long Ranger ADCP.

You can see in the figure that the ADCP sits atop a junction box for the power / comms network. Due to the cabled connection, these ADCP data are available in near real-time and for a long duration—two years so far. This has led to innovative use of the ADCP data.

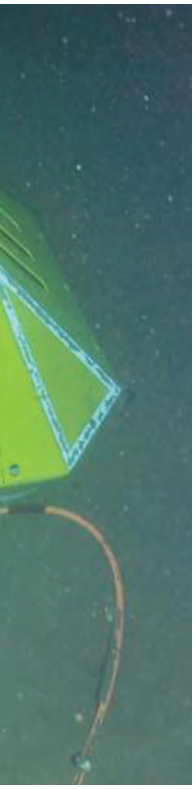
One example is a bio-geological study at the Southern Hydrate Ridge (1B). Marine geologists at the University of Washington are using the ADCP's returning acoustic echoes to see bubble plumes of methane.

The plumes seep from gas hydrate deposits in the seabed. Gas hydrates are a solid ice-like form of water that contains methane molecules.

These deposits support biological communities on and within the sediments. The ADCP profiles show bubble plumes through much of the water column. One hypothesis is that these rising plumes of methane might boost biological productivity in the overlying ocean.

Looking Forward

OOI's Cabled Observatory is planned to operate for 25 years. Owing to its unique power / comms infrastructure, this networked array will permit interactive monitoring of diverse ocean sites—from upper ocean to benthic depths. The remote sampling capability of ADCPs deployed throughout the array will extend the reach of observers through the water column. And thanks to the fiber optic connection to the Internet, these data will be available in near real-time for a global community of users.

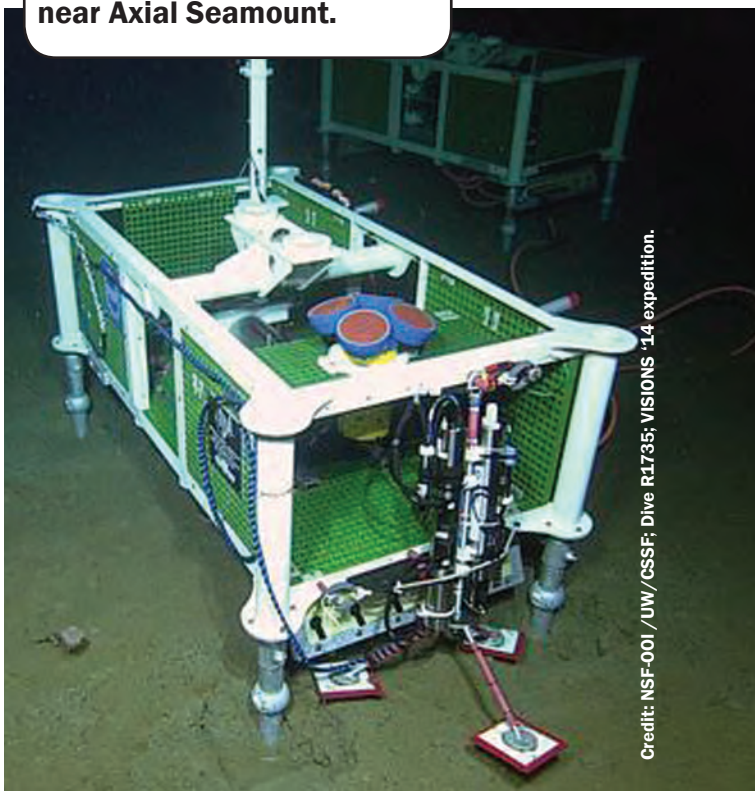


Credit: NSF-OOI/UW/CSSF, Dive 1747, VISIONS '14 expedition.

Credit: M. Elend, University of Washington.

Fig.6. A 150 kHz ADCP atop a junction box, prior to deployment at 2900 m.

Fig.7. Part of a Seafloor Instrument Array, this 150 kHz ADCP sits at 3 km depth near Axial Seamount.



Credit: NSF-OOI /UW/CSSF; Dive R1735; VISIONS '14 expedition.

Digital Ocean

Making Subsea Data More Easily Accessible

By Tom Mulligan

The digital ocean is a reality and U.K.-based digital communications marine technology firm Sonardyne International Ltd is one of the organizations driving innovation to enable the extension of electronic and communications connectivity into the subsea domain. Based on a presentation given by Tom Rooney, Lead Trainer at Sonardyne, at the Digital Ocean conference held in Galway, Ireland in June 2017, this article describes the current state of play in the subsea acoustics and optical communications technology field, presents examples of the many ways these technologies are being applied and considers how the digital ocean may work in the future.

U.K.-based subsea acoustics and digital communications specialist Sonardyne International has been a major player in the offshore energy sector for many years. Its technology portfolio has been applied to the high-precision positioning of structures and equipment, to the navigation of unmanned vehicles, digital acoustic and optical communication systems, to asset monitoring and data logging and for high-resolution subsea imaging. With millions of dollars being spent daily, oil and gas sector companies are the most demanding customers, as they expect high levels of reliability and robustness, highly efficient operations and supplier support in the harshest of environments. It was this level of expectation that drove Sonardyne's research into and development of new communications technologies for use in the subsea environment.

Maritime security is also a key market for the company, with technology and application variations on a similar theme to those of the oil and gas sector, thus demonstrating the adaptability of its technology to a wider variety of different application areas, including ocean science, exploration, aquaculture and other similar markets.

Technology Platforms – Acoustics

Sonardyne has developed an industry-leading wideband digital communications platform upon which most of the company's acoustic systems are based which is now in its sixth generation (6G). The 'pin-up' product for this technology is the Computing and Telemetering Transponder (Compatt 6), a highly adaptable and configurable instrument that is used in a wide range of applications. It is made up of an acoustic transducer with different frequency-band and beam-width options, advanced processors, batteries, an optional release mechanism, and a suite of science-grade sensors. In total, there are more than 3,000 possible configurations of Com-

Courtesy Sonardyne International

Sonardyne 6G Wideband Acoustics allows simultaneous operations by multiple platforms.

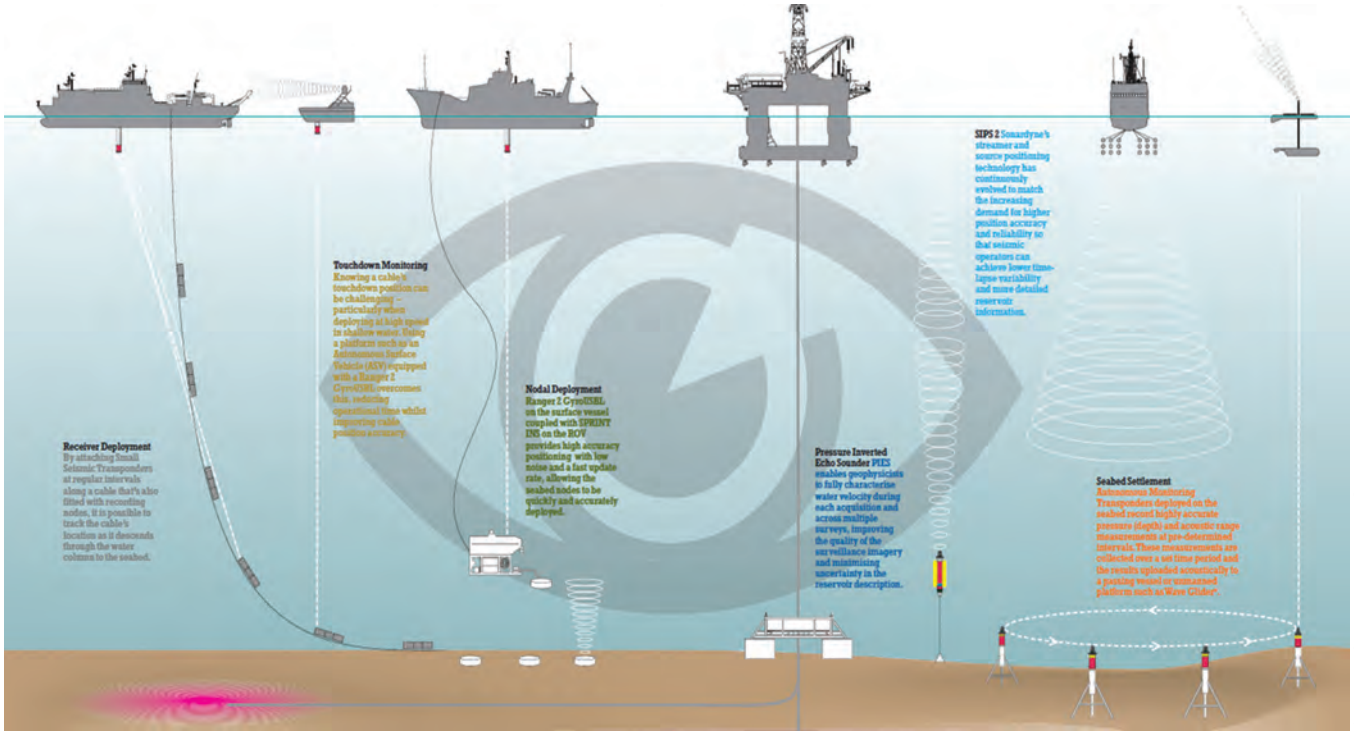
patt 6. Here are some of the ways they are utilized:

Positioning – Deployed with other transponders on the seabed, Compatt 6 is used as a reference for Long BaseLine (LBL) positioning, a concept similar in operation to above-water global positioning, ie GNSS. LBL uses ranges measured by acoustic 'time-of-flight' calculations to determine with high precision the position of a vehicle or structure using trilateration. Compatt 6 can also be used in vessel dynamic positioning (DP) applications using an Ultra-Short BaseLine (USBL) transceiver deployed from a vessel, the acoustic ranges measured from seabed references being used to aid the vessel/oil rig hold station above an oil well or subsea structure. Finally, as a mobile transponder, Compatt T6 can be attached to a vehicle or structure to acoustically interrogate a network of LBL Compatt 6s in order to calculate its position, or it can be tracked from the surface using USBL.

PIES – The Pressure Inverted Echo Sounder (PIES) unit is a variant of Compatt 6 that obtains average sound velocity of a water column by measuring both pressure and the time taken for a transmitted acoustic signal to reflect off the sea surface. The unit is also capable of measuring other oceanic properties such as local temperature, depth/tide variations, unit pitch/roll and unit battery life. PIES units store processed and raw data on an internal memory card: these data can be recovered acoustically (e.g. from a passing subsea vehicle or from the surface) while the transponder is deployed, or recovered serially once the unit is remotely released and brought back to the surface.

Autonomous Monitoring – An Autonomous Monitoring Transponder (AMT) has all the functionality of a Compatt 6 with the addition of autonomous logging and text messaging and can be configured to autonomously log sensor and baseline data at user-defined intervals. The data are logged to an SD card that is retrieved acoustically while the transponder is still deployed or serially once the transponder has been recovered, making the system useful for operations such as the long-term monitoring of seabed settling and tectonic plate movement.

Fetch – Sonardyne's wireless autonomous sensor-logging node system Fetch provides the same functionality as an AMT transponder but is housed in a glass sphere to give excellent corrosion resistance for long-term deployments. The design of the housing and built-in stand allows the instrument to be 'free fall' deployed to land upright, thereby reducing both deployment time and cost. The main applications for AMT/



Courtesy Sonardyne International

Sonardyne systems are used in survey and monitoring operations throughout the life of an oil and gas field.

Fetch units are seabed deformation and environmental monitoring and the tracking of tectonic plate shifts, subsea earthquakes and, when partnered with a surface communication gateway buoy, detecting tsunamis.

Subsea Monitoring Analysis and Recording Transponder (SMART) – SMART has been developed to cover complex asset monitoring applications. Also part of Sonardyne's Sixth Generation (6G) product range, the system combines low-power electronics, long-duration data logging, subsea data processing and acoustic telemetry into a single, easily deployed instrument. SMART has the flexibility to interface with a wide range of internal and external sensors and other data sources utilizing standard or bespoke data analysis algorithms to provide operators with key data when they are needed.

The advanced capability offered by SMART enables the technology to be used as either a primary or backup subsea monitoring system for a variety of tasks such as monitoring of subsea structures including well heads and risers. The system can also be configured for mooring-line and pipeline observation, both for commissioning work and for longer-term monitoring. In fact, with its ability to interface with most data sources, SMART can be used just about anywhere information on the performance or condition of subsea assets needs to be accessed.

SMART includes digital and analog inputs that can be configured to connect to multiple data sources. Internal sensors available for motion measurement include accelerometers, angular rate sensors and inclinometers, as well as standard and high-precision pressure and temperature sensors. External sensors that can be interfaced include pressure sensors, strain gauges and acoustic Doppler current profilers. For more bespoke applications, custom interfaces can be created to link to instruments such as corrosion monitors or vibration measurement tools.

A low-power data logger is a key feature of SMART, enabling data received from external and internal sources to be securely archived. A key benefit of SMART is its ability to process raw data in the subsea environment to provide value-added information, while the advanced data acquisition and processing system, the heart of SMART, contains a highly capable processor that can run sophisticated user-specified algorithms and perform simple data analyses such as min/max/mean statistics and thresholding for alarms and critical event reporting. By reducing high-bandwidth sensor data to small, critical packets and by efficiently managing power consumption, long deployment times can be achieved from the internal battery pack, thereby enhancing users' knowledge of the subsea environment.

In addition, where surface analysis of the telemetered data requires a more thorough review of sensor parameters, SMART enables acoustic recovery of raw data from specified time ranges. Alternately, the system can be coupled via an Ethernet connection to BlueComm (Sonardyne's high-bandwidth through-

Courtesy Sonardyne International

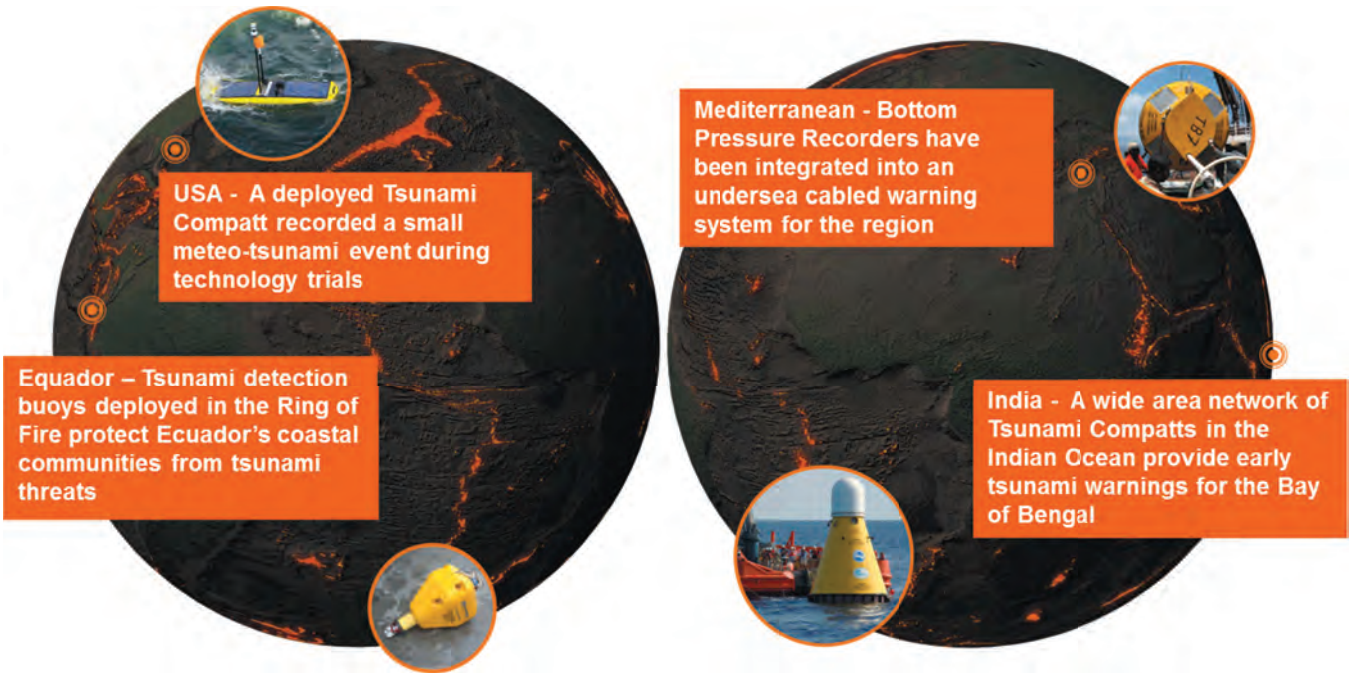
Sonardyne's technology is widely used in ocean science operations, including seabed monitoring, coastal science applications, ocean observations and aquaculture.

water optical communication link), enabling larger quantities of data to be retrieved from an ROV or AUV. All logged data can be downloaded from safe storage when the unit is recovered.

The essence of SMART is flexibility and configurability, and the ability to connect to different sensors and data sources is an integral part of the SMART product line. However, these are not the only options: SMART is available in a range of materials from aluminum and aluminum bronze through super-duplex stainless steel for the highest possible corrosion resistance. Other options include longer 'maxi' housings for increased battery capacity and different connector types and, if required, other functions, including acoustic positioning, can be added to the monitoring system.

Technology Platforms – Optical Communications

In addition to developing acoustic technologies, Sonardyne has in recent years moved into the area of free-space optical communications, successfully bringing to



Courtesy Sonardyne International

Sonardyne subsea sensors are used in conjunction with surface communications buoys to provide essential tsunami warnings to 'at risk' areas.

market high-speed underwater modems.

Bluecomm – BlueComm is a through-water wireless optical communication system that has been developed to transmit subsea data, stream video and perform tetherless vehicle control at very high speeds. The BlueComm modem family is currently made up of three variants: BlueComm 100 is optimized for shallow-water 'high ambient light' operating environments and offers a good balance between data rate and range; BlueComm 200 sends data at up to 12.5 Mbps and is suitable for deep or night-time operations; while the dual laser configuration of BlueComm 5000 supports data transfer rates of up to 1,000 Mbps.

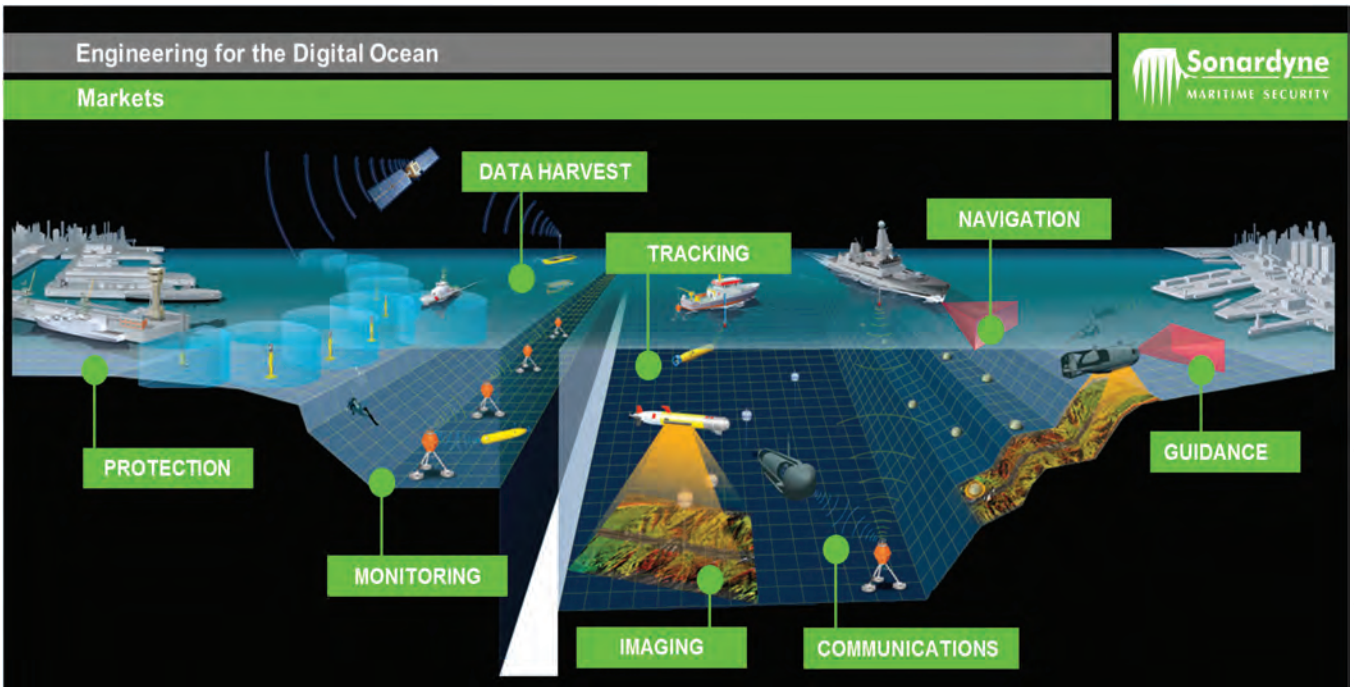
BlueComm uses the electromagnetic spectrum rather than acoustic pressure waves to transmit high volumes of data. Typically operating in the 450nm blue region of the spectrum, BlueComm can achieve data rates of greater than 500 Mbps. This optical data transmission technology is highly efficient, enabling 1 Gb of data to be transmitted with the energy contained within a single lithium D-sized cell over distances greater than 150 meters.

The applications for Bluecomm are extensive: used in conjunction with Sonardyne acoustics, low-bandwidth data can be transmitted acoustically (for example by switching on the optics remotely) and high-bandwidth data such as video or sonar imaging data files can be transmitted using the optical method. Data from seabed data storage centers or data-gathering vehicles can be collected by AUVs and then relayed to ASVs or manned surface units for transmission to ground stations via satellite.

Inertial systems – To complement its state-of-the-art acoustic systems and provide the best possible positioning solutions for subsea vehicles, Sonardyne has developed its own inertial systems, Lodestar and SPRINT. Lodestar is a combined solid-state attitude and heading reference system (AHRS) that is upgradable to become the SPRINT acoustically-aided inertial navigation system. The unit is comprised of three high-grade, high-reliability, commercially-available ring laser gyros (RLG) and accelerometers. The sensors used are the standard for commercial aviation and have a proven track record of more than 15 years and a mean time between failures (MTBF) of more than 400,000 hours.

Lodestar AHRS supports serial, Ethernet and industry-standard telegrams for easier interfacing and advanced outputs such as acceleration and rotation rates are also available. On-board data storage and backup battery functionality ensure continued operation and no data loss even if communications or external power is lost.

SPRINT is an acoustically-aided subsea inertial navigation system for subsea vehicles that makes optimal use of acoustic aiding data from acoustic USBL and LBL positioning and other sensors such as Sonardyne's Syrinx Doppler Velocity Log (DVL) and pressure sensors. This improves position accuracy, precision, reliability and integrity while reducing operational time and



Courtesy Sonardyne International

In addition to its work in the oil and gas sector, Sonardyne is also a major player in the international maritime security market.

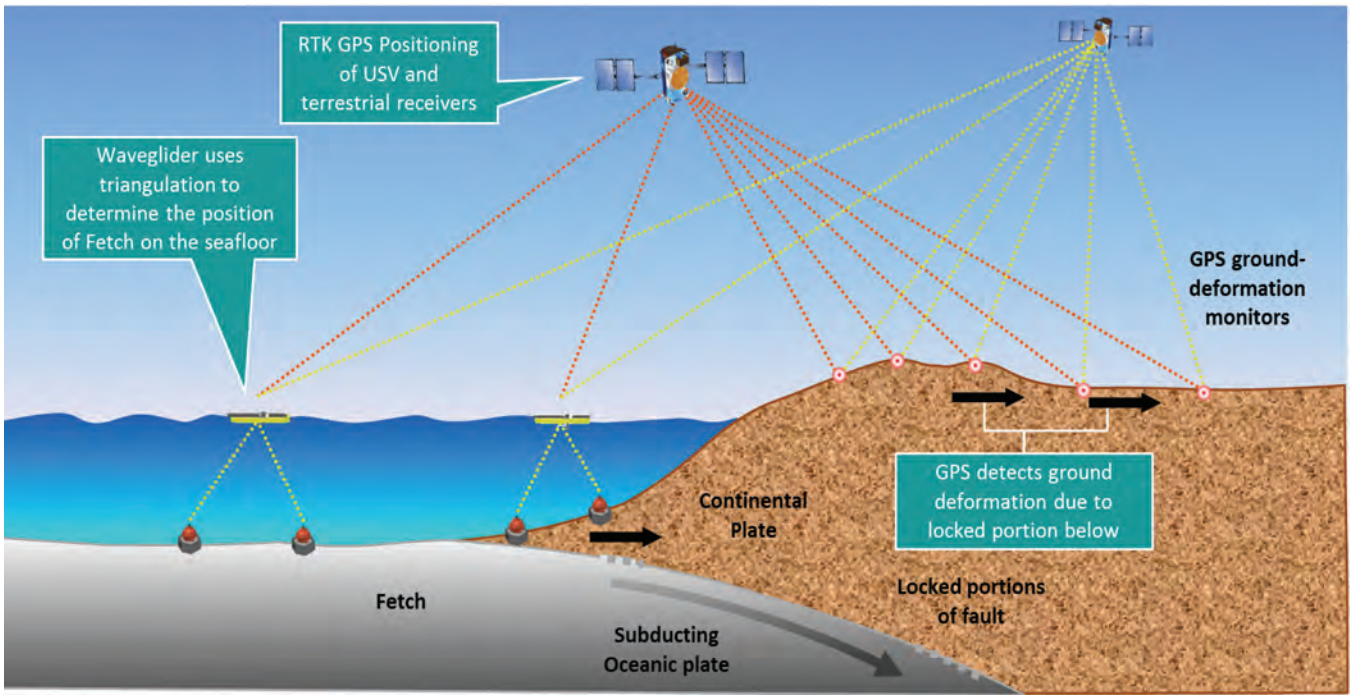
vessel costs. The system extends the operating limits of USBL transmission and can dramatically improve the operational efficiency of LBL systems. Sonardyne's new third-generation SPRINT unit offers power pass-through to aiding sensors, thereby reducing cabling and interfacing complexity.

SPRINT shares the same hardware platform as Lodestar and is a combined AHRS and INS system: running both the AHRS and INS algorithms concurrently allows inertial navigation to start or restart instantaneously on receipt of a position update, as the AHRS seamlessly provides orientation to the INS on start-up, avoiding the lengthy 'alignment' period common to other INS systems. Thereafter, the separate AHRS- and INS-computed orientations are autonomously monitored as an indication of system health.

The levels of accuracy provided by Sonardyne's acoustic-aided INS system SPRINT-Nav are now enabling operators to conduct mobile subsea laser mapping and metrology. Set-up and imaging data-gathering times are greatly reduced and the post-processed results achieved on the numerous trials and experimental projects completed in 2017 have been reported as meeting all user requirements.

Future Challenges

The challenges that remain to be addressed to complete the introduction of automated subsea navigation, positioning and communication center around achieving efficiency of operations and the use of smaller vessels. For example, the intro-



Courtesy Sonardyne International

High-precision Sonardyne subsea sensors are being used as part of a wider observation network to monitor tectonic plate activity.

duction of autonomous surface vessels (ASVs) will represent a culture change, with operator safety cases relying on redundancy and fallback systems to control vessels in the event of satellite navigation failure or error. Other challenges include the introduction and successful uptake of collision avoidance systems.

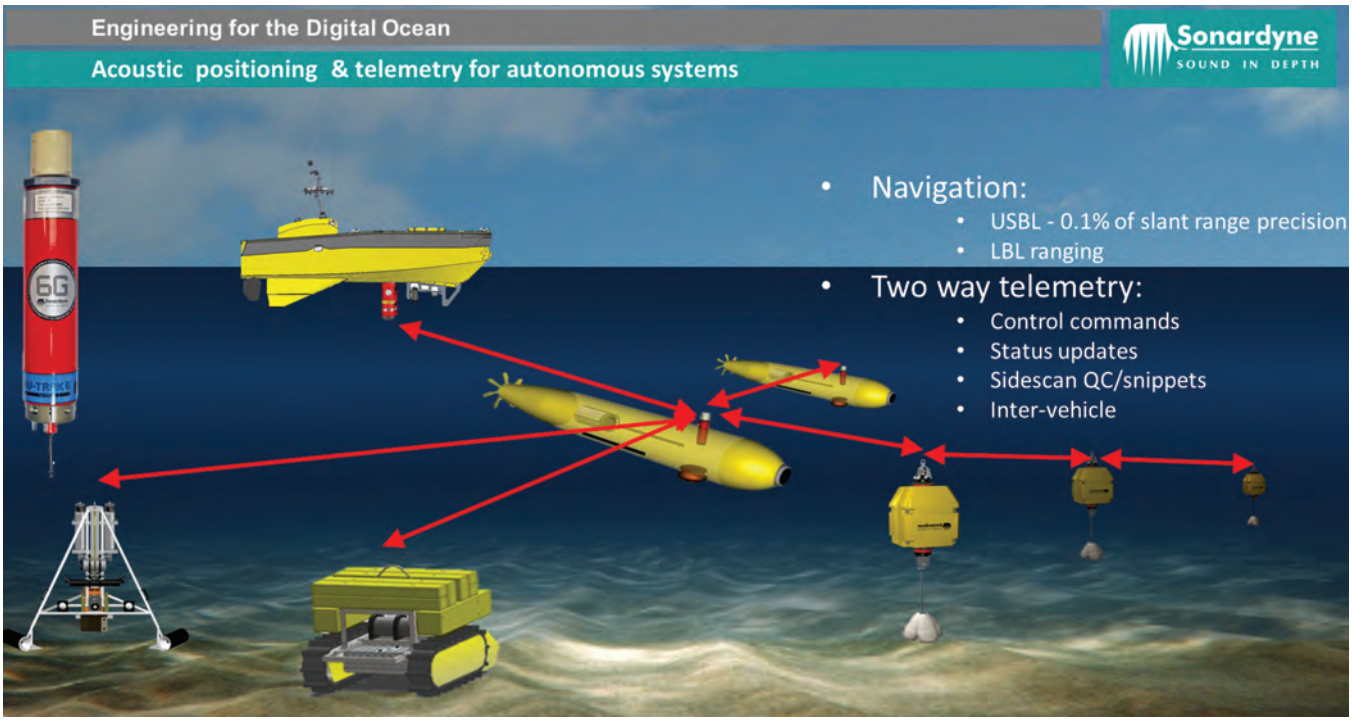
Sonardyne is able to provide a complete suite of integrated systems required for marine autonomy. Platforms such as its AvTrak 6 instrument, which is optimized for AUVs, uses the company's acoustic systems to enable long-distance, two-way low-bandwidth data and communication transfer, while the longest possible distances are achieved using acoustic-relay transponders, thereby greatly increasing the operating ranges of autonomous craft. Position data telemetry from USBL systems can be sent to a subsea vehicle's INS navigation solution processor as part of routine tracking communications and AUV status information can be sent back via the same process. This same telemetry can be used to control systems on the AUV, such as those that update the mission, or to change the settings of on/off sensor or optical modems. In the event of vehicle failure, the AvTrak 6 will also act as an emergency locator beacon, going into standby mode to save its independent battery, and it will wake up and respond to interrogations from any Sonardyne 6G system.

Where to Next?

Sonardyne has been pioneering digital oceanography technology for more than four decades yet the list of applications for the company's technology grows year-on-year, particularly where automation and remote operations are concerned.

Modern technology can land a spacecraft on an asteroid or fly one through the rings of Saturn from a control station on earth, and therefore Sonardyne believes that the operation of an underwater drone in the Earth's oceans is easily within human capability. The company stresses that with fewer (or no) people at sea, the provision of useable data for control, condition-based monitoring and data gathering is paramount, but recognizes that operating on or under the ocean presents significant technical and environmental challenges.

Sonardyne also points out that lines of communication are not point-to-point connections, but that they rely on multiple systems working together, operating in different mediums and changeable environments and with varying bandwidths across the internet, linked via fiber optics, satellites, short-wave or local wifi networks, acoustic modems, optical modems, Ethernet connections and LANs, with a multitude of data formats, protocols and operating systems that engineers have to somehow splice together to provide the seamless connectivity expected by users. Thus the main challenge in achieving effective integration of complex systems is interoperability, with the digital communications companies working together to share information and agree on standardized data strings and protocols. The aviation and automotive industries have demonstrated the success that can be achieved by working in this way, and Sonardyne believes that all sections of the maritime technology industry stand to gain from a collaborative working approach: the digital ocean is already here – it is up to the global marine community to shape it in the way that benefits the growth of the industries that will be using it.



Courtesy Sonardyne International

Sonardyne's AvTrak6 instrument provides AUVs with positioning, communications and emergency location beacon capability in one self-contained unit.

Oi '18

ExCeL London, March 13-15

It's a conference; it's an exhibition; it is arguably the strongest global event for the showcase of new subsea technology. As Oceanology International 2018 (Oi18) approaches, an event scheduled to attract more than 500 companies from more than 79 countries Marine Technology Reporter takes a look inside the exhibition hallways before they open to show you the new tech that will be on display. For tickets to attend the show visit: ***http://www.oceanologyinternational.com/register***

3D at Depth Inc., USA

Booth #: G250

Visitors to Oi18 will be able to participate in 3D at Depth's exclusive AR/VR lounge showcasing their new 3D VR Immersive Collaboration platform "Powered by iQ3". This new 3D data visualization and analysis platform allows customers to transform the value of their offshore 3D data by providing access via any laptop, desktop or smart device through a secure web portal. 3D at Depth will also be conducting workshops and demonstrations of their portfolio of subsea LiDAR products, solutions and survey support services focused on a new tiered data management service. From data collection and processing, through visualization and analysis, 3D at Depth delivers precise, repeatable, millimetric 3D point clouds to measure, map, and evaluate underwater assets, resources and environments. Customers participating in the workshops will receive a set of VR goggles.

ADEDE Search & Recovery, Belgium

Booth #: Q401

ADEDE Search & Recovery, who specialize in services surrounding Unexploded Ordnance (UXO), Geophysics and

Aquabotix
Booth #: F498

AgileTek
Booth #: Q200

Buckleys
Booth #: M100

Archaeology in water and on land, return to Oceanology International 2018, promoting their capabilities to companies and organisations who seek safety and continuity during subsea construction.

Advanced Navigation, Australia

Booth #: B350

Advanced Navigation returns to showcase its new subsea navigation product at Oceanology International, which has been in development for the last 12 months. It will also exhibit its existing products including GNSS Compass & Subsonus. These products are applicable for a wide range of scenarios including ROVs, AUVs, diver tracking and subsea assets.

Daryl Tze Kong Lee, Marketing Coordinator, said: "We are returning to exhibit at Oceanology International 2018 because navigation and positioning is critical to many of our marine customers."

AgileTek

Booth #: Q200

Subsea engineering analysis consultancy, AgileTek, has won the Small Company of the Year Award at this year's Subsea

ASV Global UK
Booth #: G401

UK awards in Aberdeen. The category recognixes excellence in overall company performance in the subsea sector, based on the company's development and impact, as well as plans for future growth.

A.P van den Berg, Netherlands

Booth #: C350

Known for designing and supplying CPT technology for onshore and offshore soil investigation, the ROSON-ST will be A.P van den Berg's focus for Oceanology International 2018. The new model has been developed by incorporating the patented unfolding ST-Rods in the ROSON seabed system to create, a compact and easy to handle ROSON-ST.

AquaBioTech Group, Malta

Booth #: R450

The AquaBioTech Group is an international consulting company strategically located in the centre of the Mediterranean on the island of Malta, operating globally. The AquaBioTech Group undertakes a variety of aquaculture, fisheries and aquatic environmental projects. This is the first time that this exhibitor has attended Oceanology International. AquaBioTech Group will be offering services at the show including new aquaculture assessments; these include environmental surveys, fish net checks and mooring system inspections. Rachel E. Cox – Marine Environmental Consultant, said: "Oi18 will be a great opportunity to meet new and old clients and to show what we have to offer. With business and projects in over 60 countries, we are able to satisfy the needs of many new aquaculture installations, whether it is on-shore, coastal or offshore environments. In addition, the multi-use of space and the multi-use of platforms approach in offshore activities is now mature and ready to be exploited and we are there to share knowledge and identify the new opportunities that this approach creates."

Copenhagen Subsea A/S Copenhagen Subsea A/S, Denmark
Booth #: J201

CHC Navigation, China
Booth #: A109

Aquabotix, USA

Booth #: F498

Aquabotix, the technology leader in portable underwater vehicles, returns to Oceanology International to introduce Integra Hybrid AUV/ROV the next generation of its hybrid vehicles. The Integra is capable of wide area searches in AUV mode and can conduct detailed inspections in ROV mode.

Ted Curley, Aquabotix's Chief Development Officer said: "Oi18 is a great venue for us, our customers and distributors to see the latest technology offerings from us as well as other industry manufacturers. It is also the premier event in our industry to meet, network and socialise."

ASV Global, UK

Booth #: G401

ASV Global will be showcasing the latest addition to its fleet of autonomous vessels, the C-Cat 3. The C-Cat 3 has been developed to complement the existing ocean going ASV Global vessels for survey and support tasks where a smaller vehicle is better suited to missions such as areas of shallow water. The design incorporates a large payload bay to enable flexibility of payloads used. The shallow draft and small size of the vehicle enables deployment in littoral areas and its modular construction facilitates the fitting of a range of scientific above and below water payloads.

BIRNS

Booth #: G450

BIRNS will be demonstrating the advanced technologies that have made the company a leader in deep submergence connectivity for more than half a century. Come to stand G450 to see the latest enhancements to the renowned 6km-rated BIRNS Millennium series, with its revolutionary open-faced pressure rated coax options, two optical ferrules sizes for high density connectors and a wide range of hybrid configurations. BIRNS has been serving the subsea industry since 1954, and

DeepWater Buoyancy
Booth #: C353

our team proudly partners with customers around the globe in defense, manned and unmanned vehicles, oceanographic and oil and gas applications.

BMT, UK
Booth #: N400

BMT will focus on the use and management of data from the marine environment at the show. Its marine and metocean professionals will be on hand to discuss the challenges of managing large data sets and the value of exploring data from multiple sources to improve the design and integrity management of a range of marine assets from offshore oil and gas platforms to wind turbines.

B Marshall Marine Ltd, UK
Booth #: P290

Returning to Oi18 after its first Oceanology International event in 2016, B Marshall Marine Ltd will be joined on its stand by SAND Geophysics.

British Geological Survey, UK
Booth #: N604

This exhibitor will show customers its new mobile solution for small boat mapping using a shallow water towed benthic imager that compliments its existing suite of geological and geophysical mapping tools. Visitors will also be able to see its products in action via videos showing the capabilities of their products.

Buckleys (Uvral) Ltd, UK
Booth #: M100

The BathyCorrometer Pro is the latest generation of the tried-and-tested, industry-standard BathyCorrometer and it will be displayed at Oceanology International. The new model brings a host of developments, designed to make measurement of cathodic protection potentials on offshore structures simpler

Geoquip Marine Operations AG
Booth #: Q400

GNOM ROV WORLD
Booth #: N201

than ever while enhancing the BathyCorrometer's reliability even further.

Business France, France

Booth #: J200, K200, K300

Business France is the national agency supporting the international development of the French economy. They are organizing The France Pavilion in partnership with Pôle Mer Bretagne Atlantique and Pôle Mer Méditerranée, which will host 21 exhibitors at Oceanology International 2018. See them on stands J200, K200 and K300.

CHC Navigation, China

Booth #: A109

If you missed out on Oceanology International China 2017, fear not, as CHC is bringing its most popular products from that show to Oceanology International in London. CHC manufactures competitive, affordable and reliable GPS and GNSS receivers and provides complete positioning solutions for surveying, construction, GIS and marine applications in more than 100 countries.

Copenhagen Subsea A/S, Denmark

Booth #: J201

Copenhagen Subsea A/S will introduce its largest thruster yet, the Version Extra Large (VXL) thruster, which fits well with ROVs, AUVs, and Manned Submersible Vehicles. Its whole product range will be launched at the show with a new and extended depth range. Allan Nygård Bertelsen, Managing Director of Copenhagen Subsea, Denmark, said: "We are returning to Oceanology International 2018 as the 2016 event in London was a great place to meet potential customers. It was also a perfect exhibition for us to be able to showcase our products to the correct markets."

Gesellschaft für Wirtschafts- und Technologieförderung Rostock mbH,
Booth #: C150

DECO Geophysical Software Co., Russia

Booth #: R300

Returning exhibitors, DECO Geophysical Software Co, will offer its RadExPro seismic software, for advanced processing of high-resolution and ultra-high-resolution marine seismic data. RadExPro seismic software is of potential interest for any company or research institution acquiring and processing HR/UHR marine seismic data for geotechnical, engineering, geological or environmental purposes. Live demonstrations are available at their booth on request and they are offering a special show promotion of 10% off regular software prices.

develogic GmbH, Germany

Booth #: G201

develogic GmbH, which develops and manufactures turnkey system solutions for subsea data collection and transmission for marine monitoring applications, will present its new AIS Drifter Buoy and ECB PopUp.

DeepOcean, Norway

Booth #: G651

DeepOcean's ADUS Manager, Mark Lawrence will speak at the Subsea imaging metrology conference about DeepOcean's vision on the development for innovative approaches to manage, manipulate and visualise large point cloud data sets.

DeepWater Buoyancy, USA

Booth #: C353

It is this exhibitors debut at Oceanology International 2018. DeepWater Buoyancy will be introducing visitors to the show its Pop-Up Buoy Recovery System (PUB) which it has added to its line of subsea buoyancy products and the StableMoor, which is specifically engineered for high current applications, designed to reduce drag and increase mooring stability in extreme flow regimes. David Capotosto, DeepWater Buoyancy Director of Business Development, said: "This is an excellent show. "

H2O Robotics
Booth #: N302

Noliac A/S
Booth #: A50

EdgeTech, USA
Booth #: H201

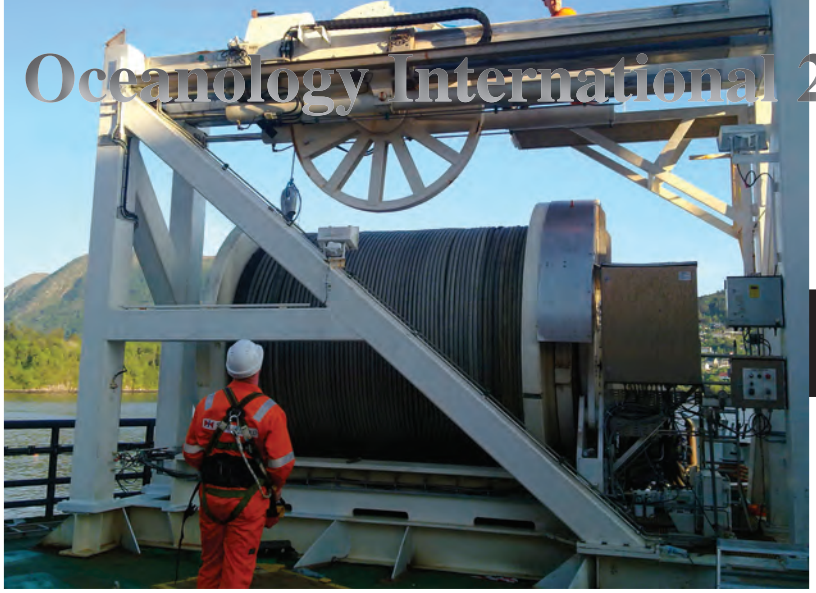
EdgeTech is known for side scan sonars, sub-bottom profilers, bathymetry systems, AUV, USV and ROV-based sonar systems, combined sonar systems, USBL systems, transponder beacons, deep sea and shallow water acoustic releases and customised underwater acoustic systems. It will launch four new products at the show: the 4205 TRI-FREQUENCY / MOTION TOLERANT SIDE SCAN SONAR SYSTEM, the 3400 Sub-bottom profiler, the 8212 Rugged Shallow Water Acoustic Release and 6205s a new Combined Bathymetry & Side Scan Sonar System.

EIVA a/s, Denmark
Booth #: D500

Celebrating its 40th anniversary, EIVA a/s, will be presenting a new deep learning software solution launched late 2017 at Oceanology International. It will also have demonstrations of the NaviSuite software products for subsea and above-water engineering and surveying tasks. Visitors can also see miniature models of the ScanFish ROTV range and ToughBoy wave buoy.

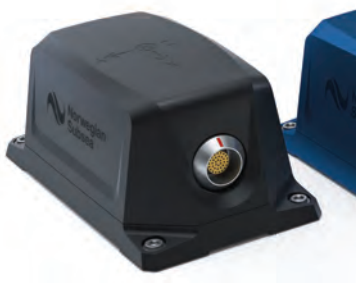
EvoLogics
Booth #: C251

EvoLogics S2C communication technology spans over an ecosystem of products, including several series of underwater acoustic modems and positioning systems (USBL, LBL, SBL). Keyword is “modular” - most products are designed to be customized. EvoLogics strives to offer highly configurable solutions instead of “bespoke tailoring” for a particular operation (still possible, as every scenario is unique). Pre-configured modules allow to build a device that precisely caters to the client’s application.



Hampidjan
Booth #: R490

Norwegian Subsea
Booth #: N450



maxon motor GmbH
Booth #: A500

Geoquip Marine Operations AG, Switzerland
Booth #: Q400

Visitors can learn of the Dina Polaris project, a brand new Multi-Function Offshore Support Vessel, which gained a 'Clean Design' certificate with help from Geoquip's deep water heave compensated geotechnical drill rigs. Deep water drilling capacities demonstrations will also take place on the stand.

Gesellschaft für Wirtschafts- und Technologieförderung Rostock mbH, Germany
Booth #: C150

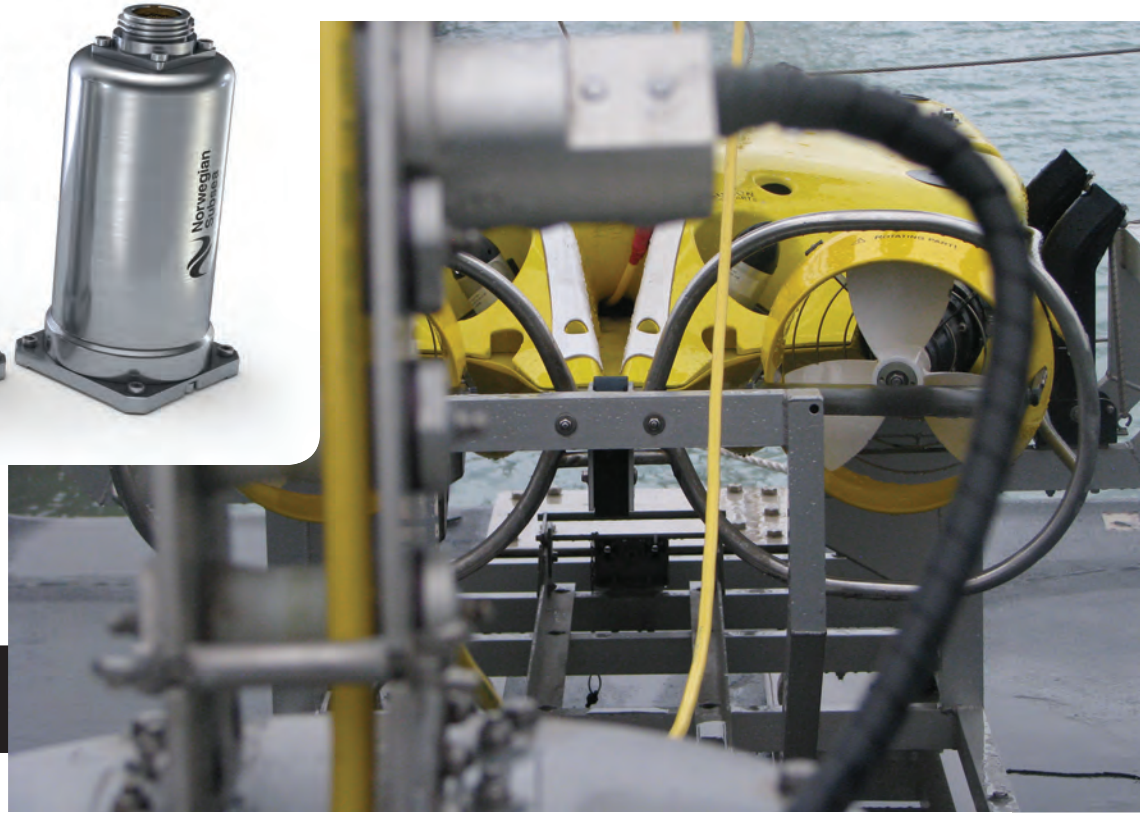
It is the first time that this exhibitor has contributed to Oceanology International. It will promote and present the new European project "INTERMARE South Baltic". INTERMARE South Baltic is an Interreg South Baltic Programme project undertaken to support the maritime economy in the whole region of the South Baltic through a network of companies and stakeholders joined under the common brand INTERMARE South Baltic. This exhibitor will also be doing a presentation about the project on Thursday 15 March at 1.20pm in the Trade and Innovation Theatre.

GNOM ROV WORLD - NORD SLOVAKIA
Booth #: N201

Having been with the Oceanology International community since 2000, GNOM ROV will launch the new compact ROV GNOM-PRO-4G at this year's event.

H2O Robotics, Croatia
Booth #: N302

At Oi18, H2O Robotics will present its first product as a spin-off company from University of Zagreb, Faculty of Electrical Engineering and Computing, from the Laboratory for Underwater Systems and Technologies. The product is an autonomous unmanned marine surface robot (USV)



Novacavi
Booth #: N200

RBR Ltd.
Booth #: G551

called 'aPad'. The aPad is easy to operate, lightweight, omnidirectional, has long-term deployment capabilities, open source software architecture and is competitively priced. Have a look on stand N302.

Hampidjan, Iceland

Booth #: R490

This returning exhibitor will be highlighting its range of DYNICE and DYNICE Dux ultra-high performance fibre ropes suitable for winching, lifting, mooring and general purpose applications. Visitors can also see the DYNICE Data, a lightweight data transfer cable for deep sea operations.

Impact Subsea Ltd, UK

Booth #: P350

Impact Subsea Ltd will be launching a new underwater sensor for ROV & AUV applications. Visitors to the exhibition can also see its range of ROV & AUV sensors: Altimeters, Depth, AHRS & FMD Systems.

Kongsberg Maritime

Booth #: D600

Norwegian marine technology specialist Kongsberg Maritime, a veteran Oceanology International exhibitor, will focus on it established and industry leading technology and solutions that enable the contemporary 'Digital Ocean' at Oi18. With emphasis on streamlining and simplifying the journey of data from below the surface to vessel, and forward to shore, Digital Ocean is built on KONGSBERG's well-known expertise in subsea technology, communication systems, data platforms and post processing solutions, many of which will be shown on its Oi18 stand.

KW Designed Solutions Ltd, UK

Booth #: B451

KW Designed Solutions is exhibiting for the first time and will

Rowe Technologies
Booth #: H450

be highlighting its existing product range and emphasizing its position as a leading supplier of bespoke special purpose pressure vessels, pressure testing equipment and associated pressure control systems. There will also be demonstrations on its stand, including the innovative ability to mate/de-mate electrical connectors during electrical testing within a pressure vessel, while subjecting the connectors to sand/silt - harsh subsea conditions.

maxon motor GmbH, Germany
Booth #: A500

maxon motor GmbH returns to Oi18 to promote its new underwater products and position as a supplier for underwater propulsion. It will introduce the new maxon Thruster 20. The MT20 is the smallest thruster with an outer diameter of 22mm. It can penetrate to depths up to 6000 meters, with a very energy efficient drive. The thruster can operate for over 1000 operational hours.

Miros AS, Norway
Booth #: C250

A long-standing Oceanology International exhibitor since 1998, Miros AS will launch the new stand-alone SM-050 Wave Radar with embedded wave processing and Web interface utilising modern IoT technologies. Miros will also present the entire range of remote sensing wave monitoring and oil spill detection products and Metocean system solutions.

Norcom Technology Limited, UK
Booth #: A525

Norcom Technology Limited, an independent software development company, will be demonstrating its new weather program ‘Weather Track’, which was launched at the London Boat Show in January 2018.

Noliac A/S, Denmark
Booth #: A50

Tecnadyne
Booth #: L700

RTsys
Booth #: J551

A piezoelectric technology specialist, Noliac A/S will be showcasing its piezoelectric single crystal components, which provide much wider bandwidth and higher sensitivity to underwater applications. This can improve the capabilities of the applications, e.g. for navy sonar arrays, vector sensors and hydrophones. They will also be returning with their market leading range of piezoelectric components and a selection of custom designed plug-and-play transducers.

Northern Diver International Ltd, UK

Booth #: P251

This exhibitor manufactures a wide range of drysuits, diving equipment and other equipment for use in, on and around water - for sport, commercial, military and rescue applications around the world. At the show they will promote their expansion of products in the commercial and offshore range. Products include: SOLAS Approved Transit Suit, LARS: Diver Launch and Recovery System with cage and NIMROD, a modular diver hand-held sonar & navigation console.

Norwegian Subsea, Norway

Booth #: N450

It is only the second time that Norwegian Subsea has exhibited at the show. This exhibitor delivers high performance MRUs, INS and motion sensors for subsea and marine use. Visitors to the show will be able to see live demonstrations of their MRU 6000 Marine and MRU 7000 Subsea as well as take a look at their existing product ranges such as MRU 3000 Marine.
Lars Torgersen, Managing Director of Norwegian subsea said: “Oceanology International 2018 is one of the best arenas to meet new and existing customers, suppliers and competitors in the marine and subsea business.”

Novacavi, Italy

Booth #: N200

Novacavi is showcasing its extensive range of extra

Xsens
Booth #: A250

Valeport
Booth #: H301

performance bespoke cables to be suitable in any harsh environment conditions with special attention to its latest extra performance cable for subsea demining.

Oceanscan Ltd., UK
Booth #: F570

Oceanscan is taking the opportunity at Oceanology International to network with clients and customers to better understand their needs, while working with suppliers to ensure we have the right solutions for future projects, such as the Sonic 2024, the world's first broadband - wideband high-resolution shallow water multibeam echo sounder - making the investment for you.

RBR Ltd, Canada
Booth #: G551

Ocean measuring equipment company RBR Ltd will be focusing on its new Generation³ logger products. Two primary factors sum up RBR's Generation³ instruments; USB-C as the standardised connector on every instrument; and AA batteries – any AA battery, from alkaline to lithium – on every instrument.

Explaining why exhibiting at Oi18 is important, Krista Brunette, Marketing Coordinator for oceanographic instrument manufacturer RBR Ltd in Canada said: "It's by far one of the biggest shows. With a wonderful group of exhibitors, it really draws in a large international crowd. Exhibiting at Oi 2018 allows us to connect with many of our customers, and other industry professionals. It also allows RBR to be discovered by visitors, perhaps considering our instruments for future projects and deployments."

ROMONA Inc, Russia
Booth #: H241

Oceanology International first-timers, ROMONA Inc, is aiming to promote its marine survey services for oil-and-gas

VideoRay
Booth #: E200

industry. With over 25 years' experience, the company offers services to the Site Surveys, Geophysical, Hydrographical and Geotechnical Survey, and Marine Construction support markets.

Rowe Technologies

Booth #: H450

Rowe Technologies employs a highly innovative staff with over 250 years of experience in development, and manufacturing of leading-edge Acoustic Doppler Current Profiler (ADCP) and Doppler Velocity Log (DVL) sonar systems. These sonars are deployed on moving vessels or fixed moorings simultaneously measuring vertical profiles of 3-axis currents, echo Intensity, and plankton/sediment size distribution, plus bottom velocity and altitude.

Rowe will release its third generation (ADCP 3) which expands ADCP capability by:

- Employing cutting-edge phased and piston array transducer technology to produce dual-frequency 4 or 5 beam sets from a single transducer array, achieving both high resolution and long-range profiling from a single ADCP.
- Dual up/down transducers to extend the profile measurements in subsurface applications.
- Advanced low power electronics for adaptable acoustic and processing operation and long battery life.
- Mooring depth range of 200-6000 m.

RTsys, France

Booth #: J551

A key manufacturer of underwater listening systems, RTsys will be introducing its multi-hydrophone antenna, an antenna composed of 16 hydrophones connected to an underwater acoustic recorder, the SYPod buoy, a small buoy geolocated by GPS to make acoustic acquisition on a channel and transmit data collected in real time by radio link, and its new embedded web interface dedicated to check in real-time data

Teledyne Marine

With 23 brands, Teledyne Marine has plenty of new offerings to display at **Booth #: F100, G100**

Teledyne TSS
HydroPACT 660

Teledyne TSS
HydroPACT 440

from sensors stations (oxygen, temperature, video camera, acoustics…). RTsys will conduct presentations on its stand through the show.

Tecnadyne, USA

Booth #: L700

Tecnadyne will be introducing its line of six high efficiency AUV thrusters to the global community at Oceanology International. With exceptional open water performance, these thrusters can be custom configured to suit any AUV thrust and speed requirements. Additionally, Tecnadyne will be introducing the Model 450 low cost thruster, addressing the needs of OEM manufacturers of low cost ROV's and USV's. Tecnadyne will also be exhibiting its existing line of underwater thruster motors, rotary and linear actuators and pressure compensators.

Teledyne CARIS, Canada

Booth #: H500

Teledyne CARIS will launch two new products to visitors at Oi18: HIPS and SIPS 11.0 and CARIS Onboard 2.0. These product lines continue to provide the latest features and capabilities for bathymetric processing, but now more user friendly and intuitive through a greatly simplified workflow and powerful process automation engine. Customers who visit its stand will also be able to watch live demonstrations in conjunction with Teledyne Marine. They will be running live on-water demos showcasing the processing power of CARIS Onboard and how it can streamline survey operations. Multibeam data will be streamed in real-time to the Teledyne CARIS booth, allowing delegates to watch seafloor mapping instantly unfold.

Teledyne Marine

Booth #: F100, G100

Teledyne Marine is an organization comprised of 23 undersea technology brands. Here is a snapshot of its planned exhibition in London.

- **Teledyne TSS**

HydroPACT 660

Small form factor pipe tracking and detection system, designed to reduce overall survey costs by being suitable for smaller subsea vehicles.

HydroPACT 440
24VDC Upgrade Kit

Enhancing the existing product range by providing the first DC power pod for the HydroPACT 440. This 24DVC power pod is also available as on option on the HydroPACT 660.

Saturn-INS

High accuracy fiber optic inertial navigation system, for marine survey and navigation applications. Available in three

Teledyne TSS
Saturn-INS

Teledyne ODI
CAN Bus Active Flying Leads

accuracy variants, in a surface or subsea housing.

• Teledyne Bowtech

Low Light IP

Low Light Monochrome IP camera designed for networked low light underwater viewing tasks. It features a wide 103° diagonal angle of view, depth rated to either 2000m, 4000m or 6000m.

HD Zoom IP

Wide Angle 10:1 Zoom IP camera ideal for overall scenes and close-up inspection, with 10:1 optical zoom and 75° diagonal angle of view, housed in a 4000m rated casing.

Upgraded LED-K Lamp

The newly updated LED-K-Series is a multipurpose lamp of various lumen outputs and colour temperatures, highly suited to colour video inspection tasks, for ROVs rated to 3000m.

GigE Camera

Compact CMOS camera with global shutter, and networkable with high speed video over Ethernet, the GigE is a low noise solution ideally suitable for viewing fast moving objects.

• Teledyne ODI

CAN Bus Active Flying Leads

Teledyne has recently qualified three new configurations that extends the range of a subsea CAN bus signal to up to 5,000 meters. With the additional variations, an additional subsea electronics control module is now unnecessary, as sensors can be located in the most efficient location within the network.

• Teledyne Impulse-PDM

Omicron 12K Connector

Reliable fiber optic connection up to 12,000 meters in a compact, cost-effective package.

• Teledyne Gavia

SeaRaptor

The SeaRaptor is a survey grade, deep water autonomous underwater vehicle (AUV). The system is depth rated to 3000m or 6000m and designed to carry a broad range of sensors.

Teledyne RESON

SeaBat T20 MotionScan

The SeaBat T20 MotionScan is a pan & tilt configuration, based on the renowned and compact SeaBat T20 high-resolution multibeam echo sounder.

Installed on a dredge barge the SeaBat T20 MotionScan will, literally at the push of a button, map the work progress in seconds – saving contractors both time and money. As a part of the modular SeaBat T-series, the T20 MotionScan can also easily be reconfigured to more traditional survey tasks.

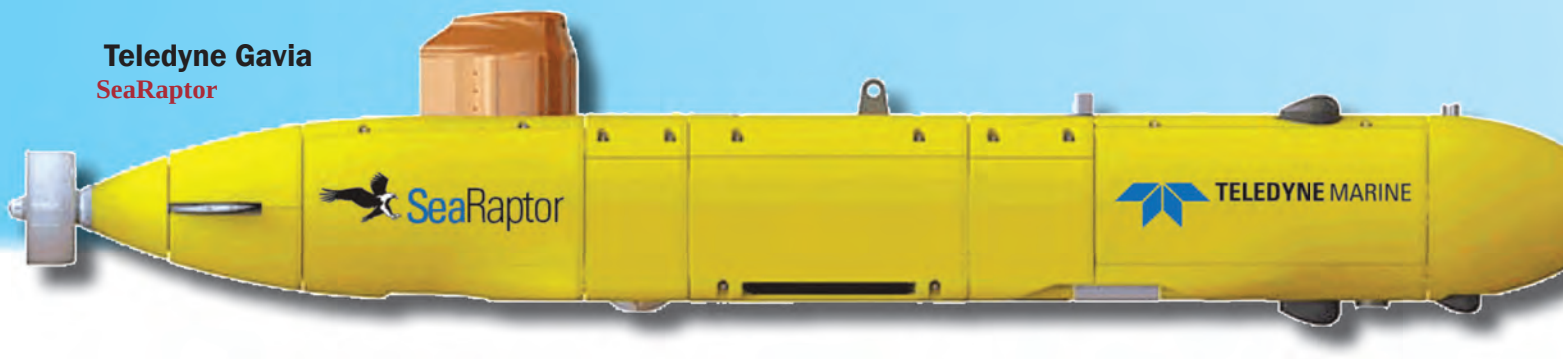
Oceanology International 2018 Tech Preview

Teledyne Marine

With 23 brands, Teledyne Marine has plenty of new offerings to display at **Booth #: F100, G100**

Teledyne Impulse-PDM
Omicron 12K Connector

Teledyne Gavia
SeaRaptor



• Teledyne SeaBotix

SmartFlight 2.0

SeaBotix SmartFlight 2.0, powered by GreenSea, delivers the latest capabilities in semi-autonomous navigation for advanced vLBV vehicle controls delivering stable, fly-by-wire vehicle performance.

ROV Simulator Software

New and experience pilots can learn or hone their ROV piloting skills using this advanced training platform that offers a variety of options and equipment to simulate real world environments.

• Teledyne Oceanscience

Z-Boat 1250

The Z-Boat 1250 is a one person portable unmanned surface vehicle designed to survey areas that were previously inaccessible with larger boats. Equipped with a single beam echosounder, the system is perfect for a multitude of applications.

• Teledyne Webb Research

Slocum Glider Rechargeable Batteries

The new Slocum rechargeable batteries provide the greatest endurance available when compared with other rechargeable gliders and can drastically reduce the cost of glider operations.

TR Arastirma Gelistirme Uretim Yazilim San. ve Tic. Ltd. Sti, Turkey

Booth #: H710

It will be the first time that TR ARASTIRMA GELISTIRME URETIM YAZILIM SAN. VE TIC. LTD. STI (shortly TR ARGE) has exhibited at Oceanology International. This exhibitor will be bringing its range of ROVs and AUVs and also its subsea solutions. Demonstrations of the products will be available through videos at their stand.

Valeport Ltd, UK

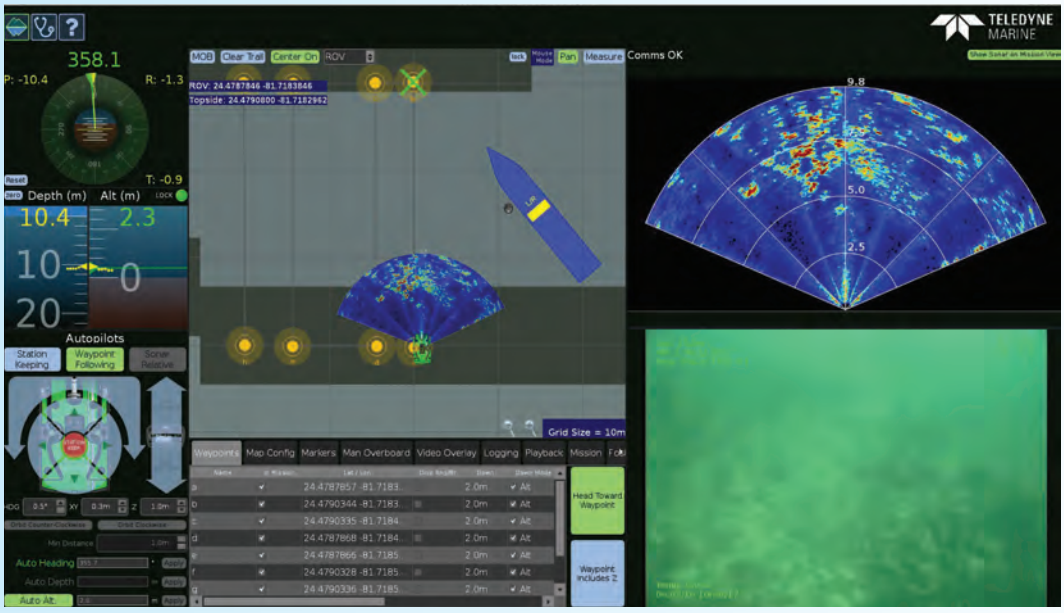
Booth #: H301

Valeport, a manufacturer of Hydrographic and Oceanographic instrumentation, returns to Oceanology International 2018 with a new product – the SWiFT plus which is a combined SVP/CTD with Turbidity. Visitors to the show will also be able to see the upgraded rapidSV and CTD probes.

Kevin Edwards, Head of Sales for Valeport Ltd, said: “We are returning to exhibit at Oceanology International 2018 because it is the biggest international show for our industry with the right cross-section of visitors. We look forward to showing customers our new and existing products.”

Teledyne RESON
SeaBat T20 MotionScan

Teledyne SeaBotix
SmartFlight 2.0

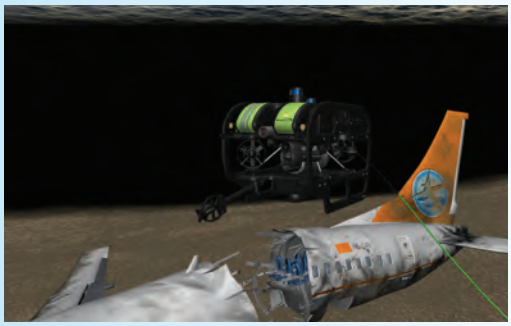


Teledyne Marine

With 23 brands, Teledyne Marine has plenty of new offerings to display at **Booth #: F100, G100**

Teledyne SeaBotix

ROV Simulator Software



Teledyne Oceanscience

Z-Boat 1250

Teledyne Webb Research

Slocum Glider Rechargeable Batteries

VideoRay LLC, USA

Booth #: E200

VideoRay, the leading manufacturer of portable observation-class ROVs in the world, will be launching the Mission Specialist Defender configuration at this year's Oceanology International. The Defender utilizes modular components providing customers unrivalled flexibility and reliability for their underwater missions. Product demonstrations including the Defender and Pro 4, will be taking place at VideoRay's stand throughout the week. Stop by during the show for giveaways and a sneak peek at some other new technologies.

Xsens, The Netherlands

Booth #: A250

Xsens will be showing the upgraded MTi portfolio for the first time at Oceanology. The hardware upgrade means improved performance on these key areas: higher accelerometer resolution, up to 50% reduction in accelerometer noise, up to 75% increase in bias stability for accelerometers, 60% reduction in magnetometer noise, 50% reduction in barometer noise, better sensor specifications for accelerometers and magnetometer and improve In-Run Compass Calibration (ICC) and Magnetic Field Mapping (MFM) performance.

Zunibal, Spain

Booth #: A405

It is the first time that Zunibal has exhibited at Oceanology International. It will launch the ANTEIA Wave Buoy, a wave measurement buoy applied to Oceanography. It provides all statistical and spectral parameters related to waves and includes the possibility of having wave-by-wave information in real time.

(Image credit: Rebecca Carey, University of Tasmania, Adam Soule, WHOI, ©Woods Hole Oceanographic Institution)

Studying the Largest Underwater Volcanic Eruption

High-resolution seafloor topography of the Havre caldera mapped by the autonomous underwater vehicle (AUV) Sentry shows the new 2012 erupted lavas in red. The volcano is nearly a mile deep (1,519 meters). The top of the volcano is at 650 meters below sea level.

In July 2012, airline passengers flying over the Southwest Pacific Ocean spotted a large and unusual object floating on the water's surface, which turned out to be a giant raft of pumice from an underwater volcanic eruption. As the raft continued to grow to roughly the size of Philadelphia, scientists observed that the eruption was extraordinarily large.

The eruption had occurred at the Havre volcano northeast of New Zealand, and was the largest to take place underwater in the past century.

"We knew it was a large-scale eruption, approximately equivalent to the biggest eruption we've seen on land in the 20th century," said Rebecca Carey, a volcanologist at University of Tasmania and co-chief scientist on the expedition to investigate the silicic eruption—a particular type of eruption that produces viscous, gas-filled lava, that often occurs explosively.

In 2015, the University of Tasmania led a mission to explore, map and collect erupted materials from the Havre volcano, together with scientists from Woods Hole Oceanographic Institution (WHOI), the University of California Berkeley, the University of Otago in New Zealand and others on board the research vessel Roger Revelle operated by the Scripps Institution of Oceanography.

Their paper published January 10, 2018 in the journal *Science Advances* describes the first up-close investigation of the historic volcanic eruption and reveals several surprises.

"Heading to the site, we were fully prepared to investigate a typical deep-sea explosive eruption," said Adam Soule, WHOI associate scientist and chief scientist for the National Deep Submergence Facility.

"When we looked at the detailed maps from the AUV, we saw all these bumps on the seafloor and I thought the vehicle's sonar was acting up," Soule said. "It turned out that each bump was a giant block of pumice, some of them the size of a van. I had never seen anything like it on the seafloor."

Havre is part of the Kermadec Arc, a chain of volcanoes, some of which reach the surface to form the Kermadec Islands, between New Zealand and American Samoa. The volcanoes are formed by conditions at the subduction zone where one of Earth's largest tectonic plates, the Pacific Plate, dives beneath the Australian Plate.

Scientists from New Zealand had previously mapped the Havre volcano, a caldera nearly 4.5 km across on the seafloor northeast of the country's North Island, using shipboard sonar instruments in 2002, and again immediately after the eruption in 2012, revealing the presence of new volcanic material on the seafloor.

More than 70 percent of Earth's volcanic activity occurs on the seafloor, but details of these events are largely hidden from view by seawater.

Despite their violence, little is known about silicic eruptions, and most knowledge about them comes from ancient rock records that lack details such as the timing, duration, source and water depth of the events. Prior to the Havre eruption, scientists have never been able to study a large underwater silicic eruption shortly after it occurred.

Seeking new information on the events at Havre, the research team in 2015

"When we looked at the detailed maps from the AUV, we saw all these bumps on the seafloor and **I thought the vehicle's sonar was acting up.** It turned out that each bump was a giant block of pumice, some of them the size of a van. **I had never seen anything like it on the seafloor."**

Adam Soule, WHOI associate scientist and chief scientist for the National Deep Submergence Facility

deployed the autonomous underwater vehicle (AUV) Sentry in a series of 11 dives that mapped more than 19 square miles (50 sq. km) of seafloor. The team also conducted 12 dives totaling 250 hours with the remotely operated vehicle (ROV) Jason to collect samples of erupted material and to capture high-resolution imagery of the seafloor inside the crater.

The scientists discovered that the Havre volcano's eruption history was much more complicated than they previously thought, with the most recent eruption alone consisting of lava from 14 volcanic vent sites between 900 and 1,220 meters below the surface.

They also discovered that, what they thought was initially an explosive eruption that would produce mainly pumice, also created ash, lava domes and seafloor lava flows. Of the material that erupted, which was nearly 1.5 times larger than the 1980 eruption of Mount St. Helens, about 75 percent floated to the surface and drifted away with winds and currents, while the rest was spread across the seafloor up to several miles away.

"Ultimately we believe that none of the magma was erupted in the ways we assume an explosive eruption occurs on land," Soule said.

Material collected using ROV Jason confirmed the diverse nature of the eruption, bringing samples of dense lava, ash, pumice and giant pumice to the surface, including one piece measuring 5 feet (1.5 meters) in diameter that is the first of its kind ever collected and is currently on display at the National Museum of Science and Nature in Tokyo.

The physical and chemical composition of these samples are now helping scientists learn how the eruption proceeded, what made it act the way it did, and how the material changes over time.

www.whoi.edu

New Product

Qimera 1.6 – New Automatic SV Correction Tool

QPS unveiled the sixth release of Qimera with version 1.6. With the release QPS is providing several new tools and feature enhancements which include but are not limited to: Electronic Chart (ENC) creation & editing, Sound Velocity correction filter, enhanced LiDAR functionality, water column geopicking. Reusing underlying technology from Qarto and Qomposer for Qimera, QPS has introduced the creation and editing of ENC object to Qimera. ENC objects can now be created directly from soundings and/or from a Dynamic Surface. Users can also import an ENC and edit existing attributes, and can create these objects using the 3D Viewer, Swath Editor, Slice Editor or in the water column viewer. This new feature is designed to make it easy for the user to mark the shallowest point of a wreck and deliver this as an S-57 object including all meta information to the cartographer. The SV correction tool represents addition of significant innovation into Qimera. Working together with the Technical University of Delft (TU Delft) in the Netherlands, QPS incorporated its sound speed inversion algorithm in QPS Qimera. The TU Delft algorithm allows for a completely automated refraction error correction. This automated and objective algorithm works by taking advantage of the overlap between survey lines, harnessing the power of redundancy of the multiple observations. For a given set of pings, the algorithm simultaneously estimates sound speed corrections for the chosen pings and their neighbors by computing a best-fit solution that minimizes the mismatch in the areas of overlap between lines. This process is repeated across the entire spatial area, allowing for an adaptive solution that responds to changes in oceanographic conditions. For accountability, the algorithm also preserves the output of the inversion process for review, vetting, adjustment and reporting.

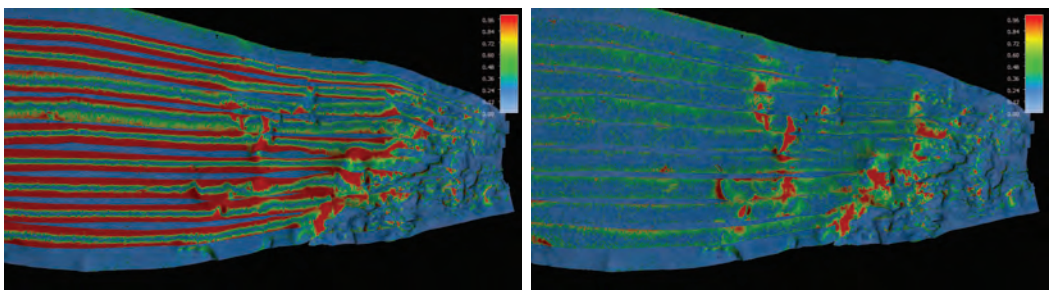


Image showing the standard deviation (2 Sigma) as well as cross section of several lines before (left) and after applying the sound velocity refraction error correction

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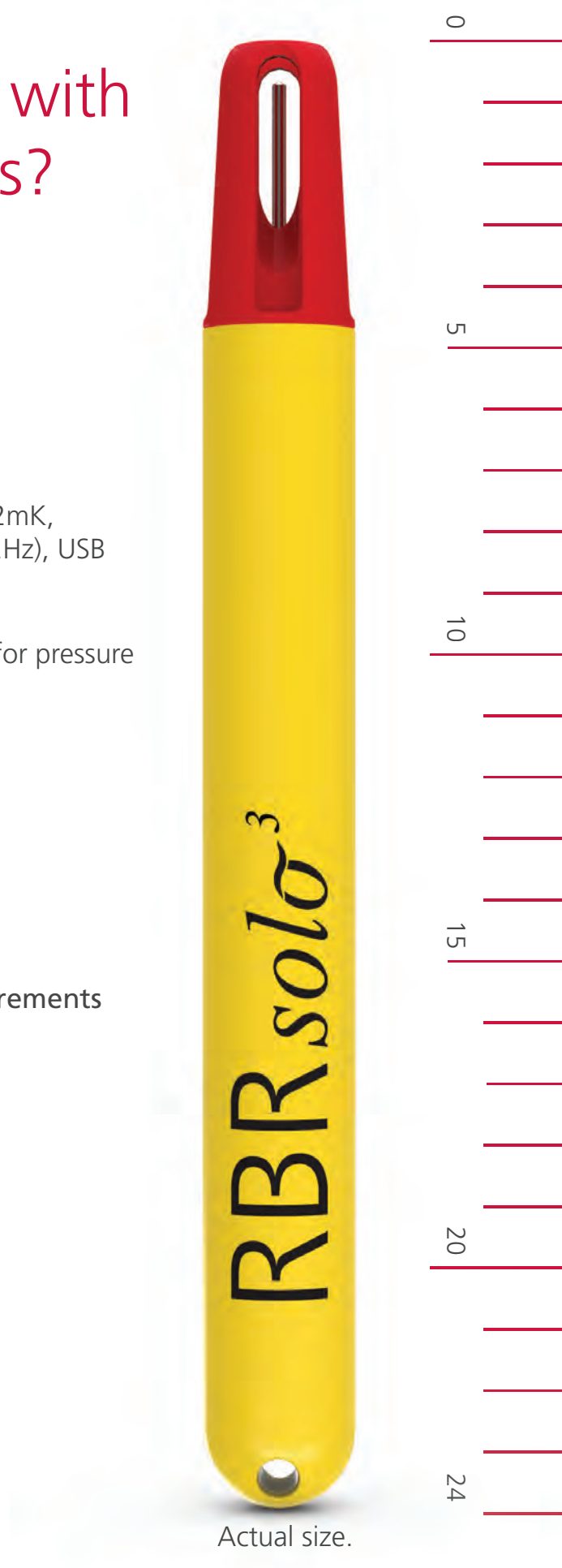

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