

# Hydro

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THE GLOBAL MAGAZINE FOR HYDROGRAPHY

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**World's Largest Planned  
Tidal Stream Project**

**Monitoring Underwater  
Noise in the North Sea**

**Exploring the Deepest  
Points on the Planet**

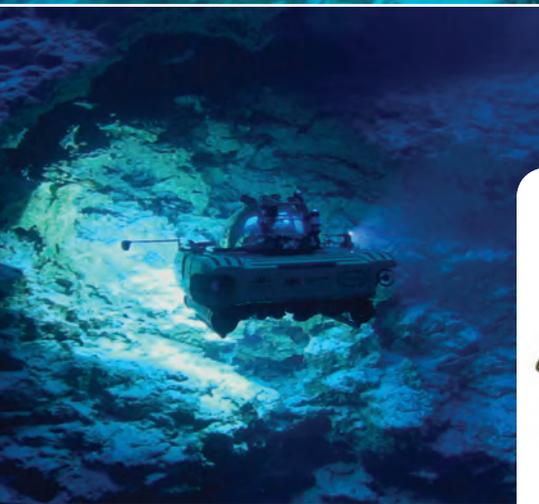
# Deep down in the Indian Ocean

## Teledyne Marine delivers solutions for NEKTON'S First Descent mission

Undoubtedly, the most visual Teledyne product used on NEKTON's First Descent mission to explore the little-known Indian Ocean is a Teledyne Bowtech underwater camera. The new Surveyor-HD-Pro ultra-wide underwater HD camera has been designed to provide the widest angle of view, while remaining compact and competitively priced. The stunning images collected from this recent expedition using this camera speak for themselves, providing amazing clarity and field of view.

To learn more about Teledyne Bowtech's camera and light solutions, visit: [www.teledynemarine.com/bowtech](http://www.teledynemarine.com/bowtech)

To learn more about Nekton's First Descent, visit: [www.nektonmission.org](http://www.nektonmission.org)



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## P. 14 Eco-engineers Strive to Save Endangered Species

Could a new type of patented marine technology be used to preserve some of the planet's most valuable commercial species of fish, while also helping to rebuild damaged reef systems? The team at ARC Marine believe so. In this interview, co-founders Tom Birbeck and James Doddrell explain their innovative solution to one of the world's most urgent marine challenges.



## P. 20 Investigating a Non-polluting Alternative to Diesel

Marine research and hydrographic activities could soon be possible without the risk of polluting either the air or the ocean. It is thanks to a new zero-emissions ship design and feasibility study led by Sandia National Laboratories.



## P. 22 Exploring the Deepest Points on the Planet

As extreme explorer Victor Vescovo continues his round-the-world expedition to become the first person to descend to the five deepest points in the Earth's five oceans using the custom-built deep submergence vehicle *Limiting Factor*, it prompts the question: 'Do we know as much about the deepest places on our planet as we thought?'



## P. 26 Will Hydrographic Geospatial Data Pass the Fit-for-purpose Test?

In 2017, OceanWise outlined the work of the UN-GGIM. The Committee of Experts endorsed the terms of reference for establishing a Working Group on Marine Geospatial Information. Dr Mike Osborne and John Pepper provide a timely update on what has been happening since then.



## P. 30 Next Step in your Hydrographic Career

Certification is the next step in your hydrographic and offshore surveying career, according to experienced hydrographic surveyor Bruce Calderbank. The Canadian Hydrographer Certification Scheme (CHCS) is a global scheme just as with the Australasian Hydrographic Surveyor Certification Panel (AHSCP) scheme.



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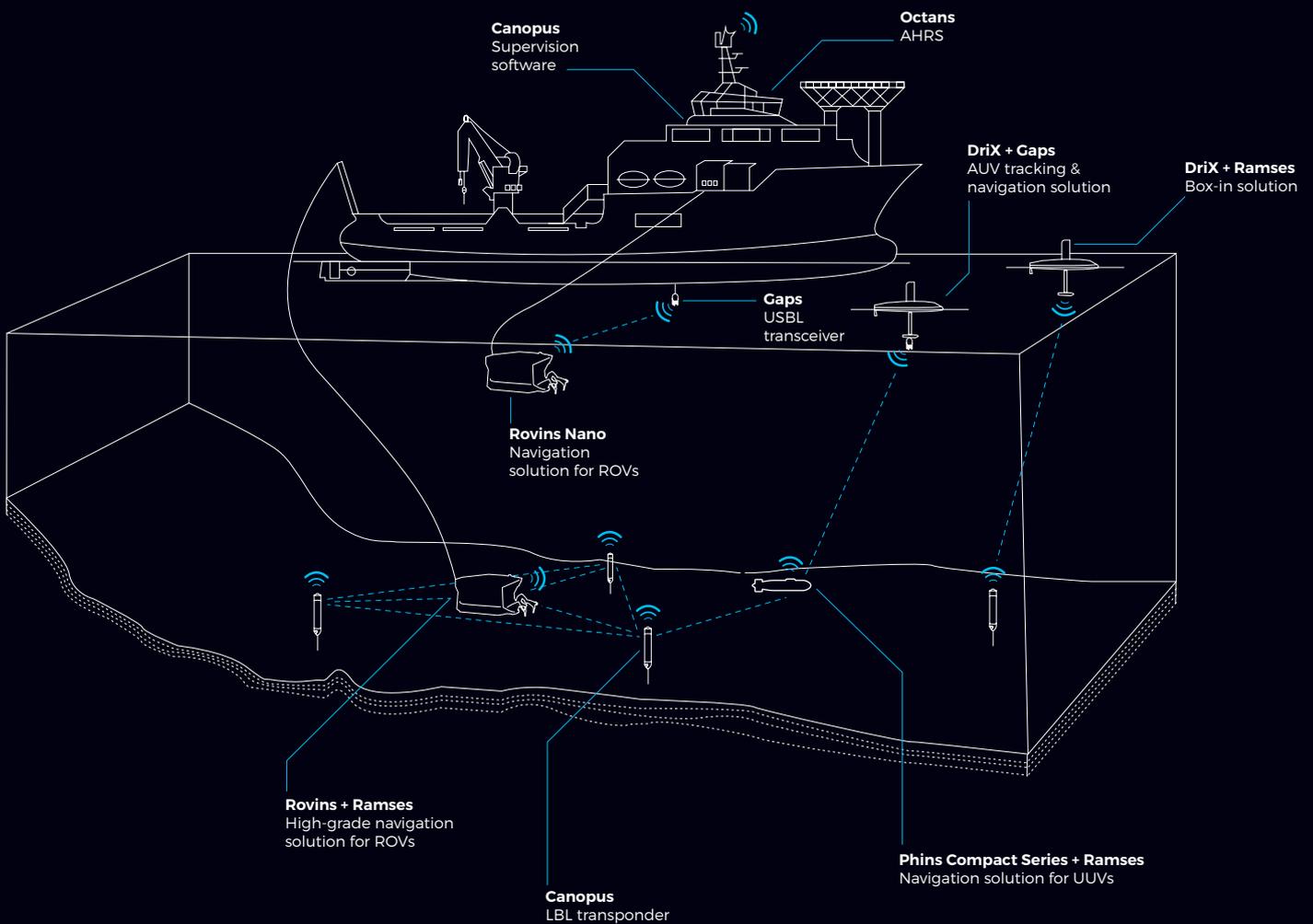
## Front cover

The Five Deeps Expedition is a round-the-world trip on DSSV *Pressure Drop*, a dedicated research vessel equipped aimed to send Victor Vescovo, the architect of the expedition, to the deepest point in each of the five oceans within one year. At the Mariana Trench the crew is launching the submarine DSV *Limiting Factor* (photo credit Tamara Stubbs). **Read more on page 22**



# From sensors to vessels.

Solutions for subsea operations



# Smile



▲ Durk Haarsma.

World Hydrography Day is celebrated each year on 21 June, which is also the beginning of the summer in the Northern Hemisphere. This year's event signals the start of centenary celebrations in our industry; 2019 marks one hundred years since the 1<sup>st</sup> International Hydrographic Conference, which was held in London in 1919. The festivities will culminate in two years' time, when World Hydrography Day will

coincide with the IHO-100 Symposium in Monaco, marking the 100<sup>th</sup> anniversary of the International Hydrographic Organization which was established in 1921. On 17 June, just a couple of days before this year's event at the Oceanographic Museum and a few kilometres further along the southern coast of France, the International Federation of Hydrographic Societies is organizing a workshop under the Oceans 2019 conference banner. During the workshop, hydrographic experts are talking about survey standards, crowdsourcing bathymetry, data rescue, hydrographic courses and education. And earlier this summer, during the grand final of the Shell Ocean Discovery XPrize, the GEBCO-Nippon Foundation Alumni Team was announced as the winner of the US\$4 million prize for its groundbreaking entry in the competition that has been initiated to accelerate the mapping of the ocean floor. So we're clearly in the geospatial era and gathered hydrographic data holds an important key to prosperity, sustainability and security.

The clear and growing need for hydrographic data, as celebrated this summer at the above-mentioned events, should put a smile on the face of every hydrographer because it means a bright future for our profession. Looking further ahead, the Decade of Ocean Science for Sustainable Development – proclaimed by the United Nations – will officially commence in 2021. Running until the end of 2030, this dedicated decade will put the importance of knowledge about the oceans for a better, safer and more sustainable world in the spotlight for a whole ten years... and that prospect should put an even bigger smile on the face of every hydrographer!

*Durk Haarsma,  
director strategy & business development*

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## USVs Offer a Solution for Staffing Problems

A 12m unmanned surface vehicle (USV) recently set sail from the English coast to the Belgian port of Ostend. It was guided across the North Sea – one of the busiest waterways in the world – by remote control, and sailed through a wind farm as well. A few hours later, after traversing two busy shipping lanes, the vessel arrived safely at the port of call: a great achievement for the crew that steered the USV remotely from the control centre in England.



▲ Cees van Dijk.

For seafarers who fear that far-reaching automation and other technological innovations will jeopardize their jobs, it should be reassuring that they can put their knowledge and experience to good use in a control centre where unmanned vessels are kept on course. For them, it could in fact be a real advantage that they no longer have to stay aboard for weeks or even months, far removed from their family and social life. More and more jobs for seafarers are available ashore; companies that focus on the manufacture and operation of USVs are constantly looking for well-educated and experienced maritime 'crew members'.

But, let's be realistic. According to a new study, visions of fleets of remote-controlled vessels sailing the world's oceans may take much longer to become a reality than technology firms predict. Automation is unlikely to lead to widescale job losses among seafarers over the next 20 years, a two-year study undertaken by the World Maritime University has concluded. Although new technology will reduce global demand for seafarers by around 22% between now and 2040, there will also be further growth in seaborne activities. This means sustained demand for skilled and experienced seafarers. Despite high levels of automation, qualified human resources with the right skillsets will still be needed in the foreseeable future.

As Durk Haarsma, director of strategy & business development at Geomares stated in his editorial in the previous issue, the hydrographic world is facing a staffing problem. Enough youngsters are graduating in this field, but after a few years many of them opt for a job ashore. The deployment of unmanned vessels, which is still in its infancy, undoubtedly offers opportunities for hydrographic specialists who, although they love their profession, no longer want a long-term stay on board a ship. At *Hydro International*, we will continue to keep a close eye on these developments for you.

*Cees van Dijk, content manager*

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# Building up capacity

The official definition in place identifies hydrography as “the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time...”. Well, this sounds very technical. Measurements and descriptions of physical features are clearly engineering tasks making best use of latest scientific insight. But beyond this technical approach, it poses the question: Who are those who apply this knowledge? Moreover, where do they come from, what is their profile and education and, lastly, who are the teachers? Some of the answers lie in the international attitude of the conduct of hydrography, a branch which is seeing standardization not only of the technical aspects but also of education and training.

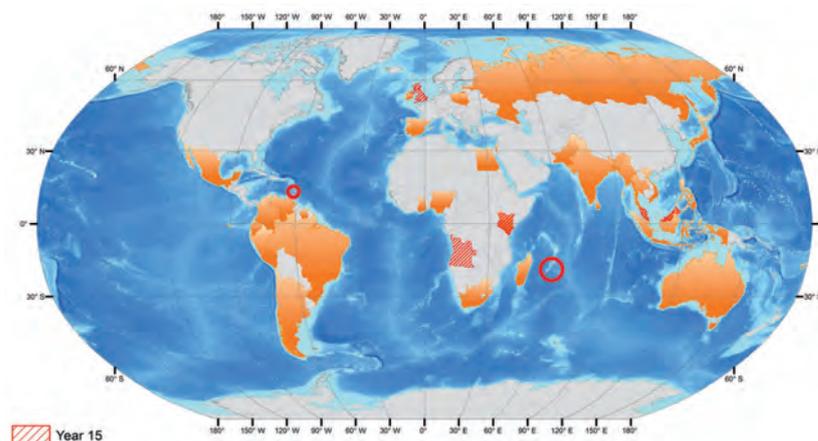
Having adopted capacity building as one of the main pillars of its work programme, the International Hydrographic Organization (IHO) oversees – in collaboration with the International Federation of Surveyors (FIG) and the International Cartographic Association (ICA) – two compilations of curricula content that institutions or professional bodies can adopt for their educational/training programmes and competency schemes: Standards of Competence for Hydrographic Surveyors and Standards of Competence for Nautical Cartographers. Those two standards are the accepted basis of the worldwide education in hydrography and nautical cartography and serve at the same time as an

assessment procedure of the providers of such education. The assessment is aimed at awarding recognition to programmes that meet the relevant standards. This approach is efficient and successful: there are currently 62 recognized programmes spread across 32 countries. Education covers establishments such as universities and colleges where teaching towards qualification is the primary business. Programmes offered by the industrial sector are either delivered commercially to fee-paying students or internally for staff development within the organization. It is encouraging that there are a good number of entities spread over all continents which offer professional education and training in hydrography and nautical cartography in a harmonized way, giving hydrographic offices, industry and academia the sound basis to refer to a comparable level of competence of hired personnel.

However, this is only one side of the coin. The pressing need to invest into hydrographic capacity lies with coastal states which do not run such establishments and are unable to afford comprehensive education of young professionals elsewhere. In order to address this problem, the IHO has established a second mechanism: as part of its capacity-building strategy, a dedicated committee assesses the individual national needs for infrastructure, education and training and coordinates support through a variety of measures – not least through regional cooperation. Moreover, this committee conducts fundraising and acquires sponsoring for training

and education. Over the years, many IHO member states have committed to it by in-kind contributions such as internship programmes. In addition, there are two very notable financial sponsoring programmes: 1) the Republic of Korea sponsors master students in hydrography at the University of Mississippi as well as internationally recruited ‘Train the Trainer in Hydrography’ courses domestically, and 2) the Nippon Foundation has been sponsoring courses in ‘Marine Cartography and Data Assessment’ held at the Hydrographic Office of the United Kingdom for more than a decade.

But there is another major global hydrographic programme which benefits from generous sponsoring: the General Bathymetric Chart of the Oceans (GEBCO) project, which produces charts and digital grids of the world ocean by collating, interpreting and contouring data, utilizing soundings and multibeam bathymetry with the aid of directional fabrics revealed by satellite gravity. GEBCO also evaluates and authorizes undersea feature names for use on its products, which are published in a Gazetteer. In recent years, GEBCO recognized the need to revitalize its human resources, and one response has been to establish an international training programme in deep-ocean bathymetry. In partnership with the Nippon Foundation, GEBCO contracted the Center for Coastal and Ocean Mapping/Joint Hydrographic Center of the University of New Hampshire, USA, to develop and offer the postgraduate certificate in ocean bathymetry training programme. This programme allows young scientists from around the world, although primarily from developing countries, to be brought together to become experts in deep-ocean mapping. After 15 years of continuity, the 90 graduates span a network of the so-called Nippon Foundation/GEBCO alumni over five continents. Though geographically separated, they keep working collaboratively for the benefit of the GEBCO project in the spirit of international cooperation to contribute their share to the greater idea referenced in the above-mentioned definition of hydrography “...for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research and environmental protection”. ◀



▲ Geographic distribution of GEBCO scholars: 2003 - 2017 in orange; 2018 in red.

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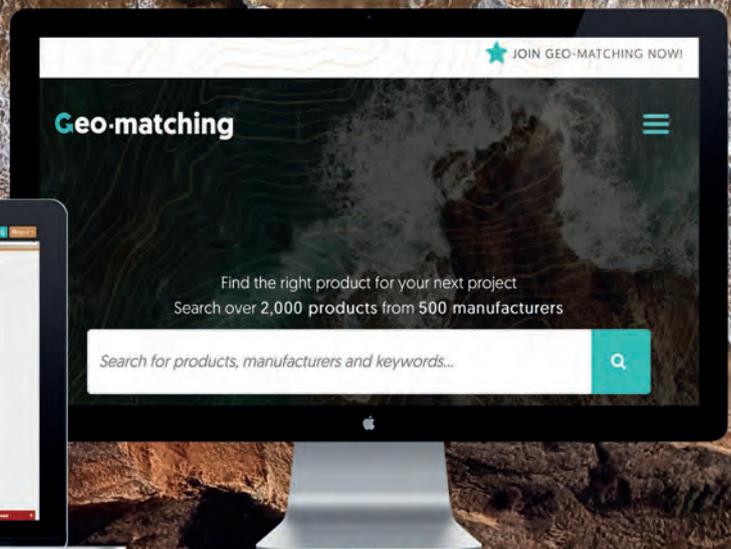
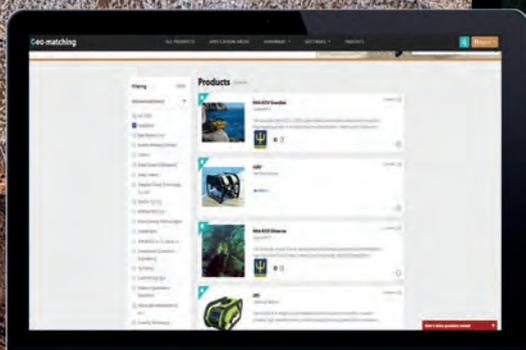
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## Open Teledyne PDS and SeaBat Sonar Courses 2019

Teledyne RESON has announced a new series of Teledyne PDS software and SeaBat Sonar training courses. The open courses cover Teledyne PDS for Dredge or Multibeam operations and Teledyne RESON SeaBat Sonar training. Teledyne PDS and SeaBat multibeam sonars are used for seabed mapping and dredging operations. The company also offers a combined training session giving trainees everything they need to know, from sonar installation to producing a deliverable in Teledyne PDS. "As the year is now well on its way we see an uptake in customized on-site training. But for some smaller groups or individuals we have again set up a series of open training courses," explains Harvey Stoelinga, software manager at Teledyne Marine. "One to look out for is our SeaBat and Teledyne PDS training which this year is hosted for the first time on the US east coast in our Daytona Beach office."



▲ Customized on-site training and open training courses.

## USV Uni-Cat for Operation in Difficult-to-access Areas



▲ Unique Group's USV is called Uni-Cat.

Unique Group, an integrated subsea and offshore solution provider, has designed and developed its first unmanned surface vehicle (USV), called Uni-Cat. With hydrographic survey capabilities, the Uni-Cat can be used effectively for bathymetry survey offshore and in shallow waters, the company stated. It is specially developed to be used in locations where conventional survey methods are not feasible. The Uni-Cat USV is purpose-built with a long-lasting battery and the endurance of the boat can be customized to client requirements by mounting different sonars and ancillary sensors suitable for hydrographic, search and recovery, oceanography and monitoring as well as inspection surveys. Uni-Cat has a 16-foot Cataraft platform and is, according to the company, designed to provide ease of mobility and operability in difficult-to-access areas. The boat is integrated with multibeam, ancillary sensors and communication links into a remote-controlled platform for quick and easy deployment. The catamaran also has a real-time positioning and obstacle-warning alarm unit along with a heading sensor, for guided navigation.

## Bathymetric Survey Using Unmanned Vessels



▲ The use of unmanned vessels offers significant benefits.

XOCEAN and 4DOcean have successfully completed over 2,000 hours of unmanned bathymetric survey off the coasts of Scotland and England as part of the UK's Lot 2 Civil Hydrography Programme (CHP), administered by the Maritime & Coastguard

Agency (MCA) subcontracted by Meritaito. Operating two different unmanned vessels, 4DOcean and XOCEAN completed surveys of multiple nearshore locations. The use of unmanned vessels offers significant benefits including safety benefits with operators remaining onshore, efficiency benefits with 24/7 operations and environmental benefits with ultra-low emissions. Altogether, these lead to significant economic savings.

## NOAA Released Etolin Strait Large-Scale Charts



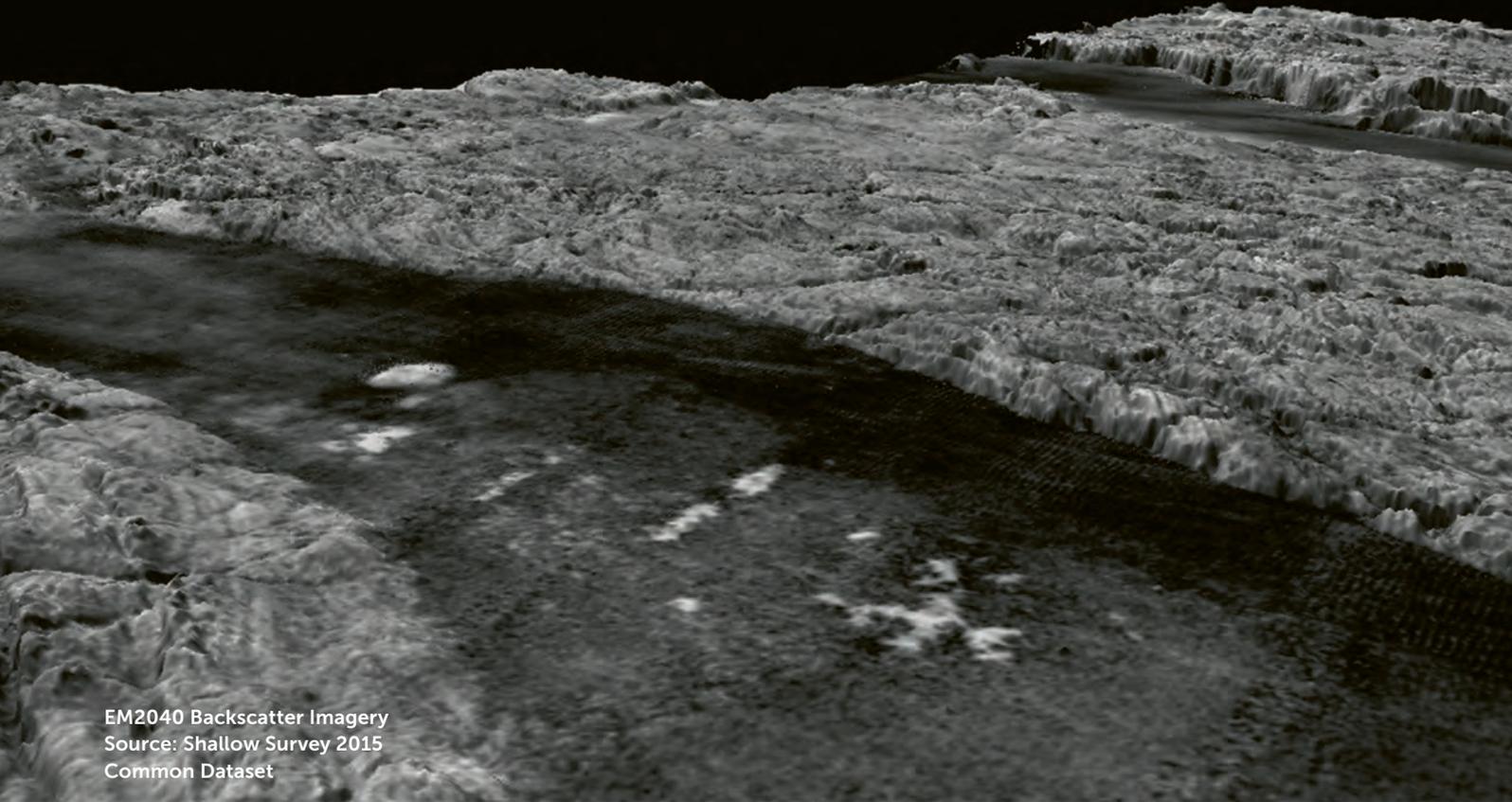
▲ Part of the 13 new large-scale electronic navigational charts of Etolin Strait, Alaska.

NOAA recently released 13 new large-scale electronic navigational charts of Etolin Strait, Alaska. These charts provide a nearly 20-fold increase in scale over the previous ENC coverage. New Etolin Strait hydrographic surveys and the resulting ENCs served as a pilot project for the overall rescheming of the entire NOAA ENC suite with a regular, gridded layout for ENC charts. Etolin Strait runs in the north-south direction between Nunivak Island and mainland

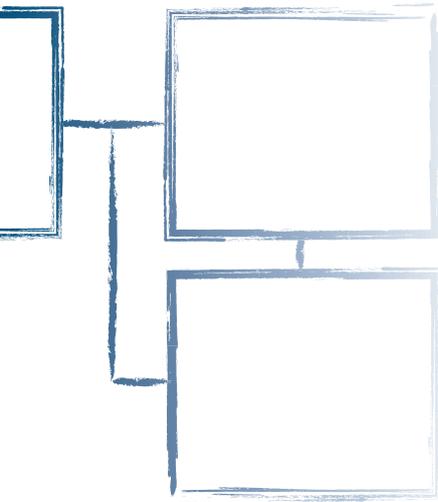
Alaska and had not been surveyed for over a hundred years. This area was charted at a 1:1.5 million general scale, making it difficult for deep-draft vessels to safely navigate among relative shoal areas. In June 2016, the Champion Ebony, a 600-foot chemical tanker, ran aground on an uncharted shoal just days before NOAA commenced planned survey operations.



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EM2040 Backscatter Imagery  
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## 3D Scan of the Interior and Exterior of a Ship



▲ The 3DMSI laser scanner at work in Falmouth dry dock.

Imagine a technology that could provide a 3D scan of the interior and exterior of a ship, including its systems, and could synchronize that with the data provided by the ship's own onboard sensors. That is the breakthrough idea which 3DMSI plans

to bring to market, with the support of an £80,000 grant from Marine-i. 3DMSI was originally focused on mine surveying but has successfully diversified into architectural surveys. The company employs leading-edge technology, as James Jobling-Purser, managing director, explains: "We are the only private company in Cornwall operating a Z+F Imager 5010C laser scanner and producing 3D models. Our work on architectural scanning sparked an idea for an innovative solution for the marine industry. Our new service uses 3D scan data to model a complete ship, including its systems, and pairs this with information from onboard sensors. Once this total scan package is completed, it can be used by design engineers and shipyards anywhere in the world to offer a superior service to their customers. We call this project '3D AMP'. It is a new technology that many shipyards will be crying out for very soon." Professor Lars Johanning of the University of Exeter, who leads the Marine-i project, says: "This is a model example of the kind of project that Marine-i was set up to nurture – strategic, innovative, loaded with growth potential, and in a specialized field of marine technology where Cornwall has a real opportunity to become world leader."

## Pioneer Grows Falcon Fleet

ASI Marine, a pioneer in long tunnel excursions and international operator for inland marine work, is expanding its Saab Seaeye Falcon fleet. Renowned for being the first to exploit the Falcon's adaptive intelligent technology by sending the 300 metre rated remotely operated underwater vehicle on a five kilometre long tunnel inspection, the company is now adding the 1,000 metre rated Falcon version to their Falcon collection. Bob Clarke, manager of ROV services at ASI Marine, says he chose the 1,000 metre Falcon to further expand the capabilities of the fleet across all areas of its inland operations.



▲ One of the ASI Falcon fleet in operation at sea.

## USV Completes First International Commercial Unmanned Transit

SEA-KIT, a 12m-long unmanned surface vessel (USV) designed and built in Essex, UK, docked in the Belgian port city of Oostende recently following a successful transit from West Mersea (UK). The voyage, which lasted 22 hours, represents the first commercial crossing of the North Sea by an autonomous vessel, and marks a significant breakthrough in unmanned ocean transit. The USV arrived at Oostende where it was welcomed by Belgian customs officers, who took delivery of a box of oysters caught around Mersea Island that SEA-KIT had delivered from its West Mersea point of departure. The modular design of the USV means that it can be easily and cost-effectively configured to a wide range of maritime tasks for various sectors. The vessel can be transported in a single 40ft container, reducing the mobilization costs. Furthermore, being truly unmanned means it can conduct its missions without placing any human personnel in harm's way.



▲ SEA-KIT docked in the Belgian port of Oostende (image courtesy: SEA-KIT International Ltd).



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## Basics of Hydrography and Inspection of Subsea Infrastructures

French positioning and geomatic specialist Geraud Naankeu Wati recently published his first book entitled *Basics of Hydrography and Inspection of Subsea Infrastructures – Principles and Practice*. After several years of experience in hydrography and inspection of subsea infrastructures, the author noticed that it is important for professionals and orderers or order-givers to have knowledge of these fields. Therefore, he decided to share his theoretical knowledge and experience of the field in positioning, hydrography and inspection of subsea. “I wanted to contribute to the training of surveyors and meet the needs in hydrography and inspection of subsea infrastructures. I also intend to help the orderers to specify their internal standards and to evaluate the technical aspects of contractor proposals, in order to get highly accurate data,” Naankeu Wati says. “Last but not least, I hope to initiate people without theoretical and practical knowledge in hydrography and inspection of subsea infrastructures.” Naankeu Wati works at Sub-C Marine, France, on the implementation of innovative solutions to optimize the operations of hydrographic surveys and inspection of subsea infrastructures.



▲ Basics of Hydrography and Inspection of Subsea Infrastructures by Geraud Naankeu Wati.

## Acta Marine’s Walk-to-work Vessel Acta Centaurus Off to Work



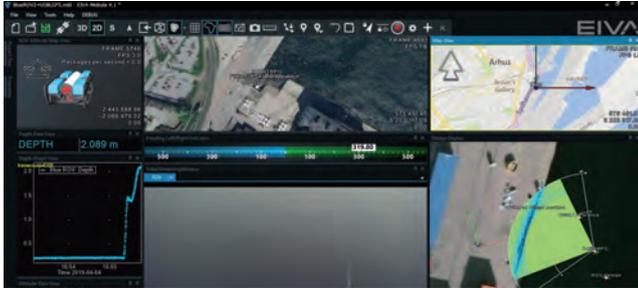
Acta Marine’s newbuild Walk to Work vessel *Acta Centaurus* has been delivered from Ulstein Verft, Norway, and has set sail for her first offshore wind assignment. The on-board logistics solutions of this vessel have been developed by considering the flow of people in various work operations. The vessel offers cargo areas of totally 1,000 square metres, indoors and outdoors, with a container skidding

system and ample space for in total 24 containers. All cargo handling is centralized, with stepless transfer to the cargo and personnel lift, and likewise over to the wind turbines or offshore platform. In addition, *Acta Centaurus* is fitted with a helideck to further support offshore operations. The overall logistics and the SMST motion compensated gangway, and integrated elevator tower will secure safe and stepless transfers of people and cargo in significant wave height up to 3 metres. SMST also delivered the 3D motion compensated knuckle boom crane which can handle 6t cargo in sea conditions up to Hs 2.5 metres. *Acta Centaurus* features hotel-style accommodation for up to 120 persons. Ample office and works spaces are available for charterers. The mess room and lounge area include a library, coffee corner and a game room. The vessel also has a sauna and a gym/exercise room and offers very low noise and vibration levels which are rated better than the requirements for DNV-GL comfort level V2 class.

## EIVA Launches a Software Solution for ROV-steering

NaviSuite Mobula, recently launched by Danish engineering company EIVA, is a new software product which offers advanced steering capabilities to ROV owners. The performance of the entry-level ROVs makes them useful for professional use – provided the right software capabilities are available, the company says. This is now possible through a NaviSuite product dedicated to ROV steering, NaviSuite Mobula. It includes features from NaviSuite Nardoa, EIVA's package for subsea inspection work, where the focus is on data fusion from the most advanced sensors and on efficiency functions that enable fast inspection of very large assets such as pipelines. By bringing this into a package for the mini-ROV segment, it becomes possible to use these for professional inspections, EIVA states.

EIVA's long-term vision with NaviSuite Mobula is to provide a software package that enables fully automated inspections through a long list of advanced features. For this reason, NaviSuite Mobula includes functionality to steer the ROV – because it's necessary for the automation features coming later. EIVA has initially focused on some of the most widely sold mini-ROV types, namely the VideoRay Pro 4, Pro 5, Defender and the Blue Robotics BlueROV2, and NaviSuite Mobula is available in versions tailored to these ROV types.



## Trident Opens Diving Centre in Fujairah, UAE



Trident, a subsidiary of the technology group Wärtsilä, has opened a diving centre in Fujairah, United Arab Emirates. With the new facility, Trident is strengthening its underwater-related servicing. This expansion into a major global shipping region will enhance Wärtsilä's ability to serve its global customers with underwater repairs, refurbishments, and maintenance. By performing this work below the waterline using fully trained technician divers, the need to dry dock the vessel is eliminated, thereby significantly reducing costs and avoiding interruptions to the vessel's operations. "Our certified technicians can perform safe, reliable, and cost-effective repairs either underwater or afloat. Furthermore, we can assess repair requirements with thorough underwater inspections by our specialist teams. This adds considerable customer value since it increases the vessel's operational efficiency while minimizing its downtime," said William Winters, Trident's managing director.

Wärtsilä already has underwater servicing capabilities in Europe through its acquisition of the Trident Group in February 2018, and its subsequent acquisition of the Spanish underwater services company Burriel Navarro later that year.

CHCS

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Hydro International interviews ARC Marine, UK

# Eco-engineers Strive to Save Endangered Marine Species

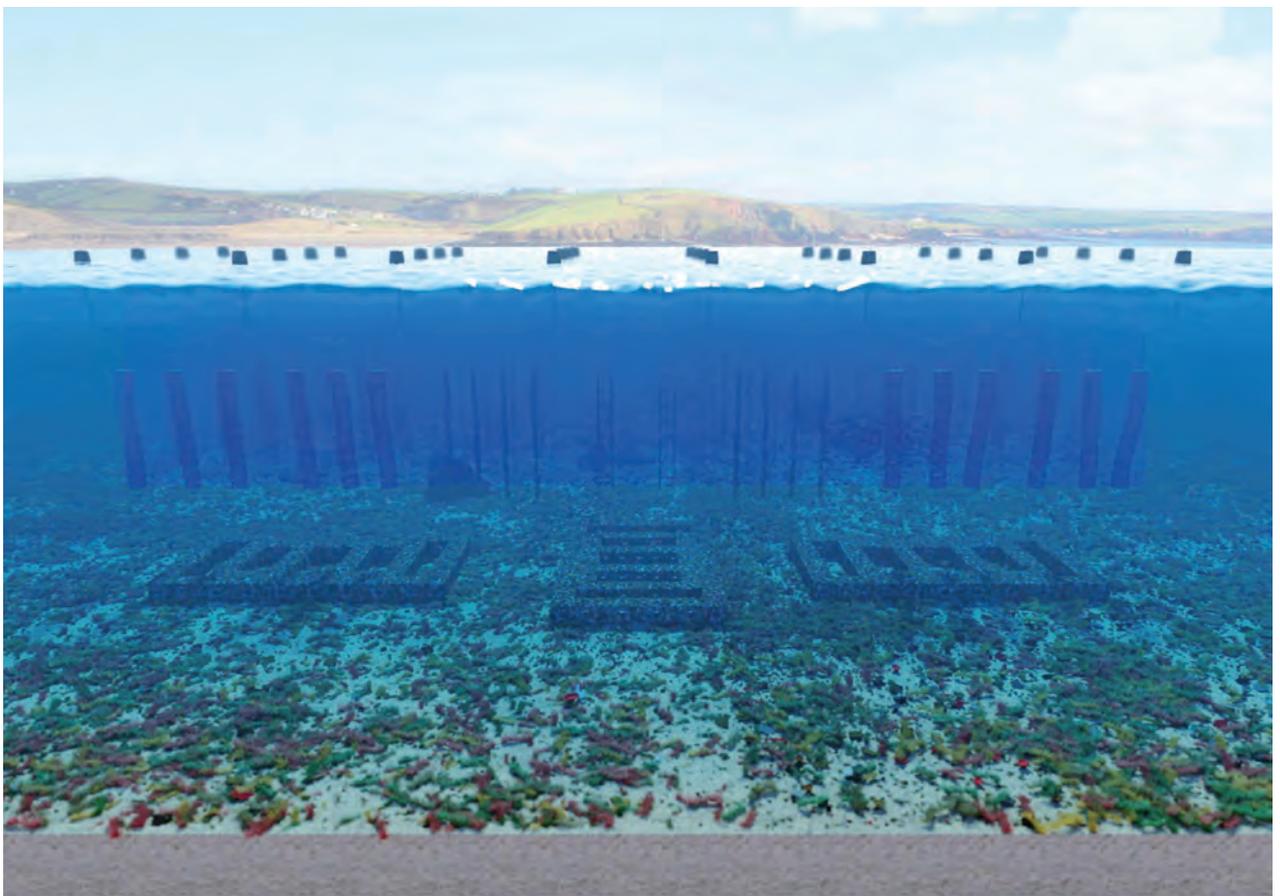
Could a new type of patented marine technology be used to preserve some of the planet's most valuable commercial species of fish, while also helping to rebuild damaged reef systems? The team at ARC Marine believe so. In this interview, co-founders Tom Birbeck and James Doddrell explain their innovative solution to one of the world's most urgent marine challenges.

**What first inspired the idea for your artificial reef system?**

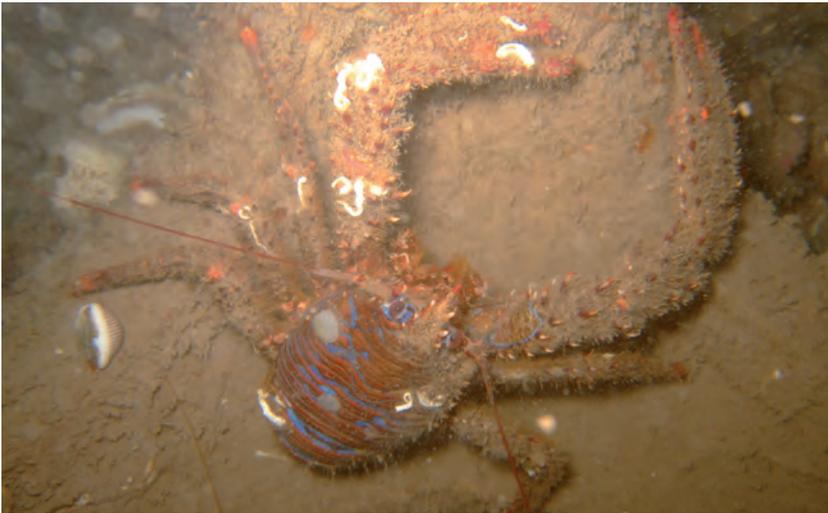
"As highly experienced divers, we had seen first-hand the damage being done to aquatic ecosystems around the world, from Europe to

Australia and Fiji. Once these fragile systems are undermined, they can reach a 'tipping point' where recovery is almost impossible. And we are not talking about the distant future... if no action is taken, there is a real danger that stocks

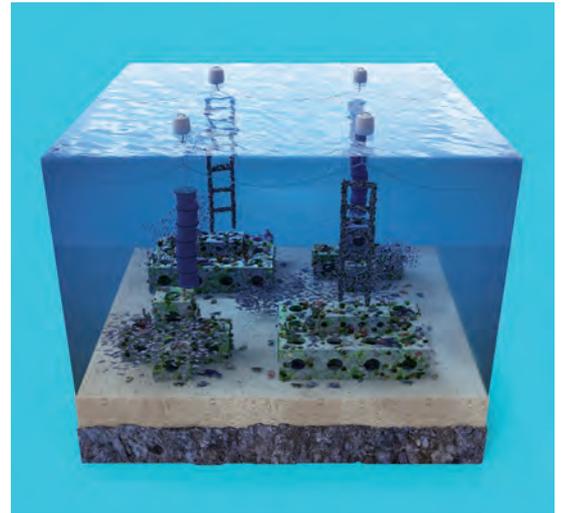
of many species that people rely on for food could collapse within the next 30 years. Important commercial species such as scallops, crabs, lobsters and shoal fish are in an especially precarious situation. Their decline



▲ Reef Cubes provide hard substrate at the base of mid-water aquaculture farms to provide a healthier ecosystem.



▲ *Squat lobster in Reef Cubes located at the 'in-water laboratory' in Brixham.*



▲ *Reef Cubes enhance aquaculture sites.*

would not only severely damage the biodiversity of our oceans, but would also have a massive impact on the fishing communities around the world that depend on these species for their survival. As part of our diving experience, we had both been involved in marine conservation projects which aimed to create new habitats by using 'recycled' structures. A classic example would be to sink a disused ship in order to form an artificial reef. We began discussing ideas for a custom-designed artificial reef system: one that could be deployed quickly and cost-effectively and could offer additional benefits beyond marine conservation. This led to the founding of ARC Marine Ltd and the creation of Reef Cubes."

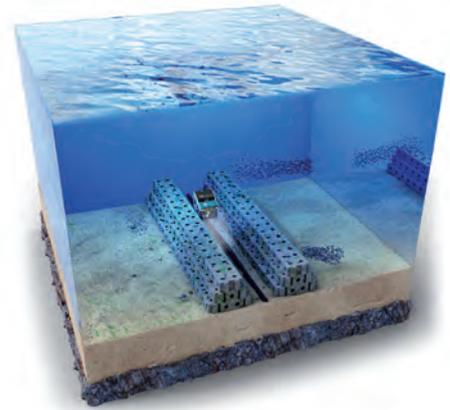
### What are Reef Cubes?

"Reef Cubes offer a robust, interlocking modular system for building an artificial reef or for creating a marine habitat around an existing structure, such as a wind turbine. Our patented design for each cube features an integral chamber and six passages through which marine creatures can access the structure. Sediment collects naturally inside the cube and this chamber also provides an excellent habitat for many diverse species. Reef Cubes are designed to be as environmentally friendly as possible. We use low-carbon concrete, with alternative binders to Portland Cement. The surface has a neutral pH so that it does not disturb the natural chemical balance of the sea water, and there are no plastic materials in the cube. Reef Cubes are available loose, in mats or in bags and do not require any special deployment techniques. As well as marine conservation, our lab tests demonstrate that Reef Cubes can play an important role

in reducing scouring of marine structures. This generates significant savings on operations and maintenance (O&M) expenditure. Furthermore, there is no need for decommissioning of scour protection or cable and pipeline protection. Reef Cubes can remain in place as a permanent structure, providing a long-term habitat for important marine species."

### How have you tested the effectiveness of Reef Cubes in marine conservation?

"Two test reefs have been in place in Torbay, UK, since April 2018 – one close to Brixham Harbour and a second near Thatcher Rock. The aim is to demonstrate the successful colonization of Reef Cubes by marine fauna and flora and also to allow us to evaluate the effectiveness of different types of concrete mixes. To date, five diver surveys have been conducted and these have identified that at least 17 different marine species are inhabiting the reef. These include the European Lobster and Edible Brown Crab, which have been observed making burrows with entrances in the lowest passages of the Reef Cubes. Lobsters and crabs tend to live in rocky holes and crevices. Previous lab research conducted in the USA showed that lobsters consistently prefer to shelter between hard surfaces and benthic substrate. Our observations of lobsters in the cubes suggest that the Reef Cube design supports this behaviour. We have also carried out marine conservation trials at a site in Lyme Bay and at a freshwater ARK site, so we are steadily building a robust body of research that proves the value of Reef Cubes in building, and re-building, marine habitats."



▲ *Reef Cube cable trenches are available where burial is not possible and leave the cable visible for inspection.*

### How will the anti-scour properties perform in ocean conditions?

"In order to break into global commercial markets, we need to have proof that Reef Cubes will be reliable in all kinds of conditions, so we have tested the structure extensively using the COAST Lab at the University of Plymouth. COAST Lab provides physical model testing with combined waves, currents and wind, at scales appropriate for device testing, environmental modelling and coastal engineering. Two sets of hydrodynamic physical model tests were performed to assess the capability of Reef Cubes to prevent scour and remediation around a monopile. The first set was performed in early 2018, in a flume with a constant current. Reef Cube bags were successful at remediating a scour pit that had been allowed to develop and, in a separate test, they successfully prevented a scour pit from developing. The second set was

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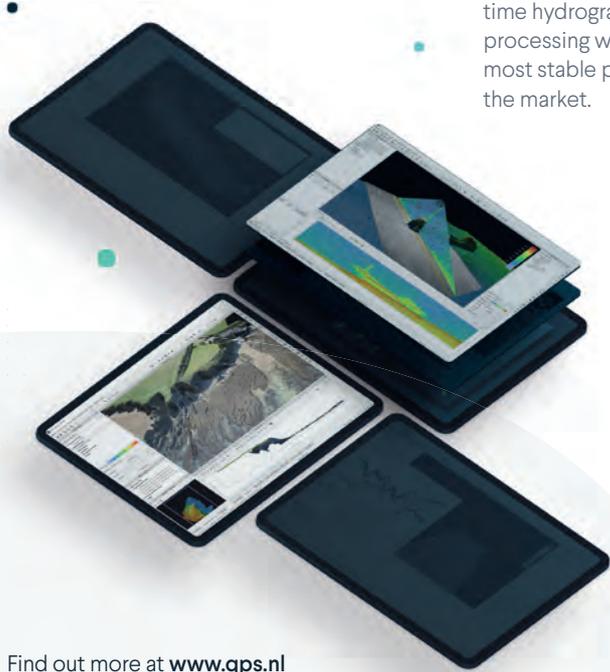


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completed in early 2019. These tests corroborated the first set, proving that Reef Cube bags are just as effective as rock bags at preventing scour around a monopile, in extremely dynamic storm wave conditions with strong currents, and at shallow depth. The better build-up of sediment at the edge of the scour protection provided a strong indication that Reef Cube bags were the most appropriate choice of scour protection tested, when compared to other available options including standard rock bags and static scour protection with filter and armour layers of rock.”



▲ Snake anemone resident in research tank at Brixham behavioural facility.



▲ Native lobsters are attracted to the Reef Cubes, taking advantage of the protection they offer.

### How are you preparing for the launch of Reef Cubes?

“Following these successful trials, we have now established our manufacturing base at Truro in Cornwall. Work is ongoing to refine our concrete mixes and to test the ecotoxicology of a variety of constituents. Much of this work has been carried out by an environmental sciences student from the University of Plymouth, using our second ‘underwater laboratory’ which is a small test reef at Thatcher’s Rock in Torquay. We have also received a grant from Marine-i for the purchase of diving equipment. The Marine-i project is part-funded by the European Regional Development Fund and is designed to help the marine tech sector in Cornwall grow through harnessing the full potential of research and innovation. This grant will help us carry out extended surveys and eco-mooring installation trials in preparation for a full commercial launch. This April we submitted a £500k bid through the Innovate UK SMART Call to trial Reef Cube bags and mats at an operational wind farm. We are considering two sites in England at the moment but are open to offers

from other developers who are experiencing scour or inter array/export cable protection issues. Parallel with this, we are in talks with wind developers in China, where previous commercial anti-scour products have failed. Chinese developers are well aware that all current commercial scour protection (except natural rock dumping) contains plastic elements which will cause long-term damage to the marine environment. They are keen to avoid the mistakes that many European developers have made in placing tons of plastic components at the base of offshore wind farms.”

### How would you summarize ARC Marine’s experience so far?

“It has been a very steep learning curve, with the Reef Cubes concept growing significantly in scope and commercial potential since its inception. Originally, we simply wanted to create an artificial reef that divers could enjoy which would also contribute to marine conservation in the UK. Today, Reef Cubes has evolved into a unique product that could reach a massive

global market. We have created a new technology that has broken the mould in reef design. ARC Marine has developed such a depth of expertise that we now have ambitions to become a global leader in marine eco-engineering and conservation projects. We also believe that, as well as being a huge commercial opportunity, Reef Cubes will deliver a lasting benefit for the world’s marine ecosystems. Our goal has been, and will always be, to create the largest man-made reef network throughout the world.” ◀



▲ Deployment of Reef Cubes at the Thatcher Rock location in Torbay.



**Tom Birbeck**, co-founder and director of ARC Marine, studied business and marketing at Bristol UWE and then worked freelance as a film researcher in London. Tom is an HSE-certified

commercial diver, with extensive dive experience. Tom also completed a laboratory apprenticeship at the Astra Zeneca marine laboratory in Brixham, England. After extensive research into artificial reefs, Tom met up with James Doddrell and they created ARC Marine, with the long-term vision of developing sustainable solutions to manage and prevent the destruction of natural rocky reef habitats.

✉ [hello@arcmarine.co.uk](mailto:hello@arcmarine.co.uk)



**James Doddrell**, co-founder and director of ARC Marine, was the technical lead on the Reef Cubes invention. In 2011 he ran a company with charitable status called ‘Wreck the

World’. As part of the project, he raised £6.5 million in funding to purchase the aircraft carrier HMS Ark Royal as she came up for decommission and tender, with the aim of using the ship to create an artificial reef. This experience inspired James to find an alternative commercial solution to building marine habitats. James is a highly experienced diver and previously ran his own SCUBA diving school.

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## Looking Back on Ocean Business 2019

# Exhibitors Focus on Renewables

Compared to two years ago, there has been a lot of development in the renewables sector, our editor Auke van der Werf noticed when he visited Ocean Business 2019. This is particularly evident for the wind farm industry which the exhibition had a strong focus on instead of the conventional oil and gas market. There has also been a clear increase in autonomous and remotely operated ships.

The exhibition was packed with delegates who were all on hand to see the new products being launched including an advanced MASS system, and several other systems that were available for different applications – from enclosed, shallow and nearshore waters, to over the horizon deep water systems. In the harbour, live demonstrations were given for several of these systems.

Some examples of MASS system demonstrations at the exhibition, include: SEAKIT, which will be conducting a transatlantic sail, and Kongsberg's new MASS system, the L3 ASV Global C-Worker 7 with a SAAB Seaeeye Falcon ROV operating remotely. XOCEAN

demonstrated their Autonomous Surface Vehicle (ASV) in the harbour and are working together with 4DOcean on performing surveys. Sea Robotics also showed their improved ASV, and Fugro demoed a scale model of their new MASS which is currently being built.

Software companies showed a clear focus on digitalization and automatization – for example, artificial intelligence from point clouds and image recognition. It is expected that we will see much more development in this area.

### EXHIBITION AND CONFERENCE

Ocean Business is a bi-annual exhibition with a conference (the Offshore Conference), held at

the Southampton Oceanography Centre. Both the exhibition and conference are well organized, visited and attended. The exhibition offers a wide range of products – there really is something for everyone. There is also a good atmosphere to do business with companies pitching their technology and showing innovations.

This year's conference, held at the fringes of Ocean Business, offered a variety of speakers who focused on innovation to solve technical problems. In his keynote, Rear Admiral Tim Lowe, acting chief executive of the United Kingdom Hydrographic Office (UKHO) and the National Hydrographer Prosperity, said "In the



▲ SAAB Seaeeye Falcon ROV

decade of ocean science, starting in 2020, sustainability and security are essential for security of lives at sea.” According to Lowe, it’s up to the hydrographic field to make sure that governments make better informed decisions in a transparent time to improve life on the planet.

### DECADE OF OCEAN SCIENCE

In his talk, Lowe referred to SDG 14 – conserve and sustainably use the oceans, seas and marine resources for sustainable development – and SDG 9 – build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. He sees both goals as crucial in the path the hydrographic sector should take in the next decade, which has been named as the decade of ocean science by the United Nations. This is the same institute that drew up the sustainable development goals.

During the Offshore Survey conference, chairman Gordon Johnston introduced – besides the acting CEO of UKHO Tim Lowe – more than 30 other speakers on topics as diverse as data & digitalization, autonomous vehicles, coastal & environmental, and education & competencies.

### WORTH A VISIT IN 2021

Ocean Business offers a great social programme too, with welcome drinks, a wine trail and a dinner – a great way to meet people and make new contacts. Will it be worth a visit to the tradeshow in 2021? We would highly recommend Ocean Business in two years’ time. Make sure you plan enough time as one day is certainly not enough to see everything that the conference has to offer. I would also recommend you register for the conference and dinner as soon as its available so you don’t miss out.

### SELECTION OF HIGHLIGHTS

Kongsberg Maritime unveiled its new Unmanned Surface Vehicle (USV) at Ocean Business 2019. The Sounder USV System is a versatile solution designed and built to provide the highest possible standard of data acquisition, the company stated when demonstrating the system in Southampton. It is a multi-purpose platform designed to work across different market segments including survey and fishery duties. It has been developed as a joint venture with Norsafe AS. The system has been configured from the keel upwards to deliver optimal hydroacoustic data quality, efficiency and productivity. Operation of the USV is managed by Kongsberg’s K-MATE ASV control system – capable of following survey



▲ Presentation by Rear Admiral Tim Lowe, acting chief executive of the UKHO.

patterns, autonomously following AUVs or simply tracking a mothership. The K-MATE system has been developed in partnership with FFI, the Defense Research Establishment in Norway. It provides autonomous, supervised and direct control capabilities that are compliant with the latest safety regulations and operational guidance in the USV industry. For more information, visit [www.unmanned-survey.com](http://www.unmanned-survey.com).

EvoLogics introduced the latest addition to their range of underwater acoustic modems – the new generation S2C T. Dubbed ‘tiny’, this light and ultra-compact design represents a size reduction of almost 20% compared to EvoLogics M-series mini-modems at only 25cm standard height and 1,200g weight. The S2C T series form factor will be available for EvoLogics’ high frequency models, catering to modern

size- and weight-sensitive applications with four frequency range/directivity options. For more details, visit [www.evologics.de](http://www.evologics.de).

AutoNaut launched the 3.5m Comms Hub which is specifically designed for deployment as a long-duration surface gateway. Flexibility of the sensor fit enables tasks including data harvesting, precision positioning and communications from and to sub-sea asset. Onward relay can be achieved via satellite for over-the-horizon missions. Payload versatility means that secondary sensors can also be fitted. AutoNaut’s near silent sound profile – the wave-foil technology involves just a few moving parts – reduces noise interference to almost zero. This enables sensors such as USBL and LBL to operate with optimal efficiency. For more information, visit [www.autonautusv.com](http://www.autonautusv.com). ◀



▲ Fugro demoed a scale model of their new MASS.

## Zero-V Marine Research Vessel

# Investigating a Non-polluting Alternative to Diesel Engines

Marine research and hydrographic activities could soon be possible without the risk of polluting either the air or the ocean. It is thanks to a new zero-emissions ship design and feasibility study led by Sandia National Laboratories.

Hydrogen fuel cells have existed for decades, and there are multiple advantages to using them instead of diesel engines to power research ships. For example, as zero-emissions technology, fuel cells will not contaminate air or water samples collected in sensitive ecological areas. Additionally they make almost no noise, so they will not upset marine life or interfere with the many sensors scientists use to listen to sound in the ocean. Despite these and many other advantages, the feasibility of a hydrogen-powered research vessel has never been

studied or proven. A report released recently by Sandia National Laboratories shows it is technically and economically feasible to build such a vessel in a manner consistent with marine regulations. The project team nicknamed the vessel 'Zero-V', short for zero-emissions research vessel.

The Sandia-led Zero-V project brought together the Scripps Institution of Oceanography at the University of California San Diego, the naval architecture firm Glasten and DNV GL, a global quality assurance and risk management

company working for the maritime industry. It was funded by the US Department of Transportation's Maritime Administration.

### ABSENCE OF FUEL SPILLS

One of the biggest additional benefits of using hydrogen to power a boat is the absence of ecologically damaging fuel spills. According to Lennie Klebanoff, a Sandia chemist and project lead, it is impossible to have a polluting hydrogen spill on the water. More buoyant than helium, hydrogen rises on its own and



▲ Rendering of the Zero-V hydrogen-powered research vessel. (Image courtesy: Glasten)

eventually escapes into outer space. “If you’re working in a sensitive ecological area and you spill liquid hydrogen there, the fuel not only removes itself from this environment, it removes itself from the planet,” says Klebanoff. In fact, the water generated by fuel cells is so pure that the ship’s crew can drink it, with conditioning, or use it for scientific experiments. This reduces the need to desalinate seawater, which currently consumes large amounts of energy. Moreover, fuel cells are electrical devices and actually offer a faster power response than internal combustion engines.

### **SAILING ON THE WINDS OF EARLIER SUCCESS**

The Zero-V project evolved from Sandia’s earlier work on the SF-BREEZE, a hydrogen-powered passenger ferry designed to operate in the USA’s San Francisco Bay. Although small hydrogen-powered pleasure crafts made for very short distances already existed, the SF-BREEZE was the first project that looked at the technical as well as economic feasibility of powering large, fast commercial boats with hydrogen. “Until we did the SF-BREEZE, very few people thought you could power a real ship, a business venture, on hydrogen fuel cell power,” comments Joe Pratt, who led the SF-BREEZE project for Sandia. “In addition to proving it was technically possible, we had to show that it would pencil out economically, so that it would have a chance of going out into the marketplace.”

The SF-BREEZE design accommodates 150 passengers on four 50-mile round trips in the San Francisco Bay per day while travelling at a top speed of 35 knots. Ensuring the ferry could achieve that speed meant adopting a 100-foot, slightly longer than usual catamaran design. All the plan elements, including ship design, weight distribution and refuelling options, had to be re-evaluated for the Zero-V. “Instead of going fast for short periods and carrying a lot of people, the research vessel goes slower for much longer distances, carries fewer people and must allow the operation of sensitive scientific instrumentation,” Klebanoff explains. “The research vessel is a different ‘animal’ from a passenger ferry.”

### **NAVIGATING AROUND DESIGN CHALLENGES**

While working on the SF-BREEZE, Pratt and Klebanoff approached the Scripps Institution of Oceanography to see whether researchers there were interested in a hydrogen-powered vessel. They were, providing that the Zero-V could

complete tasks that are routine for ocean-going research missions, such as marine ecosystem studies, hydrographic activities, physical oceanography, tsunami risk monitoring and ocean chemistry research. Mapping or installing equipment on the ocean floor requires a vessel to be stable over a single point for long periods, even in the case of wind or waves. Glosten determined that installing propulsion devices in each side hull would enable the Zero-V to maintain its position with more than 25 knots of wind and waves from any direction.

Whereas the SF-BREEZE requires refuelling after 100 miles, the Zero-V needed to be able to get at least 2,400 miles or 15 days (enough to get from San Diego to Hawaii) before requiring a refuel. Given the great distances to be covered, a refuelling terminal in one central location would not be sufficient. Instead, the Sandia team found an innovative approach that allows liquid hydrogen suppliers to drive fuel trucks directly to the ship at ports of call. Thus, the Zero-V would require little investment in fuelling infrastructure. In addition to the above-mentioned requirements, another challenge was finding a way to store the heavy hydrogen tanks while accommodating at least 18 scientists, 11 crew members and three laboratories. Part of the solution was to select a trimaran boat design, which has three parallel hulls and is usually used for high-speed boats. The design offers a great deal of space above deck for the tanks, plus adequate below-deck space for other science instrumentation and machinery.

### **TOWARD FAIR WINDS AND FOLLOWING SEAS**

The team designed the Zero-V using proven, commercially available hydrogen technology so they could be sure it would work. Once completed, the vessel design was reviewed by DNV GL and the U.S. Coast Guard. Both regulatory bodies independently came to the same conclusion: there are no ‘show-stopping’ technical issues with the Zero-V design. In fact, DNV GL hydrogen expert Gerd Petra Haugom says the Zero-V design shows an essential understanding of the safety-related properties of hydrogen, and how it can be used safely and securely on a vessel. “This project has been a good test of our own rules and the alternative design approach for using hydrogen and fuel cells,” she states. “The results from the Zero-V will be part of a benchmark to guide our assessment of similar vessels in the future.” With a solid design in place, the next step for the Zero-V is finding the funding to build it. Compared to diesel-powered research vessels,



▲ Sandia National Laboratories’ Zero-V team: Joe Pratt, left, and Lennie Klebanoff, seen here in Norway on a trip to visit partner firm DNV GL. (Image courtesy: Lennie Klebanoff)

the Zero-V has a similar capital cost, but would cost roughly 7% more to operate and maintain. Given its benefits – much quieter, zero emissions and no risk of polluting fuel spills – Bruce Appelgate, who oversees the Scripps fleet, is hoping that like-minded donors will step up to support the project. “Like other game-changing ideas, this approach initially seems expensive. But solar power was very expensive not too long ago, and now it’s affordable and widely adopted. Hydrogen fuel cells are just as transformative a technology. They produce clean, quiet, nonpolluting power to ships while enabling superior scientific capabilities,” Appelgate says. “Building and operating the Zero-V will significantly advance US marine transportation technology.” ◀

**Sandia National Laboratories** is a multidisciplinary national laboratory and federally funded research and development centre in the USA. It is operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy’s National Nuclear Security Administration. Sandia Labs has research and development responsibilities in nuclear deterrence, global security, defence, energy technologies and economic competitiveness, with its main facilities in Albuquerque, New Mexico, and Livermore, California.

## Report on The Five Deeps Expedition

# Exploring the **Deepest** Points on the Planet

As extreme explorer Victor Vescovo continues his round-the-world expedition to become the first person to descend to the five deepest points in the Earth's five oceans using the custom-built deep submergence vehicle *Limiting Factor*, it prompts the question: 'Do we know as much about the deepest places on our planet as we thought?'



▲ DSV *Limiting Factor* ready to dive (Image courtesy: Tamara Stubbs).

Today, the best global maps of the oceans have a resolution of 30 arc-second grid cells (926m at the equator). Approximately 82% of the grid cells do not include a single depth measurement (Weatherall et al., 2015), and the percentage of the seafloor that has been directly measured by echosounders is likely to be less than 18% (Mayer et al., 2018).

### THE FIVE DEEPS EXPEDITION

The recently launched Five Deeps Expedition is a round-the-world trip on a dedicated research vessel equipped with a full-ocean-depth manned submersible and supporting landers. The aim is to send Victor Vescovo, the architect of the expedition, to the deepest point in each of the five oceans within one year. The expedition includes Vescovo's own company Caladan Oceanic LLC, Florida-based submarine manufacturer Triton Submarines LLC, scientists from the UK's Newcastle University and the British Geological Survey, expedition company EYOS Expeditions, and the British documentary makers Atlantic Productions.

The primary mission is for Vescovo to dive alone to the deepest point in the Arctic, Atlantic, Pacific, Indian and Southern oceans. The expedition centres around the deep submergence support vessel (DSSV) *Pressure Drop* which is fitted with a state-of-the-art Kongsberg EM124 multibeam echosounder system, the newly designed and constructed two-person deep submergence vehicle (DSV) *Limiting Factor* and three full-ocean-depth lander systems to complement the scientific outputs of each dive and to act as sub-navigation points at depth. Although exploring the five deeps is the primary mission, the expedition has a broader remit with a comprehensive science component including a collaboration with the Seabed 2030 initiative. Seabed 2030 is a collaborative project between the Nippon Foundation and General Bathymetric Chart of the Oceans (GEBCO) that will bring together all available bathymetric data to produce the definitive map of the world's ocean floor by 2030.

### TECHNOLOGICAL CAPABILITIES

The DSV *Limiting Factor* is one of the most uniquely capable piloted vehicles of modern times. Rated to 11,000m water depth, capable of carrying two people and optimized for rapid vertical travel, *Limiting Factor* is compact and lightweight compared to previous ultra-deep capability submersibles. Occupants are housed within a titanium sphere, with three acrylic viewports allowing them to observe the marine



▲ Crew preparing the DSV *Limiting Factor* for launch at the Mariana Trench (Image courtesy: Tamara Stubbs).

environment outside. The exterior is also equipped with four high-definition (HD) video cameras used to record footage of the descent through the water column and – once it reaches the bottom – the surrounding seafloor.

The three scientific landers not only primarily serve as navigation points for the manned submersible, but also deploy an autonomous scientific payload comprising conductivity, temperature and depth sensors, and a suite of baited traps for biological specimens.

### MAPPING CHALLENGES

One issue that quickly arose during the early stages of the expedition was how to locate the deepest places in each ocean, and how to determine their exact depth. One might expect this to be easy using global datasets such as GEBCO and the ever-omnipotent Wikipedia. However, it soon became apparent while

planning the expedition that the information available is fraught with inconsistencies, including erroneous statements perpetuated online and numerous datasets of varying resolution.

Using publicly available global compilations of bathymetric data and peer-reviewed literature, it was possible to confidently identify the Challenger Deep in the Mariana Trench (10,925 ±12m depth in the Pacific Ocean; van Haren et al., 2017), the Puerto Rico Trench (8,408m depth in the Atlantic Ocean) and the Molloy Deep (5,669m depth in the Arctic Ocean; Klenke and Schenke, 2002). However, the search for the deepest point in the Indian Ocean and Southern Ocean proved much more problematic. Conflicting reports emerged putting either the Diamantina Fracture Zone or an undefined location within the Java Trench as the



▲ Victor Vescovo in front of the DSV *Limiting Factor* (Image courtesy: Tamara Stubbs).



▲ DSV Limiting Factor ready to dive to the deepest points on Earth at the Mariana Trench (Image courtesy: Reeve Jolliffe).

deepest point of the Indian Ocean. Furthermore, much of the South Sandwich Trench is in the Atlantic Ocean rather than the Southern Ocean, with the location for the deepest point in the trench recorded as being at a latitude of 55°S and thus short of the 60°S boundary between the two, as defined by the International

Hydrographic Organization (IHO). High-resolution bathymetric maps of the hitherto unknown deeps of the world's oceans, created using the latest-generation full-ocean-depth EM124, will not only allow the expedition to pinpoint the exact deepest point of the five oceans, but will also form a primary dataset for

geological and geomorphological analysis and provide the context for research into the biological communities of these deeps.

### THE FIRST THREE DEEPS

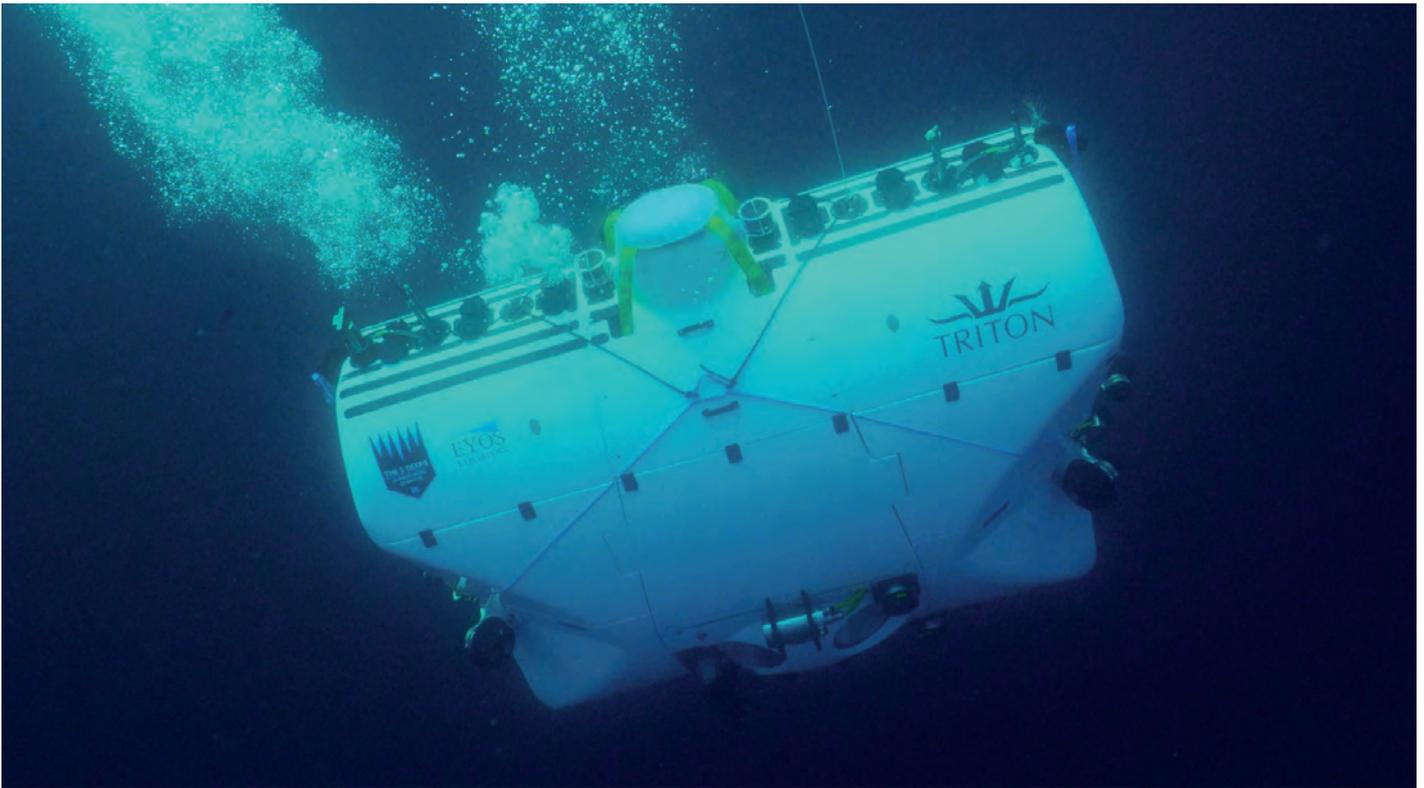
The Five Deeps Expedition started with a mission to the Puerto Rico Trench, the deepest point of the Atlantic Ocean. The deepest point of the trench was reported to be ~8,700m, located at the western end of the trench within a larger basin called the Brownson Deep. By December 2018, the area known as the Brownson Deep had been surveyed by the Five Deeps Expedition with the seafloor geomorphology revealing a large, flat-bottomed basin with little discernible topographic variation. The expedition determined the deepest point of the trench as being 8,376 ±5m at 19°42'49"N, 67°18'39"W. On Vescovo's subsequent solo dive at this location, *Limiting Factor* became the deepest-diving operational submarine in the world.

### SOUTHERN OCEAN

The most challenging dive was always expected to be the one in the Southern Ocean and the South Sandwich Trench with its reportedly unpredictable seas and short weather window for fieldwork. The deepest point in this trench is documented as the Meteor Deep (8,264m), named after the German



▲ SKAFF, just launched (Image courtesy: Reeve Jolliffe).



▲ DSV Limiting Factor on its way to the bottom of the ocean (Image courtesy: Atlantic Productions).

research vessel who first sounded it in 1926. As mentioned above, this is the topic of some debate as the Meteor Deep is just north of 60°S latitude and therefore not technically in the Southern Ocean according to the IHO.

The Five Deeps Expedition acquired EM124 data over an area slightly larger than Northern Ireland and travelled approximately 510 miles along the trench axis in January/February 2019. One of the many surprising results from the South Sandwich Trench was that the basin reported as being 8,264m deep in 1926 was confirmed by the Five Deeps Expedition to have a maximum water depth of 8,266 ±13m at 55°13'47"S, 26°10'23"W. On 4 February 2019, Vescovo became the first person ever to dive the deepest point of the Southern Ocean located at 60°28'46"S, 25°32'31"W, descending to a maximum water depth of 7,434 ±13m.

### INDIAN OCEAN

The deepest point in the Indian Ocean is also contentious as it is often reported as being either the Java Trench or the Diamantina Fracture Zone. To resolve this debate, the Five Deeps Expedition surveyed the Diamantina Fracture Zone in March 2019 recording a maximum water depth of 7,019 ±17m at

33°37'52"S, 101°21'14"E for the Dordrecht Deep. Survey work consequently undertaken in April/May 2019 revealed the Java Trench to be a maximum of 7,192 ±13m at a location further west than previously anticipated (at 11°7'44"S, 114°56'30"E), with Vescovo completing his solo dive at this location on 16 April 2019.

### FINAL TWO MISSIONS

Following the first three successful missions, the next stop is the Challenger Deep located within the Mariana Trench in the northwest Pacific Ocean. The Challenger Deep has the prestige of being the deepest place in the world and the ultimate 'end point' in marine exploration. A number of expeditions have visited the Mariana Trench in search of the deepest point with more than 18 known published maximum depths. Most recently, van Haren et al. (2017) provided an updated position and maximum depth for the Challenger Deep, citing a deepest sounding of 10,925 ±12m. Additionally, Vescovo and the Five Deeps team will visit the Horizon Deep in the Tonga Trench, which was long thought to be the deepest place in the world at approximately 10,800m. Then, they will head to the Molloy Hole in the Arctic Ocean. Located west of Svalbard with a maximum depth of 5,669m, this will be the final stop on this round-the-world expedition. ◀

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## Build a Forward-thinking Marine Community

# Will Hydrographic Geospatial Data Pass the Fit-for-purpose Test?

In 2017, OceanWise outlined the work of the UN-GGIM. The Committee of Experts endorsed the terms of reference for establishing a Working Group on Marine Geospatial Information. Here, Dr Mike Osborne and John Pepper provide a timely update on what has been happening since then.

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) aims to address global challenges relating to how geospatial information is created, managed and utilized. The UN seeks to overcome these challenges by improving access to fit-for-purpose geospatial information and for it to be an essential enabler on meeting the global community's Sustainable Development Goals (SDGs). SDG 14 refers to life below water and several other SDGs also have a marine component.

### NOBODY LEFT BEHIND

The terms of reference of the newly formed United Nations Working Group on Marine Geospatial Information (UN-WGMGI) are focused at a policy level, raising awareness and highlighting the importance of reliable, timely and fit-for-purpose

marine geospatial information to support the administration, management and governance of the marine environment. To deliver this, the working group is encouraging the use of internationally agreed frameworks, systems and standards, to improve the relationships between people and the marine environment and to support the committee of experts in developing the availability of high-quality and reliable regional capacity-building initiatives. This is aligned with the UN-GGIM's wider mantra of 'nobody left behind'.

### HYDROGRAPHIC DATA AND INFORMATION

It is no coincidence that the objectives of the UN-WGMGI mirror those of the IHO Marine Spatial Data Infrastructure Working Group (MSDIWG). Established in 2007, the MSDIWG has done much to promote and foster the wider

use, and re-use, of hydrographic data and information. The IHO C-17 document first published in 2009 still provides an excellent reference text for those wanting to know more about marine spatial data infrastructure. In 2016, the Open Geospatial Consortium (OGC) Marine Domain Working Group was established to act as a focal point for OGC activities and to present interoperability requirements, use cases, pilots and implementations of OGC standards within the marine geospatial community. As with the UN-WGMGI, this group helps to build understanding between the marine and geospatial communities. As an example of how this is being achieved, one of the outputs from the recent inaugural face-to-face meeting of the UN-WGMGI in Busan, Republic of Korea, in early March was to ask OGC to compile a non-technical guide on



▲ An officer on the bridge explains how they are charting a windfarm area.



▲ Navigational equipment on the bridge of the walk-to-work vessel Acta Centaurus.

the different standards and their roles in spatial data infrastructure (SDI).

### AIMS OF THE WORKING GROUP

The fact that the aims of these three working groups are so closely aligned is of great benefit, as witnessed at the first joint meeting. There, it was agreed to pursue these aims and create a common set of objectives and a joined-up work plan, supported by the technical capability of the OGC and the weight of the UN in influencing policy at a national level. The first meeting of the UN-WGMGI marked a major milestone in the evolution of marine geospatial information management and re-use.

### DATA MORE FREELY AVAILABLE

With the backing of the UN and links to the OGC, the hydrographic community now has more reason than ever to pursue an agenda much wider than just safety of navigation. This means the members of the community should make their data more freely available and be encouraged to move towards managing and making it available in such a way as to support a wider range of products and services, into non-traditional markets.

MSDI is often seen as being separate from a national hydrographic office's main purpose of providing nautical charting and publications. This viewpoint could not be farther from the truth, as all the basic principles of MSDI – to manage data centrally, to consistent standards, and to improve how data and information is exchanged between stakeholders – apply equally to navigational safety as they do to any other application area, be it marine spatial planning and licensing or emergency planning and response.

### MARINE GEOSPATIAL DATA ECOSYSTEM

For national hydrographic offices, this new way of working represents a real challenge. Not only do they have to educate their workforce and adapt their processes to traditional ways of working to produce data (and not a product) that is central to their operations, but they also need to assess which types of geospatial information they are responsible for, and which other data authorities they need to connect with. If national hydrographic offices embrace this new way of working, they will form part of an overall 'marine geospatial data ecosystem'. The issues of data quality, lifecycle and ultimately governance are key success factors so that they as data originators along with value-added resellers and an expanding range of users will be much better off, and the goals of the UN-GGIM can be met.

There is much work still to do, but already some key issues are being identified that provide the evidence for further work. Making existing product data more easily accessible as a legitimate means to accessing marine geospatial information can only go so far, but it is start. There are so many reasons why a nautical chart is not fit for any other purpose than navigation: shoal-bias, discontinuities across chart boundaries, and features that are removed or modified for reasons of safety, to name but a few.

### COORDINATED EFFORT IS REQUIRED

Issues of data quality must be addressed in terms of creating products and services that meet the exact needs of users. Succumbing to the temptation of making navigation product data – or the source data, such as individual hydrographic surveys – more accessible is to miss the point. The former can be misleading,

and the latter can result in a significant amount of data processing requiring specialist software to get the data in a fit state to use in GIS, for example. What is required is a coordinated effort to create a range of products and services that have an authoritative and comprehensive base, that are fit for purpose for the application they are designed to support. Navigation is one such application, but there are many others.

This all emphasizes even more strongly the need for fundamental change and improvements in how marine geospatial information is viewed and managed. The first meeting of the UN-WGMGI made this point loud and clear. Let's hope it will go from strength to strength and we can continue to build a marine community that is forward thinking, inclusive, responsive and meets the aims of the UN-GGIM and beyond. ◀



**Dr Mike Osborne**, managing director of OceanWise, is trained as a physical oceanographer and has since acquired a broad set of skills comprising environmental and engineering support,

marine data management and GIS. Mike has been pioneering the use of GIS in the marine environment for almost 20 years. He specializes in data and information management and decision-support systems for the port and maritime sectors and the creation of marine reference data for marine spatial planning. Mike is a Fellow of IMarEST and a member of the MEDIN Executive Team. He is also an invited expert on the IHO Marine SDI Working Group, which he helped instigate, and an IHO trainer. He was awarded the Association of Marine Scientific Industries (AMSI) Business Person of the Year in 2017.



**John Pepper**, marketing director of OceanWise, has 40 years' experience working in the geospatial information industry, specializing in data collection and management, policy and strategy,

new business development and marketing in the UK and overseas. He spent 27 years with Ordnance Survey involved in geodetic surveys, photogrammetry, satellite imagery analysis and cartographic development and 11 years at UKHO in product management, commercial development and data management. In this time, he has travelled widely in UK, Europe, North America, Asia and Africa. In addition to his marketing portfolio with OceanWise, John specialises in providing geospatial, business and management consultancy services in strategy development and change management. He holds professional qualifications in surveying science and geodesy, marketing and strategic planning; is a Chartered Marketer and a member of the Institute of Leadership and Management (ILM).

#### Contact

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▲ Screens dominate the bridge of a present-day ship.

## Marine Mammal Monitoring Equipment Undergoes Intensive Subsea Testing

# Largest Planned Tidal Stream Project in the World

Balmoral Subsea Test Centre in Aberdeen, Scotland, has carried out hydrostatic tests on equipment that will be used to monitor the interaction between tidal turbines and marine mammals in the Pentland Firth. This project is currently the largest planned tidal stream project in the world and is the only commercial multi-turbine array to have commenced construction, explains Steve Gibb, group public relations manager at The Balmoral Subsea Test Centre.

The linear actuators that were tested form part of a marine mammal monitoring station anchored to the sea floor. Utilizing both passive- and active-acoustic tracking techniques, the station will collect data on the underwater movements of

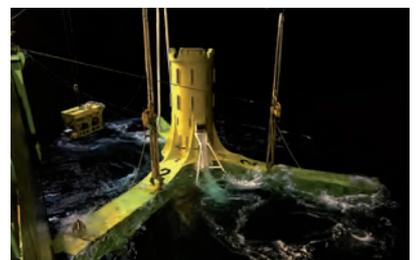
marine mammals around operating tidal turbines. This data will be used by the tidal energy industry and regulatory authorities to make informed decisions about marine mammal collision risk for tidal energy developments.

### CONFIDENCE IN THE CURRENT CONFIGURATION

The wide range of test chambers available at the Balmoral Subsea Test Centre meant that the specific needs of the test could be easily



▲ Balmoral's senior test technician, Mike Royl, and Michael Oswald of the University of St Andrews: "The testing has given us confidence in the current configuration".



▲ The first phase of the MeyGen project comprises the deployment of four 1.5MW turbines installed on gravity turbine support structures as part of MeyGen's 'deploy and monitor strategy' (courtesy Simec Atlantis Energy).

accommodated, not to mention completed within the tight timeline. “The testing has given us confidence in the current configuration and helps us to narrow our focus in future designs,” said Michael Oswald, of the Scottish Oceans Institute at the University of St Andrews, who worked on the project.

Test house manager, Derek Weir, said “We were delighted to work with St Andrews University in ensuring their equipment was fully trialled and fit for purpose.” The test centre also carries out many different types of tests from outside the oil

creates a natural channel with the mainland to accelerate millions of tonnes of water flowing between the North Sea and the Atlantic Ocean every day.

This site was originally identified in 2007 following a global review of tidal resources which concluded that the high flows, medium water depths and proximity to the mainland rendered it a prime location for development.

The first phase of the project involves the deployment of four 1.5MW turbines installed on

installation, operation and maintenance feeding into subsequent phases.

The turbines connect to the onshore power conversion unit at the Ness of Quoy where the low voltage supply will be converted for export to the local distribution network. On completion, this phase of the tidal array will generate sufficient electricity to supply 2,600 homes.

The supply chain for this phase of the project is spread across the United Kingdom, Europe and North America, with 43% of the project’s expenditure being in Scotland and includes companies in Caithness, Ross and Cromarty.

Only time will tell, but if the project reaches its maximum potential, it will be a huge win for the marine industry and everyone involved. ◀

## Linear actuators form part of an anchored marine mammal monitoring station

and gas industry and works closely with the academic, defence and oceanographic sectors.

### ACCELERATE MILLIONS OF TONNES OF WATER

MeyGen is developing the 398MW tidal stream project which lies just two kilometres from Scotland’s north-east tip. To the north of the site is the uninhabited island of Stroma which

gravity turbine support structures and will act as a precursor to the development of the remaining consented 86MW project.

### SUFFICIENT ELECTRICITY

The project will demonstrate that the development of tidal array projects is both commercially viable and technically feasible, with the lessons drawn from the construction,

**Steve Gibb** is group public relations manager at The Balmoral Subsea Test Centre, part of Balmoral Group Holdings Ltd, a privately-owned company based in Aberdeen, Scotland. Employing over 600 people, Balmoral has been providing solutions to the energy, engineering, marine, building, polymer engineering and processing sectors since 1980 ([www.balmoraloffshore.com](http://www.balmoraloffshore.com)).

## Making Hydrographers’ Tasks Easier



### Navsight Marine Solution

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### Qinertia

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# Next Step in your Hydrographic and Surveying Career

Certification is the next step in your hydrographic and offshore surveying career, according to experienced hydrographic surveyor Bruce Calderbank. The Canadian Hydrographer Certification Scheme (CHCS) is a global scheme just as with the Australasian Hydrographic Surveyor Certification Panel (AHSCP) scheme. The CHCS certifies both hydrographic and offshore surveyors and works in both English and French.

## WHY THE ACLS?

Over 60% of Canada is made up of offshore land. This land encompasses Canada's three territories, over 3,100 Indian Reserves, and all of Canada's National Parks. The Association of Canada Lands Surveyors (ACLS) is responsible for all Canadian land – which includes offshore. So, Canada Lands Surveyors should be read as Canada Lands... Surveyors, not Canada... Land Surveyors. The ACLS is a national, bilingual, self-regulated, and non-governmental professional organization created in 1985 with practice jurisdiction extending over Canada's offshore lands. The ACLS promotes and enforces the highest professional qualifications and standards through professional and ethical standards, and Continuing Professional Development (CPD) requirements. The organization provides the effective administrative capacity required, and has the

needed legislated regulatory framework, to manage the CHCS. The CHCS was approved by the International Board of Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) on 8 April 2016.

## WHY THE CHCS?

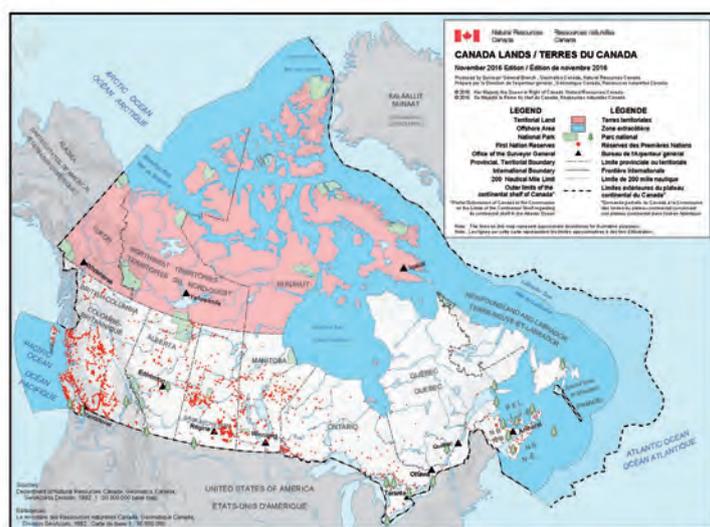
The CHCS provides a pathway for certification of hydrographic and offshore surveyors to international standards. The certification process is designed to ensure that those purporting to be hydrographic and offshore surveying specialists have the appropriate skills, knowledge, understanding and experience to meet contemporary demands. The CHCS supports individual hydrographic or offshore surveying certification for those who meet the requirements, whether they are members of the ACLS or not, and whether they are working in Canada or elsewhere in the world.

It applies International Federation of Surveyors, International Hydrographic Organization, and International Cartographic Association (FIG/IHO/ICA) competency standards for hydrographic surveyors by confirming evidence of academic study and combines this with a detailed assessment of a candidate's verified employment history and relevant experience to assess competency and award certification. The ACLS has a Mutual Recognition Agreement (MRA) in place with the other IBSC approved regional scheme administered by the AHSCP.

## ACTIVITIES OF THE CHCP

The CHCS is administered by the Canadian Hydrographer Certification Panel (CHCP). Its main activity is to critically review, examine and, where suitable, approve candidates, both Canadian and international. The ACLS wants to encourage those with suitable qualifications and experience to apply. The CHCP is encouraging Canadian academic initiatives to obtain IHO Category A and/or B recognized academic programmes. Currently, there are two CAT B-S5 programmes – CIDCO in Rimouski, Quebec; and the Marine Institute in St. John's, Newfoundland and Labrador. The more certified individuals, the greater the likelihood of uptake by Canadian and other academic institutions or private enterprises to provide Category A and/or B courses.

The CHCP has assisted the Canadian Board of Examiners for Professional Surveyors (CBEPS) to improve subject content with respect to C12 – Hydrographic Surveying, and E2 – Advanced Hydrographic Surveying. The CHCP will be reviewing the CHCS to be sure it will be compliant with the new IHO S-5A and S-5B



▲ Over 60% of Canada is made up of offshore land.



This is to certify that: La présente atteste que:

**Bruce Calderbank**

Who was assessed as a Hydrographic Surveyor Level 1 on October 5, 2017, has been recognized under the ACLS Guidelines for Hydrographic Surveyors, as adopted by the Association of Canada Lands Surveyors, and as such has been certified as a

Qui a été évalué comme hydrographe de niveau 1 le 5 octobre 2017, a été reconnu selon les lignes directrices du programme de certification des hydrographes de l'AATC, tel qu'adopté par l'Association des Arpenteurs des Terres du Canada, et comme tel, a été certifié en tant que

Certified Hydrographer  
CH

Hydrographe certifié  
H.C.

This certificate was issued by the Registrar on October 6, 2017 and remains in force subject to annual validation and continuing compliance with the Association of Canada Lands Surveyors Hydrographic Surveying Certification Program including meeting the Continuing Professional Development requirements.

Ce certificat a été délivré par le registraire le 6 octobre, 2017 et demeure en vigueur sous réserve d'une confirmation annuelle et de la conformité au programme de certification des hydrographes de l'Association des arpenteurs des terres du Canada, y compris aux exigences de perfectionnement professionnel continu.



002

Registrar Registrar

▲ *Becoming certified is just the next career step.*

standards for recertification in 2022.

The CHCP is composed of members from the private industry, academia, and the public sector, including the Director General, Canadian Hydrographic Service (CHS) or an appropriate designate.

### WHY CERTIFICATION?

Certification brings together training, understanding and competency. The British Science Council defines certification as "official recognition by one's colleagues and peers that an individual has demonstrated professional integrity and competence in his or her field". In mid-2018, the German Hydrographic Society (GHyD) sent out a questionnaire regarding individual recognition programmes in hydrography. One of the findings was that the quality of service provided, competence, experience and currency were the main concerns of the professionals in the industry.

Certification of a hydrographic or offshore surveyor is desirable because it allows the individual to stand out from their peers and allows public recognition of the hydrographers professional excellence. It increases that person's confidence and skill, and provides a formally recognized and structured career. Certification also provides an internationally recognized career path whether in the private and public sectors and establishes the person's level of expertise and competency. It also ensures the person is aware of the changing technologies in their sectors. Last but not least, it reduces the risks associated with unqualified and inexperienced persons providing these services to the public and provides the certificate holder with an enhanced profile within their industry. In addition, there are increasing instances where qualification-based selection procurement certification may be required. For instance, as of 1 April 2022, suppliers of hydrographic services to the Government of Canada pursuant to a Hydrographic Services Supply Arrangement will be required to have on staff either a Certified Hydrographer (CH) or Certified Hydrographic Technician (CHTech). There are also other government and private users which also use such qualification-based selection stipulations.

### WHY CHCP CERTIFICATION?

Becoming certified is not better than other qualifications, it is just the next career step. There are many qualifications available for hydrographic and offshore surveyors, but only two certifications are internationally recognized – the CHCP and the AHSCP.

The CHCS and the AHSCP schemes both focus on knowledge and understanding, requiring a high level of competency, which allows both national and international candidate's to have broad (for example, nautical charting or oil and gas) or specific (for example, port surveying or unexploded ordnance (UXO) surveys) practical experience. Both schemes require the same number of years experience, a project report or similar, and they are open to hydrographic and offshore surveyors. The Canadian Scheme's fees are not that onerous with the initial assessment fee for non-ACLS members being less than £290, and the yearly recertification fee being less than £200, both of which covers the ACLS's costs.

### CERTIFICATION PROCESS

The CHCS has two levels of certification. The first level is for project leaders and managers and the second level is for technologists. Each level has a variety of pathways towards certification depending on the individual's academic background.

Candidates who have graduated from a FIG/IHO/ICA recognized S-5 Category A or B training course have more flexibility in achieving certification. However, other candidates can also apply and will be assessed on their academic, training, understanding and experience. Those successful candidates who have graduated from a FIG/IHO/ICA recognized S-5 Category A or Category B programmes will have that mentioned on their certificate.

Everyone must provide a project report – no exceptions. For hydrographic surveys, in lieu of following the CHCP guidelines, a report could be based on the latest version of the IHO C-13 or the acceptance of a report of survey by a national hydrographic office.

### MAINTENANCE OF CERTIFICATION

As with any good individual recognition programme, Continuing Professional Development (CPD) is at the heart of recertification, where the CPD shows the continual development of the hydrographic and/or offshore surveyors competencies beyond those derived from their initial training. For the CHCS, each CH or CHTech has to recertify by 1 January each year. Both the CHCS and the AHSCP schemes require 45 hours of CPD over a three-year calendar period including five-hours per year of formal courses or seminars related to hydrography or offshore surveying. For the CHCS, this information must be entered via the Canadian GeoEd website ([www.geoed.ca](http://www.geoed.ca)). In addition, for those who are not a member of the ACLS ([www.acls-aatc.ca](http://www.acls-aatc.ca)), they have to provide a log of experience for the previous year. ◀

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**Bruce Calderbank, FRICS, CLS, CH, P. Eng, a Certified Hydrographer Level 1, Chartered Hydrographic Surveyor, Chair, and part of the Canadian Hydrographer Certification Panel Association of**

Canada Lands Surveyors, has been a volunteer with the ACLS for many years, as well as having worked offshore for over 38 years. In May 2016, he was awarded a volunteer award for 'extraordinary contributions to the future of the profession'.

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## Underwater Noise Monitoring in the North Sea

# Jomopans Project to Monitor Continuous Sound

Sound is of vital importance for marine animals. Eleven institutes from the countries bordering the North Sea have joined forces in the Jomopans project to implement a novel monitoring strategy for underwater sound.

Due to the growth of human activities in the sea, sound pollution is a growing concern for marine environmental managers. High levels of anthropogenic noise disturb animals, but the integrated impact of noise on the marine ecosystem is largely unknown. In the Joint Monitoring Programme of Ambient Noise in the North Sea (Jomopans) project, measurements at sea are combined with noise maps from numerical modelling to assess the quantitative levels of sound at sea.

### SOUND AND MARINE LIFE

Sound is omnipresent in the marine environment and it is vitally important for many marine animals. Three key aspects in the

survival of animals and species are food supply, reproduction and protection against threats, and the auditory senses are very important for marine organisms in this context. Usually underwater visibility is very low, either due to high turbidity – as in the North Sea – or the absence of light in the open ocean. Animals therefore use sound to navigate, find food, communicate with potential partners and as a warning against various threats. Many marine mammals use echolocation to detect their prey. Fish species produce a large variety of sounds to communicate, e.g. using their swim bladders. Even some invertebrates can make loud sounds to deter potential enemies and communicate with each other.

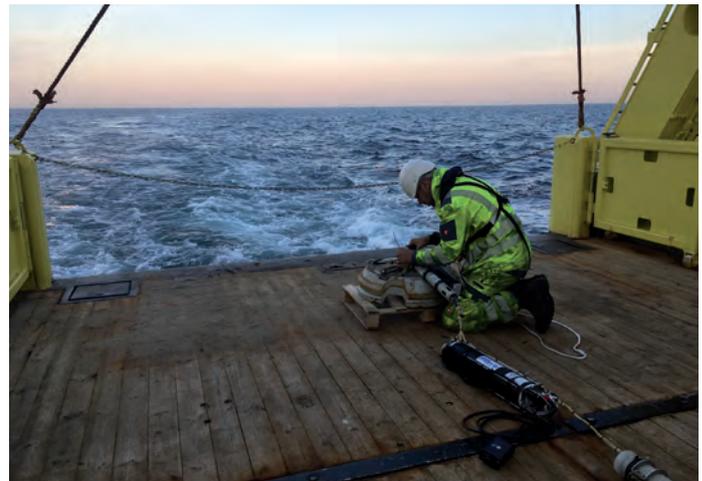
Underwater sound is much less attenuated than airborne sound. Thus marine sound carries over much larger distances than sound in air. In the deep ocean, the low-frequency sound of certain whale species may carry over thousands of kilometres. Much is still unknown about the purpose of these sounds. In a shallow sea, like the North Sea, sound can easily travel dozens of kilometres. This makes sound a very effective communication medium and source of information about the environment for marine animals.

### THREATS FROM HUMAN ACTIVITY

The North Sea is one of the world's busiest seas for the transport and maritime industries, and its



▲ Crew preparing the equipment.



▲ Locations of measurement stations (red dots) and logos of the project partners.

▲ Deployment of the Dutch measurement station (Image courtesy: Waterproof BV)

shared resources represent a crucial economic asset to the North Sea countries. Almost 30,000 ships visit the Rotterdam harbour annually, and Hamburg is directly and indirectly responsible for more than 250,000 jobs in Germany.

Over the last decades, the levels of sound have increased due to increased human activities in the sea. Most human activities in the sea produce noise either as a result of the activity (e.g. noise from ships, or from the pile driving of the foundations for offshore wind farms) or of the purpose (e.g. seismic surveying using air guns, or military sonar devices). In illustration, a wind farm will produce high levels of noise for a short period during construction, but it will also cause contribute to a higher total noise level over its entire life cycle due to increased shipping.

These anthropogenic underwater sounds can affect marine animals. Loud impulsive sounds can cause hearing loss (either temporarily or permanently) and displace animals from important habitats, while continuous sounds can mask communication and echolocation of marine animals. In recognition of the vital role of sound to marine life, anthropogenic noise is now regarded as a pollutant and should be considered in environmental quality assessments. Despite the growing interest in marine sound in the last decade, the overall impact of noise on the marine ecosystem is still largely unknown.

### THE JOMOPANS PROJECT

Quantitative information on the sound levels in the sea is very important for assessing the environmental impact of underwater noise. This

information can be combined with the distribution of species in the North Sea to derive a measure of the risk of impact on marine life. To gather this quantitative information, 11 institutes from the countries bordering the North Sea joined forces in the Joint Monitoring Programme for Ambient Noise in the North Sea (Jomopans) project. The project receives 50% of its funding from Interreg North Sea Region.

### MONITORING STRATEGY FOR CONTINUOUS SOUND

The aim of the monitoring strategy developed by Jomopans is to gather information for marine managers in relation to the Marine Strategy Framework Directive (MSFD). Monitoring can also be aimed at other purposes, including surveillance of shipping, determining noise characteristics of shipping and monitoring the effects of other specific activities, but such monitoring would be different from MSFD monitoring and is therefore not discussed here.

MSFD monitoring is needed to evaluate compliance with the Good Environmental Status (GES) standards required under the MSFD. Maps of a statistical quantity of the sound pressure level will be produced by a combination of measurements and numerical modelling (Merchant et al, 2018). Most fields of marine monitoring are primarily based on measurements, either in situ measurements or by using remote sensing techniques. Maps are usually obtained by interpolating known measurements. For underwater sound, numerical modelling has been given a major role in the monitoring, which provides a regional overview of the soundscape.

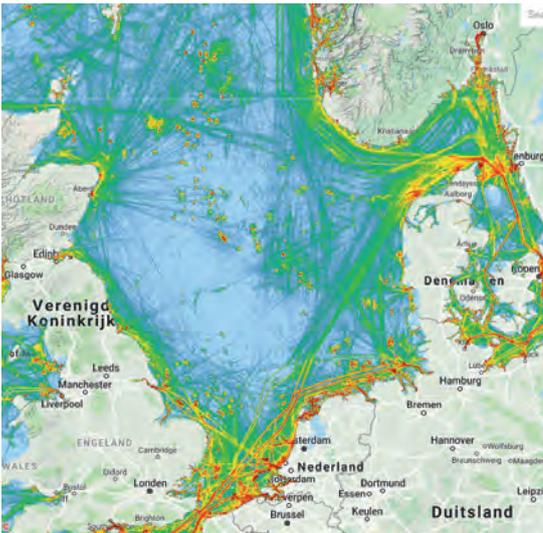
Underwater sound shows high variability in both time and space. Monitoring based on measurements would require measurements to be taken at a large number of locations and for long periods in time. This is impractical, if not impossible. Taking measurements is labour-intensive and therefore very costly, and it can be difficult to distinguish between different sound sources. Numerical modelling can in principle overcome these problems. Sound propagation is based on relatively simple physical laws, and numerical models can be used to produce sound maps for large areas with a chosen resolution. Also, the contributions from different sources and source types can be calculated separately. It is important to have good-quality measurements for the validation step of such models.

### MEASUREMENTS

The Jomopans project is using a strategy combining both measurements and numerical modelling.

For the project, 14 measurement stations are being deployed around the North Sea. The locations were chosen to obtain measurements of the different sound conditions expected to be found in the North Sea basin. Some are located near shipping routes, while others are located in relatively quiet areas. Most stations cover the shallow North Sea at 10 to 60 metres depth, but one station (in the Norwegian Trench) is located at 300 metres depth. The goal is to gather data for at least one year so that statistically relevant sound levels are obtained for all seasons.

Shipping maps and wind noise maps will be derived from numerical modelling using acoustic models. Various source and propagation models have been tested and the



▲ *Map of shipping noise in European seas. (Source: Kevin Heaney, Applied Ocean Sciences).*

results have been compared, with the objective of providing guidance on the selection of appropriate models and input parameters. Statistical modelling techniques are being applied to quantify uncertainties in the acoustical modelling.

Propagation models need a representation of the environment. Some environmental parameters, like the bathymetry, are known relatively accurately. Other parameters are not known accurately or vary over time, e.g. sea

state, water temperature and salinity. The available information about the composition of the sea bottom does not provide direct information on the parameters that are relevant for sound propagation.

Noise map models need input of information about the sound sources. Semi-empirical models are used for ship traffic and wind noise. Information of the ship traffic is derived from the Automatic Identification System (AIS), but that does not cover all ships and does not provide direct information on the acoustic source levels of ships.

As a final step, the monthly percentiles of the sound pressure level resulting from the modelling will be validated against the results from the measurements at the 14 stations.

### HARMONIZATION

Jomopans is not an isolated project. Around the world, several other projects focus on underwater sound. Jomopans has learned from previous efforts, like the BIAS project in the Baltic Sea, and has close links to other projects (e.g. QuietMed in the Mediterranean, COMPASS in Scotland and Ireland, and the ECHO project in Canada). Jomopans will pass its information and experience on to future projects, such as JONAS which is about to start in the Atlantic region. Special attention will be paid to standardization of terminology, measurements

and propagation modelling, as standards are very important to the further advancement of this new field.

As mentioned above, Jomopans covers only part of the total subject of the environmental effects of anthropogenic underwater sound. There is still much work to be done, especially relating to the effect of sound on animals, e.g. injuries or behavioural response. It is hoped that the Jomopans project will provide a solid basis for monitoring underwater sound, on which marine managers and scientists can build.

### CONCLUSIONS

The Jomopans project is developing a monitoring programme for continuous sound in the North Sea. It combines numerical propagation modelling and field measurements to obtain high-quality maps of the sound level in the North Sea. These maps will be used to assess the Good Environmental Status in relation to underwater sound. ◀

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#### References

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▲ *Close-up of the equipment (Image courtesy: Waterproof BV).*



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