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COVER IMAGE

Scientists at Washington Department of Fish and Wildlife deploy a Saab Seaeye Falcon underwater robotic vehicle fitted with high-definition video and stereo cameras to assess fish size and density for conservation studies of threatened rockfish species in Puget Sound, where precise maneuverability among complex rock formations in strong currents is vital. (Credit: Davy Lowry, Ph.D. - Washington Department of Fish and Wildlife, U.S.)

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Annual Review and Forecast.

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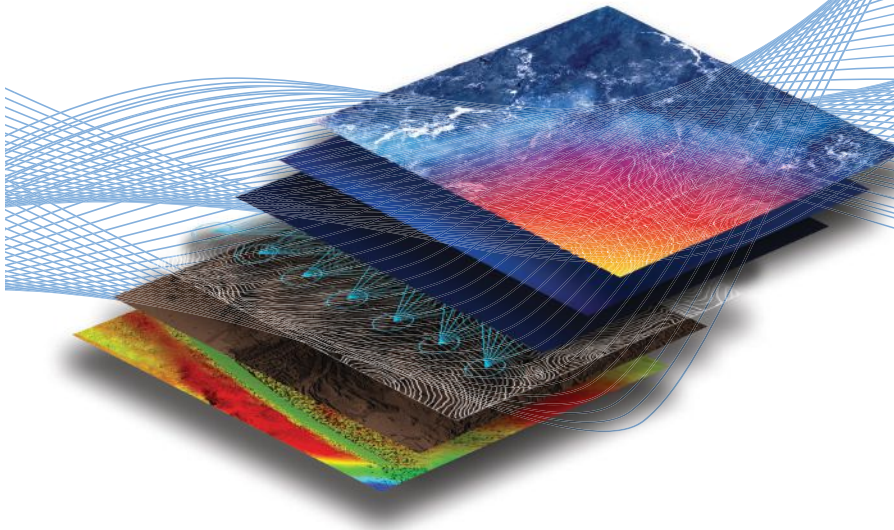
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Mapping the World Ocean

The publication earlier this year of the GEBCO 2019 Grid—the definitive, free map of the world's ocean floor—included more than double the amount of high-resolution bathymetric data as the previous edition. This sizeable leap is largely attributable to the efforts of The Nippon Foundation-GEBCO Seabed 2030 Project, a pioneering initiative to produce a complete map of the world's oceans by the end of the next decade.

Seabed 2030 is a collaboration between The Nippon Foundation, Japan's largest private philanthropic organization, and the General Bathymetric Chart of the Oceans (GEBCO), which has more than a century of experience in ocean-floor mapping. It was launched by Yohei Sasakawa, chairman of The Nippon Foundation, at the UN Ocean Conference in 2017 and supports Sustainable Development Goal 14 for the sustainable management of the oceans.

A comprehensive, publicly available map of the entire ocean floor will empower the world to make informed policy decisions, use the ocean sustainably and undertake scientific research based on detailed bathymetric information. Knowing the shape of the seabed is critical to understanding ocean-circulation patterns and how they affect climate and weather patterns; wave action; tsunami wave propagation; and identifying underwater geohazards.

Since its launch, Seabed 2030 has attracted an international network of contributors and supporters, including more than 100 organizations across 50 countries. Headed by leading ocean scientists and ocean-mapping experts, the project has four Regional Centers, responsible for assembling and compiling bathymetric information and coordinating with other initiatives in their regions. The Global Center, hosted by the British Oceanographic Data Centre, produces and delivers global GEBCO products. The Regional Centers are based at the Alfred Wegener Institute (AWI) in Germany, covering the Southern Ocean; the National Institute of Water and Atmospheric Research (NIWA) in New Zealand, covering the South and West Pacific Ocean; the Lamont-Doherty Earth Observatory (LDEO) in the U.S., covering the Atlantic and Indian Oceans; and the Arctic and North Pacific Oceans Center is jointly hosted by the University of Stockholm, Sweden, and the Center for Coastal and Ocean Mapping at the University of New Hampshire (UNH), U.S.

Identifying exactly how much of the oceans are mapped is central to the mission of Seabed 2030. It's unknown how much of the seafloor has been mapped already and what is held in private databases, so collaboration and crowdsourcing are key to the project.

The 2019 GEBCO Grid was the product of a truly international effort, pulling together data from countless organizations and mapping initiatives around the world. The increase in data coverage from the 2014 Grid to the 2019 Grid—from 6.4 to 15 percent—is equivalent to around 32 million km² of new bathymetric data, an area greater than Africa.

Maintaining this kind of progress is essential if Seabed 2030 is to meet its goals, and The Nippon Foundation and GEBCO are heavily involved in developing new technologies and building human capacity by training the next generation of ocean-mapping experts. Since its inception in 2004, The Nippon Foundation-GEBCO Postgraduate Training Program at UNH has graduated nearly 100 students who have gone on to make significant contributions to the field of bathymetry around the world. This year, a team of alumni from the program won the \$4 million grand prize of the Shell Ocean Discovery XPRIZE, a global competition challenging teams to advance deep-sea technologies for autonomous, fast, high-resolution ocean mapping.

In just two years, Seabed 2030 has made remarkable progress and will continue to do so. Mapping the oceans is essential to understanding, managing and ultimately protecting them, now and for the future. **ST**

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)) Our Ocean Conservation Report. World governments and other leadership bodies are taking vital steps to protect the ocean, but more progress is urgently needed, Oregon State University (OSU) scientists reported at the Our Ocean Conference. An OSU analysis, led by marine ecologists Kirsten Grorud-Colvert and Jane Lubchenco, concludes that more than one-third of the ocean area currently under protected status is the result of the annual, high-profile meeting. The Our Ocean Conference was established in 2014 under the leadership of then U.S. Secretary of State John Kerry. The meeting brings together global leaders of governments, industry, youth and civil society to tackle problems that threaten ocean health. As a result of the conference, more than 180 new or expanded protected areas covering 6 million km², or 1.7 percent of the ocean, are actively protected from extractive activities such as fishing, mining and drilling. Participating countries at the conference have agreed to protect 10 percent of the ocean by 2020. The OSU researchers outlined five recommended actions for world leaders: support progress so actions don't stall; ensure that protected areas are monitored and managed for intended results; support an effective online reporting tool to track progress on ocean commitments; celebrate completed actions and success stories with high-profile reporting at the Our Ocean Conference; and use the success of the conference to create momentum for a full range of meaningful, effective ocean actions, including sustainable fisheries, serious attention to illegal, unregulated and unreported fishing, significant reductions in greenhouse gas emissions, and strategies to adapt to climate change and ocean acidification.

)) Companies Pledge Not to Use Arctic Shipping. Nike and Ocean Conservancy have launched the Arctic Shipping Corporate Pledge, inviting businesses and industry to join them in the commitment not to ship through the Arctic Ocean shipping routes. Nike and Ocean Conservancy hope to inspire others to help prevent a problem before it starts. As Arctic ice continues to diminish because of climate change, it opens the possibility of cargo traffic through ocean routes that were previously unnavigable. Increasing vessel traffic on Arctic shipping routes poses great risk and potentially devastating environmental impacts. The Arctic plays an essential role in regulating global temperatures and counteracting climate change. Climate change is heating the Arctic at twice the rate of the rest of the planet, causing severe community disruptions and changes to ecosystems relied upon by Arctic residents and the region's iconic wildlife. Shipping incidents such as oil spills could impact the sensitive ice-dependent ecosystems and irreversibly harm communities' subsistence way of life. The Arctic Shipping Corporate Pledge's signatories include the companies: Bestseller, Columbia, Gap Inc., H&M, Kering, Li & Fung, PVH Corp., and ocean carriers CMA CGM, Evergreen, Hapag-Lloyd and Mediterranean Shipping Co. Global shipping currently accounts for about 3 percent of global greenhouse gas emissions but is not included in the reduction commitments made by countries in the Paris Agreement.

)) Japan, Scotland Make Joint Investment in Blue Economy. Industry body Subsea UK and its technology arm, NSRI, has announced that, through a close working relationship between Scottish Enterprise and the Nippon Foundation, £20.9 million will be invested into six R&D projects being developed by 20 companies from Scotland and Japan. Scottish Enterprise is providing £6.2 million in R&D funding to 12 Scottish companies, and Japan will contribute £4.1 million to the joint projects. A further £10.6 million is being contributed by the Scottish companies for six projects with eight Japanese partners. These were chosen based on the potential of their near-to-market technology to solve technical challenges in offshore renewables, carbon capture and storage, and oil and gas. Under the six projects, these companies will collaborate with industry bodies and universities to develop innovations in mooring, installation systems, geoscience and artificial intelligence.

)) TIGER to Drive Europe's Tidal Industry. Interreg France (Channel) England Programme has approved the biggest ever Interreg project that will be game-changing for the European tidal-stream energy sector. The Tidal Stream Industry Energiser Project, known as TIGER, is an ambitious €46.8 million project, of which €28 million (69 percent) comes from the European Regional Development Fund via the Interreg France (Channel) England Programme. The project aims to drive the growth of tidal-stream energy by installing up to 8 MW of new tidal capacity at sites in and around the Channel region, thus driving innovation and the development of new products and services. TIGER will make a stronger, more cost-effective case for tidal stream to become part of the energy mix in the U.K. and France by harnessing economies of scale via volume manufacturing and multidevice deployments. The total theoretical tidal-energy capacity in the Channel region is nearly 4 GW, enough to power up to 3 million homes.

)) ASNE Scholarships Available. The American Society of Naval Engineer's (ASNE) Scholarship Application submissions are officially open for the 2020 to 2021 academic year. Undergraduate and graduate students pursuing an education and career in engineering can now apply. ASNE awards \$4,000 in both undergraduate and graduate scholarships each academic year. To learn more about the application criteria and process, visit: www.navalengineers.org/Education/Scholarships. Applications are due March 9, 2020. **ST**

Gap-Filling Technology

MA-X Complements Side Scan Sonar Imagery

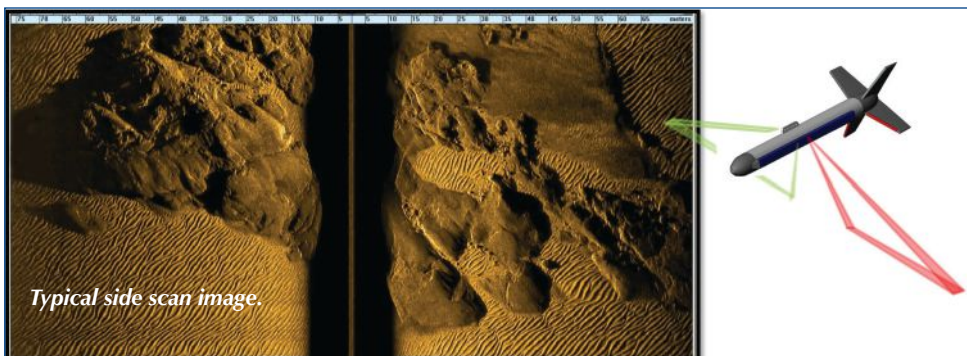
By Dean Fleury

It has been some time since something truly unique has come out in sonar imaging technology. That changed this year when Klein Marine Systems introduced MA-X at the Ocean Business Technology Exhibition in Southampton, U.K., in April.

MA-X stands for Multi-Angle X-pattern, which describes the approach used to generate images with side scan-like characteristics that fills the gap seen on the screen when using traditional side scan sonars.

In a typical side scan image, one can see the black stripe down the middle that represents the lack of coverage in the area below the towfish. The lack of coverage under the towfish occurs because the beam patterns of the two side scan transducers are oriented in such a way as to optimize range performance without creating interference from one to the other. This stripe has been referred to in the industry as the nadir region, water column and even skunk stripe. What it represents is lost time and money as the surveying vehicle has to double back and image that area, which is only a fraction of the system's imaging swath—leading to the collection of redundant data.

Alternative technologies such as multibeam echosounders cover the nadir, but their downward-looking aspect angle results in images that contain no shadows—and it is the shadows in the side scan images that provide the visual cues to both humans and interpretation software, such as automated target recognition, to assess the size of objects and the topography of the terrain. Additionally, alternative technologies have shortcomings such as range limitations and differing data formats that make automated target recognition more difficult to in-



tegrate with an overall system. Thus, there is a need for a system that collects data in the nadir area and creates images like a side scan sonar system. This means equivalent shadows, resolution and tonal quality. To achieve this, the system has to ensonify the sea bottom with a grazing angle to create shadows. The frequency and sample rate of the system have to be carefully chosen to achieve the needed range and resolution. Finally, the image processing has to result in an image similar to and aligned with the side scan image.

Method

The simplest description of MA-X is that it is a reconfigured side scan sonar, an angle-look sonar, if you will. Think of an angle-look sonar embedded in the nose of a typical AUV. There are two transducers, port and starboard, each mounted at an angle relative to the sensor platform in such a way that each narrow fan beam is oriented to look down and forward at an angle from the platform.

The starboard transducer puts out a beam that ensonifies the sea bottom starting on the starboard side of the platform extending diagonally forward to the port side of the platform track. The port transducer performs the mirror image. The two fan beams overlap, resulting in an "X" pattern on the seafloor. The port and starboard image are

System

The MA-X technology is now part of Klein's MA-X View 600 towfish. The desired functionality of the overall product—high-resolution images from both the side scan sonar and gap-filler sonar—led to the selection of complementary frequencies for the two sensors.

The side scan sonar utilizes a focused 600-kHz transmit array to provide excellent imagery out to 50 m. The typical flight altitude of 15 percent of range coupled with the geometry of the MA-X array results in an imaging range of 20 to 40 m, which is a perfect match for Klein's wideband 850-kHz technology.

Note that the side scan image is displayed in slant range, which clearly shows the nadir region, and the MA-X image is in ground range.

The imaging is the result of improvements Klein has made throughout the hardware and processing of its product lines, referred to as Klein Blue Technology. Klein Blue represents innovations in acoustics, signal conditioning and processing design that produces unmatched image quality and range performance. These innovations

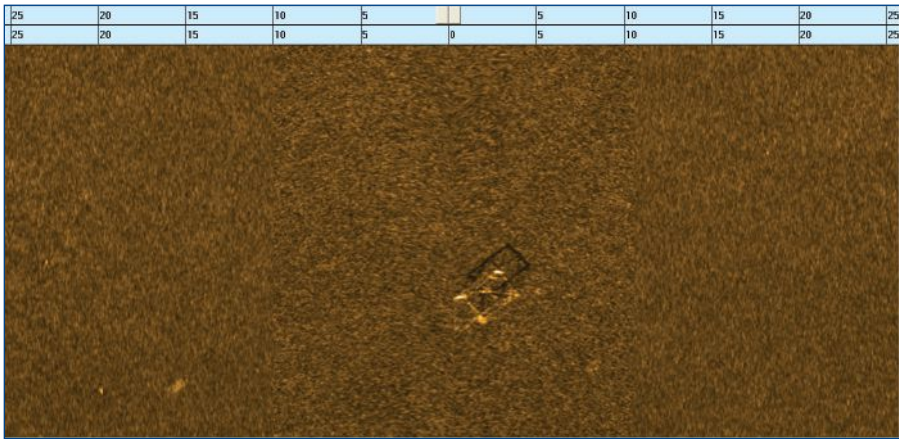
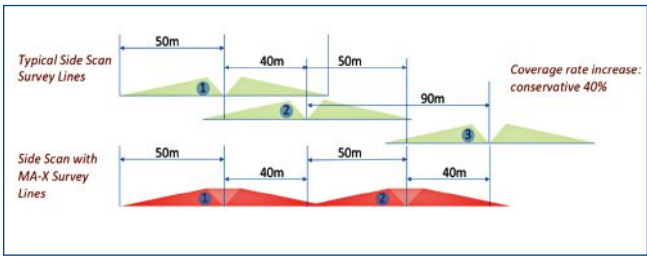
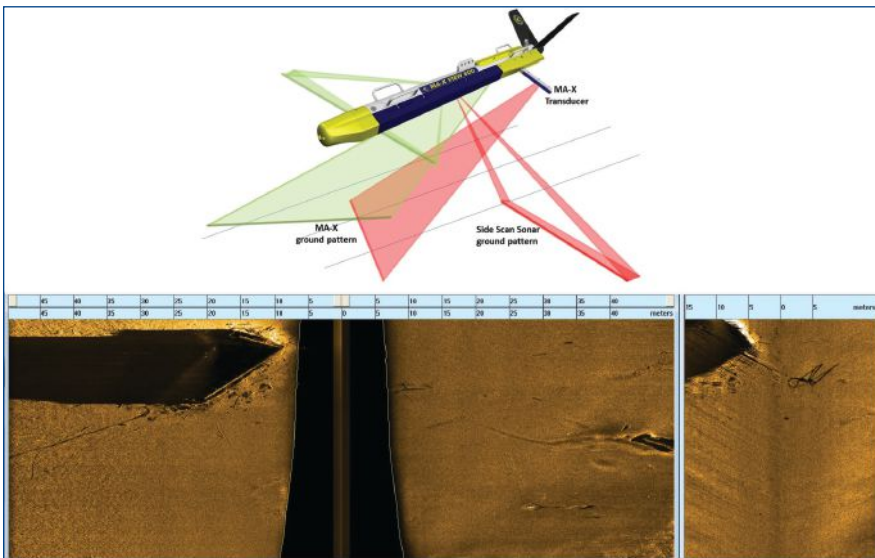
include transducers with beam patterns that are nearly indistinguishable from the theoretical; techniques such as variable transmit power for improved short-range performance; and motion tolerance for consistent imaging in high sea states that impact towfish stability.

MA-X transducers can be mounted anywhere that supports the correct mounting angle for the transducers where they have a clear view of the sea bottom ahead.

The prototype MA-X View 600 towfish had the transducers mounted to tail fins below the tow body.

The MA-X View 600 product moved to spring-loaded retractable transducers located on the sides of the tow body, where the MA-X transducers can quickly be moved into position prior to towfish deployment and snap closed should they impact an undersea object or the side of the towing vessel during recovery.

The combination of the side scan image and the MA-X image provides uninterrupted coverage of the sea bottom, with a varying amount of overlap depending on altitude, as a survey vessel passes over a target area. This reduces the required overlap between survey lines to just the variation associated with ship navigation and results in a dramatic increase in area coverage rate relative to using a side scan sonar alone, conservatively estimated at 40 percent. With traditional side scan sonar alone, the second swath must overlap the first to cover the nadir



(Top) MA-X View 600 images. (Middle) The difference in survey planning for a typical area survey with and without MA-X. (Bottom) Post-processed combined image. The area where the “stitching” occurred is around the 10-m range. However, this view cuts off a portion of the image from each sonar that provides a multi-aspect view of objects in the area where the two sonars overlap.

then combined to generate an image of the area normally seen as the gap.

The shadows associated with objects on the seafloor are different than a typical side scan image, where the shadows are perpendicular to the path of the platform. In the MA-X system, the shadows are forward and at an angle to the path of the platform.

gap in the first pass, plus an overlap to account for navigation variation. The third pass needs overlap for navigation variation. The process then repeats.

When MA-X supplements the side scan sonar, the second pass, and subsequent passes, need only overlap the preceding pass by the navigation variation.

There is no application hungrier for improved efficiency than missions performed by AUVs. AUV customers are clamoring for longer mission times. AUV vendors are scrambling to fit larger and larger battery configurations into their vehicles.

What if the mission could simply be performed 40 percent faster?

In a towed configuration, the increased efficiency with MA-X results in shorter survey times and financial savings associated with fewer labor hours, fuel costs, and wear and tear on the towing vehicle.

The options for mounting MA-X in various places on the AUV—nose, retractable arrays, tail fins—

provides AUV vendors with options for meeting the increased desire for modularity and rapid reconfiguration of the vehicles for various mission types.

With its small size, low power consumption and simple integration, MA-X can be used in a stand-alone configuration, or it can be combined with a side scan sonar to cover a much larger area in a single swath. The retractable-array configuration even provides for the possibility of using a MA-X system as a high-frequency side scan sonar when the transducers are in their retracted position. Retrofit options allow for deployment of MA-X with side scan sonars or even synthetic aperture sonars from other manufacturers.

The first AUV MA-X systems will ship in early 2020. Current consumers of Klein side scan data will find easy compatibility with MA-X data, which can be delivered in standard .sdf and .xtf formats. Third-party software vendors are already working with MA-X View 600 data. Ini-

tial passes at mosaic images have already been submitted for evaluation.

A joint exercise was held in Sweden at the end of September where the MA-X View 600 surveyed a lake littered with a variety of targets. Both the side scan sonar and the gap-filler sonar generated crisp images of targets ranging from mine-like objects to large sunken structures.

Conclusion

The MA-X technology is of great interest to users such as the mine countermeasures community, since the imagery has the same interpretation characteristics as side scan images—grazing angle and high-contrast shadowing. Because of this, the data lend themselves to be processed by automatic target recognition and computer-aided detection/computer-aided classification software as just another set of “side scan” channels. The increase in area coverage rate makes the technology an attractive upgrade to the professional survey market.

The excitement instilled in the sonar community is palpable. Initial feedback has ranged from a competitor saying, “Why didn’t I think of that?” to a potential customer standing up in the middle of a 50-person briefing and stating quite loudly, “That is [expletive] amazing!” Even Marty Klein, “the father of side scan sonar,” was awestruck when first exposed to the MA-X images.

The future looks bright for this new patent-pending technology. MA-X is a simple and elegant solution that fills the gap without compromising image quality. It does so with a small, low-power system that creates unprecedented imagery capable of being used by a vast array of end-users, with no training required. **ST**

Dean Fleury is the director of engineering at Klein Marine Systems.



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iXblue Echoes 10 000 sub-bottom imager for object detection

To meet the various needs of the sub-bottom profiling market, iXblue, a global high-tech company specializing in advanced marine, photonics and autonomy technologies, conceived a complete range of sub-bottom profilers: the Echoes Series. Developed over the past 30 years in close collaboration with the French Navy and several International Oceanographic Research Institute laboratories (IFREMER, SHOM, etc.), iXblue's products technology expertise come from extensive practicing and cumulative return on experience coupled with constant innovation and evolution. A recent mission in Scotland emphasizes Echoes 10 000 performance in shallow waters for object detection.

Back in December 2018, iXblue Sonar Systems Division and the University of Saint-Andrews used the Echoes 10 000 (10 kHz) to conduct 11 km of near-surface geophysical investigation in shallow water environments (< 25 m) near Scotland's shorelines. High-resolution seismic profiles show individual and parabolic reflective objects that correspond to decimetric rocks visible in sediment cores (Fig. 1a). This unique performance is due to iXblue's unique internal skills in the design of efficient CHIRP technology with large transducer beams (around 20°) that result in an impressive signal continuity and the identification of buried objects. This key performance brings new insights for 3D mapping of individual boulder clearance for shallow marine environment (< 150 m). It is furthermore helpful to follow the trajectory of buried pipelines (Fig 1b).

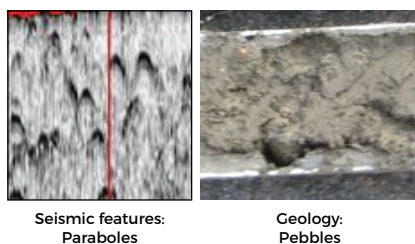
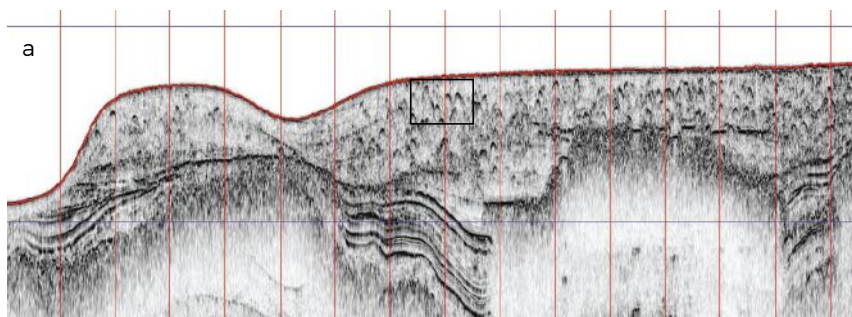
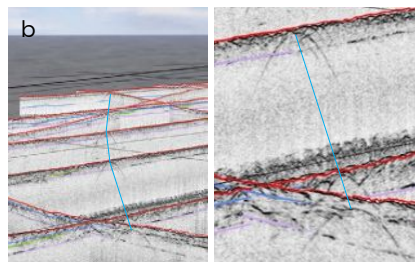


Figure 1 : Parabolic effect of buried objects with Echoes 10 000 (10 kHz): a) Decimetric rocks can be detected in sandy sediments. b) Pipe trajectory clearly identified.

The Echoes Series can be pole or hull-mounted, or integrated on Unmanned Surface Vessels (USVs) and are therefore easily operated and mobilized from vessels of opportunity, covering a full spectrum of applications, from shallow to deep water: industrial survey, physical oceanography, archaeology, oceanographic survey, marine archaeology and deep ocean operations.

iXblue also develops an open software suite for acquiring, processing, mapping and interpreting all kinds of hydrographic and geophysical data. The Delph Software Suite naturally makes the best from the Echoes sub-bottom profiler's data with possible improvement on the chirp processing and complete 3D geo-referencing of survey data both in real-time and offline.

Delph Interpretation is a complete software suite including applications and tools addressing the requirements for the processing and interpretation of geophysical datasets with optimized quality control. The software includes dedicated sensor modules (Delph Sonar / seismic / Mag) that are all linked to a mapping interface (Delph RoadMap) offering 3D visualization and quick access to raw and processed data. ■



Monitoring Arctic Glaciers

AUV Surveys Glacier Fronts in Norway for Climate Studies

By Dr. John Howe • Colin Abernethy • Professor Mark Inall

The impact of climate warming in the Arctic is profound. The region is experiencing significant environmental change and is facing the most severe climatic changes on Earth, with unprecedented warming leading to reduced sea ice cover and retreating glaciers.

Arctic fjords have numerous tidewater glaciers, which are strongly influenced by oceanic warming. The retreat of glaciers from the fjords also affects the marine ecosystem by changing the delivery of nutrients and freshwater to the fjords. Therefore, there is a need to monitor any change in the behavior of tidewater glaciers in order to

try to understand their future response to ocean warming.

To monitor the glaciers of western Svalbard in Norway, an AUV was used to collect simultaneous measurements of the glacier-front environment adjacent to, or directly in contact with, the grounded ice front. The aim was to bathymetrically survey the seabed in front of the glacier; identify the water mass structure; and document any meltwater plume activity from the glacier front.

Krossfjorden-Kongsfjorden Tidewater Glaciers

The region in front of an active calving glacier (less

Conwaybreen in Kongsfjord, western Svalbard.





(Top) AUV “Freya” launched in front of Kongsbreen. (Bottom) “Freya” surfacing into loose, brash ice, Kongsfjord.



than 200 m) can be considered a highly hazardous region to undertake oceanographic measurements from a traditional surface research vessel. The Norwegian Polar Institute, the partners in this study, consider this region an exclusion zone, and the approach of any vessel to the glacier front is strongly discouraged. In the past, vessels have been damaged and people injured by falling ice.

In order to collect data close to the grounded ice front, the Scottish Association for Marine Science (SAMS) deployed a Teledyne Gavia Offshore Surveyor AUV (“Freya”) to work in the exclusion zone. The project focused on the four tidewater glaciers of the Krossfjorden-Kongsfjorden region of western Svalbard and was supported by the nearby research station of Ny Ålesund.

The distribution and movement of some glacier fronts in the region have previously been mapped using surface vessels, yet the innermost part of these fjords and the glacier-front environments have not been subject to detailed bathymetric and oceanographic surveys.

These glaciers were chosen to demonstrate a “continuum” of glacier-ocean scenarios, from fully marine to al-

most land-terminating, to represent the present and future of Arctic fjords. All four glaciers terminate in the marine environment, and some are surge-type, experiencing long periods (decades) of inactivity followed by shorter periods of rapid advance.

The surge-type glacier, Fjortende Julibreen (Fourth of July glacier) has a grounded, shallow-water (less than 50 m) glacier front. Conwaybreen (Conway glacier, after Sir Martin Conway the 19th century explorer) has now almost retreated

entirely onto land, whereas Kongsbreen (Kings glacier) and Kronebreen (Crown glacier) are both dynamic, highly active tidewater glaciers.

Surveys

The surveys were conducted during two Arctic field campaigns in the summer of 2016 and 2017, and all the surveys were based from the Norwegian Polar Institute vessel *MV Teisten*. AUV “Freya” has a maximum operational depth of 500 m and is equipped with a Kongsberg GeoAcoustics 500-kHz GeoSwath+ interferometric sonar, with a Grasshopper benthic camera and strobe. The 500-kHz sonar was operated at altitudes of 2 to 10 m above the seafloor, with a 30-m range, providing an approximate object resolution of 0.1 m. The AUV uses a Kearfott T24 inertial navigation system providing a navigational accuracy of ± 0.1 percent distance traveled (e.g., accuracy of 0.1 m per 1 km of survey).

In addition to the bathymetry and side scan sonar, the AUV-mounted camera enabled photographs of the seabed to be obtained in order to determine the nature of the

seabed sediments. At the glacier fronts of Conwaybreen, Kongsbreen and Kronebreen, an Idronaut Ocean Seven 304 CTD instrument mounted on the bow of the AUV was utilized to collect underway oceanographic data. Underwater survey progress was monitored using an ultrashort-baseline pinger in order to communicate with the AUV at up to 2-km range. In-water endurance with a single lithium-ion battery module was 4 hr. per survey.

AUV survey lines were planned using the Gavia control-center software, with lines for bathymetry following the classical lawnmower pattern. The AUV surveys covered 1.03 km² for Fjortende Julibreen. The survey extended from water depths of less than 3 m to 55 m deep and came within 200 m of the grounded glacial front. Bathymetry was collected from an area of 0.48 km² and up to 26 m from the grounded glacier front of Conwaybreen. Shallowest depths recorded were 5 m in the east, and the deepest surveyed point was 54 m water depth in the south of the bay. Kongsbreen surveys were collected from an area of 0.39 km². The shallowest surveyed depth was 24 m and the deepest at 160 m. The surveys were obtained to within 15 m of the grounded glacial front. The Kongsbreen survey extended to an area of 1.31 km² and up to 20 m from the grounded glacier front.

Overall, the vehicle performed faultlessly; the biggest issue encountered was the moving brash or small surface ice. The blocks of ice are very susceptible to the wind, and a change in wind direction could shift the ice over the proposed AUV dive or surfacing point. The team occasionally had to maneuver the surface vessel into the ice pack to recover the vehicle from beneath the ice.

Results

The AUV revealed the recently exposed seafloor directly in front of the retreating glaciers. The seabed in this region contained numerous submarine landforms from which glacial processes can be inferred. The seafloor in front of the two most active glaciers, Kongsbreen and Kronebreen, displayed subglacial lineations, with moraine ridges, reflecting the mobility of the glacial front, seasonally advancing (producing moraines) and retreating (eroding lineations in the fine-grained seafloor). Seafloor sediments were a direct result from settling through the water column by active meltwater plumes, in addition to direct modification of the seafloor via subglacial erosion and gravity flows.

In contrast, Fjortende Julibreen and Conwaybreen displayed a seafloor dominated by numerous moraines and crevasse-squeeze ridges; the result of recently previously wholly grounded ice, now since retreated. By combining the bathymetric maps with existing satellite images (from about 1976 to 2017), estimates of the rates of glacial retreat were obtained and indicated that Fjortende Julibreen has a retreat rate of 32 m per year (with periods of surging); Conwaybreen has a glacial rate of 47 m per year; Kongsbreen 250 m per year; and Kronebreen 300 m per year.

The AUV also collected extensive underway oceanographic measurements. Analyses of these data showed that the AUV detected active submarine meltwater

plumes at two glaciers: Kronebreen and Kongsbreen. Meltwater plumes were observed emerging from tunnels within or beneath the glacier front, part of the glaciers' own internal irrigation system. These "rivers" of sediment-laden freshwater originate from pools of meltwater on the glacier surface, eventually becoming channeled into the body of the glacier into sinkholes or moulins to become ejected from the ice into the sea. The meltwater, being fresher and therefore less dense than seawater, rises up the glacier face underwater to the surface. Once on the surface, this meltwater extends as a freshwater "lid" extending over 1 km from the glacier. In addition, warmer Atlantic water was detected at both these glacier fronts, suggesting a mechanism for the melting of the glacier face and, hence, driving active calving of ice.

Conclusion

These observations show how the seafloor can influence the water masses in the glacial-front environment and in some cases lead to warmer water being actively introduced into the fjord and, hence, promoting glacier retreat. Shallow-water sills within the fjord can promote mixing; while they can protect the glacier front from direct contact with the warming Atlantic water, they can also enhance local circulation, driven in part by the meltwater injection from the glacier.

This study has highlighted the ability of AUVs to survey in the potentially hazardous proximal glacial-front zone of marine-terminating glaciers. Further work using small, readily deployable AUVs (e.g., ecoSUB Robotics m5 and micro-vehicles) in the glacier-front environment has since been undertaken by SAMS, and work continues to monitor tidewater glaciers in the polar regions.

Acknowledgments

Thank you to all the staff at the Ny Ålesund research station, Kongsfjord, Svalbard, and to the officers and crew of RV *Lance*. Thanks also to the Kings Bay Co., the University Centre, Svalbard (UNIS) and the Norwegian Polar Institute (NPI) for their wonderful hospitality and logistical support while in Svalbard. Thank you to Vidar Nilsen and Roar Strand, the masters of MV *Teisten*, and the Teledyne Gavia AUV team for technical support.

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Dr. John Howe is a senior lecturer in marine geology at the Scottish Association for Marine Science (SAMS). He has a research interest in the marine geology of the polar regions. He is also program leader for the SAMS Marine Science degree program and leads the graduate school on behalf of the Scottish Alliance of Geosciences, Society and Environment (SAGES).

Colin Abernethy is a SAMS support scientist with wide experience in piloting AUVs and conducting marine bathymetric surveys. His background is in environmental marine geochemistry.

Professor Mark Inall is a physical oceanographer researching marine mixing processes to place them in a broader context of ocean-shelf interaction in mid- and high latitudes. He is currently the director of SAGES and a member of the Scottish Science Advisory Council.

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NemoSens Micro-AUV

Open Architecture, Enhanced Navigation Offer Greater Flexibility

By Céline le Berre • Clément Niclot • Raphaël Bourdon

France-based company RTSYS has been working since 2015 on a new type of micro-AUV, christened NemoSens. Several public and private partners helped finance the project: BPI France, Brest Métropole Océane, Brittany Region and the Finistère Département. The project was certified by the Pôle Mer Bretagne-Atlantique, and ENSTA Bretagne, IMT Atlantique Engineering schools and FMC Composites contributed their expertise in signal processing and robotics.

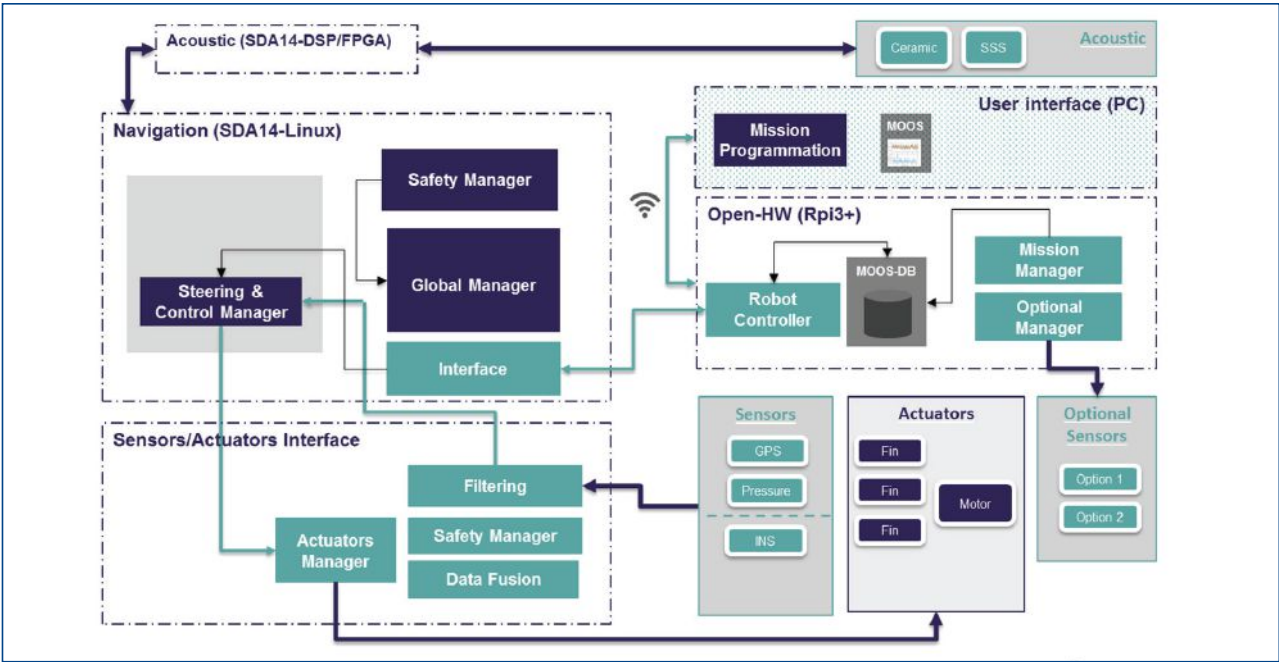
The aim was to build a new type of small, lightweight, powerful and flexible AUV, so that scientists and offshore engineers can maximize its use at an affordable price. To achieve this, NemoSens was designed with an open Linux-based architecture so end-users can develop their

own mission algorithms from a ROS or MOOS-IVP interface.

In addition, an open web forum will be available in the near future through a dedicated website. Users will then be able to collaborate, as in any open-source project.

Enhanced Navigation

NemoSens's proven navigation capabilities are operational between 2 to 7 kt., with more than 8 hr. of autonomy at 4 kt. Diving down to 300 m at its maximum depth, navigation is accurate with an integrated INS. Instead of a DVL, RTSYS incorporated its core acoustic technology, so the AUV could remain at a competitive price.



NemoSens system architecture.



ter acoustic communication (UAC) protocol based on its native UAC modem, operating with synchronous data acquisition. It transmits and receives digital data for applications such as telemetry or tracking at a typical range of 2,000 m. This enables identifying the AUV's position in real time and/or control and command (C2) of a network of AUVs.

RTSYS's network protocol accepts up to 30 nodes simultaneously and allows broadcast or addressed communication. It also provides long-baseline (LBL) positioning by means of its time-synchronized characteristics. LBL goals can either be: AUV subsea repositioning, following a master device (such as another AUV), or having a group of AUVs navigating together as a coordinated pack. To this end, RTSYS offers C2 surface units and LBL beacons and buoys compatible with NemoSens.

Short baseline (SBL) can be used as well for guiding NemoSens to a launch and recovery system (LARS).

Easy Recovery

The NemoSens mast is fitted with a GPS, flasher and UHF antenna that will work with RTSYS's GeoSys remote control for AUVs. GeoSys displays several features, such as coordinates and azimuth, an AUV-return command and mission start-up command. A handle on the top of the AUV makes it as easy to carry as a handbag.

Once the AUV is recovered, data can be transferred by Wi-Fi and later analyzed through RTSYS's human-machine interface, or by other user preferences, thanks to the open Linux-based architecture.

Personalized Setup

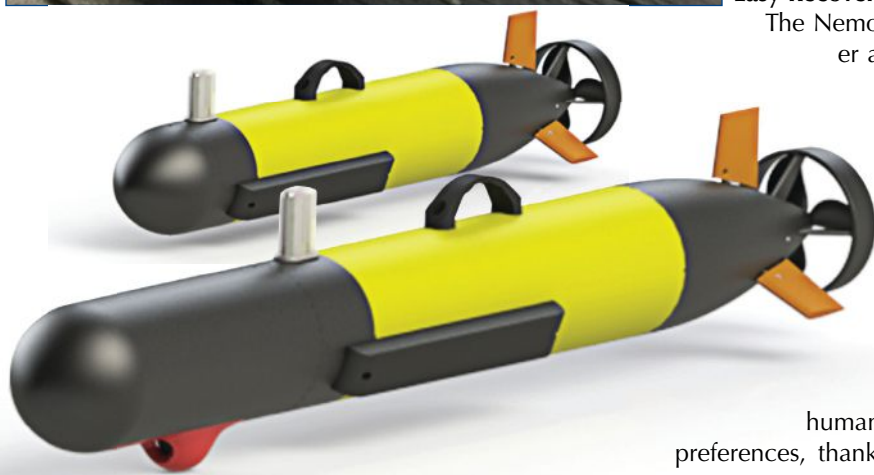
NemoSens is able to host one permanent sensor and one optional sensor, easily pluggable after removing the AUV's nose and compatible with RS232 or Ethernet protocols. The AUV's nose is also where the NemoSens battery resides, and side scan sonar will additionally be available soon. All sensors will be configurable and interchangeable via the external human-machine interface.

NemoSens is able to host various sensors, such as an RBR CTD probe, a dissolved oxygen sensor, a fluorometer or an acoustic payload to conduct underwater monitoring.

Making the AUV even more user-friendly, most items can be replaced simply by end-users, including the fins, propeller and motor.

Sea Trials

A series of navigation tests at 4 kt., comparing several solutions (propeller, motor, motor controller), were successfully conducted, thus enhancing NemoSens's efficiency.



(From top to bottom) AUV testing for propulsion, immersion and navigation. NemoSens with side scan sonar. NemoSens with an RBR Legato CTD probe and a side scan sonar. Note slightly larger size.

NemoSens kept evolving and achieving better performances than initially required. Technical achievements allowed wider autonomy.

The AUV was designed with a smaller size and higher speed by enlarging the propulsion element. The result is an AUV less than 3 ft. long at 8 kg weight with empty payload.

Acoustic Features

Several years ago, RTSYS developed its own underwa-

“The aim was to build a new type of small, lightweight, powerful and flexible AUV, so that scientists and offshore engineers can maximize its use at an affordable price.”

Testing was first conducted in the beginning of 2019 in RTSYS's water tank, then at sea off Lorient, France. Results were encouraging; an accurate and dynamic navigation was observed as soon as March 2019.

In June 2019, NemoSens's stability was established at a 2-kt. speed. Low-rate communication was also validated through NemoSens acoustics relying on COMET protocol enabling communication with RTSYS's whole range of products.

After these trials, 8-hr. autonomy at 4 kt. was reached, leaving enough energy for a payload such as a CTD probe. At lower speed, 15-hr. missions are possible and NemoSens's max distance could exceed 65 nautical miles.

Harsh-environment sea trials will be conducted in early 2020.

Multipurpose AUV

NemoSens will be useful for oceanographers and research institutes eager to conduct chemical-physical studies, especially related to observing the effects of global warming and human activities in general on our

oceans. Civil engineers may also find the AUV useful to carry out acoustic surveys and seabed imaging before starting construction projects.

NemoSens is unique thanks to the technology of the RTSYS synchronous data-acquisition motherboard, which lies within all RTSYS products, enabling powerful data transmission.

NemoSens will help meet oceanographers' and environmental engineers' needs for flexible and cost-effective surveying. The first NemoSens has already been ordered and will be delivered in late May 2020. **ST**

Céline le Berre graduated from Strathclyde University and INSA Engineering School. She is an RTSYS AUV project manager. She has international experience leading complex projects in real-time embedded systems, including in China and Ireland.

Clément Niclot is an RTSYS AUV design engineer. He previously worked with Naval Group and specializes in finding simple solutions to complex problems. He graduated from ENIB Engineering School.

Raphaël Bourdon is the RTSYS chief technical officer and one of its two founding members. The company was founded in 2010, and Bourdon now leads a group of 25 high-level engineers.

Making Hydrographers' Tasks Easier

The advertisement features a background map of the Bay of Bourgneuf. In the foreground, there is a laptop displaying the HYPACK 20 software interface, which includes a map with a survey track and various data fields. To the left of the laptop are two pieces of SBG Systems hardware: a black SBG 16X multi-beam echosounder and a white SBG 16X multi-beam echosounder. A small inset window shows a 3D model of a ship. In the top right corner, there is a blue box with the text 'HYPACK 20' and 'Booth #23'. The text 'Courtesy of Cadden' is visible on the right side of the image.

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Multibeam Evolution

WASSP Targets New Markets with W3 RDS Rapid Deployment System

By Rufus Whiteford

Multibeam sounder manufacturer WASSP Ltd. has made significant inroads into several multibeam markets over the last decade and more recently has announced its newest system: the fully portable W3 RDS (rapid deployment system). W3 RDS has been an evolution of the company's world-leading technology that has enjoyed significant growth in the commercial fishing, hydrographic survey and leisure markets. The new technology expands the reach of applications into the naval realm.

Original Multibeam

WASSP Multibeam was originally designed to help with the placement of rock lobster pots to optimize catch, and since then the technology has found many new markets and opportunities around the world, such as hydrographic survey.

With strong origins in the commercial fishing industry, WASSP's entry into the hydrographic and military markets came about in 2011 with two significant events in New Zealand. In February of that year, Christchurch, on New Zealand's South Island, was severely damaged when a magnitude 6.3 earthquake struck the region. The quake was devastating to one of New Zealand's largest cities, killing 185 people and injuring several thousand.

The earthquake epicenter was on the coast near Lyttelton, the main harbor for Christchurch, and just 10 km southeast of the city's central business district. Given that many of the roads into the region were damaged, sea access to the area was the logical step to bring in much-needed aid and supplies.

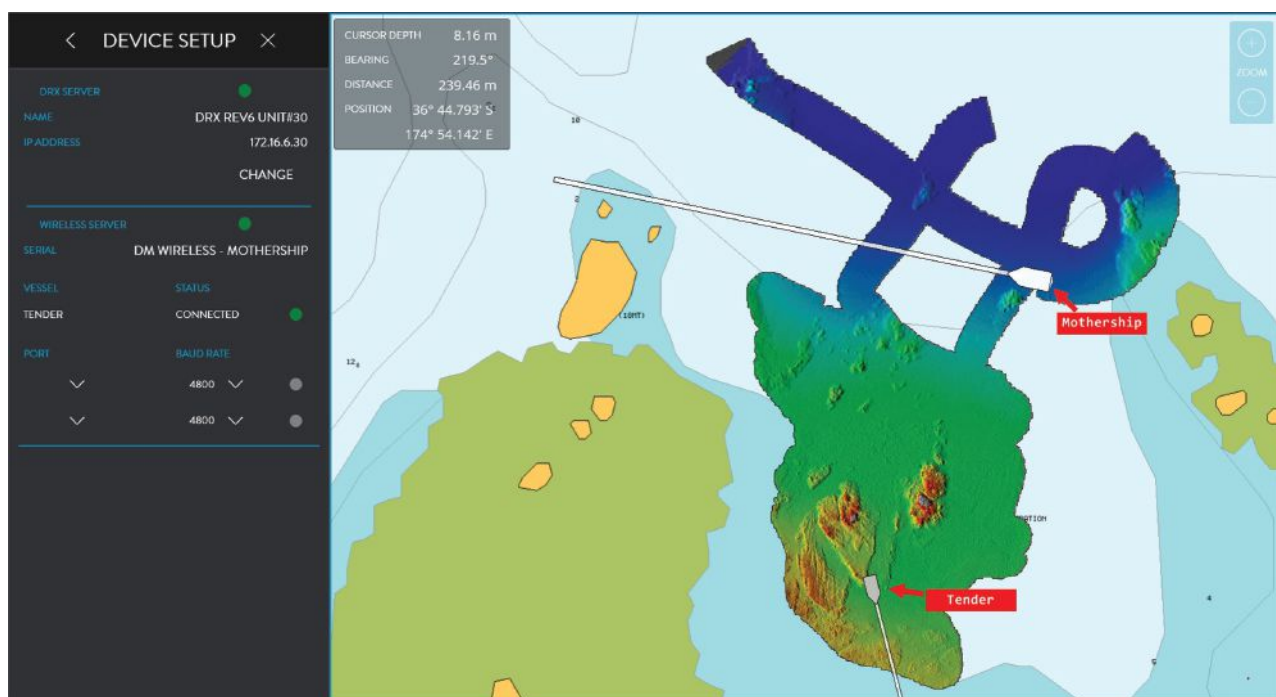
The New Zealand Navy was called upon to help with the distribution of relief aid and supplies, and so the HMNZS *Canterbury* was dispatched to Lyttelton Harbour. HMNZS *Canterbury* is a *Protector*-class amphib-



ious and military sealift vessel with a length of 131 m and a draft of 5.4 m. At the time, it was not known if the seafloor of Lyttelton Harbour had been affected by the quake and whether it was possible for the HMNZS *Canterbury* to be able to enter the harbor safely.

In the early 2000s, WASSP multibeam sounders had been widely adopted by the commercial fishing industry in New Zealand, and this technology transitioned easily into a new market when it was called on for an underwater survey in Lyttelton. The survey was undertaken by small, local commercial fishing boats with shallower drafts. Once the survey was complete, it was found that in some places the seafloor had risen by a staggering 7 m.

With the gathered hydrographic data, the HMNZS *Canterbury* was able to make safe passage into the harbor. This was WASSP's first foray into the hydrographic survey market, and applications for disaster relief and naval operations soon followed.



(Top) A sample display of seafloor profiling carried out with WASSP W3 Wireless technology. (Bottom) A WASSP multibeam system was used during the *Rena* salvage in New Zealand, 2011.

Also in 2011, WASSP was used during the salvage of the 236-m containership *Rena*, which ran aground on the Astrolabe Reef on the east coast of New Zealand's North Island. WASSP was instrumental in helping *Rena* salvagers quickly survey the surrounding coastline for sunken shipping containers.

WASSP went on to develop a number of products focused on the hydrographic survey, superyacht, cruise ship and defense markets.

W3 Wireless

From what was learned in earlier projects, WASSP identified a need for a system that was portable, could be rapidly deployed in situations such as the Christchurch earthquake and be able to deliver crucial seafloor data quickly and easily. This led to the development of the WASSP W3 Wireless for the superyacht market.

WASSP W3 Wireless systems are now installed on superyachts from some of the world's leading ship builders, including vessels from Amels, Damen, Feadship, Lürssen, Sunseeker, Fincantieri, Oceanco and Abeking & Rasmussen. These vessels range from as small as 29 m to over 190 m in length.

W3 RDS

In the case of the *Rena*, WASSP provided one of the sounder systems for the salvage effort. Dispatched from WASSP's head office in Auckland, the WASSP arrived off the coast of the grounding, and within 48 hr. of arrival it had been fitted to a survey vessel and was used to identify 12 targets, seven of which were

submerged shipping containers, some at depths down to 80 m.

The surveyors involved in the salvage effort were surprised as to how quickly they were able to get the equipment fitted and the system up and running. The Navigator and WASSP Sounder acquisition software was also easy to set up and operate. Most other multibeam systems require significantly longer mobilization time frames.

At the time, while WASSP was pleased with the results, the company decided it needed to have a faster solution: a system that could be up and running within hours rather than days. So, with that impulse, the R&D team began developing a rapid-deployment solution.

The result is WASSP's latest technology, the W3 RDS, which combines performance and portability. Revealed at Pacific Expo 2019 in Sydney, Australia, in October, W3 RDS has been designed for navies, maritime police, and

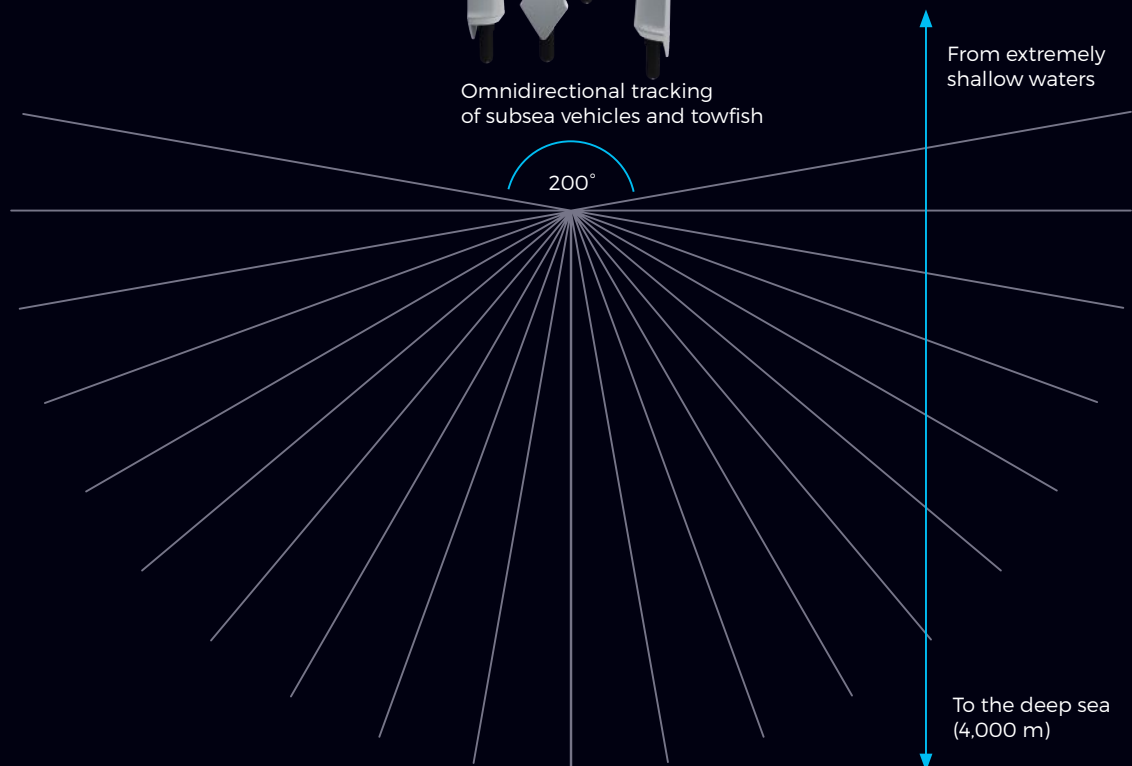
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Gaps offers a pre-calibrated positioning and communication solution for the tracking of subsea vehicles and towfish. Its new telemetry feature allows for AUV control & command, INS recalibration, as well as efficient data retrieval.



Omnidirectional tracking
of subsea vehicles and towfish





WASSP W3 Wireless fitted to a tender vessel.

search and rescue organizations for use where depths are unknown and to find safe navigation routes for larger vessels.

When a fixed-transducer installation in a small vessel such as a tender isn't practical, the W3 RDS can be utilized instead. It has been designed around a portable carbon-fiber mast that includes a streamlined transducer, motion sensor and satellite compass. This lets operators deploy the unit over the side or the transom of the vessel so that it enters the water quickly and easily, often in just minutes.

Once deployed, W3 RDS can quickly and effectively profile the seafloor and water column in search of sunken vessels, aircraft or vehicles. It can also be utilized in events such as cyclones, hurricanes, volcanic eruptions, earthquakes or military-related disasters, which can alter the seafloor in such a way as to make navigation unsafe for support vessels.

The rapid deployment system requires minimal set-up and calibration due to having fixed offsets to the transducer, motion sensor and position/heading source. When in operation, W3 RDS uses a wireless link or a secure naval communication system to send real-time seafloor map data back to the mothership bridge system and display via a WASSP CDX display software or MaxSea navigation plotting platform—all in real time.

The following vessel or mothership can view its own position over the mapped data from the RDS-equipped vessel. If the vessel with the WASSP RDS goes out of

range, the data will be buffered for up to 24 hr. and sent to the mothership when the link is re-established.

The system is designed around the fully digital DRX transceiver and features a low-power processor DRX-32 (equivalent to 1 kW), with the high-frequency WMB-160 transducer to give operators a maximum depth range of 400 m.

During the R&D and testing phase in Auckland in July 2019, working with many clients and users, WASSP was able to refine the system to be simple to use and, most importantly, quick to deploy.

W3 RDS has been designed to be compact; the DRX Processor is housed in a Pelican case to protect it from water damage. The whole system weighs in at just 70 kg (including carry cases), making it very portable and easily transported by just two people from vessel to vessel, or even helicoptered in if necessary.

The earlier W3 Wireless system has been popular with the superyacht industry due to its ease of use. The new W3 RDS is a more customizable system catering to navy and military applications. It is lighter, more robust and has the ability to meet more stringent field requirements.

Following the launch of W3 RDS at Pacific Expo 2019, WASSP has begun working through system requirements with a number of international agencies who have expressed interest in adopting the technology. **ST**

Rufus Whiteford is the global sales and marketing manager of WASSP Ltd.

Hands-On USV Training

Course Offers Field Experience in Unmanned, Remote-Control Survey

By Lisa Woodruff • Nicola Woodley

Unmanned technologies are fast emerging within the hydrographic industry. The requirement for higher cost efficiency, lower manpower and lower associated risks are becoming key factors in surveying. The future of hydrographic surveys is changing, which is creating the need for up-to-date training on the latest autonomous vessels and innovative multibeam echosounder (MBES) technology.

Swathe Services, a hydrographic survey support company in Hayle, Cornwall, U.K., recently ran the world's first multibeam echosounder (MBES) training course

using a remotely operated unmanned surface vehicle (USV). This five-day intensive course replicated a real unmanned survey from start to finish, from survey planning and data collection to processing and charting. The Inception-class MKII USV used throughout the course was provided by Swathe Services' sister company, Unmanned Survey Solutions (USS).

Hydrographic surveyors, researchers and graduates came from the U.K., France, Norway and Slovenia to attend this training. The course was a combination of classroom-based and practical, hands-on training in the



Safety briefing being given to some of the course delegates before deployment.



The USV was mobilized with an R2Sonic 2020 multibeam echosounder to collect the bathymetric data and a Velodyne VL16 mobile laser to collect the LiDAR data above the waterline. These two systems were used in combination with an SBG Ekinox-D INS for inertial navigation. The Trimble VRS Now correction service was used via a HYPACK NTRIP connection using a 4G network, enabling real-time kinematic (RTK) corrections. A Valeport SWiFT was deployed from the harbor wall numerous times throughout the survey to provide accurate sound-velocity profiles, which would later be applied to the data in post-processing.



A patch test was performed on the second day of training in Carnsew Pool in Hayle. Survey lines were created in HYPACK and driven autonomously by the USV. These lines were later processed to account for any misalignments between the MBES transducer head and the INS system for latency, roll, pitch and yaw.

For Unmanned Survey Solutions, the beauty of unmanned operations is having the ability to survey and remotely operate a vessel from the comfort of your own office.

Using a shore-based Wi-Fi antenna or 4G cellular network with remote desktop connection, the USV was operated remotely from Swathe's offices. An additional USV operator was located at the harbor as a safety precaution to take back control of the USV should the need arise.

The USV operated autonomously for most of the time, following line plans created in HYPACK. However, in some areas, remote control was used to tackle more challenging locations around boats tied up alongside the quay wall.

The USV successfully surveyed the harbor, acquiring high-definition bathymetry and laser survey data in HYPACK's HYSWEEP software module. The survey took place in calm, clear conditions and at low speeds, maximizing the resolution of the Velodyne laser data. Furthermore, the USV drove almost perfect lines, which made processing extremely easy.

SBG Qinertia Pro was used to improve the navigation and trajectory of the INS solution. Qinertia is a full-featured INS/GNSS post-processing solution and accepts RINEX data from over 7,000 base stations around the world. It is data logged from a locally set up base station.

For this training course, a Trimble R10 was set up at Swathe's offices, which was less than 1 km from the survey site. From the locally logged position data, Qinertia was able to set the base station control point without the need to use third-party software. Sensor lever arms

(Top) The Inception-class MKII USV being deployed into Hayle Harbour. (Bottom) Delegates getting hands-on training on remote-controlling the USV.

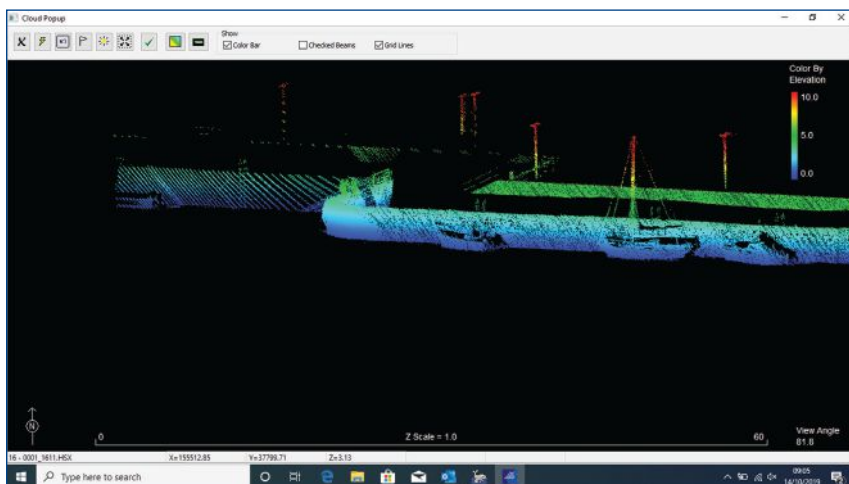
field. Training was initiated by creating projects within HYPACK, ensuring correct geodetic parameters, hardware settings, background imaging and line planning.

Harbor Survey

The main hydrographic survey took place in Hayle Harbour on a high tide. This harbor provided real-world challenges including boat traffic, vertical quay walls, changing currents, flotsam, jetsam and varying bathymetry.

The MKII USV used for the survey is a small catamaran (approximately 2 m in length and 1.2 m in width) with interchangeable payload pods providing survey versatility. The MKII USV is designed to work in shallow-water zones such as ports, harbors, marinas, lakes and nearshore coastal areas. One of the advantages of using smaller USVs in comparison to manned vessels is the ability to maneuver in difficult-to-access shallow waters.

The USV was easily transported, launched and recovered using a single manned trolley. This ease of deployment facilitated survey activities to start almost immediately upon arrival at the slipway.



Collected Velodyne laser data of the quay wall in Hayle Harbour.

were also recalculated for improved performance, and smoothed best estimate trajectory (SBET) files were produced.

These SBET files were then applied in HYPACK's MB-Max64 MBES and laser post-processing software module. Automatic filtering and manual cleaning of the data was also demonstrated as part of the training. Multiple formats were exported in accordance with typical survey deliverables, including Matrix, GSF and XYZ for further charting options.

Feedback

Delegates from the course were impressed with the innovative technology and thorough training they received. Kordula Schwarzwald, a researcher at the Norwegian University of Science and Technology, said: "This course is invaluable for me as a researcher, as we use these USVs to map rivers in Norway, so having hands-on training on remotely operating these vessels is very useful. I've learned so much in such a short time."

Pierre Mezerette from SBG Systems in France said: "I have been training with HYPACK, which is a fantastic software program for hydrographic surveying, and to see the USV operating remotely in the harbor was just amazing. It's changing the way we survey ports and harbors."

The managing director of Swathe Services, James Williams, said: "We are proud to be offering a world first right here in Cornwall, U.K. To my knowledge, we're the only company to date offering commercial, hands-on MBES training using a USV." **ST**

Lisa Woodruff manages marketing and PR for Swathe Services.

Nicola Woodley is a hydrographic surveyor at Unmanned Survey Solutions.



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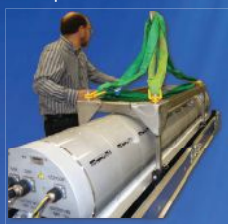
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Free Support for Brexit

Future Water Association is offering free support to those working in the water industry to better understand how Brexit will affect their business and prepare for the prospect of a no-deal Brexit. The tentative date for Brexit is January 31, 2020.

The free Brexit First Aid Kit comprises a webinar series covering: preparation for Brexit and the impact on your business; how to protect your company finances against a no-deal Brexit; and the impact of a no-deal Brexit on jobs and skills and what you need to do about it. The webinars will be recorded and transcripts available at www.futurewaterassociation.com/first-aid-kit-for-brexit.

Naming of Polar Research Vessel

One of the world's most advanced polar research vessels, RRS *Sir David Attenborough*, has been officially named at a special ceremony held at Cammell Laird's Birkenhead, U.K., shipyard. The milestone event was the centerpiece of a three-day celebration of British science, shipbuilding and engineering.

Commissioned by the Natural Environment Research Council and constructed by Cammell Laird for operation with British Antarctic Survey, the vessel will carry out intensive, multidisciplinary missions with minimal impact on the ocean environment. Kongsberg's integrated systems are central to the vessel's position as one of the most advanced research vessels ever built.

Sensor Data-Management System Verified

Fleet Data from Inmarsat, a secure sensor-data and Internet of Things (IoT) platform, has received approval in principle from Bureau Veritas. This verifies that Fleet Data can be installed safely on board, without its operation affecting existing navigation, safety and radio communication systems.

The bandwidth-inclusive platform allows shipowners and managers to take control of sensor data collected on board and pre-process, extract and aggregate data in cloud-based storage to be exploited by the operator's own decision-making software or third-party applications. Fleet Data is available via Fleet Xpress and will be rolled out to Inmarsat FleetBroadband users.

Guidelines for ICT Remote Surveys

ClassNK has released Guidelines for Remote Surveys in preparation for carrying out remote surveys using ICT (information and communication technology). ClassNK will now implement remote surveys that satisfy the requirements. The Guidelines for Remote Surveys are available to download free at www.classnk.com for those who have registered for the free ClassNK "My Page" service.

Encouraging Marine Industry in Scotland

Malin Group, a Glasgow-based engineering company with a worldwide operation, wants to create a marine

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manufacturing hub at Old Kilpatrick, one of Scotland's highest unemployment areas. Planning consent has been granted by West Dunbartonshire Council for phase one of the Scottish Marine Technology Park (SMTP). Phase one includes a large fabrication facility, consent for a deepwater jetty with a 1,100-Te ship hoist, and a remediation strategy required to develop the former oil-storage site. SMTP could result in almost 1,000 new jobs.

iXblue INS for Live Race Tracking

iXblue will supply the technology partners of the 36th America's Cup with Atlans-C and Hydrins INS for continuous tracking of race yachts, an essential part of the race management system. iXblue is partnering with Germany-based technology innovator Riedel Communications and Igtimi, a New-Zealand based company specializing in live data streaming during sporting events, to offer a highly immersive and engaging experience to the television audience.

Blockchain for Ship Registration, Renewal

The Singapore Shipping Association (SSA) is working with the International Chamber of Commerce (ICC) and Singapore tech start-up Perlin to build an advanced digital blockchain ship registration preparation system for international adoption.

The International E-Registry of Ships (IERS) is an entirely new digital blockchain-based solution to streamline, standardize and drastically improve the currently

laborious ship registration and renewal process. Immediate advantages will include very significant reductions in operating costs, timing required, human error and fraud.

Castrol: Fuels and Lubricants Are Linked

Global lubricants supplier Castrol advises the shipping industry to expect a new normal of continuous change in environmental compliance standards driven by regulation, adding layers of technical complexity for owners and operators.

With the shipping industry currently preparing for the International Maritime Organization 2020 global sulphur cap, Castrol believes that there needs to be an understanding that fuels and lubricants are intrinsically linked. Failure to consult and work in partnership with engine manufacturers, fuels and lubricant suppliers could lead to unintended consequences.

ChartCo Relocates in Rotterdam

ChartCo affirms its commitment to Europe's largest port with a new technology office. In a move which supports ChartCo's ongoing expansion, the company is relocating from Driemanssteeweg 200 to Parmentierplein 20 in Rotterdam. ChartCo's dedicated Dutch sales and support team will be based at the new site.

France Promises Environmental Shipping

During the 45th G7 summit held in Biarritz, France, in August, French President Emmanuel Macron declared his

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intention to place France at the forefront of a green-shipping revolution by slashing the emissions of the French-owned fleet, Lean Marine reported. "We will engage with shipping companies to reduce the speed of merchant ships," Macron said. "It is one of the most effective ways to reduce greenhouse gas emissions globally, and this measure would be a real change."

All Sizes of Ballast Organisms Should Be Tested

Microbiological monitoring equipment company LuminaUltra advises the shipping industry of the importance of testing all sizes of ballast water organisms identified by the International Maritime Organization (IMO) to prevent the spread of aquatic invasive species.

More than 4,000 species of organisms are carried in ballast water. IMO has specified the type and size of organisms that ballast water management systems (BWMS) are required to treat. These organisms are: bacteria; organisms between 10 to 50 µm; and organisms greater than 50 µm. The Ballast Water Management Convention requires all three sizes to be measured and assessed.

Ship & Shore Expands to China

Ship & Shore Environmental Inc. has opened a new manufacturing facility in Shanghai, China. Ship & Shore China offers the same capabilities as its U.S. counterpart while holding all rights to its own technologies.

Ship & Shore China seeks to become a leading resource for China's pollution-abatement efforts, as well as for similar efforts in surrounding countries.

Course for African SAR Professionals

The International Maritime Rescue Federation has held a basic rescue-boat operating course for maritime search and rescue (SAR) professionals from Africa. It was designed to "train the trainer." Eleven SAR professionals from across Africa attended.

Growing Market for Marine Fuel Management

According to Transparency Market Research, the global marine fuel management market was valued at \$5.7 billion in 2017. The market is projected to rise at a steady CAGR of 4.4 percent from 2018 to 2026, reaching an estimated valuation of \$6 billion by the end of 2026.

New Clients for GearConsult

Hydrex and Subsea Industries have a new representative agent in Norway: GearConsult AS. Hydrex brings drydock-like conditions to ships and offshore units. Subsea Industries is a pioneer in the development of hard-hull-coating systems and hull and propeller cleaning.

Enshore Subsea Forms

DeepOcean's trenching division has become Enshore Subsea. Enshore provides a comprehensive portfolio of seabed-trenching and seabed-tooling technology, an in-house geosciences service, and a dedicated team of experienced engineering and technical professionals that can deliver services anywhere in the world. Enshore will be based at the Port of Blyth in Northeast England. **ST**

Dual-Tail AUV for Sensing, Monitoring Applications

EvoLogics GmbH from Berlin, Germany, has introduced "Poggy," a novel bionic AUV that uses Fin-Ray technology. The vehicle is being developed as part of the BONUS SEAMOUNT collaborative R&D project, and it made its first dives at the Breaking The Surface 2019 workshop in October 2019.

Poggy has two propulsion thrusters and two independent flexible "tails" that give the robot unique mobility features. Its dual-tail construction stemmed from previous work on EvoLogics' Manta Ray AUV and its lifelike "flapping wing" propulsion system. The design was simplified and optimized: the robot lost the wings, and its tail was divided in two.

Together with the rigid part of the body, the progressively bendable tails perform as two adjustable

hydroplanes that in every steering position have an overall streamlined shape. The new concept facilitates outstanding roll and depth control combined with low-drag performance.

Both parts of the dual-tail use independent bionic Fin-Ray drives and allow for precise heave, pitch and roll adjustments, enabling dynamic climbs and dives, leveled gliding and bottom following.

Due to the small size of its basic AUV components, Poggy has high payload capacity and can carry multiple sensors and instruments at the same time. The dual-tails facilitate unique maneuvers that could open new opportunities for sensing and monitoring. The vehicle was designed to keep any desired roll angle and maintain a steady glide, even at very low speeds.

The goal of BONUS SEAMOUNT is to develop innovative auto-

nous vehicles and integrated sensor systems for complex real-time sea surveying, analysis and monitoring, and to apply these in the study of submarine groundwater discharge in the Baltic Sea.

Coordinated by EvoLogics, SEAMOUNT is funded within the framework of "BONUS - Science for a better future of the Baltic Sea region," the joint Baltic Sea research and development program.

XLe Spirit Passes Norway Fjord Test

Forum Subsea Technologies' latest ROV, the XLe Spirit, has successfully completed sea trials in Norway.

The vehicle is the first of a new generation of electric observation-class ROVs. It is the smallest in the new range and powerful enough to perform subsea maintenance and repair work. It is ideally suited to the aquaculture market and capable of tasks such as net and tank inspection.

Working with its Norwegian partner, Innova AS, Forum tested



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the XLe Spirit at a fjord in 500-m water depth. The standard equipment-function testing was confirmed utilizing all ancillary equipment, including cameras, lights, altimeters and sonars.

Digital Solution to Report NOx Emissions

The data-analytics duo Yxney Maritime and Grieg Connect are partnering with the Norwegian NOx Fund to develop a data-driven digital solution for automated NOx emissions reporting. Solstad Offshore and ferry operator Fjord1 will participate in the pilot phase of the project.

The Norwegian NOx Fund records NOx emissions from all vessels operating in Norwegian waters and collects a fee for emissions per vessel. The NOx Fund is a cooperative effort where participating enterprises pay in accordance to quantity of emission and may apply for financial support for NOx-reducing measures. It has reduced over 35,000 tons of NOx so far.

Calculating and reporting emissions has historically been a manual chore for shipowners, leaving a relatively large margin for error and adding to the workload of crew and onshore staff. The new solution, NOxDigital, will provide a digital infrastructure for emissions reporting based on the Yxney Maress software for monitoring fleet energy consumption and Grieg Connect's platform for high-res position data and geofencing technology. The solution automatically detects whether a vessel is operating in taxable waters. Data on energy usage and AIS data will complete the picture, displayed on a unique digital dashboard for each user.

The collaboration has received support from Innovation Norway through their Environmental Technology Program.

The solution will be first rolled out to the offshore and ferry segment in spring 2020, with other segments to follow suit. The next step will be to make the system available for other jurisdictions, such as

regional emission-regulated zones and Emission Control Areas (ECAs) around the world.

Intellian Partners with HGS On Smart-Ship Solution

Intellian has launched a satcom package for smart ships with marine engineering and service provider Hyundai Global Service (HGS), a subsidiary of the shipbuilding company Hyundai Heavy Industries (HHI) group.

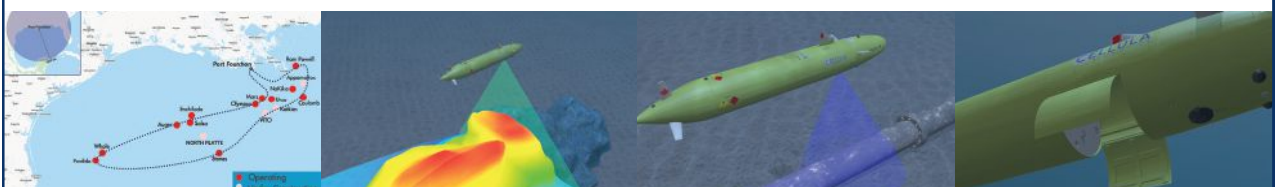
This world-first service is a combination of HHI's Integrated Smart Ship (ISS) solution, a digital ecosystem for vessel and fleet management that incorporates a powerful data-analysis platform, and Intellian's satellite-communications antenna systems. The new package will provide HGS with a standardized smart-ship solution for HHI newbuilds, while Intellian will secure new customers. By offering internet provision right from the sea trial, customers do not have to fit network services to the vessel. HGS will provide customer support. **ST**



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TerraSond Chooses MVP For Wind Farm Survey

TerraSond has recently deployed a new Moving Vessel Profiler (MVP) to support its offshore wind farm survey operations. This is TerraSond's second MVP.

TerraSond's new system is an MVP30, a compact solution designed for surveying in coastal waters.

AML Oceanographic's underway profiler was chosen for surveys conducted ahead of turbine-foundation construction, which requires accurate characterization of the seabed. The MVP will continuously collect sound velocity, pressure and temperature data as the vessel covers the vast area, transferring it to the multibeam system in real time for immediate incorporation.

Equinor, SSE to Develop Dogger Bank Projects

Equinor and its partner SSE have been awarded contracts to develop three large-scale offshore wind projects in the Dogger Bank region of the North Sea. This will be the world's biggest offshore wind farm development, with a total installed capacity of 3.6 GW. The projects are expected to produce enough energy to power the equivalent of 4.5 million U.K. homes.

The Dogger Bank wind farm will comprise three projects: Creyke Beck A, Creyke Beck B and Teesside A.

The partners are planning for final investment decision for the first project during 2020, and first power generation is planned for 2023. Further phases of the Dogger Bank project will be developed thereafter.

SSE will lead the construction phase, and Equinor will lead operations.

EMEC Supports Wave Energy Site in Korea

The European Marine Energy Centre (EMEC) has entered an agreement to continue to support the development of the Korea Research Institute of Ships and Ocean

Engineering - Wave Energy Test Site (KRISO-WETS) on the western coast of Jeju Island. This agreement builds on three years of strong collaboration and strengthens the ties between EMEC and KRISO.

Previous collaborative work focused on test-site design aspects, such as electrical infrastructure, data acquisition and SCADA (supervisory control and data acquisition) systems, and operational aspects such as environmental monitoring and consenting guidance.

As KRISO-WETS enters operational mode, EMEC will provide further operational guidance on environmental impacts, metocean data, commercial guidance and third-party verification.

BVS Wants Industry To Improve Ship Recycling

Bureau Veritas Solutions Marine & Offshore (BVS) is encouraging the shipping industry to embrace higher standards in ship recycling and is offering its guidance to help meet the challenge of compliance with the Hong Kong Convention and EU requirements. This guidance is both during the operational life of a vessel and through the end-of-life phase to enable all parties to fulfill their regulatory obligations and meet best-practice standards.

The company's compliance tips for ship recycling include: fleet-wide planning; understanding your inventory of hazardous materials (IHM); budgeting for sampling; developing and maintaining IHM during operations; understanding the benefits and risks of recycling decisions; following industry best practices for recycling; and developing and publishing your ship-recycling policy.

Fugro Enters Offshore Wind Market in South Korea

Fugro has signed a memorandum of understanding with Underwater Survey Technology 21 (UST21) in a move that opens up the South Korean offshore wind farm market. Growing demand for alternative

energy sources has led South Korea to explore its potential for wind energy, and Fugro's global experience on more than 100 offshore wind farm projects will be key to realizing South Korea's offshore wind farm ambitions.

The agreement with UST21 will facilitate collaboration on marine projects in South Korean waters, whereby Fugro will expand UST21's local hydrography capacity to provide site-characterization services, including geotechnical, geophysical and offshore metocean solutions.

In return, UST21's local hydrographic expertise will provide logistical and operational support to Fugro's offshore metocean projects. For example, in conjunction with UST21, Fugro will deploy several Seawatch Wind LiDAR buoys offshore South Korea to perform vital wind-resource assessments.

Wind Propulsion to Advance With Project Launch

The WASP (Wind Assisted Ship Propulsion) project, funded by the Interreg North Sea Europe program of the European Regional Development Fund, has been officially approved and launched. It brings together universities and wind-assist technology providers with shipowners to research, trial and validate the operational performance of a selection of wind-propulsion solutions, thus enabling wind-propulsion technology market penetration and contributing to a greener North Sea transport system through harvesting the region's abundant wind potential. This aligns with the wider program's objective of promoting the development and adoption of products, services and processes to accelerate the greening of the North Sea region. Shipping partners include Scandlines, Boeckmans Ship Management and Van Dam Shipping, plus two more partners to be added soon. Wind-propulsion, shipping-logistics and innovation experts will monitor and evaluate operations and develop pathways and applications to tackle the regulatory and business-related issues inhibiting the uptake of new technologies. **ST**

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ROV Navigation Control



The Handheld Control Pendant can work with SEAMOR ROVs to increase comfort for pilots during long jobs. Users can step away from the console when needed while still being able to control the vehicle, particularly during ROV launch and retrieval or when using an alternate display when navigating via sonar or other instruments. SEAMOR Marine Ltd.

Ship-Maneuvering Software

DYNASIM incorporates state-of-

the-art models of ship hydrodynamics and runs on Windows platforms. The ship simulator employs modular mathematical models for the various components of a ship (hull, propellers, rudders, thrusters); environmental effects (wind, current, waves); and waterways (bottom, pier walls) to achieve a faithful mathematical representation of the ship. Dynaflo Inc.

24-VDC Inverter

Catering to commercial marine users, the 2,000-W/24-VDC inverter applies to 24-V battery systems. The inverter is certified to UL458, with marine supplement. It follows the same design and engineering as other products of the FREEDOM X family and can withstand environmental stresses such as moisture and corrosion. Xantrex LLC.

Digital Classification, Certification

Veristar Equipment enables request of BV services online; arranges BV surveys to be carried out on site; allows access at any time, from anywhere, including mobile devices; allows access to details required for the status of current orders and certification history; and enables uploading of documents. Bureau Veritas Solutions Marine & Offshore.

Map Software

With the release of Version 9.0, a "Plug-In" is now available for Hydromagic PC mapping software (Eye4Software of the Netherlands) to seamlessly integrate bathymetry and sediment geotechnical characteristics. Map overlays can be obtained from satellite photographic maps, user-generated maps, state plane grid maps and other similar cartography. Unabara Corp.

Two-Seat Simulator



Featuring seats for helmsman and navigator, the fast-craft crew-training simulator provides ultra-high-definition graphics, creating more realistic training scenarios. A 4.5-m-high screen caters to a larger projection system and conveys a wider field of view. Cruden B.V.

Vibration Isolation for Ships

Sylomer Marine minimizes wear, noise and damage to ship infrastructure. The polyurethane material is specifically for maritime use to dampen vibrations and oscillations. Getzner Werkstoffe GmbH.

Underwater LEDs

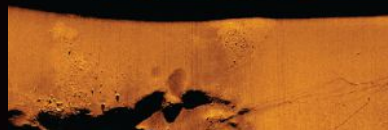
Gen5 is a Thru-Hull range of underwater LEDs, available in single colors of blue or white in the 9 and 24 series and full RGB color in the 24 series. A one-piece, corrosion-proof polymer housing allows existing customers to upgrade to Gen5 without hauling the boat or replacing their current housings. Aqualuma.

SONARWIZ7

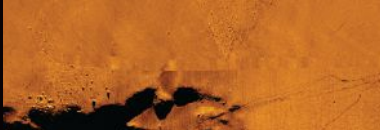
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Before ALS Gap Filler



After ALS Gap Filler



Klein MA-X View 600 image processed in SonarWiz

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- ▶ Added LOD support for point cloud rendering, can handle +100 million data points for better visualization
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- ▶ Process data from WASSP WMBF, SSAM SAS sonar and PDR1200 SBES
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The new ProZero 12-m site-management boat features a large aft deck can, and it can be configured with cranes and winches and a wide range of single- and twin-engine propulsion options. The boat is built in sturdy glass and carbon-fiber composites, reducing weight, improving speed and lowering fuel consumption. ProZero Norge AS.

Marine Navigation App

iNavX now delivers AIS data to boaters on phones or tablets without the need for a transponder. The new iNavX AIS LIVE service allows the user to connect any mobile device to the AIS Live global network of antennas. Ship movements are broadcast to the iNavX app in real time and presented directly on the chart. iNavX.

Turbidity Sensor with Wiper



Turbidity Plus has a minimum detection limit of 0.05 NTU and a maximum range of 500 NTU. The integrated wiper is triggered by the user. The sensor is designed for integration with multiparameter systems and data loggers from which it receives power. Applications include harbor dredging, underground pipeline installation and riverine works. Turner Designs Inc.

Command-and-Control Terminal

CRiB is an all-in-one battle management system with unmanned-systems-control capability, voice/data communication and full-motion video. It is usable on the move, is transportable and has Windows 10 and Android 6.0 support and Cloud Relay connectivity. Steatite Ltd.

Ocean Series Speakers

Available in 6.5- and 8-in. models, these blue-LED-lit speakers are two way, waterproof (IPX6 rated), low profile and surround sound. They

are sun, salt and corrosion resistant. Poly-Planar LLC.

Electric Tug

The e5 Tug is an electric-propulsion harbor tugboat powered by a large-capacity battery and a hydrogen fuel cell. CO₂ emissions are minimized by the fuel cell. Tokyo Kisen Co. Ltd. and e5 Lab Inc.

Triaxial Shock Accelerometers

Models 356A04 and 356A05 are PCB's smallest ICP triaxial shock accelerometers. They were developed for electronic drop testing at accelerations up to 5,000 and 20,000 g's, respectively. PCB Piezotronics Inc.

Vessel-Tracking Service

The latest version of OceanFinder, a digital maritime service to detect, identify and track collaborative and noncollaborative vessels worldwide, offers enhanced imagery and AIS data correlation to identify the precise location of a nonresponding vessel in near real time. Proprietary algorithms determine a vessel's

identity in just a few seconds. New tools provide the most relevant acquisition plan to predict routes and projected locations of vessels. Airbus Defence and Space.

Software-Defined Radio System

HiveComm provides full-duplex digital communications, enabling data transmission at 40 Mbps. The adaptive modem, AiMo, operates in single-carrier or multi-carrier modulation. Commtact Ltd.

Enhanced Drive

Sea-Drive now has a heavier cast housing for more corrosion resistance. High-viscosity grease improves internal component lubrication and won't leak from the unit, even on hot days. Golden Boat Lifts.

Coating for Carrier Tanks

NOA PC 700, a phenolic/novolac-based epoxy, is resistant to various chemicals, solvents and petroleum products. It is self-indicating to confirm film thickness. Nippon Paint Marine. **ST**

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Corals Could Use Nutrient Storage to Survive Bleaching

Corals mostly get their nutrients from microscopic algae living inside of them, but if those algae aren't creating enough sustenance, corals can use their tentacles to grab and eat tiny prey swimming nearby.

A new study from researchers at the Woods Hole Oceanographic Institution (WHOI), the University of New Mexico and Scripps Institution of Oceanography is revealing that more of corals' nutrients come from this sort of hunting than previously expected, information that may help predict the fate of coral reefs as global ocean temperatures rise.

When there is a heat wave, corals start bleaching. Symbiotic algae, which live inside corals and provide them with most of their nutrients, are expelled from their body. If corals stay bleached for too long, they basically starve to death. But

if a coral has the opportunity to eat a lot before it bleaches or while it is bleached, it can survive off its fat stores long enough to regain those symbionts when water temperatures cool off. Understanding when, where or why corals are eating could shed light on why they survive better in some places than others during future bleaching events.

Super-Water-Repellent Material from Porcupinefish

Researchers reporting in *ACS Applied Materials & Interfaces* have made a durable and flexible super-water-repelling material inspired by spiky porcupinefish skin.

Superhydrophobic materials are extremely water repellent, causing droplets of water that fall on them to roll or bounce off. Such surfaces could be used for applications such as self-cleaning, anti-icing and corrosion prevention. The materials typically owe their water repellen-

cy to tiny, needle-shaped structures on their surfaces. However, these micro- or nanotextured surfaces are fragile and easily damaged by bending. In addition, the prickly structures can be scratched or sliced off.

Drawing inspiration from the spiny yet flexible skin of the porcupinefish, Yoshihiro Yamauchi, Masanobu Naito and colleagues wanted to develop a harder superhydrophobic structure. The team prepared microscale pufferfish-inspired scales made of zinc oxide. To give the material elasticity, they added a silicone polymer, which combined with the spines to form a porous framework. The material, which could be molded into various shapes or coated onto other surfaces, is superhydrophobic and highly flexible. Unlike other superhydrophobic materials, the porous structure retains water repellency after being repeatedly bent or twisted. And because the structures exist throughout the material, not just on the surface, scratching or slicing doesn't affect the material's repel-



The poster features a green background with stylized white and blue wavy lines representing water. In the center, the text 'CHC 2020 CONFERENCE' is displayed in large, bold, white letters. Below this, 'Canadian Hydrographic Conference' and 'Hydrography 2020: Dynamic Evolution' are written in blue. The location 'Québec City' is noted in white. On the right, the dates 'February 24 - 27 2020' are shown in blue. A circular logo in the bottom right corner depicts a lighthouse on a rocky island, surrounded by the text 'CANADIAN HYDROGRAPHIC ASSOCIATION' and 'ASSOCIATION CANADIENNE D'HYDROGRAPHIE'. In the bottom left, a QR code is provided for online registration, with the URL 'chc2020.org/registration' listed next to it.

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lency. The flexibility and porosity of the material helps cushion against mechanical impacts and deformation, according to the researchers.

Students on Ice Use CTD In Canadian Arctic

In August, the *MS Ocean Endeavour* steamed into Croker Bay at Devon Island, Nunavut, in the Canadian Arctic. There, a group of 131 students in zodiacs cast an RBRbrevio³ CTD into the Arctic Ocean as part of their hands-on discovery of the polar region on a Students On Ice (SOI) expedition.

Within sight of Devon, the world's largest uninhabited island, students lowered the CTD on a line to a depth of about 35 m. On recovery, they twisted the CTD's cap, which activates its Wi-Fi and transfers the data to the Ruskin Mobile app that shows the data right away on an iPhone. The experience showed students how a CTD cast is conducted and why oceanographers use CTDs.

Since 2000, Students on Ice has run more than 30 expeditions to the poles, taking high-school and university students from around the world on educational polar expeditions, enabling youth to connect with and better understand the polar regions and local communities.

WASSP Multibeam Aids Students in Surveying

Oceanography students at the University of Rhode Island who are specializing in marine robotics, remote sensing and mapping have begun using a WASSP S3 Multibeam system as part of a project to survey inland ponds and coastal estuaries.

The students have deployed the WASSP Multibeam system aboard a specially developed autonomous kayak.

The kayak can be deployed out of the bed of a pickup truck to collect environmental data and conduct bathymetric surveys. It also serves as a test platform for new autonomy algorithms.

During initial trials, the WASSP multibeam was able to profile ripples on an estuary floor up to 15 cm apart.

NOAA Grant to Improve Sea Ice Modeling

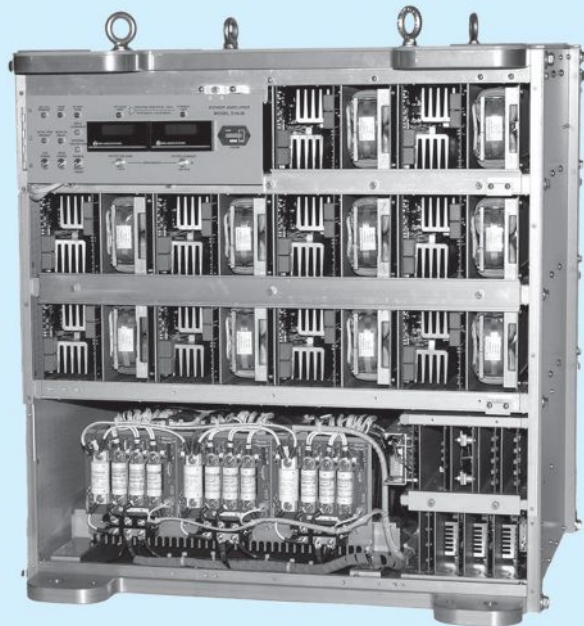
The Arctic sea ice record only dates back 40 years, and current sea ice models are having difficulty accounting for the variability and decline seen in recent years. Qinghua Ding of UC Santa Barbara's Earth Research Institute plans to evaluate climate models against observations to determine which work well, which fare poorly and why.

His proposal has received a \$200,000 grant from NOAA's Climate Program Office as part of the Modeling, Analysis, Predictions, and Projections (MAPP) Program. Ding will focus on Arctic sea ice models and how they interact with other model components.

He is tracking down factors that could account for the gaps between observations and model predictions. **ST**

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contracts

ShipServ, London, England, will deliver a full supplier integration solution to increase efficiencies and the speed of processing multiple transactions. This will help drive customer retention and the ability to win more business through faster turnaround times. AMOS Group Ltd.

Kongsberg, Kongsberg, Norway, has signed a memorandum of understanding to explore the potential for collaboration on a common data infrastructure for the maritime sector. MAN Energy Solutions.

Unique Group, Dubai, United Arab Emirates, has signed an agreement to acquire five USV DriX units for such tasks as geophysical and hydrographic surveys, touchdown monitoring of pipelines, subsea positioning, and ROV/AUV tracking. iXblue.

VPLP Design, Paris, France, has developed a 121-m-long RoRo vessel for transporting components of the Ariane 6 rocket from Europe to French Guiana. Equipped with four Oceanwings, the vessel is designed to have minimal environmental impact. ArianeGroup.

Marlink, Oslo, Norway, has agreed to a multi-year renewal and expansion of a partnership to provide broadband services to maritime vessels worldwide, ensuring that shipowners and operators have access to reliable, high-quality, always-on connectivity. Intelsat.

The U.S. Army Corps of Engineers, Europe District, Wiesbaden, Germany, has selected a joint venture to provide architecture, engineering, master-planning and design services. The contract will support projects in 30 European countries and has an estimated completion date of August 2024. Woolpert and Black & Veatch.

Team TBG, Washington, D.C., has been awarded a task order to provide facilities management and sup-

port services, including support and oversight to headquarters personnel and tracking of lease and occupancy agreements, regulations, requirements and technologies to promote the safety and security of facilities and assets throughout the continental U.S., Hawaii and American Samoa. NOAA Office of National Marine Sanctuaries. **ST**

meetings

JANUARY

January 6-9—HYPACK 2020, Jacksonville, Florida. 860-635-1500, Brittany@hypack.com or www.hypack2020.com.

January 7-9—Challenge of Science Leadership, Totnes, England. info@scienceleadership.co.uk or www.scienceleadership.co.uk.

January 14-16—Blue Innovation Symposium, Newport, Rhode Island. 401-847-6650 or https://salve.edu/blue-innovation-symposium.

January 15-16—Coastal Futures, London, England. bob.earll@coastms.co.uk.

January 21—iXblue Users Conference, London, England. www.ixblue.com/users-conference.

FEBRUARY

February 4-6—EUROMARITIME, Marseille, France. +33 1 56 59 15 07, anne-charlotte.micca@gican.asso.fr or www.euromaritime.fr.

February 4-6—Underwater Intervention, New Orleans, Louisiana. ui@naylor.com or www.underwaterintervention.com.

February 11-13—Subsea Expo, Aberdeen, Scotland. www.subseaexpo.com.

February 17-21—European Shipping Week, Brussels, Belgium. Smoloney@elabor8.co.uk.

February 24-27—Canadian Hydrographic Conference, Quebec, Can-

ada. chc2020@conferium.com or www.chc2020.org.

MARCH

March 9-10—World Ocean Summit, Tokyo, Japan. +971 552215208, oceansummit@economist.com or www.woi.economist.com/world-ocean-summit.

March 17-19—Oceanology International, London, England. +44 (0)20 82712133 or www.oceanologyinternational.com.

March 23-25—International Lidar Mapping Forum, Washington, D.C. www.lidarmap.org.

March 31-April 1—Decommissioning & Abandonment Summit, Houston, Texas. www.decomworld.com/gom.

APRIL

April 6-9—OCEANS 2020 Singapore, Singapore. info@oceans2020singapore.org or https://singapore20.oceansconference.org.

April 13-16—MTS Buoy Workshop, Wilmington, North Carolina. rickcole@rdsea.com.

MAY

May 4-7—AUVSI XPONENTIAL, Boston, Massachusetts. meetings@auvsi.org or www.xponential.org.

May 4-7—Offshore Technology Conference, Houston, Texas. http://2020.otcnet.org.

May 6-7—Remote Hydrography Conference, Southampton, England. helen@ths.org.uk or www.ths.org.uk/content.asp?page=99.

May 18-19—Maritime Transport Efficiency Conference, Geneva, Switzerland. bernard.schopfer@maxcomm.ch.

May 19-21—International Conference on Ocean Energy (ICOE), Washington, D.C. www.icoe2020.org.

For more industry meetings, visit sea-technology.com/meetings. **ST**

people

Phoenix International Holdings Inc. has promoted **Kent VanHorn** to vice president for Global Submarine Rescue. He is a retired U.S. Navy submarine warfare officer, a prior commanding officer of the Navy Undersea Rescue Command, and current U.S. Navy Submarine Rescue Operations and Maintenance contract program manager. In his new position at Phoenix, he will execute, manage and coordinate all Phoenix submarine rescue and intervention contracts.



TDI-Brooks has hired **Richard Byno III**, PMP, to lead vessel operations and activities as the director of marine operations. He has served in the U.S. Marine Corps, where he was a member of a Marine Special Operations Command team. He has more than 17 years of critical operations experience and most recently served as a high-level strategic senior military adviser to the Department of Defense, intelligence community and Executive Branch.

MacArtney Canada Ltd. has named **Darren E. Penney** as the head of item sales for Central and Eastern Canada. He will support customers in finding solutions to their connectivity and data-acquisition needs. Penney brings with him 20 years of industry experience in technical sales and service. He has established a network of 20 representatives in 29 countries.

Xodus Group has appointed **Stephen Rivers** as subsea and pipelines manager for Asia-Pacific as the company targets strategic growth and new projects in the region. Rivers's previous roles have included engineering director for Peritus International Pty Ltd. and senior vice president for INTECSEA for Australia and New Zealand.

Ship & Shore Environmental Inc. has appointed **Jim Stone** as vice president of sales. Stone has more than 25 years in product and business development in the air-pollution-control and hazardous-materials industries.

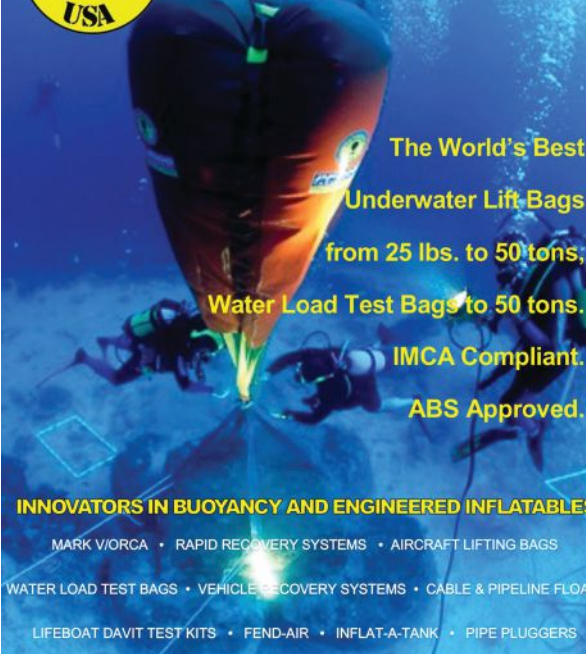
Yara Marine has introduced Dr. **Thomas Koniordos** as its new CEO. Koniordos was previously Yara's head of environmental solutions and chairman of the board. He succeeds **Peter Strandberg**, the company's founder.

Henning Høgh has joined Teledyne Marine Europe as vice president of supply chain. Høgh's role will focus on streamlining the supply chain and manufacturing capabilities across Marine Europe, as well as participating in Teledyne global supply-chain initiatives. **ST**



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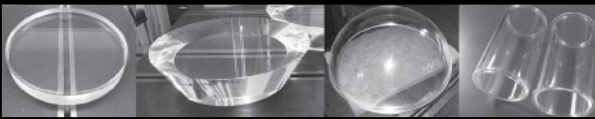
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OTEC Advances with First Technical Specification—Pat Grandelli

Pat Grandelli is an ocean engineer and a U.S. member of the International Electrotechnical Commission's TC114 marine energy committee. He



has worked at two OTEC plants and designed other renewable energy and civil engineering projects. He graduated from the University of Hawaii and the U.S. Naval Academy and is a professional engineer at PCCI Inc. in Alexandria, Virginia.

Next time you visit a harbor, look for renewably powered commercial ships. Count the wind-driven container ships, wave-powered tankers or solar research vessels.

It's doubtful you will see a single one.

Commercial seafarers prefer fossil-fuel-driven vessels because humans can't control the intermittent wind, the Earth's daily rotation or the waves.

If only there were a continuous source of renewable energy.

Well, there is.

This past June, the International Electrotechnical Commission (IEC, the leading standards organization for all electrical and electronic technologies) published the first design guidance and assessment requirements for utility-size ocean thermal energy conversion (OTEC) plants.

OTEC plants use solar-heated tropical ocean water (warmer than 25° C) and deep, cold seawater (at 1,000 m the ocean is about 5° C) to generate grid-quality electricity on a 24/7 basis. Seawater is pumped through dam-size pipes and heat exchangers to drive a refrigerant-based turbine-generator. One-third of the electric output drives the seawater pumps, and the other two-thirds can be sold. The water flow per megawatt through an OTEC plant is about the same as through Bonneville Dam on the

Columbia River. It is a low-head dam that generates 1,050 MW from a flow rate of 288,000 cubic ft. per second.

The IEC team writing the new OTEC technical specification was led by the United Kingdom, with international representatives including the designers of small OTEC plants now operational in Hawaii; Kumejima, Japan; and Goseong-gun, South Korea. Our expected audience is developers, engineers, regulators and finance authorities.

The Technical Specification focuses on the OTEC-specific components of the power plant, particularly the marine aspects of the warm- and cold-water intake systems. It references other established standards where OTEC components are very similar to utility power plants or deepwater oil and gas production systems.

The new specification also redefines OTEC power ratings to match other generation technologies. For example, a plant might generate 120 MW continuously during summer and 80 MW during winter. Earlier designers would have rated such a plant as "100-MW average," but it would now be rated as "120 MW," with a capacity factor of 0.83 to express the annual variation. In comparison, corresponding wind or solar systems have capacity factors of only 0.3 to 0.4 and are noncontinuous.

Research-size OTEC plants are often land-based. South Korea's larger new system is barge-mounted, and it operated successfully on September 30, 2019.

I predict that commercial-size OTEC plants will resemble floating oil rigs. Floaters will have the shortest possible water pipes, can ride out tsunamis and storm surge, and can be mass-produced to a common design. The first commercial OTEC plants will probably sell electricity to niche markets such as Kiribati, the Bahamas, Hawaii and

throughout the Caribbean. Once the industry is established, open-ocean OTEC plants could make a noncarbon synthetic fuel, such as ammonia (NH₃), to eventually replace oil and coal.

OTEC will become more than a pipe dream because today's pillars of U.S. renewable energy policy—wind turbines, solar cells and ethanol—are impractical at truly large scale. The intermittent nature of wind and solar is why they generated only 3.1 percent of U.S. energy in 2017. We get more energy (7 percent) from wood, ethanol and hydropower because they can operate on demand.

Federally mandated ethanol is not scalable either. Ethanol replaces 10 percent of gasoline (only 2 percent of all U.S. energy) yet consumes a whopping 38 percent of the U.S. corn harvest. Despite all the carbon-free lobbying by landlubbers, 80 percent of U.S. energy still comes from fossil fuels, and 10 percent is from nuclear power.

Where will we find a renewable energy source that is continuous and can scale up to global size? The answer is the tropical ocean, which has the area of nine Sahara Deserts to absorb solar energy, so OTEC can be scaled large enough for global energy production. Its upper limit for sustainability is probably the global thermohaline (deep, cold seawater) circulation. Ocean modelers have shown that OTEC can be sustainable for thousands of years while generating 7,000 to 14,000 GW, a power rating similar to the world's oil consumption of 100 million barrels per day. Switching to OTEC will enable fossil fuels to become an "ore" for useful products like plastic and petrochemicals, instead of merely being burned into heat and carbon dioxide.

We live on an ocean planet—a lasting solution for sustainability will be to convert energy from sunshine on the sea. **ST**

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