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AUGUST 2022

**GEOPHYSICAL EXPLORATION
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FEATURING:

UAV-Borne Bathymetry

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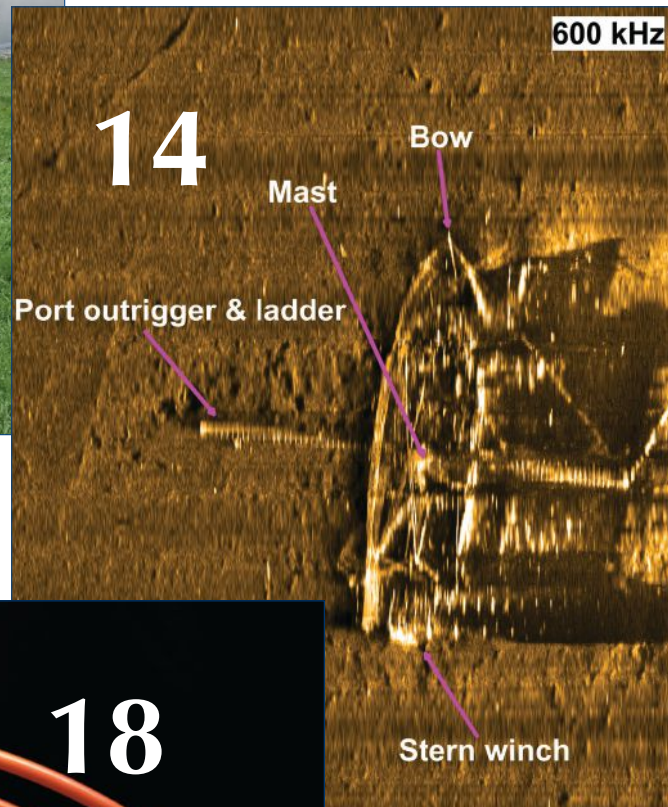
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TDI-Brooks engaged in a seabed geophysical survey off the East Coast of the U.S. in July 2021 using the RV *BMCC* in support of US Wind's MarWin offshore wind project off the coast of Maryland. The goal was to better understand the geological issues that may exist with project development to ensure safe and long-term operations and performance of the facility. (Credit: Brandt Broussard, TDI-Brooks)

NEXT MONTH

Remote hydrographic surveying ... Fishing innovations to decrease bycatch ... AUV with AI software to map and monitor coastal systems ... Methanol-to-hydrogen generator ... Trash skimmer invention for coastal cleanup.

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)) Complete Ban on Russian Commodity Exports Accelerates LNG Growth, Energy Transition. War in Ukraine is transforming the outlook for the supply, demand and price of hydrocarbons and the pace and cost of the energy transition. While the precise timing and implementation of future bans on Russian commodity imports are difficult to predict, a restructuring of energy trade flows is now underway. With the global economy on shaky ground and energy prices structurally higher, there is a real risk of some global supply being lost. Europe's push for more LNG as it looks to reduce Russian pipeline gas has pushed spot prices to record levels and is supporting strong demand for coal. At the same time, supply-chain risks are growing, and inflation is increasing costs across the energy sector. These are the latest insights from new analysis by Wood Mackenzie, a Verisk business, which also found that against this backdrop and with coal currently more resilient, further advancing the energy transition could be more expensive and potentially prove more carbon intensive. "It is inconceivable that Europe will abandon its diversification strategies and return to any meaningful dependence on Russia," Massimo Di-Odoardo, vice president of Gas and LNG Research at Wood Mackenzie, said. Based on the assumption that Europe bans all Russian commodities by the end of 2024, Wood Mackenzie's new analysis considers the impact on commodities over the next decade, as well as on investment, the energy transition and geopolitics. The research by Wood Mackenzie emphasizes that a future ban on Russian gas will see competition for LNG intensifying as Europe competes with Asia for limited supply growth to around 2026. Across all hydrocarbons, LNG looks to be the most compelling investment option over the next few years. "A huge increase in LNG project investment is being supported by a rapid increase in European LNG demand, with U.S. developers already looking to fill the space," said Di-Odoardo. "As a result, there is a potential for 50 million tonnes per annum of new U.S. LNG capacity that will take final investment decisions over the next two years—and this could double if Europe bans imports from Russia by 2024." Di-Odoardo added: "The most successful governments, companies and investors will be those who best navigate these complex market conditions to accelerate the energy transition."

)) UNCTAD Calls for 'Blue Deal.' The United Nations Conference on Trade and Development (UNCTAD) is promoting a "Blue Deal" for global trade, investment and innovation, which it brought up during the 2022 UN Ocean Conference in Lisbon. This Blue Deal for a sustainable and resilient ocean economy should benefit everyone, support an inclusive recovery from the COVID-19 pandemic, and help cushion the world against current and future crises. UNCTAD is calling for sufficient and reliable long-term investment in the Blue Deal to conserve and sustainably use the ocean for sustainable development (UN Sustainable Development Goal 14). The ocean is the next great economic frontier. The ocean's resources provide food, jobs and income for almost 3 billion people, most of whom live in developing countries. But these resources and opportunities are under threat, and their protection is underfunded. UNCTAD supports countries to tackle challenges such as plastic pollution, unsustainable fishing and the carbon intensity of maritime transport to ensure a sustainable ocean economy.

)) First Accurate 3D Manta Ray Model. South Florida is an important habitat for manta rays, which suffer injuries from boat propellers and getting entangled in fishing lines. The Florida Manta Project, a research group within the Marine Megafauna Foundation, used drone technology, aerial surveys, and in-water photography and videography to collect measurements and track the area's manta ray population. For modeling, the team spent a week working offshore searching for manta rays. Many of the manta rays had already been observed. One manta ray in the study was an 8-ft. juvenile male named Skye. Researchers previously observed Skye in June 2020 and have since spotted him more than 20 times. Using collected footage and measurement data, the animator recreated his shape, gills, mouth and other attributes, including identifying details and texture, such as the ray's scars from a boat propeller. The model was also rigged with detailed animation, which accurately depicts Skye's swimming motion and the lifelike movement of his cephalic fins during feeding. The model of Skye is the only accurate 3D model of a manta ray and an invaluable digital representation that aims to fill knowledge gaps in manta ray morphology and swimming and feeding motions and behaviors. The 3D model can be used to study energetics of movement and manta ray body condition and health, which will help conservation efforts for this threatened species.

)) ORPC's First River Hydrokinetic Power System in Patagonia. Ocean Renewable Power Co. (ORPC), a developer of renewable power systems that generate electricity from free-flowing river and tidal currents, and its wholly owned subsidiary, ORPC Chile, have an agreement with the municipality of Chile Chico in the Aysén region of Patagonia to install a RivGen power system there in 2023. A gateway community to Chile's Patagonia region, Chile Chico's 6,218 residents are serviced by both on-grid and off-grid electricity networks. The community is situated on General Carrera Lake, which forms the headwaters of the Baker River, the largest volume watercourse in the country and considered the strongest in Latin America. ORPC's RivGen will be deployed at the meeting point of General Carrera Lake and Bertrand Lake, where the Baker River begins. The initial device will be connected to the Edelaysen utility regional grid network. Electricity delivered from ORPC devices would displace diesel fuel in the market. **ST**

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Green Bonds Can Finance Marine Conservation

Ocean conservation is entering a critical phase. The need for a fundamental shift in how the blue economy is financed is becoming increasingly urgent, as climate conditions worsen and biodiversity plummets. The most effective driver of change will come via the implementation of practical solutions for investors.

A major hurdle to achieving a sustainable blue economy is the inefficiency of marine protected areas (MPAs). The reason behind MPAs' struggle to meet conservation targets is clear: 91 percent of MPAs suffer from staffing shortages, and 65 percent have inadequate budget to meet basic management needs.

The sobering reality for the ocean economy is that, in their current format, MPAs are failing. At least 70 percent of MPAs are currently falling short of conservation goals. If the global economy is to reach its goal of protecting at least 30 percent of the world's land and ocean environments by 2030, it will fall on investors to boost the efficiency of MPAs.

The global funding gap for MPAs is estimated to be approximately \$100 billion per year. As such, investors can play a major role in increasing the efficiency of the conservation of MPAs.

One solution that will facilitate the shift toward sustainability is having recognized criteria for conservation. The most effective—and efficient—way to measure conservation performance is for a protected area to meet the conditions of the globally recognized International Union for Conservation of Nature (IUCN) Green List standard.

The IUCN's Green List is a certification program that recognizes effectively managed and fairly governed terrestrial and marine protected areas that are achieving their conservation outcomes. The IUCN Green List of Protected and Conserved Areas is the first global standard of best practices for area-based conservation and was established with the aim of increasing the number of natural areas delivering long-lasting conservation results for both investors and the natural world.

The application process is rightfully rigorous: There are four major components, with 17 further criteria that must all be met in order for a protected area to be accepted to the list. So far, 30 MPAs globally have achieved the IUCN's Green List standard—but in order for more MPAs to meet the required targets, the funding gap perpetuating inefficiencies must be dramatically narrowed. Using the IUCN's Green List as a financial instrument to boost investment and drive efficiency is one solution that would have tangible impacts and catalyze long-lasting change to power a sustainable blue economy.

The IUCN's Green List could serve as a bond model, with candidate MPAs generating a management plan that includes a detailed budget and anticipated timeline for achieving Green List status. In this proposed model, investors would pay the principal equal to the total amount of funding for each MPA to the public administration (PA) authority, which would in turn be distributed to each MPA. The fund, based on public-private partnership, would help an MPA improve efficiency, and every time an MPA achieves Green List status, the PA authority would pay back investors, with interest. The benefits of this bond system are universal, rewarding both issuers and investors while providing tangible advantages to MPAs.

The primary challenges of this green bond model lie in deciding who would pay the transaction costs and whether an intermediary would be required to act as issuer. But the potential gains mitigate these concerns, including high rates of return for both investors and issuers. Ultimately, the biodiversity of this planet and the economy that relies on it will benefit the most. **ST**

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JANUARY

Annual Review & Forecast

**OCEANS 2022 Chennai, February 21-24, Chennai, India

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

**Oceanology International, March 15-17, London, Excel, U.K.

MARCH

Electronic Charting/Vessel Management/
Ports & Harbors/Dredging/Homeland Security

**AUVSI XPONENTIAL 2022, April 25-28, Orlando, FL

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

**Offshore Technology Conference, May 2-5, Houston, TX

MAY

Communications, Telemetry, Data Processing

**Undersea Defence Technology (UDT), June 7-9, Rotterdam, The Netherlands

**EUROMARITIME, June 28-30, Marseille, France

JUNE

Seafloor Mapping/Sonar Systems/Vessels

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22 Editorial Calendar

UE DATE

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Deck Gear, Cable, Connectors, Power Systems & Salvage

****CLEAN PACIFIC 2022**, August 23-24, Renton, Washington

AUGUST

Geophysical Exploration/Seafloor Engineering

****IMAGE '22**, August 28-September 2, Houston, TX

SEPTEMBER

Ocean Resources Development & Coastal Zone Management

****OCEANS 2022 Hampton Roads**, October 17-21, Virginia Beach, VA

****EURONAVAL**, October 18-22, Paris, France

OCTOBER

Environmental Monitoring, Remote Sensing & Pollution Control

****Offshore Energy 2022**, November 29-30, Amsterdam, The Netherlands

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UAV-Borne Bathymetry

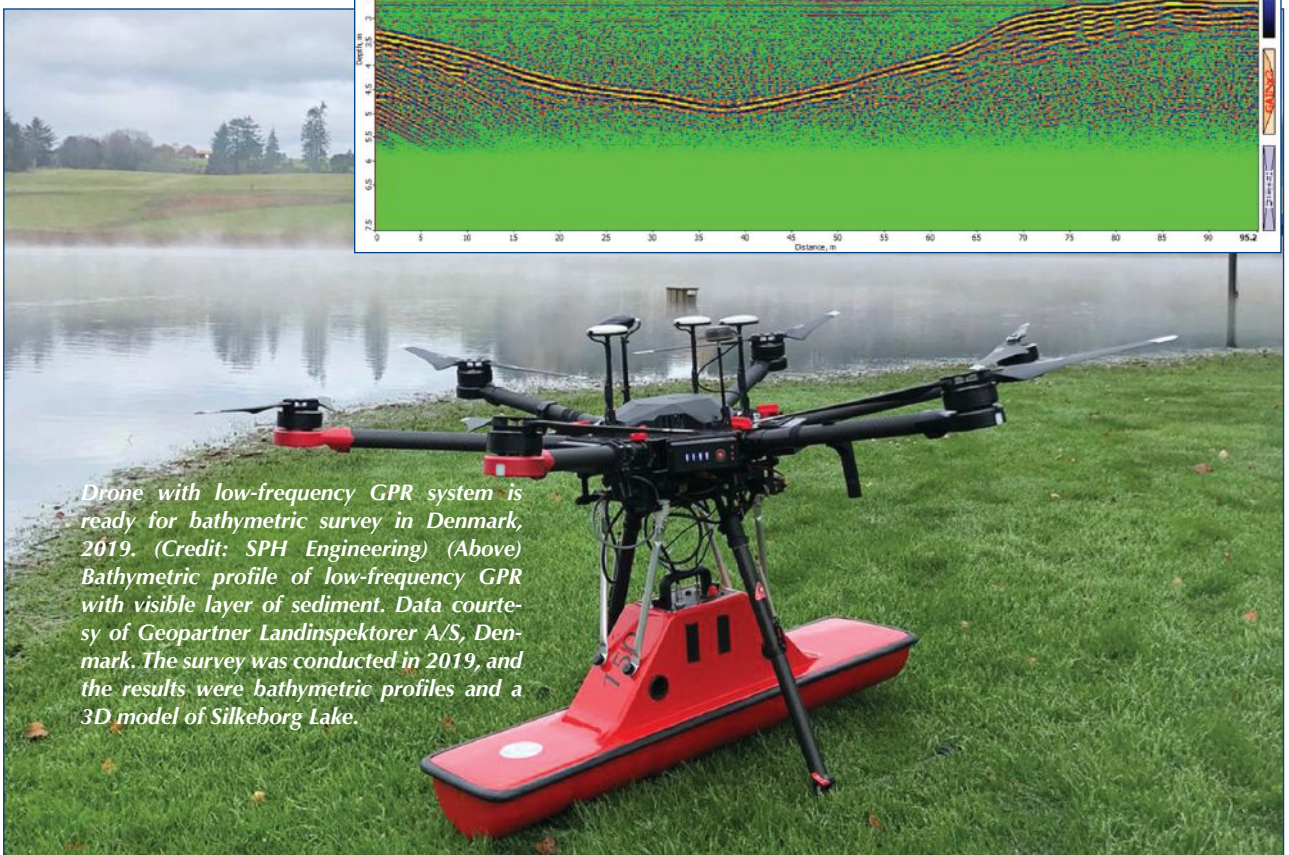
Aerial Drone with Echosounder on Rope/Cable Broadens Applications

By Alexey Dobrovolskiy

The most popular methods of bathymetry have stayed the same for decades: single-beam echosounders (SBES) and multibeam echosounders (MBES) on crewed or uncrewed boats, and measurement poles/sticks and GPS receivers for very shallow water. These methods work well but require physical access to the water. Use of poles and a GPS receiver additionally requires someone to enter the

water—and that may not be an attractive option.

So, there is demand for application of remote sensing techniques for bathymetry, especially when standard methods can't be used. Such instances involve lack of physical access to the water body, or conditions too dan-



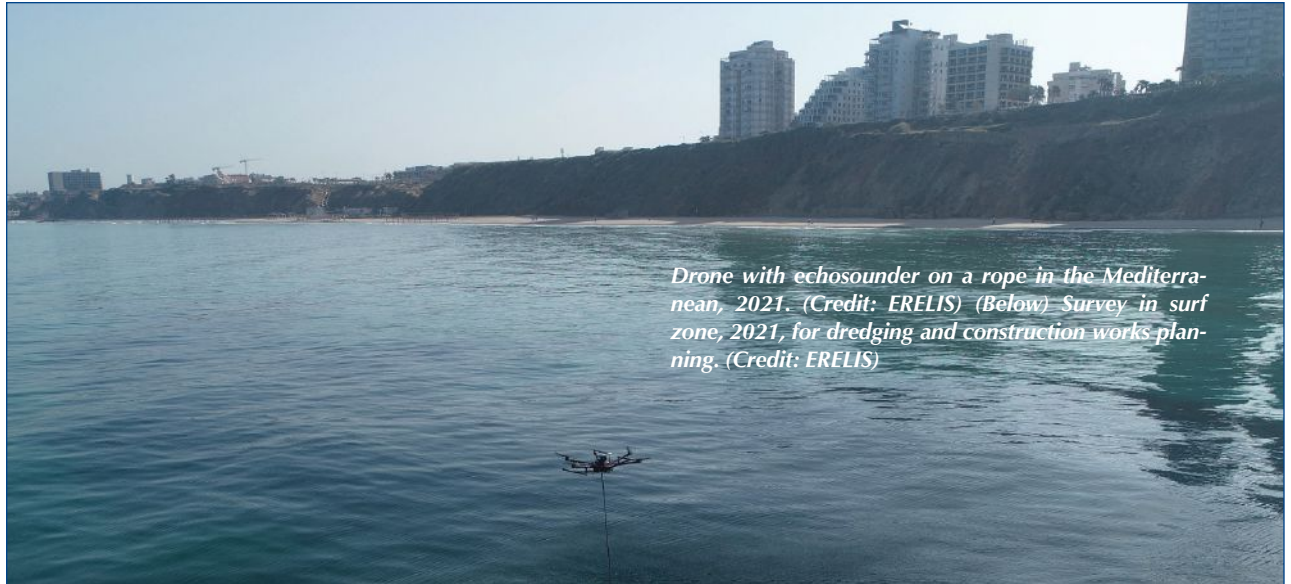
gerous to deploy crewed/uncrewed boats or to enter the water. Sometimes, standard methods don't work at all; for instance, in the case of surf zones and surveying nonwater reservoirs, such as acid pools.

Flying drones, or unmanned aerial vehicles (UAVs), can facilitate remote bathymetry. Currently, there are at least three technologies commercially available for remote bathymetry using UAVs: green-wavelength bathymetric LiDAR; low-frequency, ground-penetrating radar (GPR); and classic single-beam echosounders on ropes. Each method has its own benefits and drawbacks.

Green LiDAR

Green LiDAR is a contactless method with very high performance in terms of area coverage in a specified time period; the capability to gather topography together with bathymetry; and high precision. The first commercially available devices suitable for UAVs were introduced approximately five years ago, but that technology hasn't become widely adopted yet.

The high price of the sensor is a challenge for small/medium businesses, especially in combination with the risks. Imagine that you will need to carry the \$100,000



Drone with echosounder on a rope in the Mediterranean, 2021. (Credit: ERELIS) (Below) Survey in surf zone, 2021, for dredging and construction works planning. (Credit: ERELIS)



sensor over saltwater using a commercially available drone—a problem in the field could lead to the full loss of equipment. Insurance is recommended, but it is complicated and/or expensive to purchase insurance for the drone and sensor because of the high price of the system.

The second major drawback of green LiDAR is the limited maximum depth in turbid water, typically estimated as 2 to 3 Secchi disk depths. That automatically excludes applicability of LiDAR technology for most inland water bodies and, in many cases, for surf zones in oceans and seas.

Low-Frequency GPR

Another noncontact method, low-frequency GPR is based on the fact that low-frequency electromagnetic waves can penetrate water. This method has more drawbacks than benefits: limited maximum depth (based on practical experience, it may be 10-m max for an

80-Mhz GPR system with antenna elevated 1.5 m above water surface); works only in water with low salinity (conductivity); and lacks precision compared to green LiDAR and echosounders. Additionally, data processing for GPR is more complex compared to LiDAR and echosounders.

But, as it is a contactless method that can work in turbid water and even through ice, it has applications where other methods will not work: bathymetry of shallow turbid waters with extremely high current (mountain rivers, above/below waterfalls); surveying of frozen water bodies; and areas with lots of seaweed. An additional benefit of GPR is that it enables sub-bottom penetration to some extent, allowing estimates of sediment thickness and even detection of objects buried in silt/sediment.

Echosounders

While both LiDAR and GPR were not designed initially for ba-

thymetry, echosounders were invented to measure water depth. The cost is not very expensive, even for survey-grade models. Echosounders can work in any liquid, and the difference in sound speed may be accounted for in post-processing. They are compact and allow for greater maximum depth (up to a few hundreds of meters, even for compact devices). Echosounders have been in use for almost 100 years, delivering high-precision and predictable results for bathymetric surveys.

In combination with a drone, the drawback of echosounders comes from the method of mounting, which involves using flexible rope or cable. Echosounders are very sensitive to sudden wind gusts and waves, and heavy housing to stabilize an echosounder in the water is expensive.

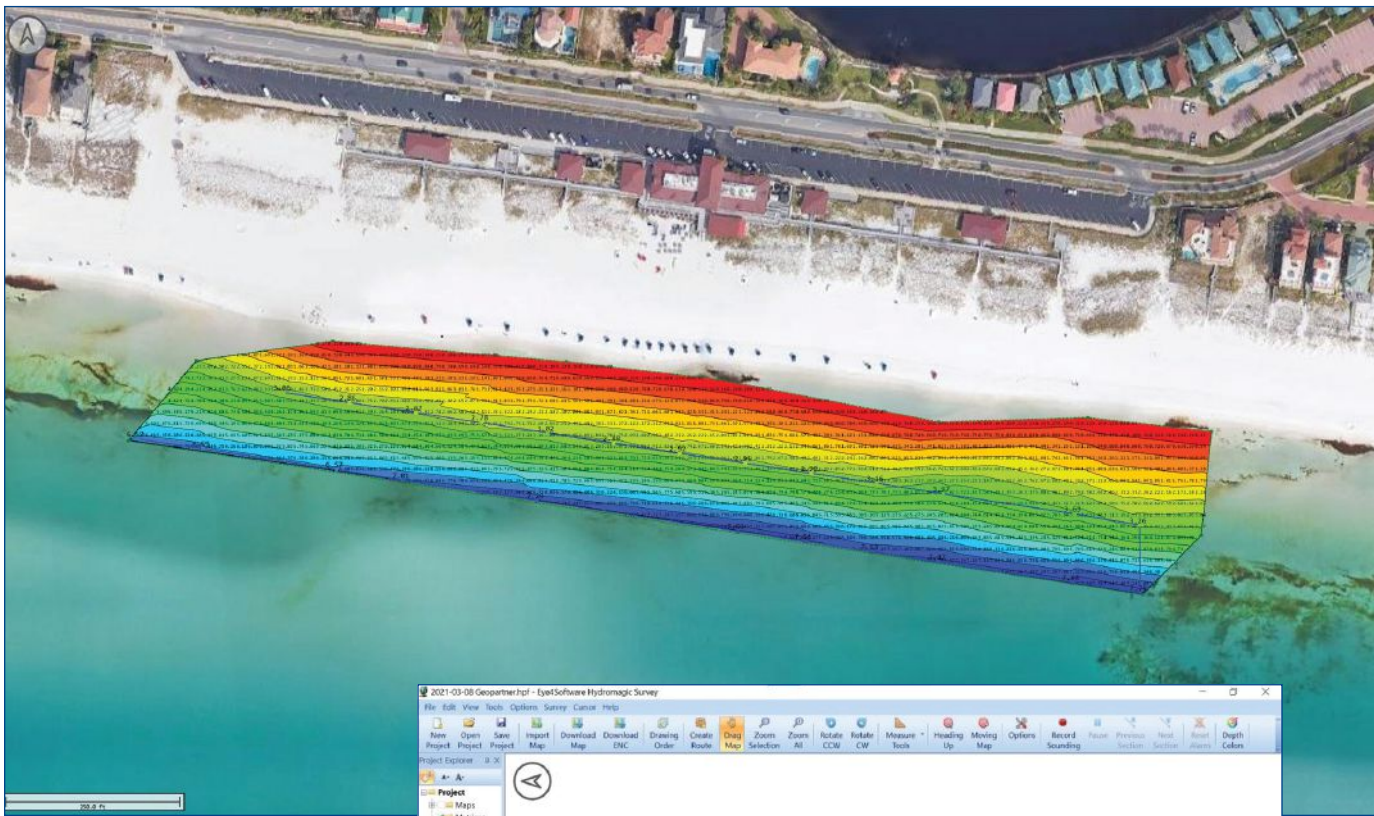
SPH Engineering's UgCS airborne integrated UAV solutions features echosounder-and-drone integration. We recommend DJI Matrice 300 RTK drone, but our customers use various drone models. Standard rope/cable length is approximately 2.1 m. We place the echosounder's cable in expandable PET braided cable sleeving to protect the cable and hold the weight of the echosounder and housing.

With initial trials in a shallow area of the Baltic Sea as part of system commissioning last year, we found that a small echosounder in heavy housing may be stable enough in the water if it has tilt in the range of 5 to 10°, which is comparable with hard mounting on a crewed or uncrewed boat. In order to eliminate imprecise readings when the echosounder tilt was out of the set range, we used Echologger ECT echosounders with integrated tilt sensors.

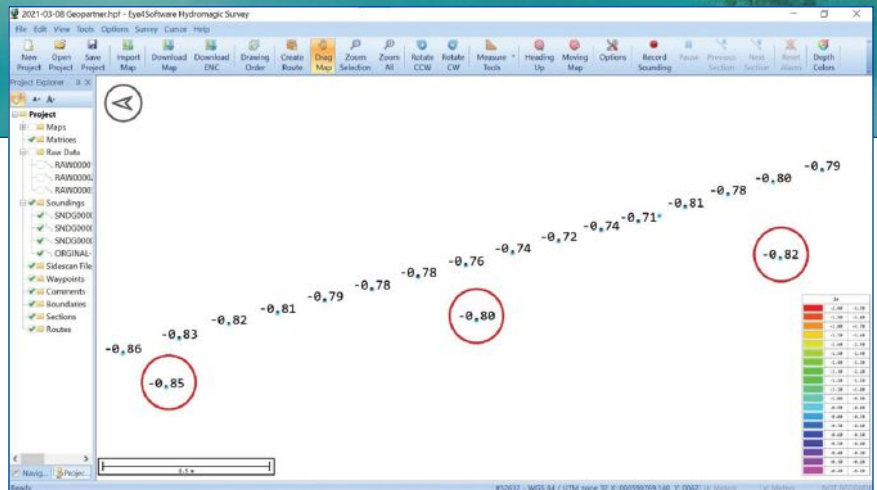
The real limiting factor for that system is the maximum survey speed. As the water drag is proportional to the second power of the speed, the real practical limit is around 0.8 to 0.9 m/s, which is approximately half the normal speed of autonomous boats.

Based on the experience of multiple UgCS customers around the world, we have determined the





(Above) Result of bathymetric survey in surf zone in Florida, 2022, for shore-line restoration works. Data courtesy of Aerospectrum. (Right) Checking the accuracy of measurements made using a drone with echosounder on rope in Denmark, 2021. Measurements in red circles were made using a measurement pole with Trimble GPS receiver. Data courtesy of Geopartner Landinspektorer A/S, Denmark.



main benefits of the system comprising an aerial drone with an echosounder on a rope. The system offers the possibility to conduct surveys of locations with take-off/landing positions far from the survey area. It works when physical access to the water body is limited or not possible. It also works in surf zones where crewed and autonomous boats can't be used. The system can be deployed for surveys of nonwater reservoirs, such as open-air acid pools or contaminated water, with the limit being the resistance of the sensor, housing and rope/cable to the liquid for a specified period. In some conditions, bathymetric survey using an aerial drone with echosounder is more economically reasonable for small-scale surveys than hiring a boat with a set of bathymetric equipment.

We also tested the combination of drone and echosounder on a flexible rope for the repeatability and precision of data using a Trimble RTK GPS receiver on a pole. Repeatability was regularly monitored using check lines as part of normal quality assurance procedures, and some users of the system did their own comparisons of

the system's results with data gathered using a more traditional method. The difference in the results between the two methods is minimal.

Conclusion

There are three widely adopted technologies for remote bathymetric surveys using a UAV. Green LiDAR can be used in large areas with clear water, in saltwater and in strong current. Low-frequency GPR works in turbid water, ice-covered freshwater, in strong current, and for sub-bottom and sediment profiling.

SPH Engineering's system comprising an aerial drone with an echosounder on a rope works best for turbid water or other liquid, saltwater, sediment profiling and in surf zones. The experience of SPH Engineering and its customers demonstrates the efficacy of this UAV-borne bathymetry method. **ST**

Alexey Dobrovolskiy is the chief technology officer at SPH Engineering in Latvia.

Search for Wreck of FV *Emmy Rose*

Side Scan Sonar Sheds Light on New England Maritime Tragedy

Dr. Pete Ramsay • Michiel van de Visser

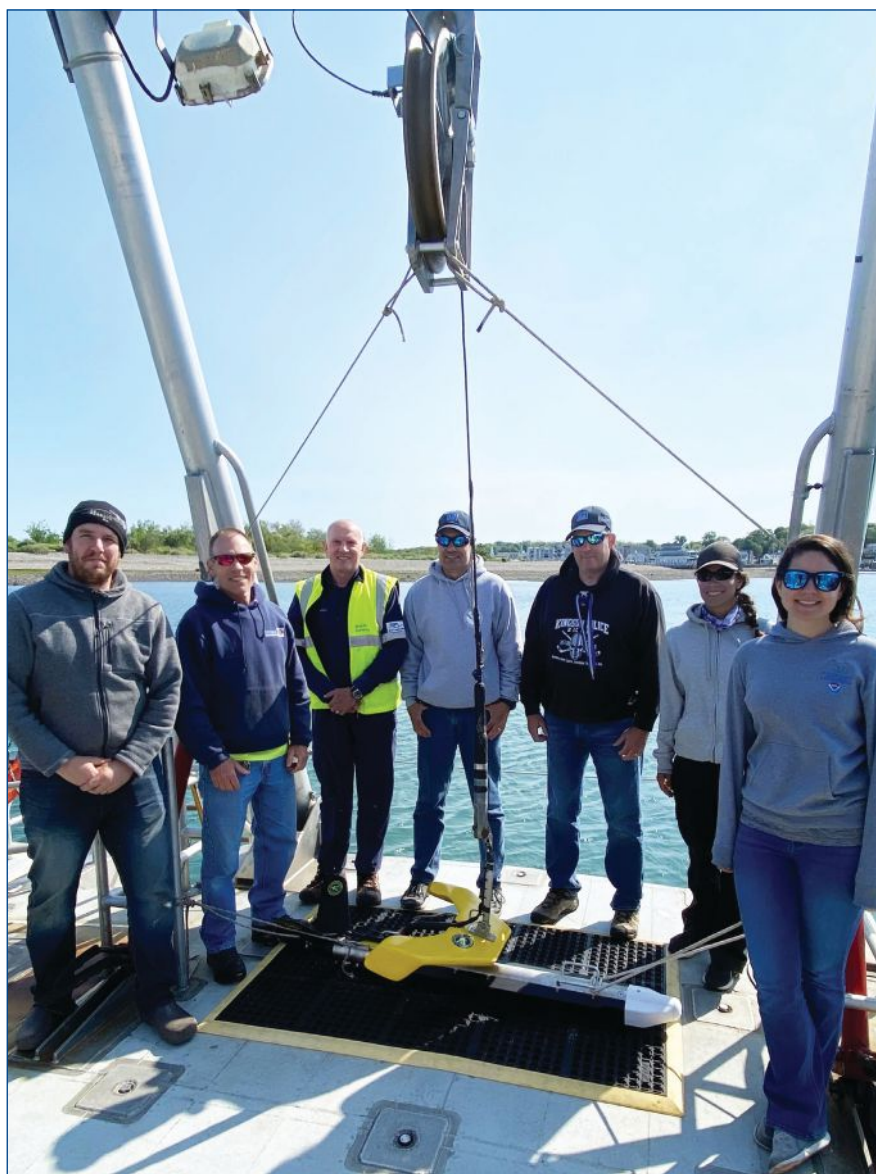
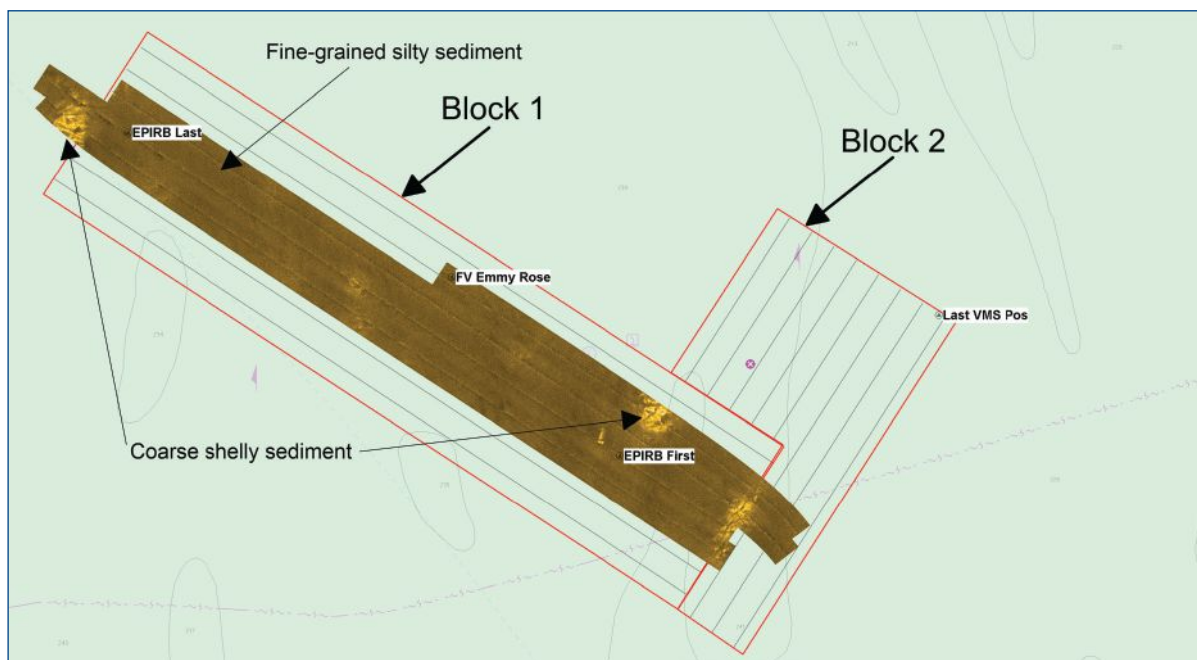
The 82-ft. fishing vessel *Emmy Rose* was returning from a seven-day trip to the Georges Bank when it sank in the early morning on November 23, 2020 with four crew members on board. At about 1:30 a.m. U.S. Eastern Standard Time, the emergency position-indicating radio beacon (EPIRB) on the vessel emitted a distress signal, and the U.S. Coast Guard (USCG) arrived on scene 1.5 hr. later and found a debris field, diesel fuel odor and an empty life raft. The Coast Guard searched more than 7,555 sq. km (2,200 sq. mi.) over a 38-hr. period but was unable to locate the vessel or its crew, who

are presumed dead. The accident was classified by the U.S. Coast Guard as a major marine casualty.

In May 2021, MIND Technology was contacted by NOAA, USCG and the National Transportation Safety Board (NTSB) to conduct a side scan sonar search for the fishing vessel *Emmy Rose*. The FV *Emmy Rose* was presumed to have sunk, with all hands lost, in approximately 244 m of water (800 ft.) off the Massachusetts coastline about six months earlier. The MIND Technology team worked closely with the USCG, NTSB and NOAA in analyzing the vessel monitoring system (VMS), EPIRB

Photograph of the starboard side of the FV Emmy Rose (courtesy of Robert Serbagi). Note the ladder on the outrigger and other superstructure features, which can be clearly seen in the side scan sonar imagery.





(Above) Chart showing the Blocks 1 and 2 search areas and the survey line plan in relation to the last VMS position of the FV Emmy Rose, first EPIRB position at 1:47 a.m. and last EPIRB position at 3:02 a.m. The 100-kHz side scan sonar mosaic of four lines covered in Block 1 is overlaid on the chart together with the location of the FV Emmy Rose wreck. (Left) The MIND Technology and NOAA survey team posing on the RV Auk with the prototype Klein 4K-SVY side scan sonar used to obtain high-resolution imagery over the wreck site.

and life raft positional information to define search blocks for the survey.

Even with all this information at our disposal, the team could only narrow the sonar search area to two blocks, covering 26 sq. km and 10 sq. km, respectively. It was anticipated that a thorough side scan search of these areas would take at least two to three days to complete, based on the long transit times to get to the site from Scituate Harbor, Massachusetts.

Survey Methodology

A Klein 4000 (100/400 kHz) and prototype Klein 4K-SVY (300/600 kHz) side scan sonars were mobilized onto the NOAA vessel RV Auk

for the search. The Klein 4000's lower frequency pairs were better suited to longer scan ranges, and this sonar was used as the primary search sonar. The prototype Klein 4K-SVY's 600-kHz side scan sonar frequency was used to obtain higher resolution data over the wreck site to assess the condition of the vessel on the seafloor. The towfish was accurately positioned using a combination of differential GNSS (DGNSS) positioning, cable counter on the winch cable and layback algorithms in Klein's SonarPro and HYPACK software packages. A real-time side scan sonar mosaic was produced to assess the data coverage, targets of interest and potential wreck debris fields on the seafloor.

The initial side scan sonar search plan was based on a scan range of 200 m (producing a 400-m-wide seafloor swath), and survey lines were spaced 350 m apart to ensure sufficient coverage of adjacent swaths. For the primary search, the side scan sonar towfish was flown at an altitude of 30 to 40 m above the seafloor for a 200-m-range scale, whereas the higher resolution passes over the wreck site were acquired at towfish altitudes of 15 to 20 m above the seafloor on a 75-m-range scale. The depth of water necessitated the use of long winch cable lengths, with much of the survey being conducted using 700 to 800 m of armored cable. A maximum cable

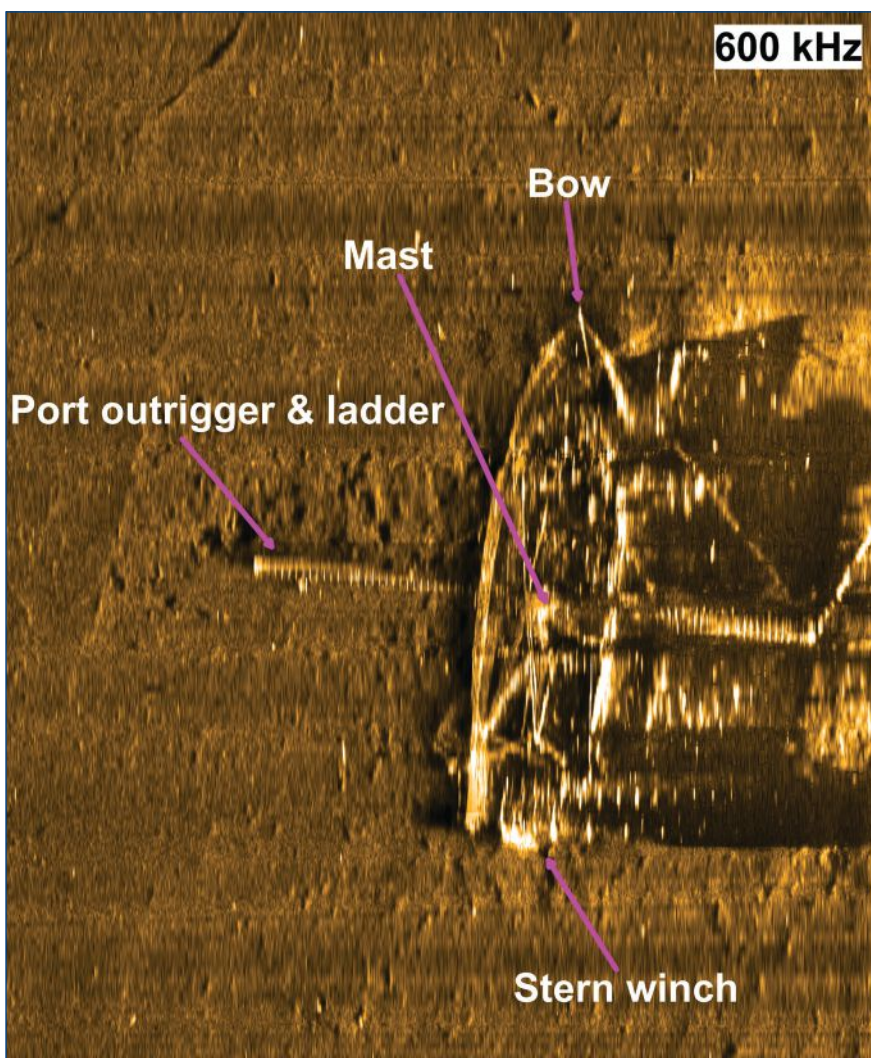
length of 818 m and vessel speed of 3.8 kt. was used to get the towfish sufficiently close to the seafloor for high-resolution, 600-kHz wreck imagery without the risk of entangling the towfish in the vessel rigging.

Finding the Wreck and Assessing the Condition

The FV *Emmy Rose* was located on the fourth survey line after only 6.5 hr. (40 line km) of the side scan sonar search on May 19, 2021 at 2:15 p.m. using a Klein 4000 (100/400 kHz) side scan sonar. Subsequent higher resolution 600-kHz sonar passes were acquired over the wreck site using a prototype Klein 4K-SVY (300/600 kHz) side scan sonar the following day. The wreck site is located approximately 6.5 km west of the last VMS position at a depth of 242 m and is approximately 46 km (25 mi.) off the coast of Provincetown, Massachusetts.

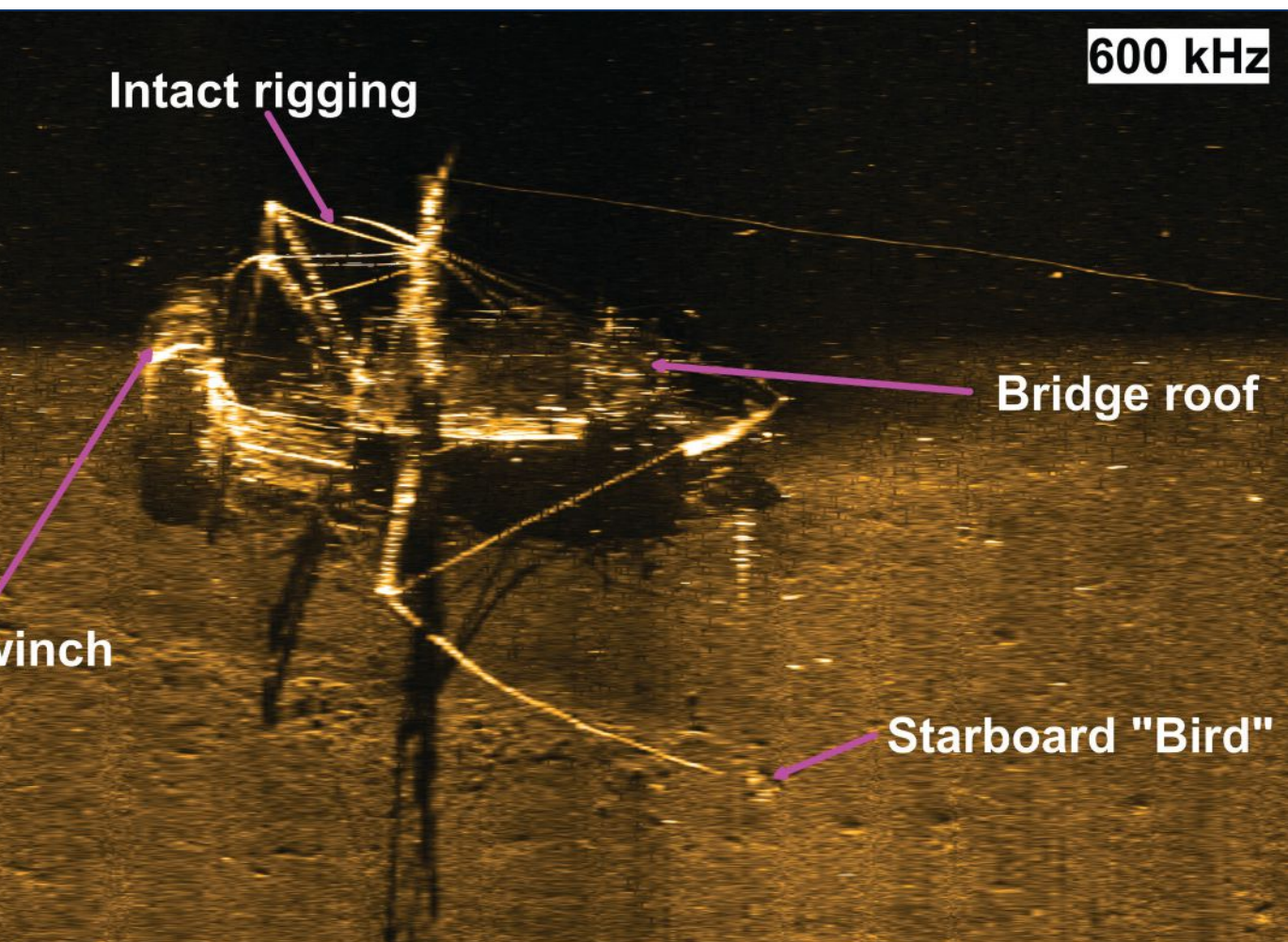
The seafloor in the search area is relatively flat, with water depths varying from 234 to 242 m. The seafloor consists of fine-grained silty sediments with areas of coarser shelly sediment in the northwest and southeast margins of Block 1. Evidence of fishing trawl marks in the seafloor sediments are prevalent throughout Block 1, which indicate that there is ongoing fishing activity in the area.

The FV *Emmy Rose* wreck was located sitting upright on the seafloor with the outriggers fully deployed. There was no apparent debris field on the seafloor close to the wreck. Additionally, there was no visible damage to FV *Emmy Rose* evident as the mast, wire rigging and superstructure features all appear intact. The ladders on both port and starboard outriggers were clearly visible in the sonar imagery together with the "birds" extending from the outriggers onto the seafloor (birds are stabilizers deployed from the outriggers of fishing vessels to reduce the amount of roll a vessel experiences when underway).



(Left) Prototype Klein 4K-SVY 600-kHz (75-m scan range) imagery of the FV *Emmy Rose* lying upright on the seafloor with the port and starboard outriggers deployed. No vessel damage is visible. (Top right) Prototype Klein 4K-SVY 600-kHz (75-m scan range) imagery of the FV *Emmy Rose* with the towfish flown almost directly over the wreck, showing the intact rigging and superstructure features.

Stern w



From the authors' personal perspective, the vessel seemed like it is resting peacefully on the seafloor.

Tribute to the FV *Emmy Rose* Crew

After the successful location of the FV *Emmy Rose* using side scan sonar, the NOAA and MIND Technology team aboard the survey vessel performed a memorial tribute at sea for the four souls who lost their lives in this tragedy. The crew consisted of Captain Robert Blethen Jr., Jeffrey Matthews, Ethan Ward and Michael Porper.

We hope that the finding of the wreck brings some closure to the families of the crewmen who lost their lives when the vessel sank.

WHOI ROV Dives on the FV *Emmy Rose*

In September 2021, NTSB and USCG investigators partnered with the National Science Foundation and Woods Hole Oceanographic Institution (WHOI) to survey the FV *Emmy Rose* using an ROV. The ROV was deployed from the Coast Guard Cutter Sycamore (WLB-209) and provided videos and high-resolution photos to assist investigators in attempting to determine the cause of the sinking. MIND Technology undertook a detailed analysis of the Klein sonar data and produced a report for the investigation. As of the writing of this article, the USCG and NTSB continue to investigate the sinking of the FV *Emmy Rose*.

Acknowledgments

The authors would like to express their sincere appreciation to the NOAA Stellwagen Marine Sanctuary team of Captain Pete DeCola, Ben Haskell, Dave Slocum, Amy Meloski, Doug Costa, Eric Morgan and Dr. Tammy Silva for providing the NOAA vessel RV *Auk* and their maritime expertise during the FV *Emmy Rose* search. **ST**

Dr. Pete Ramsay is the director of Strategic Hydrographic Systems at MIND Technology, focusing on the conceptualization, development, testing and qualification of new sonar and multichannel UHR seismic instrumentation for the marine survey industry. He is a specialist in hydrographic surveying, marine geophysics and advanced seafloor data post-processing methods.



Michiel van de Visser is a product application engineer at MIND Technology focusing on the end-user of side scan sonar systems to understand their specific technical requirements and delivering a fully engineered and integrated solution. He is a specialist in side scan sonar surveying, customer training and on-site support.



Cable in Search of *Endurance*

Fiber-Optic Design for Expedition of Shackleton's Legendary Wreck

By Stephen O'Riorden

Whether to use an AUV or ROV, that was the question. Each has its distinct advantages, but this was a rather unique shipwreck. This was the famous Sir Ernest Shackleton's *Endurance*.

On the Imperial Trans-Antarctic expedition of 1914 to 1917, the *Endurance* became stuck in pack ice, and after nearly a year at its mercy, *Endurance* slipped below the surface. This story captured the fascination of the world due to its tales of extreme survivalism and miraculous rescue of all 22 men, who survived polar conditions for over 18 months. Flowing ice and unknown currents made the exact resting place a mystery for over 100 years.

AUV vs. ROV

In March 2022, the Falklands Maritime Heritage Trust announced that *Endurance* had been found 4 mi. south of its last recorded location.

Searching for a shipwreck in the vastness of an ocean is one thing, but searching for one 3 km beneath the thick Antarctic Ice Shelf is another thing altogether, presenting unique challenges and dangers.

In an open-sea situation, one may be able to employ an AUV, sending it on its mission and awaiting to retrieve valuable data upon return. In this case, however, the polar environment is too unpredictable to bank on the safe





return of an autonomous vehicle. Use of an AUV is an all-or-nothing proposition. Since underwater high-bandwidth wireless communication can only work up to 50 m, the vehicle must return to the ship to transmit data. This was a \$10 million mission, and the inability to retrieve any data should the AUV be lost under the ice was a risk the team was not willing to take.

Using an ROV in this situation would present its own difficulties, as the team would need to decide on the type of ROV, appropriate cable design and tether management. Ultimately, a battery-powered ROV (Saab Sabertooth) was chosen, which allowed for the use of a fiber-optic tether solely for communication.

that of seawater. The basic building block of the cable lies in the STFOC (Strong Tether Fiber Optic Cable) at its center. This patented technology relies on a jacket of extruded LCP (liquid crystal polymer) designed to provide strength and moisture protection to an otherwise delicate, bare fiber-optic element. Surrounding this center fiber-optic element are torque-balanced Vectran strength members. Vectran yarn is made from the same resins as Linden's LCP strength members and exhibits an ultimate tensile strength of approximately 450 kpsi when made into fibers about 23 μm in diameter, due to the high level of molecular alignment. The cable was finished with a ruggedized, low-density polymer outer jacket.



Cable Design

Linden Photonics was brought on to design the cable. Given that the exact location of the wreck was unknown and at 3-km depth, the communication link to the ship would need to be quite long. Practically, the extreme length of the tether would rule out an electro-optic cable. Transmitting power over long lengths would require conductors of such large size that this type of cable would be unmanageable.

The cable chosen for this expedition was the LINDEN-SPE-7098. Linden Photonics had already been outfitting Sabertooth ROVs with a fiber-optic tether of significant lengths (more than 3 km continuous). This cable is a high-strength, low-profile, neutrally buoyant design. At 3.5 mm in diameter, it has a tensile strength of more than 350 kg, and its density nearly matches

Manufacturing Challenges

As with any type of manufacturing, cable manufacturing presents unique challenges. Cable yield is an issue for every cable maker. A single glitch during manufacturing can often lead to irreparable defects in the cable. If such a defect occurs in the middle of a 1-km run, the result is two cables 500 m in length. Joining these two fiber-optic cables is really only possible through use of a fiber-optic connector—and the use of a fiber-optic connector will ultimately lead to an increase in diameter at that location, optical insertion loss at the connection point and usually a significant loss in tensile strength. Additionally, even the most low-profile connector will present issues with cable winding.

Because of all this, Linden Photonics was tasked with building a single continuous length of cable, something we are very acquainted with doing regularly. Particularly with our STFOC cables, we can routinely produce single continuous lengths close to 50 km. However, for the LINDEN-SPE-7098, the braided strength members and outer jacket present other yield issues.

Extruding the primary and secondary layers of STFOC onto bare fiber is done at a high rate of speed, such that each layer of a 50-km length can be manufactured in a



(Top) Extrusion of low-density outer jacket. (Bottom) LIN-DEN-SPE-7098 attached to Saab Sabertooth ROV. (Credit: Falklands Maritime Heritage Trust)

single work shift of less than 8 hr. While this can also present yield issues, we have developed a robust process and can routinely produce such lengths.

Applying strength members over the STFOC is a different story entirely. Braiding is a mature process that has existed for a long time. Ropes, for instance, are widely available in many shapes and sizes, but generally only offered in short lengths, with a maximum length generally a few hundred meters. Braiding 25,000 m of strength members over the STFOC is a long-term project that requires constant attention and management.

While the STFOC is a tough fiber-optic element, the 16 individual strands of Vectran designed to provide more than 350 kg break strength are stronger. A 16-carrier braider intertwines 16 individual bobbins of Vectran around the substrate, and proper tension must be kept on the fiber-optic element as it is braided to avoid kinking and sharp bending that could result in a discrete loss point or, at worst, an optical break rendering the cable useless.

30 to 45 cm/min., even running a two-shift operation, this part of the process will still take nearly 12 weeks for the full 25-km length.

Additionally, the bobbins can only contain several hundred meters of material and will need to be continually replaced during the process. This insertion of new material is called a tie-in. These tie-ins are staggered along the cable so that they don't all occur in a single location. At a single location, the resultant increase in overall diameter at that location would be problematic for smooth extrusion of the outer layer.

Tending to this process for 12 straight weeks; maintaining proper tension; replacing bobbins of Vectran and manually tying them into the braid; checking for material buildups at any of the guiding grommets; and various other necessary manufacturing controls make for a tedious process critical to the final outcome.

Extrusion of Outer Jacket

The principles of extrusion for the outer jacket are



Stern of the Endurance. The wreck was discovered in the Weddell Sea at a depth of 3,008 m. (Credit: Falklands Maritime Heritage Trust)

much the same as for that of the STFOC jacketing. First, the resin is fed into the hopper. This holds the resin and feeds into the barrel. The barrel and screw are heated to appropriate temperatures to soften and melt the resin in stages. As resin moves from the hopper into the barrel, it is pushed toward the cross head by a screw. The screw design is critical and must be matched to the resin one is extruding.

The screw moves the melt forward, which then goes into the crosshead and turns 90°. The substrate, in our case, a 25-km-long, braided fiber-optic element, to be coated is fed from the back through the center hole of the mandrel. The fiber and melt are now moving in the same direction within the crosshead. Finally, the fiber and melt exit from the front face of the die where the melt contacts the fiber. If all parameters are set correctly, the melt forms a jacket of a controlled thickness and uniformity around the fiber. The coated fiber is immediately immersed in a water trough with running water to cool and solidify the melt rapidly.

This process is not without risks. Even though this is run at a much higher speed than braiding (approximately 25 m/min.), it still takes 16 hr. to complete. And unlike braiding, the process cannot be stopped and restarted. If for some reason the process breaks down at any time during the 16 hr., the result will be a cable that is not 25 km in length. Because of this, one must continually monitor the process, looking for any issues.

A decrease in material output, changes in tension in the payoff or take-up spools, die drool, etc. all have to be attended to by a competent and knowledgeable operator for the full 16 hr. For such a long run, even situations that are beyond our control must be considered, such as power outages. Because of this, the possibility of storms

in the area must be taken into account, and the timing of such a long run needs to be scheduled on a day with no weather events forecast.

The Final Result

Assuming each and every step in this process goes without incident, the result is a continuous 25-km-long, fiber-optic cable. Nevertheless, there is one final check of the optics that must be performed in hopes that nowhere along the line is the delicate underlying fiber-optic glass adversely impacted. This is performed with an optical time domain reflectometer, which transmits light pulses along the entire length of fiber and allows an operator to look at the full cable from an optical perspective.

For the *Endurance* mission, Linden Photonics performed this process not once but three times—successfully.

On March 5, 2022 with the 25-km cable attached to a Saab Sabertooth ROV, after days of running patterns on the seafloor beneath the Antarctic ice, the *Endurance* was located. This was the first time anyone had laid eyes on it since it sank beneath the sea over a century ago.

Sir Shackleton himself surely couldn't have imagined that the next time anyone took a look at his fateful ship it would be via an underwater robot with digital images transmitted by light pulses along a 9- μ m-wide, 25-km-long glass conduit. Perhaps even the great polar explorer would be impressed. **ST**

Stephen O'Riorden is the president of Linden Photonics Inc.

USV Crosses Atlantic on Solar Power

Mahi Two Makes Journey Powered Solely by the Sun

By Pieter-Jan Note • Quinten Lauwers • Tess Smallridge

USVs have been making world news over the last few years. In 2018, Offshore Sensing's Sailbuoy achieved what is supposedly the first transatlantic crossing by a USV. In 2019, a Saildrone USV completed transatlantic crossings in both directions via wind and solar power. In 2022, Mahi Two became the first USV to successfully cross the Atlantic Ocean purely on solar power.

Mahi Two left the coast of Spain in September 2021 and reached Martinique, in the French Lesser Antilles, six months later after more than 8,000 km at sea without maintenance. It's a success story—and so much more. What happened between the coasts of Europe and America tells a lot about the potential of new technology, human creativity and the importance of never giving up.

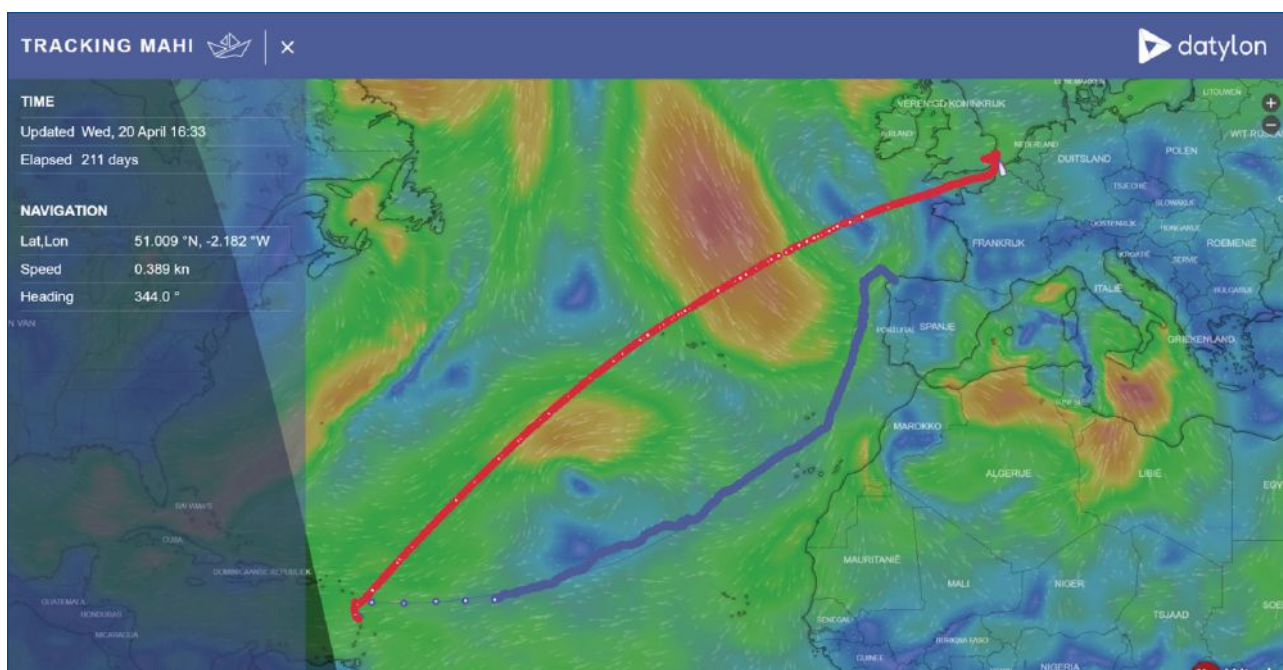
Project Mahi

Project Mahi started as an idea in 2015 by a small

group of engineering graduates from Belgium. Eager to apply their technical knowledge and curiosity for sustainability and entrepreneurship, they decided to take on a challenge that had never been done before: sending a solely solar-powered autonomous surface vessel (ASV) across the Atlantic Ocean. It was not just the ocean crossing they were after. More importantly, they hoped to demonstrate that ocean data can be collected in a sustainable manner through small, unmanned, solar-powered vessels. What started as a wild idea for a two-year project turned into a six-year adventure and a world record: the first solar-powered autonomous surface vessel to cross the Atlantic Ocean.

Powered by a Torqeedo electric motor and Solbian solar panels, Project Mahi's Mahi Two 4-m USV traveled 4,300 nautical mi. (nm) across the Atlantic, from Spain to Martinique over six months. Battling severe storms and





The inventors and fans of Mahi Two followed the vessel in real time during its journey across the Atlantic (blue line). (Credit: Project Mahi)

high waves, it proved the potential of the technology and spun a real-life tale of robot adventure and human ingenuity.

The Team

Like many great tech success stories, Project Mahi started in a garage. A group of friends, all engineering graduates from the University of Leuven, were spending their free time developing a robust autonomous vessel.

In order to tackle such a complex project, a multi-disciplinary team was required. The team divided the activities according to each person's skills and interest. Pieter-Jan Note focused on the design of the vessel and project management; Bertold Van den Bergh focused on embedded systems and wireless communications; Andreas Belderbos focused on electrical and energy management; Quinten Lauwers focused on situational awareness and collision avoidance; Julien Meert focused on vessel construction and CAD design of components; and Koen Geurts focused on navigation.

Vessel Development

The team's initial expectations were to complete a vehicle in two years. The team ended up developing three different vessel models over six years. The first vessel, Mahi Zero, was 2 m long, and the following two models, Mahi One and Mahi Two, were both 4 m long.

The first prototype, Mahi Zero, was developed to quickly and cheaply build up expertise, validate production techniques, test electronics and attract interest from potential sponsors. The team experimented with novel bio-composites, composite manufacturing techniques and coatings. From these experiments, and through

the advice of project sponsor Vosschemie-Benelux, the team selected composite materials comprising basalt fiber, bio-epoxy and recycled PET core sandwich for all three vessels' hulls. Bernico, a powerboat manufacturer in Belgium, helped the team construct the USVs. The structural calculations were performed according to the ISO-12215-5 standard to ensure the vessels' structural integrity and capabilities on the open ocean.

Learning from the capsizing of Mahi One in a heavy storm in the Bay of Biscay during the first attempt, computer simulations and experimental tests were performed for the design of Mahi Two to ensure that the watercraft could right itself in heavy seas ($H_s > 6$ m).

Project sponsor Solbian's flexible solar panels were installed in two separate circuits, each having its own maximum power point tracker, to create redundancy. Mahi Two had 470-Wp solar panels that needed to generate sufficient electricity to propel the vessel, plus power the electronics and sensors. Two Torqeedo Power 24-3500 batteries stored energy to get through cloudy days and nights.

Torqeedo, another Project Mahi sponsor, supported the project from the beginning with a Cruise 2.0 pod drive and related equipment and know-how. Project Mahi developed a steering system to rotate the electric drive, which reduced the complexity of the system by eliminating the rudder. With the powerful Torqeedo pod drive, Mahi Two's top speed is about 8 to 9 kt. To prepare the pod drive for its longest continuous run ever, local Torqeedo partner Eric Wouters from Variodrive provided the team with some new parts and maintenance the night before the departure of Mahi Two.

Autonomous Technology

At several stages during the project, the team scoured the internet to find off-the-shelf components, only to be disappointed by the unavailability of low-cost, low-power, marine-grade equipment. This posed an additional



Mission accomplished: The Mahi Two on a beach in the Lesser Antilles. (Credit: Project Mahi)

challenge, forcing the team to develop several components themselves: affordable, saltwater-proof encoders to determine the position of the azimuthing pod drive; integrated satellite and GPS modules to determine position of the vessel and transfer data from the vessel to shore; and ultralow-cost, submersion-proof cameras. Three cameras were present on Mahi Two: two on-deck cameras (forward and rearward looking) and one underwater camera.

Most importantly, the autonomous computers and software to control the vessel were also developed in house. Several AI algorithms were developed, powering the autonomous vessel and data collection. During the journey of Mahi Two, multiple collision avoidance actions were undertaken and vessels were detected using AIS data. To ensure safety of all maritime space users, Project Mahi guided the autonomous vessel in the coastal zones. During the transatlantic crossing, Project Mahi was in close contact with the navigation area coordinators to issue navigational bulletins to inform seafarers of Mahi Two's position.

Battery and energy management algorithms were also developed and implemented on board the solar-powered vessel. Over the course of Project Mahi, the electronics and their protective casings were optimized to lower power consumption and improve robustness. By the time Mahi Two launched, the continuous power consumption of the electronics was down to 2 W, 0.4 percent of the installed solar power.

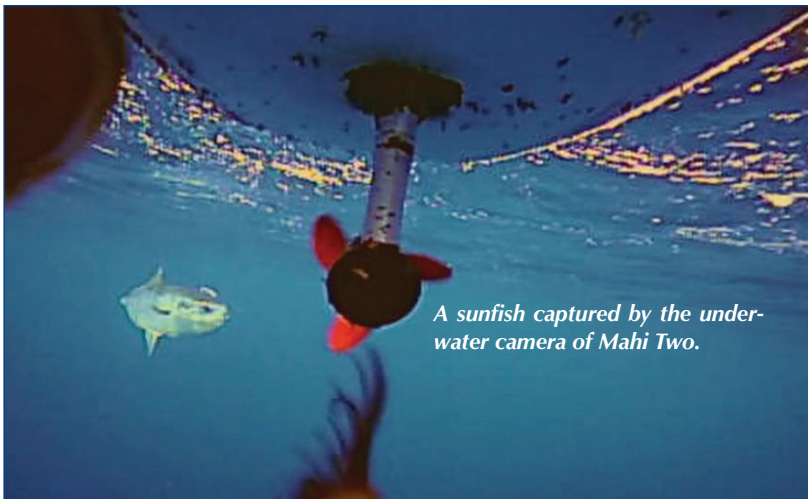
Transatlantic Crossing

By the end of September 2021, Mahi Two was ready for its transatlantic crossing. The team chose to launch 70 nm offshore of A Coruña, Spain, in order to avoid most of the dense shipping lanes between Northern and Southern Europe. After launch, Mahi Two navigated about 500 nm along the Portuguese coast before passing the southernmost tip of Europe. The ASV passed east of Madeira and turned southwest between Madeira and the Canary Islands. In about 35 days, Mahi Two traveled 2,500 km, leaving the Canary Islands behind. Then, the open Atlantic Ocean lay ahead, and the vessel turned slowly to a more westerly course to reach the Caribbean. The length of the journey totaled a whopping 8,000 km (4,300 nm).

In the fall of 2021, everything went according to plan. While navigating down the coast of Portugal, Mahi Two made excellent progress and avoided several large ocean vessels. Fair winds and weather followed the vessel to the Canary Islands and further west. Mahi Two traveled more than 60 km per day, with the day record standing at 85 km.

The boat communicated via an onboard satellite modem. The Project Mahi crew received data updates every 15 min. regarding location, speed and sensors. Fans of the project could follow the vessel in real time on the website: projectmahi.com.

In the Mid-Atlantic, the Mahi Two encountered bad weather and thunderstorms. For long stretches, the USV slowed down to a speed of 1 or 2 kt., and during



A sunfish captured by the underwater camera of Mahi Two.

Meanwhile, the Mahi team analyzed the data Mahi Two had sent home, looking for answers. No obvious failures could explain the loss. Then, two months later, the team received a call from the Maritime Rescue Coordination Centre Fort-de-France: Mahi had been located.

The Mahi team was thrilled to hear that Mahi Two had completed its mission, navigating across the Atlantic Ocean all by itself. The unmanned vessel made the transatlantic journey without assistance or maintenance during the six-month journey.

The USV captured 2.4 terabytes of data: camera feeds, hydrophone data and atmospheric data. The Project Mahi team was

delighted to see underwater video showing that the USV had encountered the large and odd sunfish and the sleek and elegant mahi-mahi, its namesake, as it made its way across the Atlantic. In the end, Project Mahi was able to ship the Mahi Two back to its home in Belgium through the support of several sponsors, including but not limited to: CMA CGM, DEME, Port of Antwerp-Bruges and Royal Belgian Shipowners' Association.

the night, when the engine was shut off to preserve energy, it was often pushed back. Nevertheless, the team was delighted with the overall progress.

In January, however, disaster struck. Mahi Two suddenly started using more power. But the vessel was thousands of miles away from the nearest land. Then, the team lost communication with Mahi Two altogether, just 700 nm from completing its mission. The Maritime Rescue Coordination Centre in Fort-de-France, Martinique, was contacted, and it requested that nearby vessels keep a sharp lookout for the small ASV.

delighted to see underwater video showing that the USV had encountered the large and odd sunfish and the sleek and elegant mahi-mahi, its namesake, as it made its way across the Atlantic. In the end, Project Mahi was able to ship the Mahi Two back to its home in Belgium through the support of several sponsors, including but not limited to: CMA CGM, DEME, Port of Antwerp-Bruges and Royal Belgian Shipowners' Association.

MAHI

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ing by a fully solar-powered USV, some members of the Project Mahi team started the company MAHI (www.mahi.be) to bring maritime autonomy solutions to the market. MAHI is developing software and hardware products that enable vessels to detect obstacles and other vessels accurately and avoid collisions according to the International Regulations for Preventing Collisions at Sea (COLREGs). Projects like Project Mahi will build the confidence in the technology.

MAHI's first product, MAHI Sense, launched in March 2022. It is an embedded autonomous computer, providing an additional layer of safety and operational efficiency. MAHI Sense brings valuable support to remote operators of unmanned vessels or captains on watch on manned vessels.

Conclusion

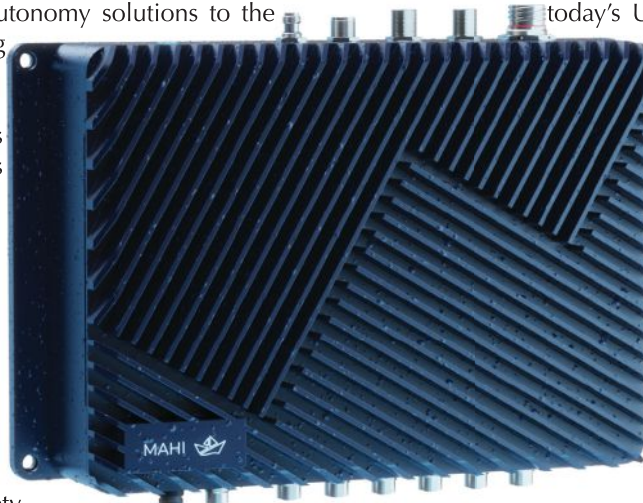
Electric propulsion systems in USVs and ASVs are already transforming the way we collect data at sea. These emission-free robot boats are often used in environmental and ocean research and monitoring, seafloor map-

ping, infrastructure inspection, wind farm support and oil and gas exploration. For most of these applications, today's USVs are under the remote command of qualified pilots located onshore or on board nearby crewed vessels.

Today's USVs improve safety and operational efficiency and deliver lower CO₂ emissions, but there are also secondary benefits to electrifying small ocean vessels. Station-keeping during data collection often requires rapid cycling between forward and reverse thrust, especially in challenging offshore conditions. Electric drives can do this indefinitely without

damage and deliver considerable savings in maintenance costs and reduced downtime compared to fossil-fuel-powered vessels. Renewable onboard charging from solar, wind and wave generators extend time on station. The quality of the data collected is also improved because the electric drives are silent and vibration free.

As autonomous technology like that developed for Project Mahi progresses, range and capabilities increase and the benefits of electrification will be further leveraged within ocean industries. **ST**



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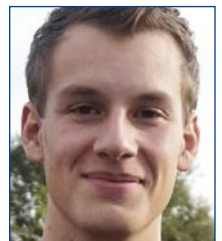
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Pieter-Jan Note is the co-founder and CEO of MAHI and team lead of Project Mahi. He specializes in marine engineering and autonomous systems. Note has a master's in mechanical engineering from the University of Leuven and a master's in naval architecture and marine engineering from the University of Southampton.



Quinten Lauwers is the co-founder and COO of MAHI and a team member of Project Mahi. He developed the autonomous technology behind the transatlantic ocean crossing. Lauwers is a software engineer who works on agricultural and industrial autonomous vehicles. He has a master's in computer science and artificial intelligence.



Tess Smallridge is the communications manager for Torqeedo, the supplier of Project Mahi's electric drive system.



Q&A: Vickie Jensen

Vickie Jensen's new book, "Deep, Dark and Dangerous" (Harbour Publishing, <https://deepdarkanddangerous.ca>), uncovers the little known history of the subsea technology industry in British Columbia (BC). It shines a spotlight on the underwater trailblazers of this Canadian province who built, operated, equipped and sold the inventions that have contributed heavily to the development of the global ocean technology industry. Jensen, a former editor of *Westcoast Mariner*, shared her thoughts with *Sea Technology* on BC's contributions to ocean tech, innovation and exploration, along with career advice for young professionals.

What made you want to write this book?

I emigrated to Canada in 1972, trading the cornfields of the U.S. Midwest for British Columbia's coast. I landed the dream job of editing *Westcoast Mariner* magazine. Every month for four years, I went out on different types of coastal workboats and wrote about those jobs.

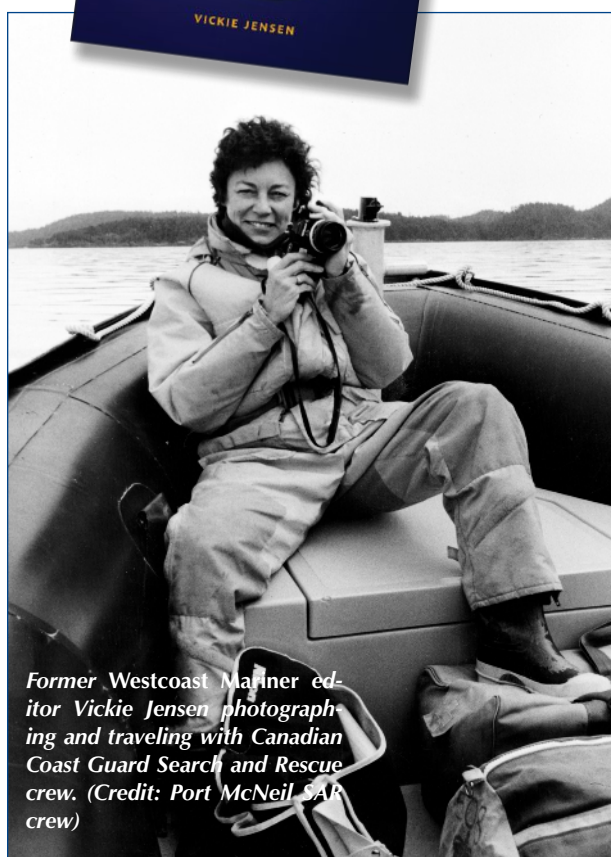
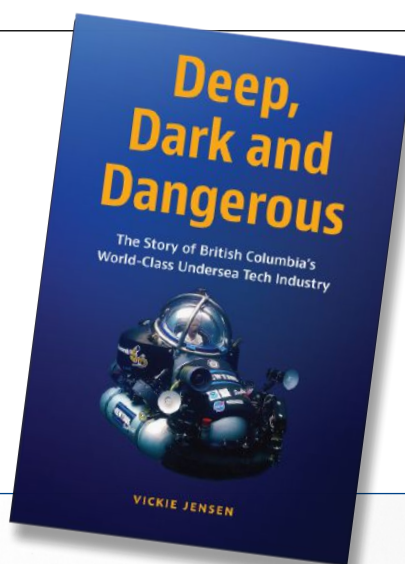
One day, a reader named Harry Bohm asked: "You write about everything happening *on* the water. What about what's happening *underwater*?"

Harry introduced me to the world of submersibles, ROVs and AUVs. I also began meeting remarkable folks working, inventing and researching underwater. He was right—there was an entire subsea world to learn and write about!

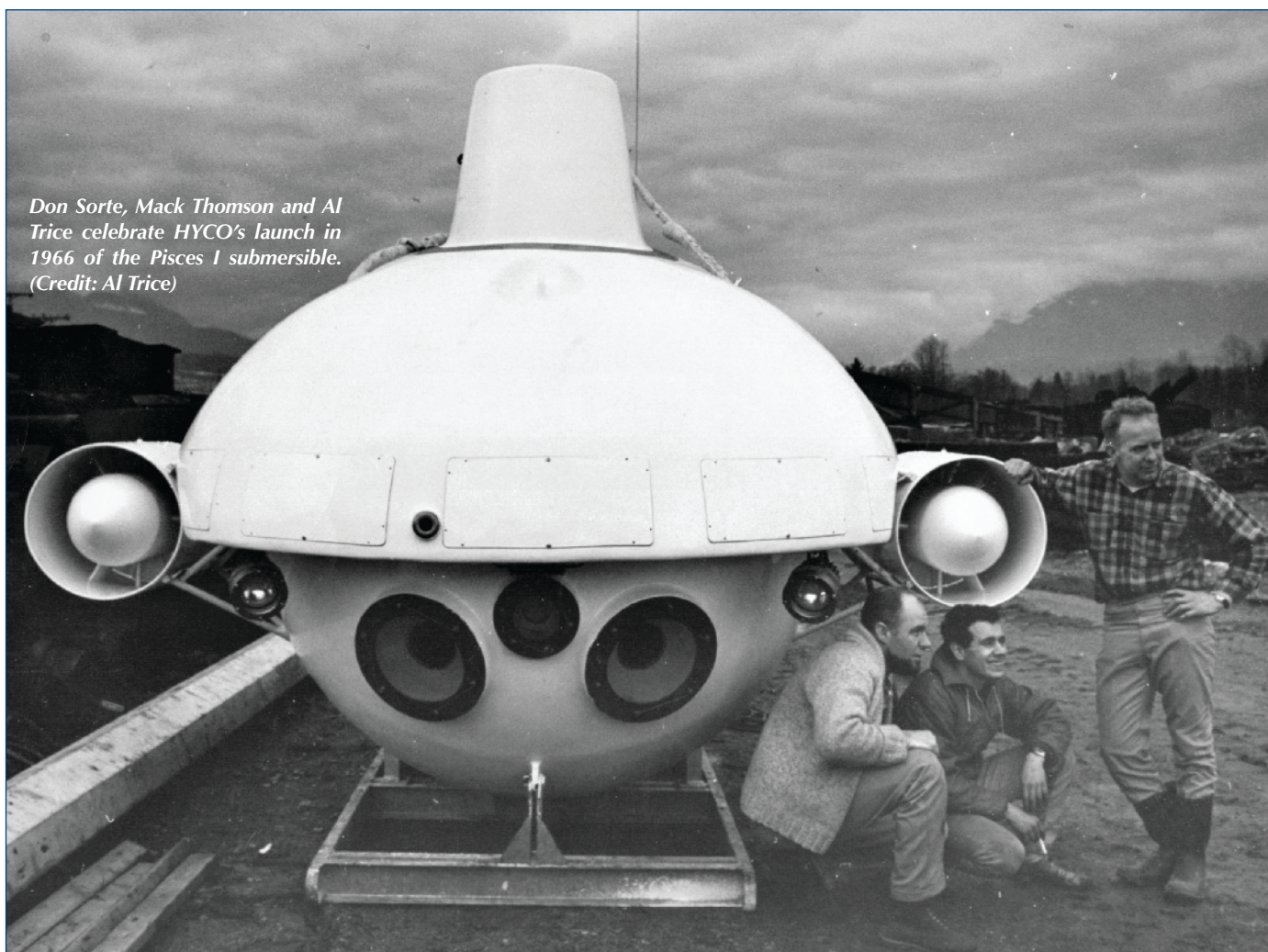
What elements did BC have that led to it becoming the "subsea NASA of the North" in the 1960s?

Phil Nuytten, along with Dr. Joe MacInnis, pioneered diving and equipment for Arctic waters. He notes: "It's a little-known fact that much of what is now routine deep-sea diving stuff worldwide was actually developed right here in BC."

Les Ashdown [of Atlantis Submarines] states: "Because Don Sorte, Mack Thomson and Al Trice formed HYCO here in BC, the expertise came here. Later, other compa-



Former *Westcoast Mariner* editor Vickie Jensen photographing and traveling with Canadian Coast Guard Search and Rescue crew. (Credit: Port McNeil SAR crew)



Don Sorte, Mack Thomson and Al Trice celebrate HYCO's launch in 1966 of the Pisces I submersible. (Credit: Al Trice)

nies spun off. But that was because all the expertise were here at the time. So, if you wanted to work in the subsea industry, this is where you showed up."

Author Tom Henry [who wrote the book "Westcoasters: Boats That Built BC"] adds: "Although HYCO folded as a business in 1989, its subs, in the hands of other firms, continue to work to this day, as do its former employees, many of whom now manage Vancouver's elite underwater research firms. Among this crowd, HYCO is referred to as the 'kindergarten'—the place where it all began."

Which technology stories in the book do you think will surprise readers the most, and why?

Every story, every interview widened my admiration for the determination and accomplishments of these subsea innovators. I was continually impressed by how they used their diving smarts, often coming up with different ways of solving the problems they encountered. They operated under huge pressure and time constraints, which is always the case when big money is on the line.

I was surprised at the number of innovators and companies largely unknown in Canada but who have successfully operated and sold equipment globally. It's a story I heard over and over and wondered why.

People think space is the big challenge, but subsea work is literally deep, dark and dangerous.

Your book is one of discovery and exploration. What are the common traits you see in the pioneers you highlight that made them successful in their careers?

Al Robinson joined HYCO, becoming chief hydraulics technician. Once, when he and Mack Thomson were discussing a project, Al commented: "'Jesus, Mack, isn't that impossible?' He gave me the nastiest look and stated, 'That's not a word we use around here.'"

Whether inventing or working a piece of equipment, these guys made do, innovated on the fly, and thought of alternative ways to operate or solve a problem. They just kept at it, learning more from failures than from successes.

Recently Phil Nuytten and I did a presentation together where he talked about the difficulties of underwater work, but at the end mentioned the pure joy of inventing, of challenging yourself to solve a problem ... and doing it!

The ocean continues to be a frontier for exploration and research for various purposes. What do you see as the focus of the future when it comes to technologies meet-



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Diver/inventor Phil Nuytten is known for his creative design, whether it's fabricating a prototype dive mask for the "Abyss" film or making adaptations for his next atmospheric-diver suit upgrade, the Exosuit. (Credit: Vickie Jensen) (Below) Phil Nuytten with author Vickie Jensen in his DeepWorker submersible. (Credit: Harry Bohm)

ing new and evolving goals in deeper waters?

Today's ocean frontier is not unlike the revolution that took place in the '50s and '60s for commercial diving, where working depths went from less than 100 ft. to 1,000 ft. in a decade. That same push to go deeper and do more was also true for subsea craft—submersibles were followed by ROVs, then AUVs and cabled seafloor observatories. Now, fleets of tiny Argo floats, solar-powered gliders and other craft operate independently and for long periods of time.

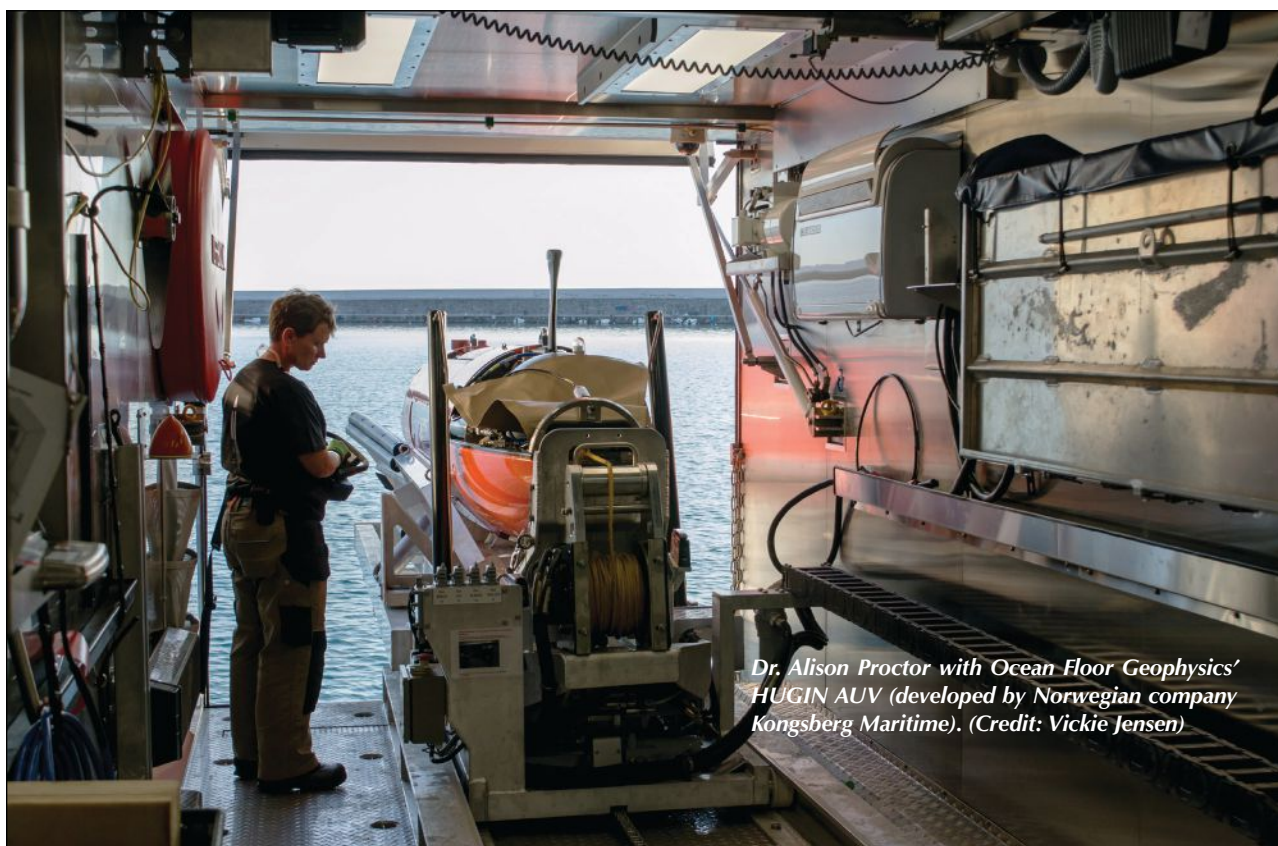
So, look for: increasingly more data transfer and interface with pilots, other craft or space; lighter-weight materials; new types of materials and technologies; alternative power sources and better (battery) storage capacity; modular construction for easy transportation, flexibility and adaptability; increasing miniaturization and equipment that can transform to fit extreme space limitations and job requirements; and more data and global awareness of the role oceans play in our planet's balance, with



modification/prohibition of detrimental fishing, harvest and mining practices.

The book includes a section with advice for young people who want a career in deep-sea engineering. What are the key takeaways for these young folks?

As an educator, parent and organizer of maritime job fairs, I especially enjoyed researching this chapter. Almost everyone agreed that today's young people pretty



Dr. Alison Proctor with Ocean-Floor Geophysics' HUGIN AUV (developed by Norwegian company Kongsberg Maritime). (Credit: Vickie Jensen)

much need a degree or two, but the “real” learning still happens on the job. I’m curious what *Sea Technology* readers would add from their experience.

Early on, John Whitney [an engineer at HYCO and Atlantis Submarines] got an engineering degree, but quickly learned that while that paper opened some doors, it didn’t make him anything special. When comparing his seven years of education to guys with seven years of practical subsea experience, he often wondered, “Who’s smarter?”

Eric Jackson [president of Cellula Robotics] also took an engineering degree. He recommends finding a school with a co-op program and adds that, when recruiting, Cellula Robotics also looks for some kind of keenness or passion about robotics and/or the ocean.

James A.R. McFarlane, former ROV pilot, notes that artificial intelligence and data management is the way of the future. He encourages young people to learn how to write code, because data collection/compilation is growing massively.

Mavis Mitchell teaches mechanical engineering students. She notes that half of Scandinavia’s engineering graduates are women, but despairs at the lack of women in North America entering the field: “If you like hands-on work, it’s a great career!”

Both Mark Atherton [who worked with Phil Nuytten’s Can-Dive] and Jean-Marc Laframboise [senior technical adviser for International Submarine Engineering] stress pragmatic skills in addition to a degree: “Learn how to tie a knot correctly and get your Power Squadron ticket or your sport-diving ticket.”

Jean-Marc adds: “Today, most people grow up with video games and no sense of how to use tools. Hardly anybody has ever changed a tire by themselves. That means we get engineers who can design an ROV, but don’t know the importance of making it easy to be repaired in the field or underwater.”

Phil Nuytten has the last word, recalling that the old hard-hat divers had a terse way of summing up their trade to aspiring young deep-sea divers. Referring to a diver’s first descent into the depths, they would say: “The bull-shit ends on the ladder.”

And they were absolutely right, he tells young people: “You are now on that ladder. And the most important thing is to figure out what you want to accomplish. That’s not easy, but be decisive and do it. Remember that the road of life is paved with flat, dead squirrels who couldn’t decide.”

Anything you’d like to add or emphasize?

No matter where a subsea company is located, there’s innovative work going on. But most of it is unknown, and the innovators involved are largely unsung heroes. So, I encourage companies to document their history and their industry. These stories are fascinating and sharing them with the wider world is well worth the effort.

When I finished up at *Westcoast Mariner* magazine, I wrote a final editorial to readers saying: “Your stories have become my stories. Your lives have enriched my life. And I will never be the same again.”

That realization is also true of the four years I spent researching and writing “Deep, Dark and Dangerous.” **ST**

international

Shell Divests Russian Investments

Shell Overseas Investments B.V. and B.V. Dordtsche Petroleum Maatschappij, subsidiaries of Shell plc, have completed the sale of Shell Neft LLC, Shell's retail stations and lubricants business in Russia, to PJSC LUKOIL.

All people currently working for Shell Neft, more than 350 in total, will remain employed by Shell Neft, which is now owned by LUKOIL.

The transaction is part of Shell's wider withdrawal from all Russian hydrocarbons, which is being conducted in a phased manner, in line with its announcement in March. The sale has been carried out in full compliance with all applicable laws and regulations.

Columbia Finance Solutions Invests in Ahorn

Columbia Finance Solutions, the financing arm of the Columbia Group, has strengthened the range of financial services it is able to offer its clients and partners, by taking a stake in Ahorn Capital GmbH, a Hamburg-based platform for institutional and professional investors.

The partnership allows Columbia Finance Solutions to provide its clients with flexible financing options for their fleet expansions and individual projects. In turn, Ahorn will tap into Columbia's market access, internal asset expertise and extensive know-how.

Certification for METIS IoT Solution

Bureau Veritas (BV) has awarded type approval certification to an IoT solution offered by METIS Cyberspace Technology SA. The METIS IoT system combines the two services METIS Ship Connect and METIS Space. It offers data acquisition and analysis through a highly sophisticated AI-based system.

To obtain the type approval certification, METIS has demonstrated to BV cybersecurity experts that its system ensures the integrity, confidentiality and availability of data collected within a fully secure architecture.

USVs for South Devon Maritime Academy

South Devon College, celebrating its 90th birthday this year, has acquired two USVs that will give marine autonomy students at its new marine academy hands-on experience of remote vessel operation.

The REAV-16 and REAV-10 USVs, named USV Dart and USV Exe, were built by Exeter-based HydroSurv for research collaborations and demonstrations that catalyzed the company's international growth. HydroSurv has since refitted and upgraded the electric, zero-emission vessels for use by future students at the academy.

Familiarization with current and future unmanned vessel innovations will be a key element of the college's planned marine autonomy training, due to be rolled out across multiple learning levels from September 2022.

Svitzer's Decarbonization Plan

Svitzer, a global towage operator and part of A.P. Moller-Maersk, has unveiled its decarbonization strate-

gy that will see the company become fully carbon neutral by 2040. The strategy has two phases. First, Svitzer aims to reduce the CO₂ intensity of its entire fleet by 50 percent by 2030. This will pave the way for fully carbon-neutral operations just 10 years later in 2040, which is in line with A.P. Moller-Maersk's ambition. Svitzer will measure progress against a 2020 baseline.

Sustainability Technology Hub

Wärtsilä Corp. has opened the Sustainable Technology Hub in Vaasa, Finland, to advance the global decarbonization of marine and energy by fostering innovation, collaboration and the development of green technologies using sustainable fuels and digital technologies.

Wärtsilä already has engines operating on carbon-neutral fuels. The Wärtsilä 32 Methanol engine came to market this year, and an ammonia concept will be ready in 2023. A hydrogen concept is expected in 2025.

Teledyne Geospatial Office Move

The Teledyne CARIS and Optech sales and support office in the Netherlands has moved to the High Tech Campus in Eindhoven. The newly renovated facilities enable an increased capacity for hardware support.

CARIS and Optech join other Teledyne companies, plus 12,000 professionals from leading tech companies (established ones and startups) operating on the campus.

New Global Maritime Defense Company

Forcys brings to market solutions from technology partners Chelsea Technologies, EIVA, Sonardyne, Voyis and Wavefront. Backed by over 50 years of experience, Forcys offers the global maritime defense sector remote, autonomous and networked control capabilities that deliver integrated situational awareness to customers in the underwater domain. The company covers a range of maritime operations, including asset protection, littoral strike, mine warfare, submarine rescue, and submarine and anti-submarine warfare.

Ship Delivery for USCG

Bollinger Shipyards LLC has delivered the USCGC *Douglas Denman* to the U.S. Coast Guard (USCG) in Key West, Florida. This is the 175th vessel Bollinger has delivered to the U.S. Coast Guard over a 35-year period and the 49th fast response cutter (FRC) delivered under the current program.

Bayonet Ocean Vehicles Launch

Greensea Systems Inc. has launched Bayonet Ocean Vehicles, a new company to develop, manufacture and distribute a line of amphibious robots recently acquired from C-2 Innovations Inc. The deal includes the acquisition of the IP and inventory of C-2 Innovations' crawling robot product line. The robots have been rebranded as the Bayonet 150, Bayonet 250 and Bayonet 350 vehicles.

New US National Security Cutter

Hill has christened *Legend*-class national security cutter *Calhoun* (WMSL-759).

The ship is named in honor of Charles L. Calhoun, the first master chief petty officer of the U.S. Coast Guard. Calhoun served in the U.S. Navy for three years during World War II and was honorably discharged in 1946 as a torpedoman second class. He enlisted in the Coast Guard that same year and held varying positions of leadership over the course of his career.

TDI-Brooks Geotechnical Coring in GOM

TDI-Brooks has recently completed six geotechnical coring programs in the Gulf of Mexico (GOM) for numerous operators from its research vessel RV Gyre. All of the programs included deployment of TDI-Brooks' cone penetrating test, piston and jumbo piston corers and box corers. In some instances, the geotechnical coring supplemented AUV operations.

These programs covered a wide range of operations, including surveying in channels off the coast of Galveston, surveying LNG export loading facilities and surveying of oil export pipeline routes, to name a few.

Chevron's Latest Energy Transition Moves

Chevron Corp., through its subsidiary Chevron Mu-naigas Inc., and JSC NC "KazMunayGas" (KMG) have signed a memorandum of understanding to explore potential lower carbon business opportunities in Kazakhstan. Chevron and KMG plan to evaluate the potential for lower carbon projects in areas such as carbon capture,

utilization and storage; hydrogen; energy efficiency and methane management; and carbon financial disclosure methodology. The collaboration will support Kazakhstan's goal to achieve carbon neutrality by 2060.

In other Chevron news, the company has completed its acquisition of Renewable Energy Group Inc.

Trident Sells Cannon Mining Division

Trident Maritime Systems, a provider of maritime systems and solutions for government and commercial customers and a portfolio company of investment affiliates of J.F. Lehman & Company, has completed the sale of its Cannon Mining division to J.H. Fletcher & Co.

The acquisition enables Trident to focus on its core maritime and defense offerings and strengthens J.H. Fletcher's current mining equipment product lines and domestic and international aftermarket support.

Donation for Coast Guard Foundation

The Coast Guard Foundation, a nonprofit organization committed to strengthening the U.S. Coast Guard community and service, has received a charitable donation from the Coast Guard Marathon to support morale and wellness initiatives for Coast Guard members and their families.

The Coast Guard Marathon presented its inaugural in-person 5K road race in March 2022, along with a half and full marathon, including more than 1,400 runners. **ST**

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Acteon Restructures

Acteon has three new client-facing service divisions: Data and Robotics; Engineering and Moorings and Foundations; and Energy Services. They represent a further milestone in the implementation of the strategy Acteon unveiled in 2021 to deliver services with demonstrable commercial and environmental benefits that help to enable the energy transition. This new structure better aligns Acteon's service offering to closely match the needs of clients in offshore renewables.

France Offshore Wind Survey

iXblue has completed a bathymetric survey of the Saint Nazaire offshore wind farm using its DriX USV. Relying on 4G and satellite communication, the operation, located 20 km off the west coast of France, was conducted remotely by the iXblue team in LaCiotat.

The survey was undertaken to verify the seabed conditions before deployment of Jan de Nul Group's offshore jackup installation vessel.

The DriX was fitted with a Kongsberg EM 2040 multi-beam echosounder and successfully conducted the survey despite strong winds and currents and was able to work around the monopiles and vessels on site. The DriX

did not need a support vessel, relying on its situational awareness and obstacle avoidance system.

Tidal Power Testing at EMEC

California-based tidal energy developer Aquantis Inc. will test its Tidal Power Tug at the European Marine Energy Centre (EMEC) in Orkney, Scotland. Aquantis has signed a berth agreement for a six-month testing program in 2023 at EMEC's Shapinsay Sound scale test site.

The Tidal Power Tug is a second-generation floating tidal energy converter. The versatile spar-buoy platform supports a 10-m-diameter, two-bladed, variable-pitch rotor and 160-kW drivetrain. By testing at EMEC's scale test site, Aquantis will gain experience of marine operations, while generating performance data to validate its loading and dynamics model, controller functionality and load mitigation techniques.

EMEC will support Aquantis's testing with tidal resource monitoring and the provision of its Test Support Buoy, enabling remote communications with the device, data relay via EMEC's supervisory control and data acquisition (SCADA) system and safe dissipation of power generated on site. EMEC will also provide project management, operations, consenting, monitoring and performance testing support.

Wind-Powered Merchant Ship

NEOLINE is one step closer to launching its first Neo-



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liner, a 136-m wind-powered merchant ship. Construction is scheduled to begin this year, and the ship is to enter service in 2024/2025. It will save 80 to 90 percent of fuel compared to a conventional ship of the same size.

Following technical studies carried out by Chantiers de l'Atlantique, Neopolia, Mauric and D-Ice, the ship's rigging will consist of two Solid Sail folding rigging systems, including two masts of 76 m in height, each equipped with the Solid Sail sail technology of 1,100 m² and a flexible jib of 400 m², with a total sail area of 3,000 m². The expected lifetime of the sail is 25 years, which will reduce maintenance costs compared to soft sails.

More Site Characterization for Atlantic Shores

Fugro has performed a third year of integrated site characterization services for the New Jersey-based offshore wind farm developer Atlantic Shores Offshore Wind. Work included geophysical, metocean and environmental scopes. Geotechnical work was done using a newly commissioned Fugro C30 mobile rig.

As with the previous field season, all project geodata were delivered in near real time to Atlantic Shores via Fugro's Gaia.Hub web-based platform (*Sea Technology*, April 2022). Gaia.Hub provides a single source of information for the entire Atlantic Shores project team and stakeholders; users can access geodata any time, from any location, via a simple, intuitive website.

Partnership for France's Renewable Energy Market

BOURBON has entered into a strategic partnership with IWS Fleet AS, the vessel-owning company of Integrated Wind Solutions ASA (IWS), to address the French commissioning and maintenance market of offshore wind farms. This agreement will allow BOURBON to market and operate IWS's *Skywalker*-class walk-to-work vessels in France. The ship management will be performed by the French affiliate Bourbon Offshore Surf.

France aims to install more than 7 GW of offshore wind by 2030, according to Green Ducklings A/S.

Safety Hub for Offshore Wind

VIKING Life-Saving Equipment has selected Norfolk, Virginia, as the hub to support the safety needs of North America's fast-emerging offshore wind sector. VIKING will coordinate delivery, service and lease agreements for sector-specific personal protective equipment and other gear from offices in Norfolk.

This moves comes as offshore wind looks set to become a major component of U.S. energy.

Investment in UK Offshore Wind to Total £155 Billion

The Offshore Wind Industry Council's Offshore Wind Skills Intelligence Report shows huge potential growth for the industry's job market in the U.K. by 2030. The sector will employ 100,000 people during that period.

Between 2022 and 2030, the industry will see £155 billion of private investment in new offshore wind projects, according to the report. **ST**

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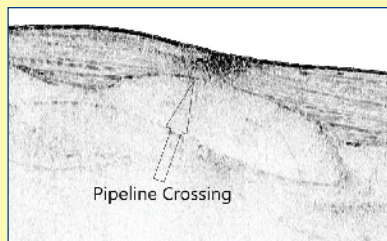
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Updated Sonar Combo



Pipeline survey mode has been added to the 2050-DSS combined sub-bottom profiling and side scan sonar system. This enables selection of a smaller hydrophone subarray for a larger fore-aft beam width and faster transmission rate to increase pipeline detection when running crosslines. The 2050-DSS generates high-resolution images of the sub-bottom stratigraphy in oceans, lakes and rivers with various bottom types. EdgeTech.

Cooling Fans

OD172SAP DC fans offer a 12- to 28-VDC voltage range, 2.1-A maximum current and 13.2- to 50.2-W input power range. DC fans come in frames with dimensions of 60 to 172 mm and have IP68 or IP69K rating. These fans feature a dual ball bearing system, PBT, UL94V-0 plastic or aluminum die-cast frames, and are designed for heavy wash-down applications. Orion Fans.

Modular Diving System

Divator Pro allows thousands of CE-approved variants. The system includes a completely new and groundbreaking harness and regulator, cylinder pack, full face mask and several accessories for more advanced dives. Since many of the parts are available in several designs, a diver can choose from thousands of possible configurations. Interspiro.

AI Vision Navigation Sensor

AI-ris (Artificial Intelligence Recognition and Identification System) uses digital cameras and AI

processing to detect, track, classify and geolocate objects, vessel traffic and other potential obstacles in the majority of operational conditions, day or night, to equip crew with best-in-class situational awareness. Computer vision helps improve safety for vessels and is also a critical technology for the advancement of autonomous command and control systems. Sea Machines Robotics Inc.

Subsea Compact Color Camera



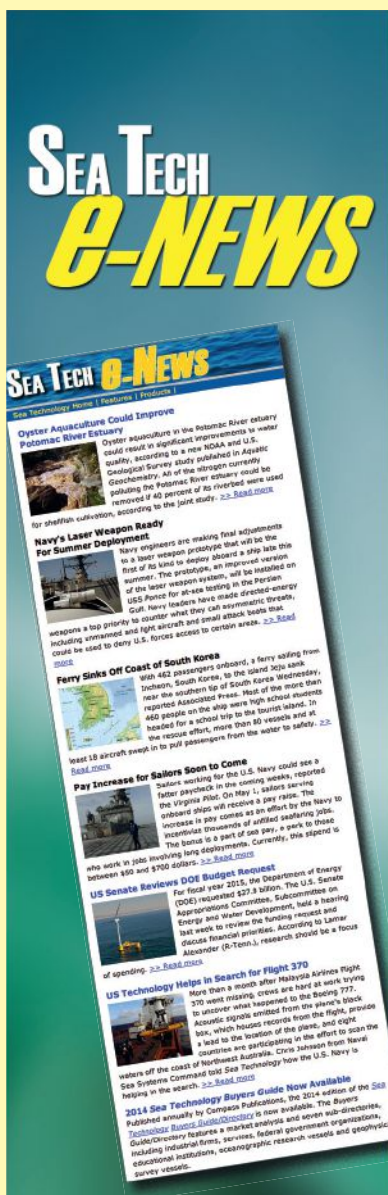
C7 has an integral high-intensity controllable light ring to illuminate the underwater environment, providing clear video footage at depths down to 6,000 m. It offers 800 TVL resolution composite video output with a wide dynamic range for superb video quality under all lighting conditions. The integral light ring has 12 LEDs that can provide light output of up to 2,250 lumens. OceanTools Ltd.

Multichannel LED Torch Light

WolfFish sets a new bar with configurable combinations of colors for specialized uses, as well as wide-flood and focused-beam light, all in a single 6,000-m-rated housing. Its ultrabright (30,000 lumens), high-quality, dimmable, true-color output suits blue-chip film making and heavy ROV work alike. Arctic Rays LLC.

Safety, Sustainability Assessment

MyISRS is a digital self-assessment tool based on ISRS (International Sustainability Rating System) that



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delivers an assessment of an organization's safety and sustainability performance, using a set of digital surveys that can be completed in a couple of hours to help quickly and effectively identify their practices' critical strengths and weaknesses. DNV Energy Systems.

Rugged Atomic Clock



mRO-50 Ruggedized provides a one-day holdover below 1 μ s and a retrace below 1E-10 in a form factor (50.8 x 50.8 x 20 mm) that takes up only 51 cc of volume (about one-third of the volume compared to standard rubidiums) and consumes only 0.36 W of power. Its wide-range operating temperature of -40° to 80° C is ideal for applications such as underwater, military communications, radars, low Earth orbit, electronic warfare and airborne and unmanned vehicles. Orolia.

Offshore Rescue Tech

Swift Rescue Conveyor was devel-

oped in collaboration with sustainable naval architect Chartwell Marine as an automatic water-to-deck rescue conveyor belt and is to be fitted on the *Guardian*-class, a new remotely operated rescue vessel designed by Chartwell. The conveyor system is for tackling man overboard (MOB) incidents offshore. Zelim and Chartwell Marine Ltd.

Submersible Data Relay

Nemo-V is a versatile data relay designed to send data and commands to a marine vehicle or platform. Submersible to 7,500 m, it has RS-232 communication built in to easily interact with any device connected. Commands are sent remotely via Iridium short-burst data (SBD) communication. Xeos Technologies Inc.

Crowdsourced Map App

Genesis crowdsourced mapping data are now available on the C-MAP navigation app, as well as across Lowrance, B&G and Simrad apps powered by C-MAP charts. The Genesis layer provides access to C-MAP's extensive crowdsourced database of marine mapping data that have been reviewed and quality controlled by C-MAP engineers. Genesis adds more than 30,000 submissions to C-MAP charts. C-MAP.

Coronavirus Protection

KN95 masks and a full range of

no-contact UV sanitation solutions can protect workers from the coronavirus, with an expected increase in cases during the summer. UV disinfection equipment uses UV 254- or 222-nm light to eliminate the coronavirus on surfaces and in the air. Handheld UV devices can clean surfaces and small tools. UV sanitation carts are designed for large-scale surface sanitation, and UV air sanitation products are also available. Larson Electronics LLC.

Waste Heat-Derived LNG Fuel

Hi-eGAS (Hyundai High Efficient Gas Supply System) has received DNV's approval in principle for 300K VLCC. The system enables the engine to continue running normally in the event of an incident to the LNG fuel system, such as forcing vaporizer leakage or failure of the JCW booster pump, temp and pressure control valves. The system utilizes a new heat exchanger with low freezing risk. Korea Shipbuilding & Offshore Engineering and Hyundai Heavy Industries.

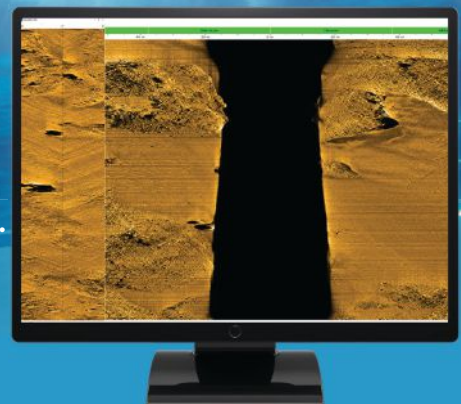
Large Navigation Buoys

These polyethylene buoys are well suited as maritime aids to navigation. They have two large lifting and mooring points and are interconnected by 316-grade stainless steel tie bars. The float section is standard with closed-cell polyurethane foam to increase wall strength in event of vessel impact. Sealite Pty Ltd. **ST**

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Red Sea Research Partnership

Ocean Aero has established a partnership with King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and Saudi Shelf Subsea, part of the Shelf Subsea Group of companies headquartered in Perth, Australia, with extensive operations in Southeast Asia and the Middle East.

Red Sea research will focus on: tailored payloads for Saudi-specific applications with local maritime organizations; exploration of advanced concept development utilizing existing and joint IP; and continued execution of scientific services with a fleet of Ocean Aero's TRITON autonomous underwater and surface vehicles (AUSVs).

ROV Piloting from Shore

Earlier this year, during NOAA Ocean Exploration's 2022 ROV and

Mapping Shakedown on NOAA Ship *Okeanos Explorer*, with all other objectives having been met, engineers from the Global Foundation for Ocean Engineering (GFOE) turned their attention to a new use of telepresence: piloting the ROV Deep Discoverer from shore in Rhode Island, approximately 2,575 km (1,600 mi.) away from the ROV in the depths of the Straits of Florida. During the test, a shoreside GFOE engineer piloted the ROV for more than an hour of typical exploration activity over a boulder field in an unexplored canyon on the West Florida Shelf.

The test required coordination between the shoreside pilot and the shipboard team of ROV engineers, officers, and scientists to determine and control ship moves and the camera and ROV manipulator arm functions required for the imaging

and geological sampling typically performed during a dive.

Earlier efforts to improve the telepresence capabilities aboard *Okeanos Explorer* have resulted in a significant reduction in the communication delay between ship and shore. During the recent test, the shoreside engineer was able to initiate ROV movements and actions (e.g., imaging and sampling) from shore and view the ROV's response in the livestreamed video, taken 1,800 m (5,906 ft.) underwater, in a mere 1.25 sec.

Cold Spells May Benefit Kelp

Giant kelp forests around the world have struggled to stay healthy in recent decades, with some vanishing altogether. But along Patagonia's rugged southwestern coast, giant kelp are thriving, showing remarkable stability for almost 200 years. New research suggests frequent marine cold spells could help keep kelp healthy.

The researchers found that the

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southwestern giant kelp forests haven't experienced an extreme marine heat wave since 1984 and, in fact, the area has had regular marine cold spells that are growing more intense. From 2014 to 2019, the region saw more severe and extreme cold spells than over the rest of the study period. Glacial melt and increased wind activity could explain these quick, localized cooling events: More cold water enters the ocean environment, which can create very short peaks in cool temperatures, from a few days to two to three weeks. Cool waters can act like air conditioning for the kelp, regulating their environment and keeping temperatures comfortable. Wind patterns that affect ocean surface circulation and heat fluxes, or cold water traveling around Antarctica, could also be factors.

In her previous work, marine geographer Alejandra Mora-Soto, lead author of the new study, which was published in AGU's *Journal of Geophysical Research-Oceans*, compared nautical charts as far back as Charles Darwin's *Beagle* expedition to modern satellite imagery of kelp and found little had changed, despite climate change and human influence. The outlook for these kelp forests may stay bright, at least for the immediate future. Current climate and ocean models predict the Southern Ocean, the waters in which these thriving kelp forests live, will avoid warming dramatically. But as glacial melt increases, that freshwater can bring with it sunlight-blocking sediment, different sets of nutrients and even too-cold temperatures.

New Insight on Wave Behavior

In a new study on ocean wave breaking, researchers have demonstrated that the breaking behavior of axisymmetric "spike waves" is quite different to the long-established theories on the breaking of traveling waves. Traveling waves break when waves become so steep that the crest is no longer stable. This leads to a breakdown of wave motion and energy loss. As a result, the height of the wave is limited by the breaking process.

Most understanding of wave breaking is routed in theories developed and experiments carried out in two dimensions, when waves are moving in one direction. However, wave breaking in the ocean is a three-dimensional process.

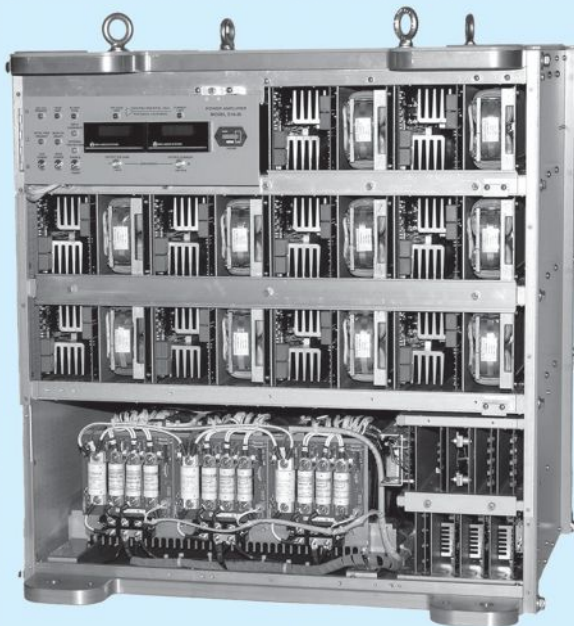
To establish the differences between wave breaking in two dimensions and three dimensions, researchers used the circular wave tank at FloWave Ocean Energy

Research at the University of Edinburgh to reproduce an extreme three-dimensional axisymmetric wave, the spike wave.

The experiments showed that, unlike traveling waves, the crest height of the spike wave was not restricted by the onset of breaking but by the stability of the jet. Understanding spike wave dynamics could lead to advances in maritime safety based on improved data. **ST**

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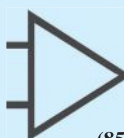
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Digital Twin Pilots

Aras, which provides a low-code platform with applications to design, build and operate complex products, and Bureau Veritas are deploying digital twin pilots across different markets to provide accurate and detailed information in real time and further advance classification processes.

Bureau Veritas has embarked on a major revamping of its digital tools supporting its Marine & Off-shore services. As part of this global program, the deployment of digital twin technology will enable Bureau Veritas to create a single source of truth for each ship and asset; ensure end-to-end traceability of ship data; anticipate the evolution of regulatory requirements; continuously update data from design to operations; and increase collaboration with real-time access to ship data. As a result, Bureau Veritas will enhance its customer experience through solid and reliable data collection and updating that will support classification services. This digital twin will also be a foundation to further develop data services to improve safety, operational and environmental performance for all types of assets.

DNV's New Notation for Digital Infrastructure

DNV's recently published D-INF (data collection infrastructure and vessel connectivity) class notation has been approved for digital infrastructure solutions developed by COSCO, Kongsberg Digital and Samsung Heavy Industries (SHI).

Digitalization of the maritime industry is set to radically enhance the operational efficiency, safety and environmental performance of ships, but it is currently taking place in a fragmented way, with no pan-industry alignment on data infrastructure reliability and data quality in compliance with global standards.

As ships get smarter and increasingly packed with sensors, the central onboard servers gather data from components and systems that

typically feature different types of data infrastructure. Lack of standardization means data cannot be combined in a uniform way, leading to a lack of trust in protocols for data transfer and security.

DNV's D-INF notation addresses this key challenge by setting out the requirements for the complete data collection infrastructure, including onboard data servers, data relay components and remote data servers, covering the full ship-to-shore communication framework.

DNV implemented the notation as part of approval-in-principle projects, the first stage of formal type approval, newly granted to Chinese shipping group COSCO SHIPPING, Korea shipbuilder SHI and technology vendor Kongsberg Digital for flagship digital solutions.

The COSCO SHIPPING pilot formed part of a wider project with DNV to develop an onshore smart ship data management center to aggregate data from a large range of vessels across its huge fleet. The project with SHI focused on the infrastructure and data stream of its SVESSEL BIG system, while the Kongsberg pilot confirmed its Vessel Insight solution, providing value-adding digital services for customers.

Historic Emission-Free Sail

Havila Kystruten's passenger ship *Havila Castor* proved it could sail in and out of the Geiranger Fjord, designated as UNESCO World Heritage, with zero emissions with help from the largest battery pack installed on board a commercial vessel. This marks the first time in history that a large passenger ship has sailed this route silent and emission free. This proves that technology is ready even for large ships to operate in zero-emission mode for longer periods of time.

Havila Castor is one out of four identical ships built for Havila Kystruten to operate on the coastal route between Bergen and Kirkenes in the north of Norway. The full roundtrip takes 11 days and is an

epic journey through some of the most scenic and unspoiled nature. Corvus has delivered a complete 6.1-MWh Orca battery system for each of the vessels.

The energy storage systems along with all other environmental technologies on the ship reduce CO₂ emissions by around 30 percent and NOx emissions by 90 percent. With the gradual blending of biogas, emissions of CO₂ will be reduced to 50 percent in 2023 and 80 percent in 2024.

Digital Delivery Framework

Ocean Technologies Group (OTG) has developed a new Digital Delivery framework to increase infrastructure security and reduce dependence on physical logistics for content and software application updates.

OTG offers learning brands, software as a service (SaaS) solutions for fleet management operations (TM Master) and maritime HR (COMPAS) that includes integrated onboard modules. The new hardware-agnostic technology infrastructure will facilitate over-the-air delivery of OTG's applications, providing its customers with faster, more secure updates while supporting constant synchronization between ship and shore.

Digital Delivery will be rolled out to expedite OTG's customers' transition to its Ocean Learning Platform, with support for the complete suite of OTG learning, fleet management and crew management solutions to follow.

Patrol Boat for Singapore

BMT's latest hybrid vessel for the Maritime and Port Authority of Singapore (MPA) has been successfully commissioned. Developed in collaboration with Penguin Shipyard International, the advanced hybrid-electric aluminum catamaran, christened "MPA Guardian," is a 35-m patrol boat designed to conduct patrolling activities, search and rescue, oil spill response, drone operations and salvage support. It will also be used as the government's testbed for new technologies and equipment. **ST**

Titan Joins LNG Coalition

Titan LNG, an alternative fuels supplier, has joined SEA-LNG, the multi-sector industry coalition established to demonstrate LNG's benefits as a viable marine fuel.

LNG offers a transition to net-zero greenhouse gas emissions based on incremental decarbonization of existing assets as fuel production, transportation, storage and bunkering infrastructure, and engine technologies develop.

These innovations will not come about automatically. Collaboration across the maritime value chain is essential to drive the required innovation and investment. SEA-LNG represents expertise spanning LNG production, bunkering, engine technology, ship owning, banking and port and ship operations from all around the world.

SEA-LNG's recent analysis of the effects of bioLNG on vessel compliance under the International Maritime Organization's Carbon Intensity Indicator (CII) system shows that LNG will allow vessels to meet their CII obligations until 2030, while thereafter, for every 10 percent increase in bioLNG or renewable synthetic LNG blended with traditional LNG, a vessel will gain two years of additional compliance.

Methanol Institute Gets New Member

Alfa Laval has become a member of the Methanol Institute. Founded in 1989, the Methanol Institute serves as the global trade association for the methanol industry, representing the world's leading methanol producers, distributors and technology companies.

The Methanol Institute works to protect existing markets for methanol while promoting the growth of emerging energy markets. One key area of growth is the marine industry, where the move to green methanol is a major advance toward decarbonization.

Alfa Laval offers marine methanol solutions such as the FCM Methanol low-flashpoint supply

system. The company has received the industry's first approval in principle for firing boilers with methanol. Because methanol changes the energy balance on board, Alfa Laval is also providing ways for vessels to become more energy efficient, such as the E-PowerPack, which converts waste heat into electricity by means of organic ranking cycle technology. Alfa Laval has an R&D facility with 2,800 m² of testing space, where Alfa Laval and partners are pushing deeper into methanol handling, methanol combustion and fuel cell technologies.

Provisional Acceptance of Southern Cross NEXT Cable

The Southern Cross NEXT submarine cable project has been granted provisional acceptance. The culmination of the submarine segments of the cable system marks the nearing completion of a project six years in the making that will be the largest and lowest-latency route connecting Australia, New Zealand and the United States.

Pioneer Consulting managed market and business case analysis, procurement and contracting, project implementation, quality assurance and shipboard representation for the project, ensuring the successful commissioning of the subsea system between each cable station.

Granting provisional acceptance for the subsea system, which includes the trunk cable between Sydney, Auckland and Los Angeles, along with branches to Fiji, Tokelau and Kiribati, represents the material completion of the Southern Cross NEXT system marine program.

US Needs MPA Protection Beyond Central Pacific

More than 98 percent of U.S. waters outside the central Pacific Ocean are not part of a marine protected area (MPA), and the ones that are tend toward "lightly" or "minimally" protected from damaging human activity, research led by Oregon State University shows. Published in *Frontiers in Marine*

Science, the study examined the 50 largest MPAs in the U.S. Those 50 account for 99.7 percent of U.S. MPA coverage. That means critical marine systems, such as those in the Atlantic, Arctic and northeast Pacific oceans and the Caribbean Sea, are vulnerable to "unprecedented pressures" and so are the coastal economies dependent on them.

USV for Research on Chinese White Dolphins

The Pearl River Delta is home to the world's largest population of Chinese white dolphins, classed as "vulnerable" on the IUCN Red List of Threatened Species. Earlier this year, a USV and passive acoustic monitoring technologies were used in China for the first time to monitor and investigate the population of Chinese white dolphins that inhabit the National Nature Reserve in the Pearl River Estuary of Guangdong.

An OceanAlpha M40P was equipped with sonar acoustic equipment towed at the stern to quietly record the sounds of the white dolphins for scientific research.

Seaforth Geosurveys Buys iXblue Gaps M5 USBL

Seaforth Geosurveys, a Canadian marine survey company, has acquired an iXblue new Gaps M5 USBL system to support data acquisition for marine geophysical survey projects, including one in the Canadian Arctic and a project to support side scan sonar operations during lost and abandoned fishing gear identification and retrieval efforts.

The Gaps M5 features simultaneous tracking capability to track and position multiple assets.

Pulse 8X Recovers Evidence

JW Fishers' Pulse 8X metal detector is an invaluable tool in the search for and recovery of missing, metallic evidence. It is used by Orange County, California's Sheriff's Department and Nassau County's Dive Team in New York, as just a few examples.

Depending on the size of an object, the metal detector can scan and detect deeply below the surface. **ST**

contracts

The Pacific Community (SPC), Nuku'alofa, Tonga, has contracted to acquire topographic and bathymetric LiDAR data and aerial imagery to develop digital elevation models for the Kingdom of Tonga. The information and derived products will support nautical charting for navigation safety, infrastructure planning and rehabilitation, and disaster resilience and recovery. Woolpert.

Soil Machine Dynamics (SMD), Wallsend, U.K., has entered into a parts and services framework agreement to share industry insight and knowledge to work together to radically change the way traditional customers, vendors and original equipment manufacturers (OEMs) work together. Van Oord.

OceanWise Ltd., Hampshire, U.K., has just been awarded a framework agreement for the provision of GIS marine data until 2026. Government of Scotland.

Scantrol AS, Bergen, Norway, has a new cooperation with a Texas-based manufacturing company for the supply of control systems, including active heave compensation (AHC). C-LARs LLC.

Vestdavit, Laksevåg, Norway, has secured a contract with a U.S. shipbuilder to supply one of its HN-5000 workboat davits for each of two vessels, named "Oceanographer" and "Discoverer," that are under construction for NOAA. ThomaSea Marine Constructors.

Nefco, Helsinki, Finland, has signed a loan agreement with a Finnish clean tech company to finance the expansion of production of Rotor Sail technology for auxiliary wind propulsion for the shipping industry. Rotor Sail has a proven average fuel savings record of 5 to 25 percent. Norsepower Oy Ltd.

Neptune Energy, London, U.K., has signed a cooperation agreement to progress the L10 large-scale off-

shore carbon capture and storage project in the Dutch North Sea. ExxonMobil subsidiary XTO Netherlands Ltd., Rosewood Exploration Ltd. and EBN Capital B.V. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

SEPTEMBER

September 1—The Nautical Institute Singapore Branch Conference, Singapore. Singapore.branch@nautinst.org or <https://reg.eventnook.com/event/nauticalinstitutesg2022/> Agenda.

September 6-9—SMM, Hamburg, Germany. www.smm-hamburg.com/en.

September 8—Energy ESG Conference, Houston, Texas. EnergyESGConference.com.

September 13-14—Antifouling Conference, Gothenburg, Sweden. <https://innovatum.confetti.events/antifouling-conference-2022>.

September 13-15—International Conference on Computer Applications in Shipbuilding, Yokohama, Japan. www.rina.org.uk/ICCAS_2022.

September 18-23—International Marine Debris Conference, Busan, South Korea. www.7imdc.org.

September 19-22—Moored Systems for the Future Buoy Workshop, Wilmington, North Carolina. <https://mtsociety.memberclicks.net/buoy-workshop>.

September 20-22—Fleet Maintenance & Modernization Symposium, Virginia Beach, Virginia. 703-836-6727 or www.navalengineers.org/Symposia/FMMS2022.

September 26-29—SNAME Maritime Convention, Houston, Texas.

www.sname.org/smc-2022-general-information.

September 27-28—Teledyne Marine Workshop – Tech on the Lakes, Traverse City, Michigan. www.teledynemarine.com/events/TeledyneMarineWorkshop-Tech-on-Lakes.

OCTOBER

October 3-7—National Marine Electronics Association (NMEA) Conference, Anaheim, California. 410-975-9425 or www.nmea.org.

October 5-7—NOIA Fall Meeting, Colorado Springs, Colorado. noia.org/noia-2022-fall-meeting.

October 9-12—Maritime Cyprus, Limassol, Cyprus. <https://maritimecyprus.dms.gov.cy>.

October 16-19—AAPA Annual Convention & Expo, Orlando, Florida. <https://my.aapa-ports.org/AC2022/Home/AC2022/Home.aspx>.

October 17-18—Sustainable Ocean Summit, Barcelona, Spain. www.sustainableoceansummit.org.

October 17-21—OCEANS 2022 Hampton Roads, Hampton Roads, Virginia. hamptonroads22.oceansconference.org.

October 18-20—International Ocean Conference on Ocean Energy and Ocean Energy Europe, Donostia/San Sebastián, Spain. <https://icoeoe2022donostia.org>.

October 18-21—EURONAVAL, Paris-Le Bourget, France. euronaval.fr.

NOVEMBER

November 2-4—MAST Med 2022, Athens, Greece. <https://mastconfex.com>.

November 8-10—CLEAN GULF, New Orleans, Louisiana. www.cleangulf.org.

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

people

Greensea has promoted **Chelsea Allen** to vice president of operations. She joined the company in 2018 as production manager. She provided program management to Ocean Infinity's Armada fleet and oversaw production of the RNAV2 diver navigation systems. Allen is now responsible for the software and hardware production teams, as well as the quality and documentation teams, which represent more than 50 percent of Greensea's workforce.



MacArtney Offshore Wind Solutions has recruited **Bjarne Siig** as general manager. With over 20 years of global experience at top management level in the wind energy sector, he will head MacArtney's wind division, supplying handling and installation equipment, including cable carousels, offshore power quadrants,

tensioners and service solutions.

MidAtlantic Engineering Partners has named **W. Stuart Lewis**, P.E., as a partner in the firm. Since joining MidAtlantic, he has led the company's Marine Services Division, growing it as a multidisciplinary infrastructure group providing in-water and waterfront engineering and consulting services, including diving, structural design, permitting oversight and inspections. MidAtlantic has also hired **Joseph Mele**, P.E., P.P., P.L.S., as part of a growth initiative for northern New Jersey and an expansion of services in New York. He will be opening and managing a new office location.

Ethan Butler has joined Ocean Power Technologies Inc. (OPT) as vice president of engineering and operations. He is an accomplished leader with more than 25 years of experience executing commercial and government development programs for products in and around the ocean. He was most recently director of program management with Insulet Corp.

MARINE CONSULTANTS (bMC) has boosted its naval architecture and marine engineering business with the hire of industry specialist **Jacek Jazdzewski**. He brings a wealth of up-to-date and relevant naval architecture skills, particularly on casualty cases requiring modeling or simulations, as well as longer term projects such as newbuild or refitting.

FarSounder has made big leadership changes: **Matthew Zimmerman** is taking the helm as CEO, and former CEO **Cheryl M. Zimmerman** is continuing her role as chairman of the board, as well as taking on the position of market development strategist.

International subsea equipment rental and solutions specialist Ashtead Technology has appointed **Phil Middleton** as survey and robotics director. He was most recently with MacArtney Group as U.K. managing director.

Dwight S. "Bo" Ramsay, a veteran of the oil and gas industry and founder of Aries Marine, has passed. He was a decorated veteran of two wars. He served in the Army's 11th Airborne Division, and he was a recipient of the Purple Heart. Ramsay served during the occupation of Japan at the end of World War II. He also saw combat action as a tank commander during the Korean War.

Brandi Smith has been named vice president of the Columbia-class program at Hill's Newport News Shipbuilding division. The U.S. Navy has identified the Columbia-class as its top acquisition priority. Twelve Columbia-class boats will replace the fleet of Ohio-class nuclear ballistic submarines.

North Star, a U.K. offshore infrastructure support vessel operator, has appointed one of its cadet program graduates as its first female assistant superintendent, **Victoria Diamond**, who completed a three-year cadetship and gained qualifications to become a third engineer.

Karley Smith has joined Brookes Bell as a marine consultant and its first female master mariner. **ST**

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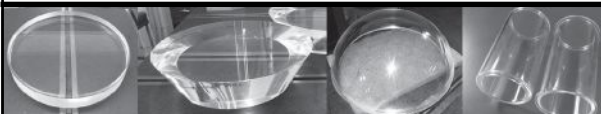
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The Ukraine War Will Not Derail Europe's Energy Transition—Sverre Alvik

Sverre Alvik is the director of energy transition research at DNV. He is responsible for DNV's Energy Transition Outlook, a forecast of the world's energy system through 2050. Alvik has worked more than 20 years at DNV in the energy and maritime industry with strategy and politics, research and innovation, environment and sustainability, technology and finance and the interface between them.



As Europe struggles to build energy security in response to Russia's invasion of Ukraine, uncertainty looms on many fronts. By turning its back on Russian oil and gas, will Europe speed or slow down its response to the more global crisis of climate change?

That is a complicated question, and hinges on the extent and duration of the war. But, as things stand, our conclusion at DNV is that improved energy security does not come at the cost of decarbonization, and there is likely to be a small acceleration in Europe's energy transition. Decarbonization and emissions reduction will total 580 Mt, or 2.3 percent reduction in emissions in Europe in the period 2022 to 2030.

European policy makers are determined to slash the EU's Russian gas dependence by two-thirds this year. The replacement will be painful and costly, with increased import of LNG taking center stage.

However, there is currently insufficient regasification capacity in Europe, and production in places linked to the European gas pipeline networks in Norway, Algeria and Azerbaijan can only inch their output upward. Replacing two-thirds of Russian gas by year-end looks like a tall order, and the European energy security ambition therefore hinges on additional policies. Beyond nudging consumer behavior toward

lower energy use, there is scope for a concerted policy push for energy efficiency, a postponement of nuclear retirements and an extensive renewable energy buildout. There is certainly opportunity for acceleration in Belgian nuclear, French heat pumps, German solar and pan-European wind.

While nonfossil supply and energy efficiency can and will be accelerated, there are counterforces at work against the energy transition. These include burning more coal to replace natural gas and increasing costs of electric vehicle batteries and photovoltaic panels. To this extent, the push for energy security works against the transition.

Other effects of the war that are not linked to energy security, including reduced global trade and cooperation such as the realignment of global logistics to address a mounting food crisis and a shortfall of critical minerals could also slow down the energy transition.

The next edition of DNV's annual Energy Transition Outlook is due in October, but we have run the model now to assess how changes since February are likely to influence Europe's energy transition.

The largest uncertainties have to do with the war itself—its duration and possible escalation, and whether strengthened countermeasures bring the export of Russian oil and gas to Europe to a complete stop. While it is likely that Europe's commitment to its Fit for 55 climate plan will endure, public reaction to energy affordability may challenge its momentum in the short term. There are many other uncertainties, like whether the war will give rise to a new cold war, or end in a calmer détente.

With all these uncertainties in mind, we have chosen to model a scenario where the European energy system discontinues the importation of Russian gas, with zero Russian gas imported from 2025

onward. Ease and means of gas replacement depend on which sector it is used. Growth and greening of electricity, and hence the decarbonization of end uses in the transport, building and manufacturing sectors, is the most important means to decarbonize European energy use.

Renewables and nuclear have low operating costs and are at the top of a cost merit order in our analysis. These quantities are not sufficient in the short term to cope with the entire shortfall in gas—that is when gas needs to be replaced by coal, which also has higher costs as a result of the war. The switch to coal is temporary. Being the fuel of last resort, we find that by 2024 only 6 percent of the reduction in natural gas use will be taken up by coal.

Unlike most other energy sources, bioenergy costs have not grown due to the war, and it is possible to increase bioenergy, mainly from sewage and wastefills, slightly over the coming few years. We find bioenergy makes up for 20 percent of the shortfall in Russian gas in 2024.

Hydrogen is another important pillar in securing both Europe's energy independence and the sustainability of its energy mix. But its main challenge is affordability. When Europe is in dire need of gas to replace the phaseout of Russian gas, it is unlikely that significant amounts of surplus natural gas will be available for producing blue hydrogen. In spite of increased support, green hydrogen use in Europe will remain modest by 2030, albeit 25 percent higher compared with our pre-war model output.

The ultimate metric for decarbonization is lower greenhouse gas emissions, and the net effect of the Ukraine war will be a small acceleration of decarbonization and emissions reduction. As with COVID-19, we see Europe capable of dealing with both a short-term crisis and the long-term climate crisis. **ST**

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