MARINE TECHNOLOGY REPORTER

May/June 2021

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Ballard

Ocean explorer Robert Ballard opens up in his new memoir *"Into the Deep"*, offering rare personal insights on his life & career

Hydrographic Survey
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Volume 64 Number 4

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ADVANCED NAVIGATION

May/June 2021
Volume 64 • Number 4

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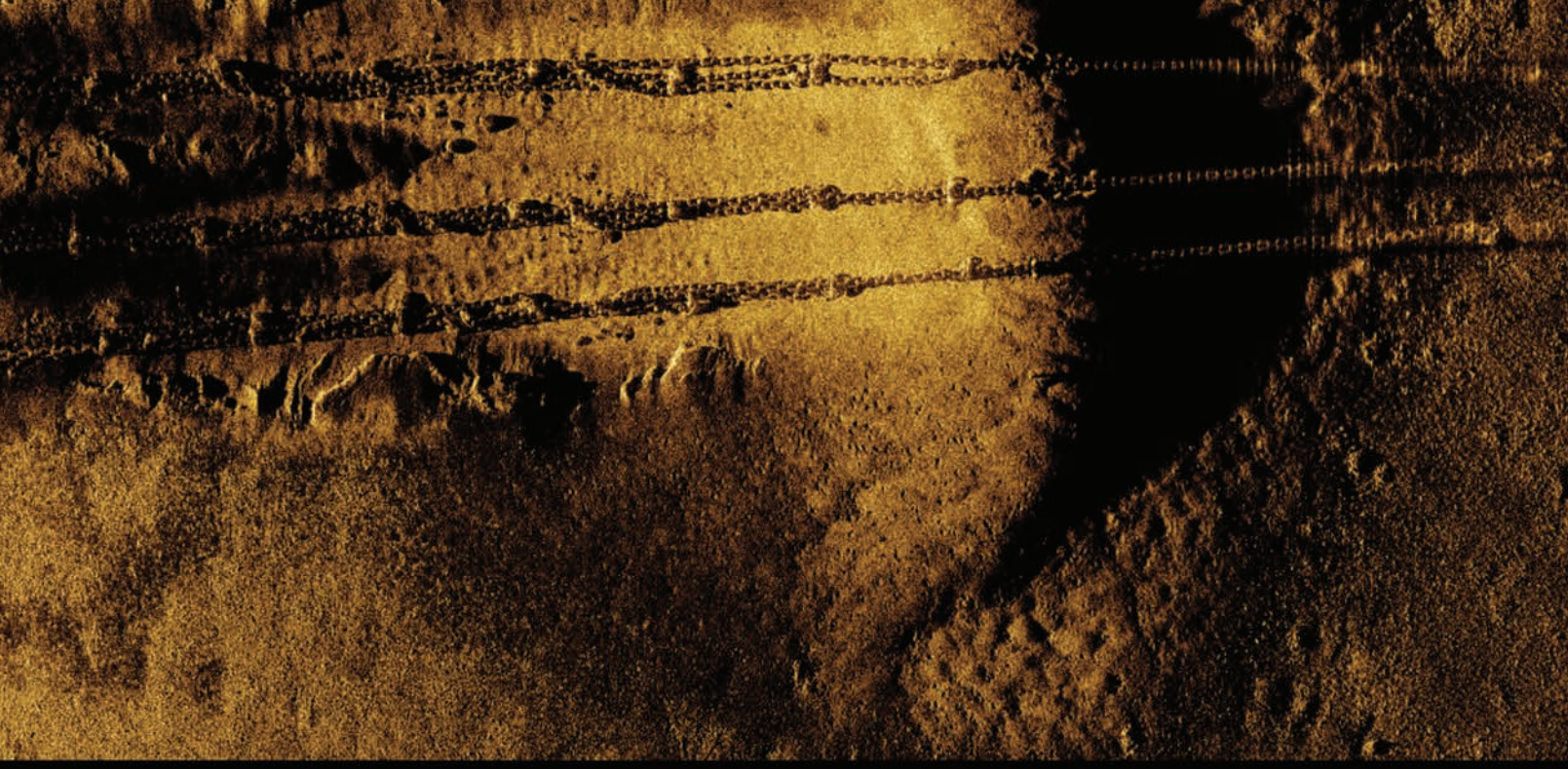
On the Cover

In 2019, Nautilus plied the Pacific waters off the island of Nikumaroro, searching for any sign of Amelia Earhart's lost plane. In the cool, dark control room, we kept a 24-hour vigil.
(Photo Gabriel Scarlett/National Geographic Image Collection)



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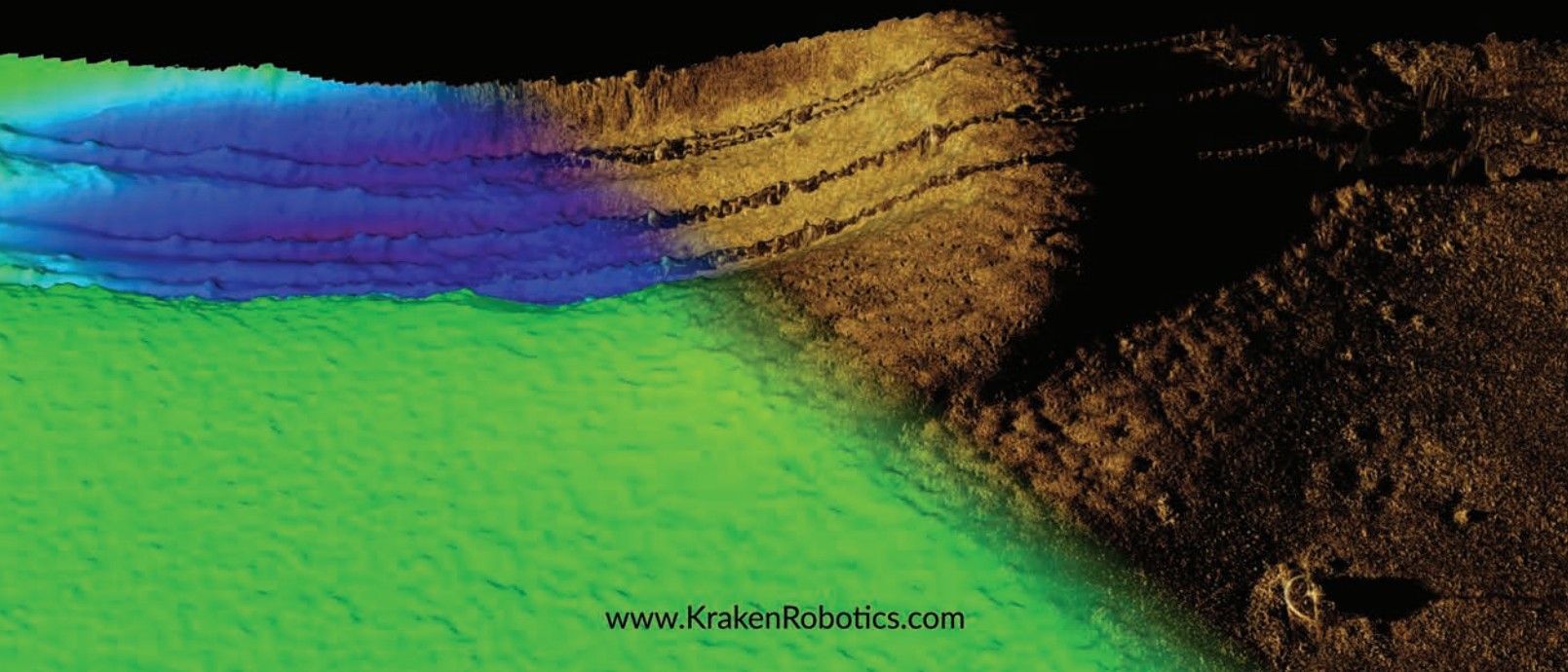

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Editorial

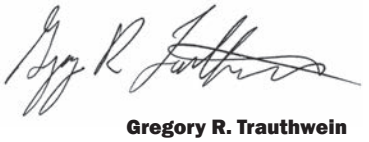
A Life Discovering

In the summer of 2005 we published the first edition of *Marine Technology Reporter* in its current format, my 'entrance' into the subsea community – though there was ample crossover from my maritime and offshore energy titles. A seminal moment for *MTR* was a few months later when **Dr. Robert Ballard** reached out to me direct to invite me up to the University of Rhode Island for the day to discuss with him and his students the development of an Archaeological Oceanography doctorate program at the University of Rhode Island, a story that we published in the January 2006 edition [**bit.ly/3fq0s8x**].

In the 15 years between, cumulatively across our four magazine titles I have published an additional 585 magazines as well as hundreds of thousands of individual articles across our four main websites.

While I have run into Dr. Ballard a number of times since then, we never sat down for another feature until this month, to discuss his latest book, *Into the Deep*, which is a deeply personal look at the man and his missions.

Robert Ballard is best known as *'the man who found the Titanic,'* and while his works have been documented extensively in papers, books and television shows, none of the former truly showed the person behind the missions. As he approaches 80 years of age, Dr. Ballard is still going strong and gearing up to make is 158th expedition. While still driven by science, the hunt and the discovery, he's more reflective in his new book, which will also be a National Geographic television special airing June 14, 2021 – particularly in opening up about his family and his dyslexia. I was able to meet with Dr. Ballard via video interview on May 11, the day his book was released, and invite you to read up on the man, his greatest challenges and his missions starting on page 34.



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This survey has been done with an APOGEE INS under very challenging conditions for the GNSS receiver (red dots).

The boat is crossing multiple times three large bridges including one made of steel.

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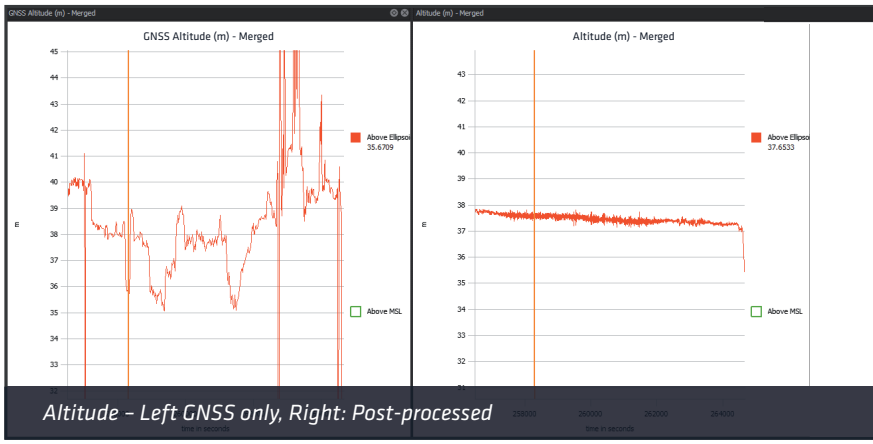

Altitude – Left GNSS only, Right: Post-processed

The Fastest PPK Software

Log duration: 2h15
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Example: up to 80 seconds *outages and multi-path effects*
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Many thanks to Hydro Systems Development (HSD Japan) for their kind collaboration.

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“

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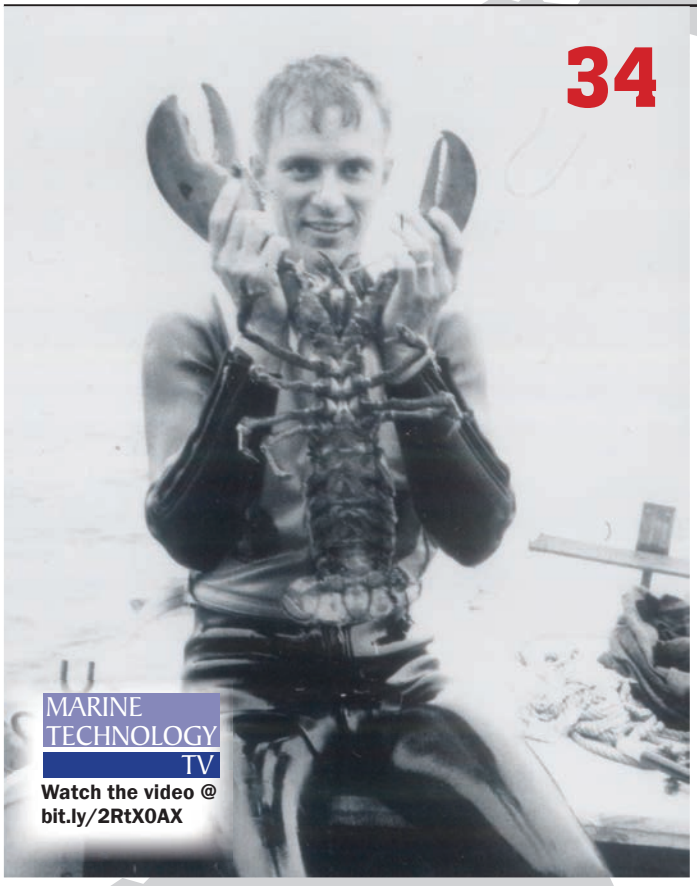

"I didn't know I was dyslexic until I read the book *The Dyslexic Advantage.* *I remember when I read the book … slowly … I cried because it explained me to me for the first time …* I wanted to talk about that, because I view it as a gift.

• • • • •

Robert Ballard
Scientist, Ocean Explorer

• • • • •

Born in Kansas yet a California kid, I still found myself right at home with the Boston Sea Rovers during our annual lobster dives. (Photo Courtesy of Robert Ballard)

MBARI's new research vessel will honor Silicon Valley pioneer **David Packard**, *who founded Hewlett-Packard (HP) in a Palo Alto, California, garage with Bill Hewlett. His philanthropic endeavors included funding the creation of the Monterey Bay Aquarium in 1984, and three years later, Packard founded MBARI.*

"Quotable"

"The mission then becomes: **how do you drastically scale ocean data collection while simultaneously, radically improving the user data experience** with that now scaled data? So that's the mission, two-fold – data collection, data interface."

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Joe Wolfel, co-Founder, co-CEO, Terradepth

Terradepth

Comprehensive Study or NW Australia's Deep Coral

All images courtesy Schmidt Ocean Institute

Scientists discovered a sea snake thought to be locally extinct and saw several species such as the great spotted cowrie (Perissersoa guttata) for the first time in the Ashmore Reef Marine Park, off Australia, during Schmidt Ocean Institute's recent 18-day expedition.

A team of scientists, led by Dr. Karen Miller of the Australian Institute of Marine Science (AIMS), also documented for the first time in high-resolution great diversity in coral-dominated areas, calcareous algal beds, and sponge gardens, and collected samples that will provide understanding into the biology of deep-water corals.

The science team gained new ecological insights of mesophotic species and communities in depths between 50-150 meters using the underwater robot, ROV SuBastian. "Our observations of the reefs showed the mesophotic zone at Ashmore to be diverse, vibrant, and healthy," said Dr. Miller. "We found no evidence of coral damage, showing the marine park is helping to preserve this special ecosystem."

The robot offered the capacity to look at animals and these underwater areas in great detail, unlike previous deep-water survey methods completed in NW Australia. The dives were streamed live to the public, sharing 148 hours of never-before-seen footage of the Ashmore Reef seabed, and over 500 high-quality specimens were collected to share internationally for further research.

"Mesophotic ecosystems are hypothesized to have significant ecological importance, including the potential to reseed shallow water reefs under environmental stress, said Dr. Nerida Wilson, Western Australia Museum. "The ability of these environments to provide a refuge for coral reefs needs critical attention, as all reefs face a range of stressors including a changing climate. However, it may be that mesophotic environments are unique in their own right."

Australian artist Ellie Hannon sailed with the scientists in the Artist-at-Sea berth, capturing the beauty of Ashmore Reef in her paintings created on-board. She was also able to paint a panel for the deep-diving robot, SuBastian. The expedition was led by Australian Institute of Marine Science, and included scientists from the University of Western Australia, Curtin University and Western Australia Museum with support from Parks Australia.

TERRADEPTH PUT TO THE TEST

MARINE TECHNOLOGY TV

Watch the video @ bit.ly/3u8TBoa

Terradepth is a company with an unmanned submersible system that is showing promise to deliver ocean data economically, at scale. The system was recently put to the test in Texas, as Judson Kaufman and Joe Wolfel, ex-Navy SEALS, co-founders and the co-CEOs of Terradepth, discussed with Marine Technology TV.

Kaufman and Wolfel were industry outsiders before they started Terradepth, but they felt that there was something missing in the quest to gather, disseminate and analyze ocean data at a scale found in other industries, including space exploration.

"Joe and I got into this industry as outsiders, aside from our Navy experience, which did not include very much undersea technology," said Kauffman.

"We saw an opportunity here to bring some pretty modern technology into this somewhat aging industry … so we stepped in full force."

The Mission

"The vision of the company is to create a complete, accurate and immersive virtual ocean experience, to connect humanity with what is the last frontier on earth," said Wolfel. "The mission then becomes: how do you drastically scale ocean data collection while simultaneously, radically improving the user data experience with that now scaled data? So that's the mission, two-fold – data collection, data interface."

According to Wolfel, the first key to dramatically scale high resolution, deep ocean data collection is to remove or minimize the human from the data collection loop. "The way that our data collection platform differs is we have a single variant dual purpose solution. We make one type of robot that's capable of existing at the surface and replicating what is a currently manned surface vessel. And we've got the exact same robot, its twin, underwater, doing a deep ocean high resolution, high energy data collection mission," said Wolfel. "When we run low on energy submerged, because we're on battery power, we simply switch places on the water column and continue on mission. A simple solution that we think improves reliability, improves resilience, therefore improving endurance and drastically reducing the cost of that operation."

The second key is on the user interface side of the house. "Here we're taking a lot of the acoustic data that's coming off the robot, we're transforming it into a point cloud and we're making it available for user interaction on a cloud platform," said Wolfel.

Put to the Test

Earlier this year Terradepth completed Phase 1 trials to put its system to the test on Lake Travis in Texas. "The focus really was just to prove to ourselves and to our stakeholders that the robot that we build could operate fully autonomously, end-to-end," said Kauffman. "Could the robot go into the water, see something, and then make a decision based on what it sees and about what it should do next, without contacting a human and saying, "hey, here's a picture of something. I don't know what it is, but standing by for further for their mission tasking."

The test was a success, as Kaufman explained: "So it was in-situ data processing at the edge decision-making, that's really what we proved."

The next step for the Terradepth team will be to prove the ability for that same

robot to recharge its own batteries while deployed at sea, which it aims to trial in the summer of 2021.

According to Kauffman, Terradepth has a patent for hydrogen fuel cell system, but at the moment it's using heavy fuel in a standard diesel electric system. Alternative fuels and hybrid propulsion are in its future. "So the way that it works is while it's submerged, it's using the batteries for power. Once those batteries run low, the system comes to the surface where it can "breathe" air, and when it can breathe air, it can turn on the generator and that generator then charges those batteries. Once fully charged it dives back down to continue its mission," said Kauffman.

Challenges Ahead

While the Terradepth team has progressed rapidly, there remain hurdles ahead to accomplish its ultimate mission of dramatically scaling high resolution, deep ocean data collection.

"I'm sure most of your readers are familiar with the signal attenuation problem that exists in the ocean," said Wolfel. "The reason that we don't have high resolution bathymetric maps of the entire ocean is because we can't fly all the satellite constellations that we have over the ocean and have that energy penetrate to the water column to get that accurate image.

That means you've got to be underwater. Once you start going underwater, if you're going to remove the human from the loop, now you've got very sophisticated sensor packages that need to be powered, and those sensor packages are extremely expensive right now, especially considering they have to, in many cases, go into their own pressure vessels. (In short): it's just really expensive to send stuff underwater and then have it hopefully come back on its own."

Getting that ocean of data is one challenge, processing it quite another, as Wolfel cites lack of data interoperability in general. "File formats are all over the place, and they don't work well together," said Wolfel. "There's not a whole lot of ocean data out there that's really usable, and even if it is usable, it's not searchable because you haven't aggregated it all in one place and your search functions don't work on those different file formats."

The market for data from the ocean's depths are broad, "but I think who will benefit the most are those stakeholders and the markets who currently can't afford to pay the rates of what it costs to purchase this kind of data. We want to scale it to such a degree that we democratize that data."

ACOUSTIC TECH TO UNDERSTAND THE ARCTIC

The R/V Sikuliaq during a cruise to research sea ice in the Beaufort Sea.

Photo ©: Onpoint Outreach.

Major changes are occurring in the ocean. Climate change and subsequent melting sea ice are not necessarily good changes. Why are acoustic Doppler current profilers an invaluable tool to get a complete picture of the Arctic's changing wave conditions in the context of climate change?

In the Arctic, the end-of-summer sea ice extent in 2020 was the second-lowest in the last 42 years.

"The ice used to melt out in June or July. Now it melts out in May. It used to come back in September or October. Now the ice comes back in November or December," said Professor Jim Thomson, Senior Principal Oceanographer at the University of Washington's Applied Physics Lab and a Professor in the Department of Civil & Environmental Engineering.

The implications of the Arctic's changing sea ice are many. On a global scale, sea ice influences global climate. Within the region, activities such as commercial shipping and naval operations may find life easier with the decline. For local communities, however, the loss of sea ice means the loss of a protective barrier that shelters their homes from harsh waves driven by storms that would otherwise batter and erode coastlines that are not resilient to their impacts.

In a twist, waves along the coast and further offshore may become a more prominent feature as the sea ice continues to decline.

Studying Sea Ice and the Impact of Waves

While sea ice lies on the ocean surface, there is less space for waves to form. Any waves that do so find their energy scattered and dissipated by the ice. Historically, winter waves might reach just over half a meter in height, but today they far exceed this. In September 2012 – the year with the lowest recorded end-of-summer sea ice extent – Thomson and colleagues detected waves some 5 m high with a 600 kHz acoustic wave and current profiler (AWAC) mounted on a subsurface mooring in the Beaufort Sea.

Waves can do several things that can expedite ice's decline. First, waves can erode the ice edge. Second, they can break the ice up.

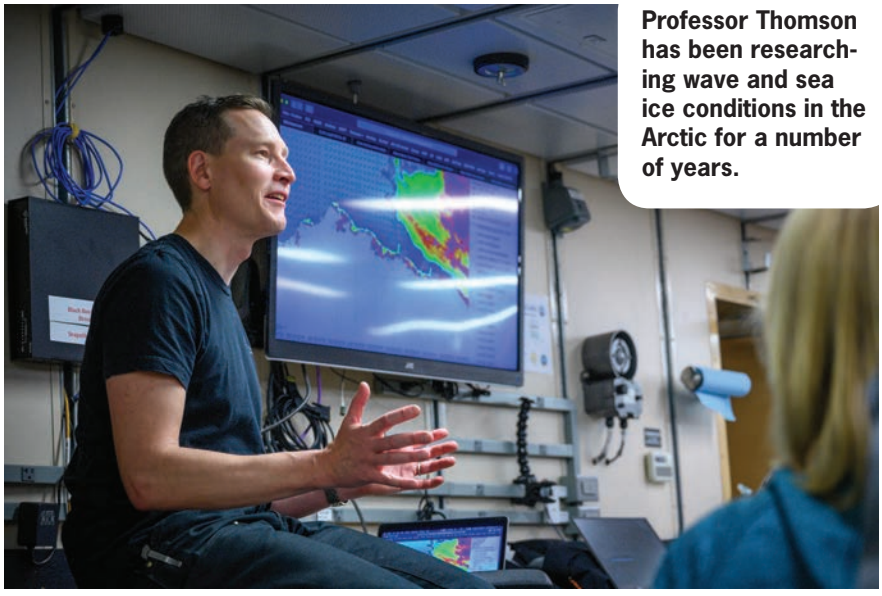
"Imagine there is a nice big flat sheet of ice, and the waves break it up into lots of bits. Once it's broken up, it has more surface area exposed to the ocean, and if the oceans warm, the pieces of ice are more likely to melt," Thomson said. "There's a potential feedback mechanism wherein you lose a little bit of ice and make some waves, and those waves eat away at the ice edge or break it up, and so you lose more ice, and then you make bigger waves, and now you're off and running."

Thomson's research in the Arctic has continued. Recently, he and his team paired Nortek Signature500 acoustic Doppler current profilers (ADCPs) mounted on fixed moorings with drifters equipped with Signature1000 ADCPs to get a complete picture of the Arctic's changing wave conditions.

"The moorings [equipped with upward-facing Signature500 ADCPs] provide us with a long time series of data. They sit at one place, and watch the world go by," Thomson says. The instruments, which collect data on the waves, currents and sea ice when it is present, are duty-cycled to record data every

Jim Thomson readies a fixed mooring equipped with a Signature500 ADCP for deployment in the Beaufort Sea. The instruments were left in situ for a year.

Photo ©: Onpoint Outreach.



Professor Thomson has been researching wave and sea ice conditions in the Arctic for a number of years.

Photo ©: Onpoint Outreach.

hour. "They have been great for power management. It's really good to be able to have the instruments reliably collecting data for a whole year and retain robustness in the data collection," Thomson says.

The Signature1000s have also been attached to moorings to assess waves in shallower waters. In the Chukchi Sea, Thomson and Dr Lucia Hošeková captured a four-day-long wave event near the Alaskan coast, allowing them to explore how sea ice dampens the wave's energy.

"A next-generation acoustic profiler that really moves things forward"

Thomson's Arctic investigations are continuing, with much of the research being conducted largely made possible by the technical advances being made in the equipment. "The Signature instruments, in general, have been nothing short of a game-changer," Thomson says, noting the ability of the instrument to capture multiple different types of measurements. "We have a next-generation acoustic profiler that really moves things forward. The data are much cleaner, much higher quality than they used to be."

COMPACT DEPLOYMENT SYSTEM MAKES EXPLORING DEEP SEAS EASIER

SMALLEST DEEP-SEA SYSTEM THAT CAN PROVIDE A LIVESTREAM VIDEO FEED

The answers to many of life's mysteries have been discovered far below the surface of the seas. However, getting to those depths has not been easy. Thanks to a new fiber optic reel system invented by Brennan Phillips, an assistant professor of ocean engineering at the University of Rhode Island, deep-sea exploration is about to get much more affordable and accessible.

Shrinking the System

Having worked on large research vessels all over the world, Phillips is well aware of the expense, planning and massive scale involved in deep-sea exploration.

"If you have a large underwater vehicle that you're using, you need several people to run it and a large research vessel to operate it, which is very expensive," said Phillips. "By making the vehicles smaller, the cables smaller and the winches smaller, we can save a lot of money and go more places in the world."

Two years ago, Phillips created a miniature, inexpensive deep-sea camera system called DEEPi. However, he still had to rely on a large research vessel to get it in the ocean. That led to his development of a small deployment system.

"It all comes down to the diameter of the cable," said Phillips. "A cable that is three-quarters of an inch in diameter ends up weighing many tons when you have 4,000 meters of it, which means you need a massive winch to go with it. If you make the cable smaller, everything scales down accordingly."

After experimenting with a custom-designed cable that was still too wide, Phillips ended up using something that can be spotted all over Rhode Island in the summertime, a fishing reel.

"I wanted to get to the point where I had a winch that could get me somewhere deep in the ocean, but I could carry it in a suitcase," said Phillips. "An electric fishing reel is essentially a miniature winch and it's available off the shelf."

Collaborating with Industry

Having solved the scale issue, Phillips' next step was to figure out how a cable small enough to wrap around a fishing reel could transmit data, including video, in real time while underwater.

"We didn't have a cable that size with fiber optics in it for data transmission, so we had to invent it," Phillips said.

Not having the necessary equipment to integrate the fiber optics in the fishing line, Phillips requested the help of Jim Owens, principal of Nautilus Defense in Pawtucket.

"When I told Jim that I wanted to a make fiber optic fishing line, I thought he would say 'that's impossible' or 'I can't do it,'" said Phillips. "But he surprised me by saying, 'I think we can do that.' A week later he mailed me a prototype."

"Brennan had very clear parameters and objectives for the system and he let us run with our part of the project," said Owens. "We developed a fiber optic tether that was mass and volume-efficient using our in-house braiding equipment."

With the fishing reel and fishing line now at the same scale as the deep-sea camera he previously developed, Phillips successfully produced the smallest, most compact deep-sea system in the world that can provide a livestream video feed.

The fiber optic reel system is described in the April 2021 issue of Sensors. Co-authoring the journal article with Phillips were URI ocean engineering students Nicholas Chaloux and Russell Shomberg; Adriana Muñoz-Soto, who did an internship on the project for the University of Puerto Rico Mayagüez; and Owens.

Phillips and Owens have filed for a provisional patent for the fiber optic reel system, with the application being sponsored by URI and Nautilus Defense.

Putting it to the Test

Phillips began working on the fiber optic reel system before the pandemic started, but did the bulk of the testing during the pandemic.

In the summer of 2020, he deployed the system a couple

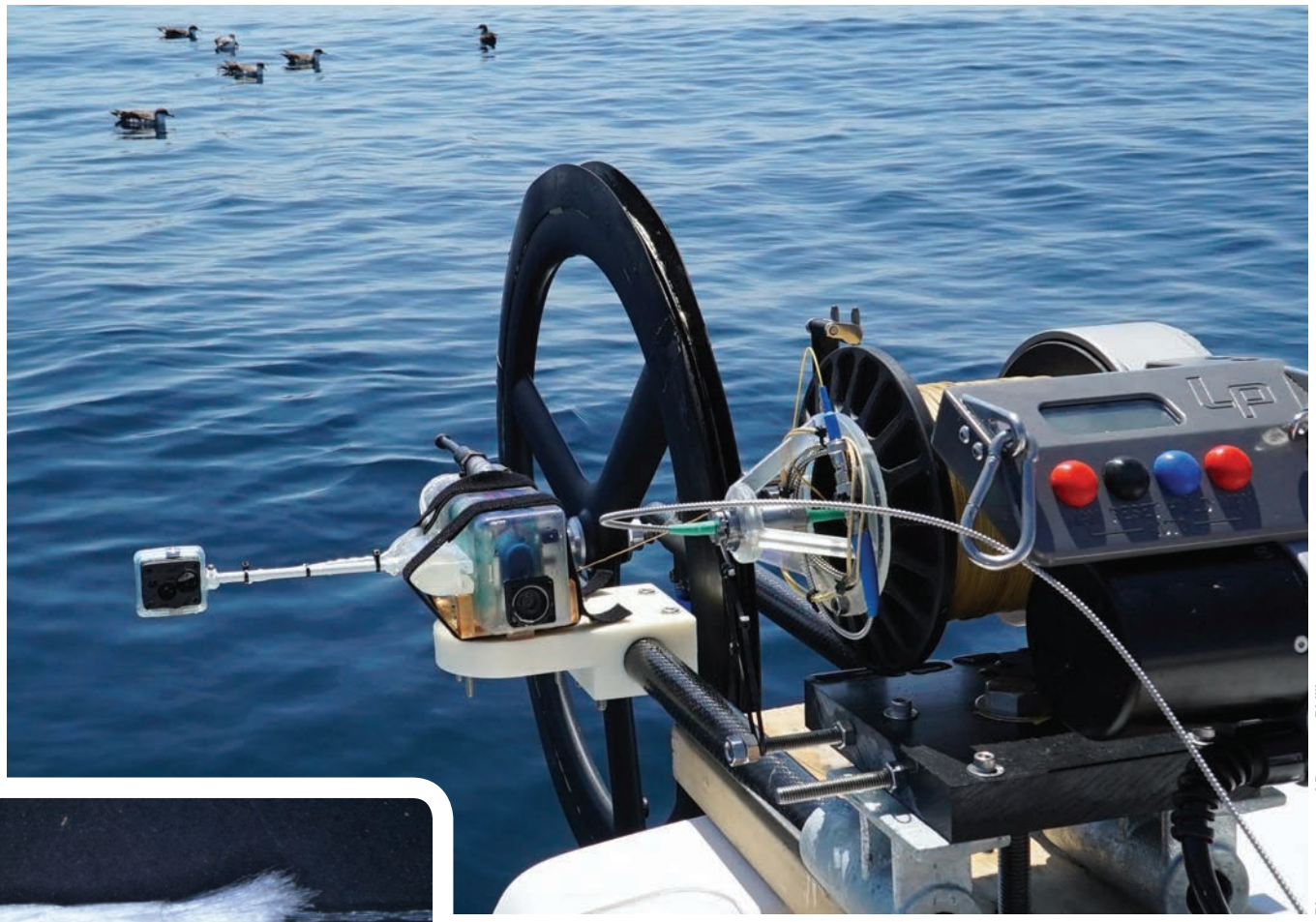


Photo courtesy of Brennan Phillips

Left
A sample of fiber optic fishing line with the inner fiber optic core exposed, next to a United States quarter for scale. The outer diameter of the fishing line is less than one millimeter.

Above
The fiber optic fishing reel system with a live-telemetry fiber optic imaging payload prepared for deployment in deep water over Atlantis Canyon in July 2020.

of times in the Narrow River in Rhode Island, where the water was calm and flat. He used his own personal boat for the test. Another conducted another test in Narragansett Bay, near Newport. The first deep-water test took place later in the summer on a day-long boat trip to Atlantis Canyon, 100 miles off the coast of Falmouth, Massachusetts.

"Because of the pandemic, a lot of larger boats were inaccessible at that time," said Phillips. "But because we had this compact reel system, we could do the trip with just three people – me, the captain and one of my students – and still be COVID-safe."

At a depth of 350 meters, the system successfully transmitted live video throughout the cast, capturing footage of euphausiid shrimp, anemones, benthic fish, and other organisms and phenomena, including flashes of bioluminescence.

The reel system was tested at a much greater depth in December of 2020 in Bermuda, reaching 780 meters. Like the previous tests, the system was deployed and retrieved without any issues. "The results were better than I expected," Phillips said. "I never truly believed it would work because the system includes several components that have never been tried before. I'm sure I screamed at the top of my lungs when it actually worked."

Portability Saves on Expense

Since the fiber optic reel system is a fraction of the size and weight of a system using a traditional winch, cable and camera, a much smaller boat can be used to transport the system.

"We can use a fishing boat to get this new system deep in the ocean instead of a 100-foot vessel," said Phillips. "That means each time we go out on the water, we'll be saving many times what it would normally cost for an operation."

Potential Applications

For researchers such as Phillips, the fiber optic reel system will be a quick, low-cost way to get a camera, sensor or physical sampling device that needs data transmission down deep in the water. But scientists won't be the only ones who could benefit from a system with these specifications.

"Currently, there isn't a way to deploy deep-sea equipment using an autonomous vessel or a drone using a winch that weighs several thousands of pounds," said Phillips. "But the U.S. Navy would probably have some interesting applications for something that is much smaller and more compact."

The fiber optic fishing reel system with an imaging payload deployed in deep water over Atlantis Canyon in July 2020.

Photo courtesy of Brennan Phillips

As a commercial product, the system could be a game-changer for the fishing industry.

"There would be a lot of benefits to be able to see what your bait or lure is seeing, especially deep in the ocean," said Phillips. "There are a couple of systems on the market that can take pictures or record video, which you can watch later, but this system would provide live video, enabling the person who is fishing to adapt on the fly to what they are seeing."

Educational Benefits

Phillips won't have to look far to see the reel system put into use. He expects engineering students at URI to find many creative ways to apply it to projects.

"If we have this compact reel system that can be taken out on any boat on any day, it's really great for students because they can make all types of stuff to go on it," said Phillips. "We can enable students to make their own deep-sea equipment using this type of system." Phillips is excited to see what the students will come up with. "When I look around my lab, I see a bunch of successful and failed projects that students designed," said Phillips. "That's how good engineering happens, through trying and failing."

Photo courtesy of Brennan Phillips

The fiber optic fishing reel system while still under construction in Brennan Phillips' lab at URI's Narragansett Bay Campus.

2020: A year like no other with a mixed outlook for subsea

On many levels, 2020 was a pretty horrific year, "a year like no other", according to Mike Beveridge, managing director of energy investment firm Simmons Energy, a division of Piper Sandler.

It's easy to see why. A dip into a negative WTI contract prices, Brent troughing at $23/b – the indicators were all pretty grim. The scary thing is, it could have been worse. But there is light at the end of the tunnel.

Speaking at the Society of Underwater Technology's (SUT) annual subsea market outlook, usually held in Aberdeen, but this year held online, Henning Bjørvik, VP of energy research at Rystad, said that, with around 140 subsea tree awards in 2020, "We were basically now more or less back to what we saw in 2016," a year which was a record low (around 100 trees).

The challenges, in 2020, multiplied. Coronavirus changed our lives, the energy transition gained pace and the threat of peak oil is now looming, Beveridge told the SUT event earlier this week (April 20).

While the intervention of OPEC+ improved prices (50% of global supply, while Russia remains in the group), it's still a finely balanced market, he says. Anti-fossil fuel thinking has been gathering pace, the Biden administration has re-signed the Paris treaty, the UK government has committed to net zero and the country is hosting COP 26, while investors "continually shift their attention away from fossil fuels", due to a realization that peak oil demand is on the horizon, Beveridge said, citing a recent report from Goldman Sachs which suggested anemic demand after 2025 and peak oil as early as 2026, a sentiment repeated by Rystad on Wednesday (April 21).

"Investors are increasingly focused now on carbon footprints, there's more government policies, society's demand, customers care what the emissions of their supply chain look like, employees care," said Beveridge. Carbon taxes are coming, operators are looking to attract capital by being seen to be green and most oilfield services deals have to demonstrate to potential buyers how they're service or technology helps to reduce emissions, he said. "This is a critical feature that didn't exist in deal making two years ago." It's a tough environment for the oilfield services sector where equity values are 71% down compared to 2017, despite Brent having recovered 14%, he said.

For the subsea market, it's been especially tough. Another slump down to around 140 subsea tree awards in 2020 was a major step down from the 530 per year ordered in the hey days of 2012-2013, and some way off the 300 or so that had been forecast for 2020, prior to the Covid pandemic and another drop in oil prices.

Equinor

Equinor's Breidablikk project in the Norwegian North Sea, with 23 wells, was one of four projects adding to subsea tree order numbers last year.

Prior to Covid, projects like Bay du Nord, Cambo and Rosebank were on the verge of being sanctioned. "But we're not in this world anymore," said Bjørvik. Last year, subsea tree ordered for Woodside's Sangomar off Senegal, ExxonMobil's Payara off Guyana, Equinor's Breidablikk in the North Sea and Petrobras' Mero III in Brazil's Santos basin, made up the bulk of the subsea tree orders, Bjørvik said. "If those four projects weren't moving ahead, 2020 would be a devasting year for the subsea market," he told the SUT event.

But there's hope within sight and "subsea players should be ready for a ramp up," says Bjørvik. In Norway there has been a tax relief package, which has lowered breakeven prices by 40% on average and the results of that are being seen; there are a lot of projects in the pipeline, he says. Brazil is still ploughing ahead with its FPSO projects, Guyana will still also be there, as ExxonMobil forges ahead with its Stabroek block finds, which will require quite a lot of subsea trees.

"For subsea tree awards, we are a bit more bullish for 2021 compared with 2020," says Bjørvik. That's partly due to Petrobras' Buzios tender, which includes 53 trees. Without Buzios, the forecast would be more like 2020. "So the real recovery, back to 2019 numbers (ca.300 trees), we see in 2022," he says, "when there are a lot of competitive projects in the pipeline, and hopefully the covid situation has been resolved and the oil price is stable." More broadly, investment numbers are expected to ris, up to 2023, he says. Offshore greenfield project sanctioning is expected to increase from under $50 billion in 2020 (just a bit above the 2016 low), to nearly $120 billion in 2023, says Bjørvik.

That raises a question; will the industry be able to meet the demand, he asks. While many have been able to live off their

backlogs, order intake last year took a hit. "We are expecting to come back to 300 trees by 2022," however, he says. But after dropping back to 140, can 300 be delivered and what will the impact be and should operators be concerned about capacity, asks Bjørvik.

He also says the future is likely to be dominated by scaled down and phased developments. "We see operators being focused on scaled down, phased and accelerated developments," he says, which is likely to be positive for the subsea tieback market. At the same time, we're likely to be moving towards the end of an era when it comes to mega-projects, he says. While there are a couple on the near-term horizon, such as Equinor's Wisting and Bay du Nord projects, it's otherwise hard to identify many mega-projects in the longer term, says Bjørvik.

For Beveridge, there's some positivity in the North Sea, with newer operators in the basin, although there is a 'but'. "I'm not negative about the North Sea, I think it's reinventing itself again," he says. "These new operators coming in are investing for the long term; they have clear strategies, access to capital and plans to develop their assets, as long as they have a license to operate and that that's not taken away."

While there are fewer private equity investors wanting to plough money in, there are still investment themes, around well decommissioning, brownfield and subsea IRM, robotics, AI, software and emissions analysis and reduction, he says.

Tellingly, an increasing focus at Simmons is in another sector; offshore wind. Floating offshore wind, specifically, is an incredibly exciting prize, says Beveridge. "The links between subsea oil and gas and floating wind are really quite pronounced," he says. "You have massive know how sitting in our industry in areas like electric systems, cabling, mooring, floating infrastructure, repair and IRM of dynamic structures, that positions our industry incredibly well to capitalize on floating wind." Time will tell, but the world does appear to be heading in one direction – the question is how quickly it will get there.

– Elaine Maslin

Boreas D90: Digital Fiber-Optic Gyroscope (DFOG) Technology

Advanced Navigation recently debuted a new digital fiber-optic gyroscope (DFOG) technology, a tech that has promise to revolutionize many subsea and maritime market navigation applications. Xavier Orr, CEO discussed the innovation and the potential.

By Greg Trauthwein

Advanced Navigation is a privately owned Australian company that specializes in the development and manufacturing of navigation technologies and robotics, including a broad range of fields including sensors, GNSS, inertial navigation, RF technologies, acoustics, robotics, AI and algorithms. Today the company has more than 40,000 products in the field and operating, globally in the automotive, maritime, subsea survey and offshore oil and gas sectors.

In May 2021 Advanced Navigation debuted the Boreas D90, touted as a new generation of closed-loop fiber-optic gyroscope.

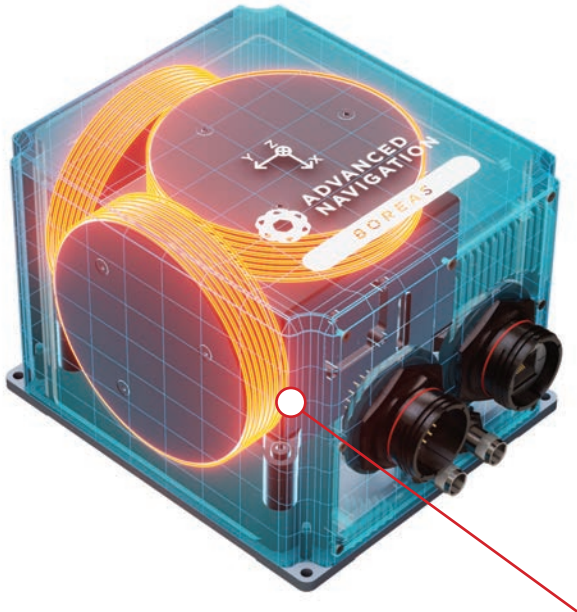


Image courtesy Advanced Navigation

"Fiber-optic gyroscopes use a coil of optical fiber and measure an effect known as the Sagnac effect to determine rotation very accurately with no moving parts," said Orr. "So, basically, they are the most accurate and reliable method for measuring angular velocity currently available. Boreas takes that technology into a new generation," comparing FM radio to the current generation of FOGs whereas "Wi-Fi or digital radio would be our new technology." Another benefit according to Orr: "Thanks to the DFOG technology, Boreas will be roughly 30% cheaper than traditional FOGs with similar performance."

Boreas D90 & DFOG

Size and weight are generally two of the top agenda items when delivering any maritime or subsea product, and according to Orr, one of the outstanding features of Boreas D90 is that "it is roughly 40% smaller, lighter, and lower powered than competitive systems," while still delivering performance and reliability. The key ingredient: digital FOG, or "DFOG" as Advanced Navigation calls it, a patent-pending technology that's been in development for the last 25 years across two universities.

According to Orr, there are three elements to DFOG:

[1] Digital Modulation Techniques. "Rather than sending a sine wave over single frequency through the coil, you're sending spread spectrum signals, so you're sending a whole heap of frequencies."

[2] Specially Designed Coils to make the most of those digital modulation techniques. "Those two things, combined, allow us to detect in-run errors in the fiber optic gyroscope and correct for them, that normally would just be errors in your data in other systems."

[3] An optical chip that combines nine different discrete components into a single chip. "That allows us to do a lot of optimizations and earn performance gains. We also can reduce the size, weight, and power through that chip."

To date Advanced Navigation, by Orr's estimation, has invested around 100,000 staff hours into the development of DFOG. "Then, on top of that, there's probably half a million hours that have been spent at universities, the two universities, over the last 25 years working on this technology," a

"Fiber-optic gyroscopes use a coil of optical fiber and measure an effect known as the Sagnac effect to determine rotation very accurately with no moving parts"

Xavier Orr, CEO, Advanced Navigation

MARINE TECHNOLOGY TV

Watch the video @ https://youtu.be/EqES9Zs-wEk

breakthrough that Orr said comes from the university's work on gravitational research. "Advanced Navigation saw the potential of this technology, so we developed it through to the commercialization point."

Applications

There are multiple opportunities to leverage this technology across industries, but looking strictly at the maritime sector, some of the biggest categories would be ROVs, AUVs, marine surveying and ship navigation.

"BOREAS allows for solid state, north seeking, or gyro compassing at a fraction of the size, weight, power, and cost of systems currently on the market," said Orr. "That makes it viable to take systems that are currently using magnetic heading and move them across to much more reliable gyro compassing or north seeking technology." As technology in general starts to evolve more quickly, Orr sees a number of trends in the maritime and subsea sector that could be drivers for DFOG technology and Boreas D90 for a generation to come. "What we're seeing is there's a big focus on autonomy in the marine and subsea marketplace at the moment," said Orr. "So companies are investing a lot of money in automating both subsea systems and also sea systems. Applications that currently use unreliable magnetic heading or are heavily reliant on GPS, can now use gyro compassing and highly accurate INSs within their range."

"The biggest opportunities we would see are in the U.S. and Europe at the moment," said Orr. "We're seeing a huge amount of interest in autonomous systems, a huge demand for INS systems for subsea and maritime applications."

Need a survey?

THERE'S A US

Fugro

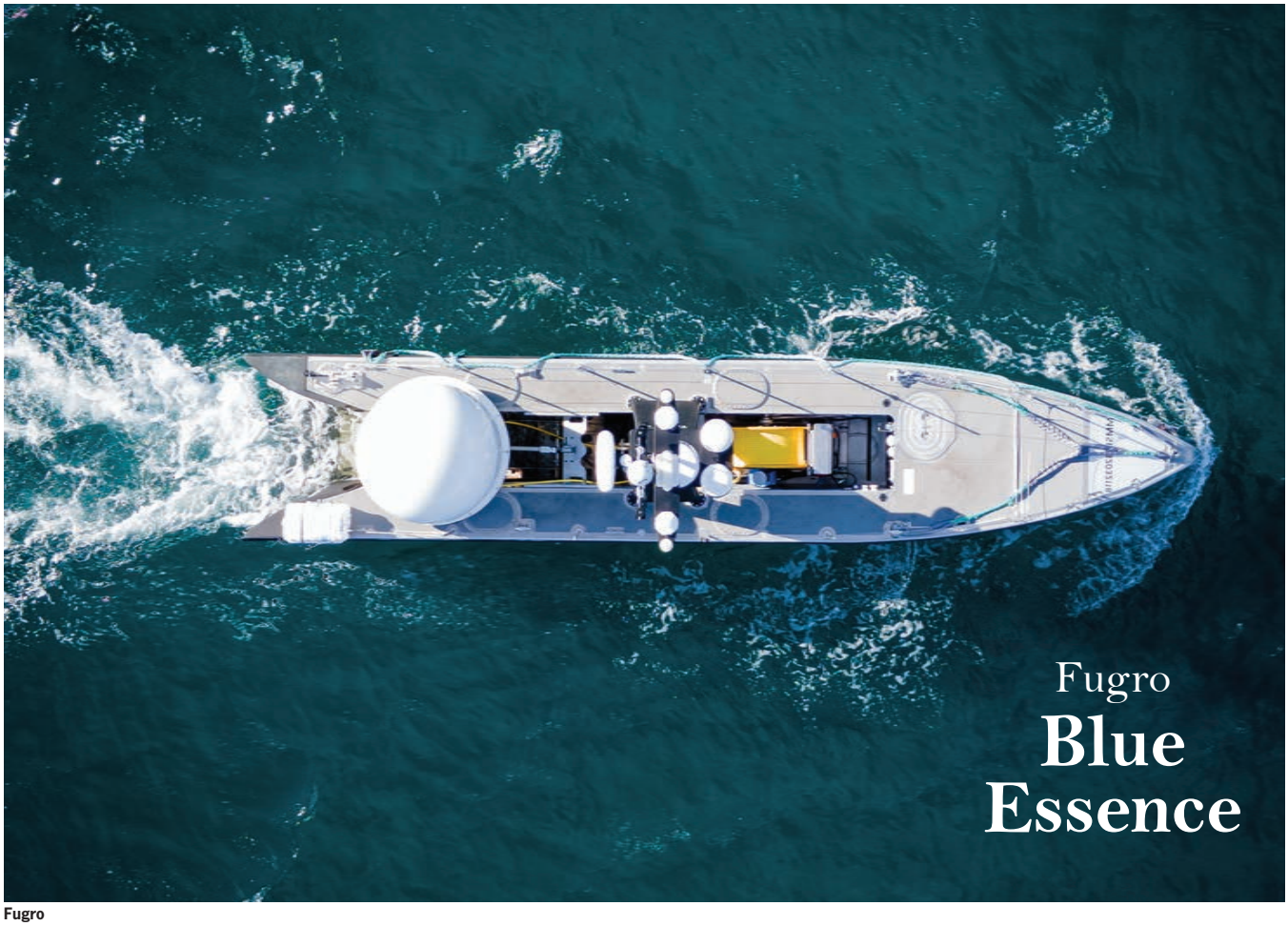
Blue Essence

Fugro

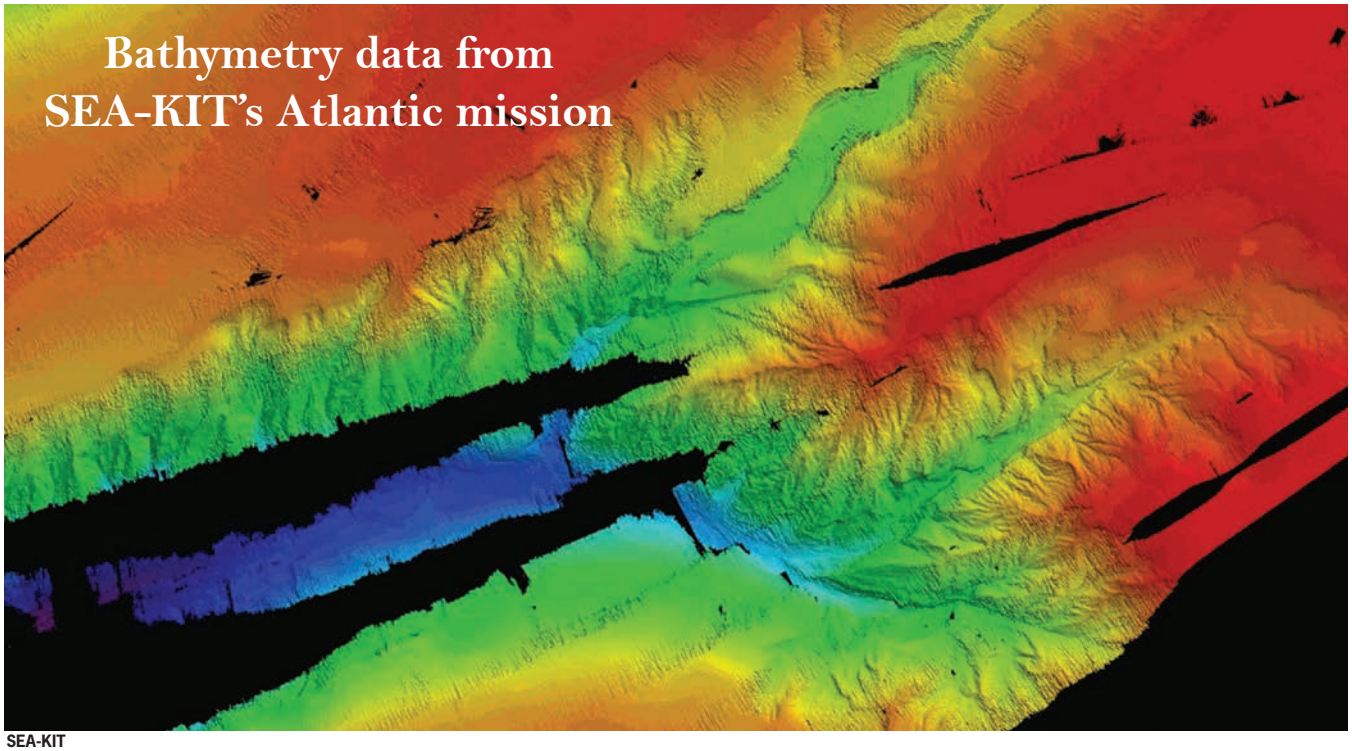
While the adoption of unmanned/uncrewed surfaces vessels (USVs) was initially in defense, use of these low footprint systems has spread into other sectors, not least survey, and now the race is on for greater capability, endurance and autonomy.

By Elaine Maslin

SV FOR THAT.



Fugro



SEA-KIT

SEA-KIT

After starting small, in inland waterways, use of USVs for survey operations has moved into coastal and now offshore waters. Given the extensive amount of seabed and rapid growth in offshore wind, there's plenty of work out there for them to do.

With the travel restrictions posed by Covid and increasing awareness of climate change, the incentives to use them have only increased.

"We are seeing a strong drive for USVs to become mainstream," says XOCEAN's CEO James Ives. "USVs offer three key benefits; safety – no people required to go offshore; environment – our USVs emit 1,000 times less carbon emissions than a conventional survey ship; and economics – USVs can deliver the same data, at a lower cost."

"USVs consume up to 95% less fuel than traditional, crewed vessels, supporting international ambitions for net zero global emissions in the marine industry," says Ben Simpson, CEO as USV manufacturer SEA-KIT.

"The decrease in at-sea man-hours, reduced operator workloads, increased efficiency, along with extended endurance, and decreased carbon footprint, have also provided significant risk reduction and environmental benefits," adds Rick Williams, Director, Unmanned Surface and Subsurface systems in the Maritime Sector, at L3Harris.

The trajectory is clear. Ivar de Josselin de Jong, director of remote inspection at Fugro, thinks that in the next decade, there will be more uncrewed operations than crewed operations. "That whole business will look completely different," he says. "An offshore survey vessel has 30-50 people on board. We're moving to solutions where we have all personnel working in the safe onshore environment, with HSE and CO2 footprint reduction. It's super exciting."

FUGRO

Fugro started working on USVs 6-7 years ago, says de Jong, with the goal to make operations more effective and more efficient. One of the first initiatives was a 2m-long prototype with an MBES and remote-control capabilities for inland waters. Fugro also converted a small survey boat to uncrewed for cable landing surveys and shallow water activities. Seabed mapping followed, in partnership with ASV Global Ltd., now L3 Harris ASV, with whom Fugro developed its 9m-long diesel-powered Blue Shadow vessel, equipped with an EM 2040 MBES and "developed to provide a high-speed hydrography solution," says de Jong. Fugro envisions multiple Blue Shad-

ows operating as force multipliers from a parent vessel – covering more area without additional people offshore.

Part of that development meant developing an adaptive line planning system, which recognizes the data and water depth and then automatically applies the right line spacing in the survey program to comply with whatever the level of quality of data is required for any specific job.

"These units are operational and we are delivering two large survey scopes in Australia for the Australian Hydrographic Office," says de Jong. The first was a 1,000 sq km survey in the Gulf of St Vincent the second was in the Torres Strait in northern Queensland covering 1,200 sq km. Over four months (starting May) another survey is being done north of Broome. Both have seen a parent vessel and USV deployed from that vessel, using a dedicated LARS, performing survey operations, as part of Australia's HydroScheme Industry Partnership Program (HIPP).

Meanwhile, the first of Fugro's 12m, SEA-KIT-built Blue Essence hybrid USVs, which come with a Blue Volta eROV, have also gone into operation on pipeline inspection work off Australia. The second is scheduled for delivery to Fugro in Aberdeen in June this year. Designed for up to 30 days operation, supporting regular survey operations, or ROV inspection for up to 10 days, these vessels are operated beyond visual line of site. A bigger 24m vessel is coming, which will have similar survey capabilities, as well as geotechnical investigation capabilities. The goal is to cover the whole marine site investigation and marine asset integrity business scope, says de Jong.

DRIX

iXblue launched its diesel-powered 7.7m DriX USV, designed for seakeeping, stability and low noise, in 2017. On a survey mission, working at 8kts, it can run for five days, before needing to be recovered, refuelled, inspected and relaunched – itself just a three-hour exercise, says Guillaume Eudeline, USV and boats Business Development Manager at iXblue.

About 10 DriXs have been sold to date, including one to the US' National Oceanic and Atmospheric Administration (NOAA) and organizations in South Korea and Australia. They're mostly being used for traditional survey/seabed

Sounder USV

Kongsberg

mapping, which DriX's stable submarine-shaped form and payload gondola supports. But it's also done pipeline/cable inspection, positioning of beacons and positioning and communications with an AUV in 1,000m water depth and it can carry a wide payload suite, from MBES to integrated USBL and LBL, sub-bottom profilers and magnetometers, all within the gondola, says Eudeline.

Recent DriX projects include work with SHOM, the French Navy's Hydrographic and Oceanographic service, using a launch and recovery system (LARS) on board the Beautemps Beaupré (BHO) hydro-oceanographic vessel. Reference areas down to 200m deep were surveyed, at up to <14 knots and in rough seas, with over 2,000 km of survey lines completed over two, 72-hour non-stop missions.

In trials last year, DriX operated in 25-50m water depth with 35kt winds generating 2.5m wave height and peak 4.5m waves (sea state 5/"rough"), but was able to conduct MBES lines staying within 1m and with heave at only -1.2-1.2m. iXblue has also tested remote operation of DriX, over 900 km, and its collision avoidance systems. In recent trials, when four catamarans in a sailing school went past DriX at speed, it automatically avoided them all, faster than a guard boat could react, says Eudeline.

iXblue's next steps for DriX include developing a towfish payload, to further expand its capabilities. iXblue also wants smaller survey companies to be able to use DriX, so it's exploring a small launch and recovery boat, initially crewed, but eventually uncrewed. In the short-mid-term, the goal is full ocean depth sensor capabilities, which means a bigger version of DriX. Longer term, iXblue is eying something even bigger that can work directly out of port without support, says Eudeline. This could also be a platform for other systems, such as ROVs and AUVs and would take a different form to DriX, says Eudeline.

SEA-KIT

SEA-KIT made its name as part of the winning GEBCO-NF Alumni team entry to the Shell Ocean Discovery XPRIZE competition, which involved surveying seafloor at 4,000m depth, completely uncrewed. The GEBCO-NF team did that by getting SEA-KIT's parent company Hushcraft to design a

USV capable of launching and recovering a Hugin AUV.

SEA-KIT's proof-of-concept USV Maxlimer has gone on to do pipeline inspections (deploying a Hugin) up to 100km from the shore and has carried MBES for full ocean depth operations (as part of a 22-day Atlantic mission, surveying more than 1000sq km of previously unmapped ocean floor). With Fugro, it's also integrating ROVs into USVs.

Payload evolution has been a big part of SEA-KIT's development, but it's also been about moving from line-of-sight to over-the-horizon remote control and line-of-sight AUV launch/recovery to over-the-horizon AUV launch/recovery and remotely controlled navigation in congested waters and extended ocean survey operation, says Simpson.

The company delivered one vessel last year and will deliver three this year and expects to maintain that speed of growth for the foreseeable future, with more classes of vessels. SEA-KIT's latest offer is the 12m X-Class. This year, it's working on the design, build and delivery of its 24m-long Omega class USV and a surveillance platform, both as full Class builds, working with Lloyds Register. These will "offer higher payload capacity, higher cruising speed, longer endurance, additional redundancy, etc." says Simpson. Increased autonomy, improved dynamic positioning, additional sensors, higher capacity communications and more advanced obstacle avoidance are also on the cards, he says.

KONGSBERG

Kongsberg Maritime's 8m-long diesel-powered Sounder USV is due to see its first delivery to a customer this summer; TASA – a Peruvian fishing company. It will be equipped with fish-finding sonars. Another two, ordered by the Norwegian Institute of Marine Research, equipped with ocean science sonars, MBES and sub-bottom profilers, are due for delivery in 2022-23.

A big focus for Kongsberg is control systems, such as K-MATE, which was integrated into SEA-KIT's GEBCO-NF XPRIZE USV, and marine broadband communications, which allow for going beyond line of sight, to enable continued safe remote operation with a level of navigational autonomy and yet extend the range of operations.

L3HARRIS

Founded in 2010, UK-based ASV Global was early on the scene as a USV developer. Now part of L3Harris, the firm has more than 125 USVs in operation and 2,100+ hours at sea. The firm's USVs use its ASView platform, which uses

L3 Harris

artificial intelligence and machine learning for its mission and situation awareness autonomy.

L3Harris's 5.5m-long, diesel powered C-Worker 5, designed to operate for up to seven days at 7 knots, with a variety of payloads, including multibeam sonar, side scan sonar and sub-bottom profilers, has become a regular hydrographic survey platform.

"Since 2015, a NOAA contractor uses our C-Worker 5 platform each year in Alaska as a force multiplier, with over 20,000km of operational experience to date, to update nautical charts in remote areas," says Williams. L3harris USVs have also been used to update nautical charts along Florida's Gulf Coast for NOAA. "There are intentions to use the same class of vehicle to do a similar job for the Australian Hydrographic Office off the country's south coast," he adds.

XOCEAN

Founded in 2017, XOCEAN has done more than 100 projects, largely covering bathymetric surveys for hydrographic offices and site-investigation surveys, many for offshore wind companies, with its XO-450, a 4.5m-long diesel-electric USV with 18-day/1,512m-range, at 4kts.

It recently delivered a site investigation survey on Ørsted's Hornsea One Offshore Wind Farm, the world's biggest offshore wind farm. One of its XO-450s was launched and recovered from shore, transiting over 120km to the survey location to complete the survey in up to 1.9m max wave heights, providing high-resolution seabed data in 30m water depth, says XOCEAN.

The firm has its sights on growth. Having doubled its staff to 82 over the last 12 months, it's on target to quadruple revenue in 2021 and is looking to grow its fleet from 14 USVs to 40 by the end of next year (2022).

Challenges

It may seem like these vehicles have had a smooth journey to industry adoption. However, customers have had to get over a misperception that the survey data they gather is somehow inferior to that obtained from a traditional crewed vessel, says Williams. In fact, the data quality is often better – as well as safer and less expensive to acquire, he says. Many also think it means people are not involved, when USVs are actually controlled by people in remote operations centres (ROCs), says Simpson.

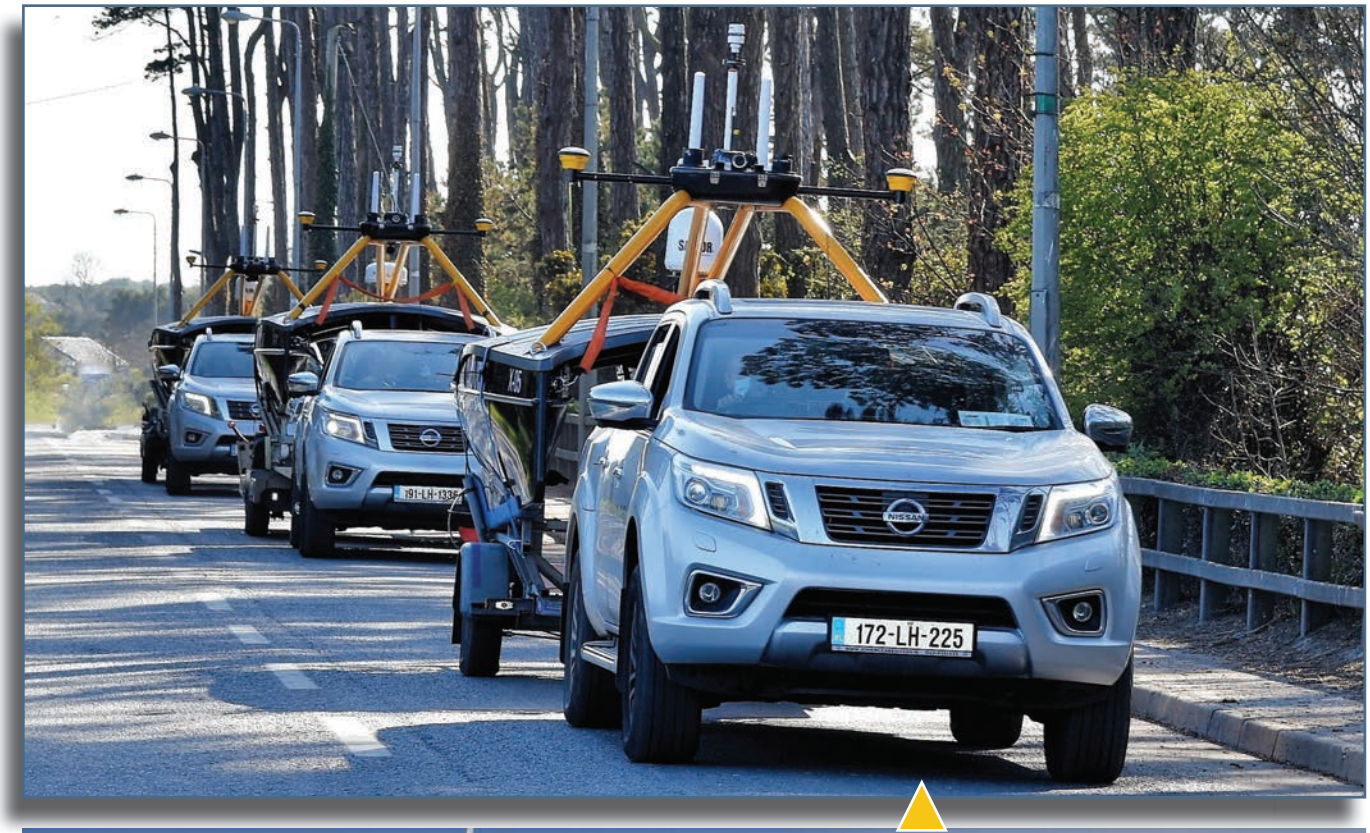
There are other misconceptions to overcome. Initially, many looked at USVs as toys, says Eudeline. But, when customers then test and use it, they see they can reduce margins down, get better data and do less post processing and that it's reliable. Now the challenge is that customers keep asking for more and more capabilities, and of course they want it yesterday.

People also always ask about redundancy – what happens if something goes wrong or you lose connectivity, says de Jong. "There are a lot of redundancies in the systems we develop; there's no single point of failure in communication or control. A lot of people don't realise how far the technology is already," he says. "We can operate an ROV in 1,500 m of water on northwest shelf of Australia from our Aberdeen ROC."

Communications

Still, there's some concern about communications during longer missions. "We're providing cleaner data, which needs less post-processing, but what do we do with that huge amount of data?" says Eudeline. The options are to store and retrieve it, at the end of a mission, or use costly satellite communications. It's a challenge iXblue and others are trying to address though bandwidth exploitation.

Kongsberg's Seatex Maritime Broadband Radio (MBR) offers high bandwidth communications and direct control over



XOCEAN
USVs Departing for Site

XOCEAN

10s of km, says Mills. Telemetry, video, payload or mission data can then be rebroadcast anywhere via Kongsberg's Kognifai cloud services. Doing this with satellite communications is a next step, but this will mean dealing with bandwidth limitations and latency. "So we will need to be more selective about what information is transmitted and what commands are available," he says. "That may mean transferring more autonomous capability to the USV in the long term."

Fuel use

How future systems are fueled is also being examined. Many currently use diesel or diesel-electric hybrids. It's a trade-off, says Eudeline. DriX's 38hp engine uses 2l/hour. An electric equivalent would need a 7-ton battery, he says. However, using DriX results in 1.5kg of CO_2/mile compared with 90kg/mile emitted by a crewed vessel, he says. But, "as technology advances and USVs evolve, we're exploring different things, such as hybrid propulsion," says Eudeline.

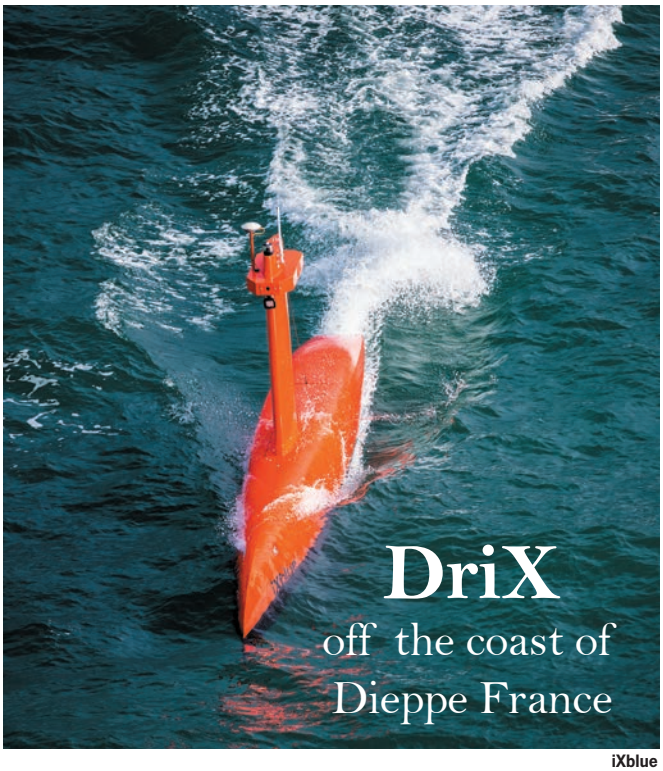
Fugro's next generation, 24m USVs will be all electric. "We simply need to move to net zero vessel propulsion and that's a choice between hydrogen and electric," says de Jong. "Looking at, for example, offshore wind and the availability of offshore power, it might be logical to recharge in the field."

Regulations

Regulations – or a lack of them – remains an issue. It will take time, but it's not likely to stop progress, says Eudeline. "A big challenge we are going to face is that the regulations we currently have go back centuries," says de Jong. "We are now creating a new operational maritime environment where, technology-wise, we are there. We can operate a vessel or even an ROV in Australia from Aberdeen. But covering that with the right regulatory framework, we are not there yet. The IMO says that, at normal speed, it will take 30 years (to create that framework), if we do our best it will be 10-20 years."

"At the moment technology is leading legislation when it comes to things like collision avoidance and safe navigation," says Mills. "In other aspects, there are requirements like SOLAS (Saving of Lives at Sea) where the concept of operations and legislation is informing technological developments. Finally, operator confidence is still in its infancy, in what is an emerging marketplace with immature levels of experience. This confidence will grow over time and inform technological development, legislation and concepts of operation to improve efficiency, optimize safety and improve productivity."

There are a lot of opportunities and the market is growing – in number and use, but also in their capability and acceptance. "It's a new vessel, new software, new ROV, new legal framework, new personnel, new procedures," says de Jong. "There are 9-10 topics that are new to the industry. This isn't just about a new survey tool, it's a new way of working."



iXblue

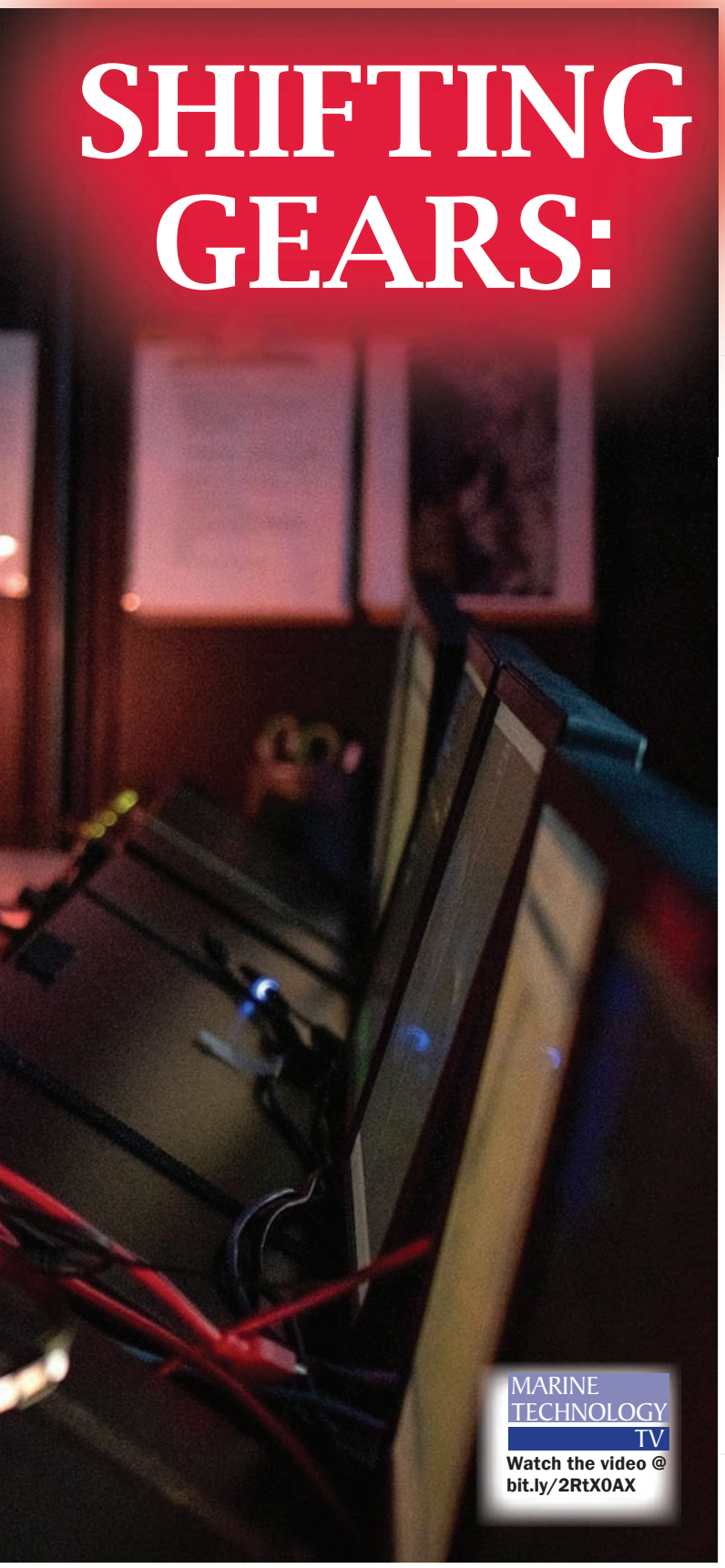
In 2019, Nautilus plied the Pacific waters off the island of Nikumaroro, searching for any sign of Amelia Earhart's lost plane. In the cool, dark control room, we kept a 24-hour vigil.

Gabriel Scarlett/National Geographic Image Collection

SHIFTING GEARS:

Up Close and Personal with Ocean Explorer

Robert Ballard



Ocean explorer and scientist ***Dr. Robert D. Ballard*** *– best known as 'the man who found the Titanic' – opens up on his personal life and his world-famous ocean discoveries like never before in his new book,* **"Into the Deep."** MTR *interviewed Ballard on the contents of the book, which was released in May 2021 with a follow-up National Geographic television special scheduled for June 14, taking a deep dive into his dyslexia, the importance of his family throughout his career, and reflections on what's important – and what is not –in life and in a career spanning 62 years, 157 (soon to be 158) expeditions and the long list of 'world first' deep ocean discoveries under his command.*

By Greg Trauthwein

At the age of 78, Robert D. Ballard is and always will be a scientist, an ocean explorer intrigued by finding clues to the unknown. Currently engaged in a 10-year, $100m program with NOAA's Office of Ocean Exploration to map and characterize the US EEZ, a project which teams his ocean exploration trust with Woods Hole, the University of Rhode Island, the University of New Hampshire and the University of Southern Mississippi, Ballard has not been on the sea for nearly two years due to the impact of COVID.

But Ballard – the author of multiple books, papers and articles, the subject of TV and film – took the time to take a different path of discovery and reflection, into not just his career but also his personal life.

"I wrote a book, Eternal Darkness, with Princeton Press, and it got a really good review from the New York Times. But then they said, 'I didn't learn a thing about the person,'" said Ballard. "So this is a very personal book, and it also talks about parts of my life that I even at the time I wasn't aware of."

"The Gift of Dyslexia"

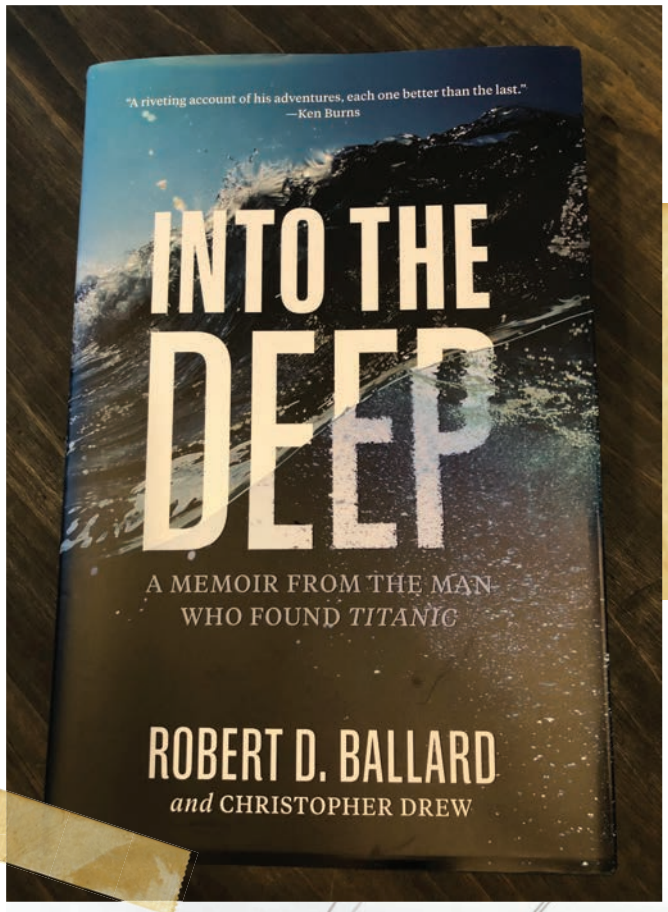
"I learned through my daughter that I'm dyslexic like her, and that was quite an awakening," said Ballard. "And I thought, maybe this is time to talk about being dyslexic."

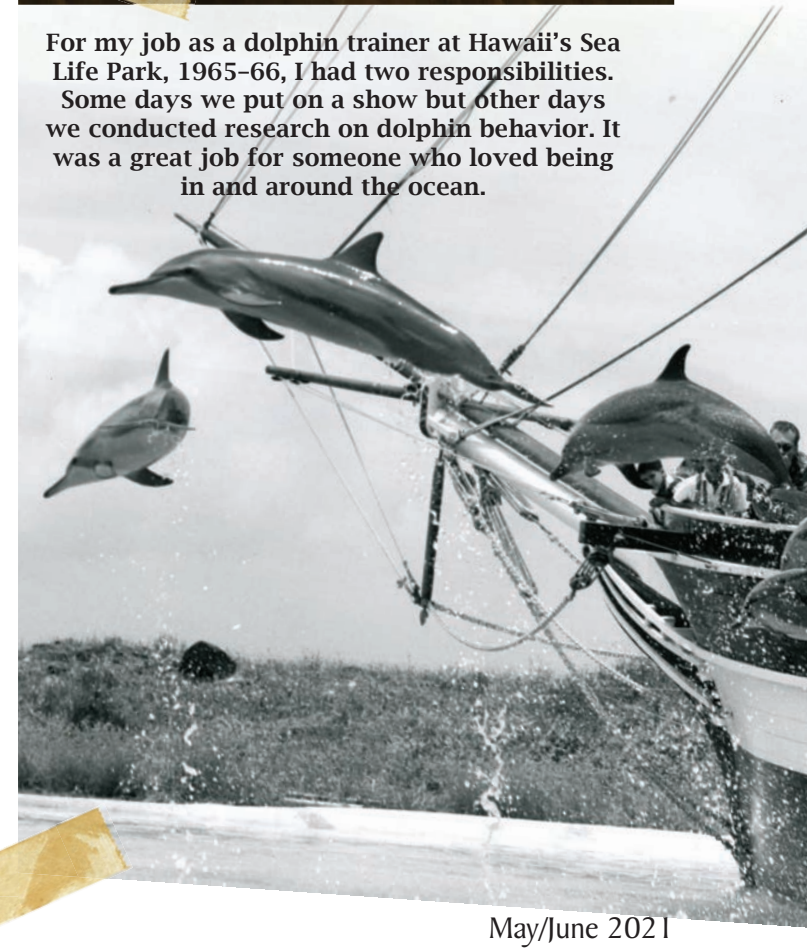
Following in the footsteps of his "super brilliant, non dyslexic older brother" Richard – who Ballard admits that even now is the smartest human being he's ever met – was a challenge for Ballard, particularly when he shared the same teachers.

"I had A's and B's, but there's a huge difference between an A minus and my brother's A plus, and that's because I learn differently," said Ballard. "I wanted to talk about that, because I view it as a gift. And most kids that are dyslexic won't talk about it and feel they've been told they're stupid. And I really want to reach out to that audience to say no, you're not. You're following a path where the rules were written by non-dyslexics. And I want to tell you about the path I went down to success, where I was able to take advantage of the gift of dyslexia."

"I didn't know I was dyslexic until I read the book The Dyslexic Advantage. I remember when I read the book … slowly … I cried because it explained me to me for the first time," said Ballard. "And now I've really embraced it. And I realize why I was able to do what I've been able to do, because I'm such a vigil creature. I can imagine things in my mind, and it's perfect when I go down to the darkest depths, I look at my sensor systems and I can form a mental image in a world of eternal darkness. I think it explains how I tick."

As Ballard gets closer to his 80th birthday, he has become more reflective on the balance of personal and work. "Two years ago I was in a Redwood forest and a brilliant professor from Harvard, Arthur Brooks, talked about how to stay happy while you grow old," essentially three things you need to do, said Ballard. First on the list is developing closer bonds with friends, which Ballard has done spending more time "hunting





For my job as a dolphin trainer at Hawaii's Sea Life Park, 1965–66, I had two responsibilities. Some days we put on a show but other days we conducted research on dolphin behavior. It was a great job for someone who loved being in and around the ocean.

***Dr. Robert D. Ballard**'s new memoir* **Into the Deep** *"... is a very personal book" full of information and images that the ocean explorer has never shared with the public.*

Born in Kansas yet a California kid, I still found myself right at home with the Boston Sea Rovers during our annual lobster dives.

Commissioned as a second lieutenant in Army Intelligence as I graduated from the University of California, Santa Barbara, in January 1965, I'm proudly saluting in front of the family car.

All photos on spread courtesy of Robert Ballard

and fishing" rather than academic and professional projects. Second is mentoring the next generation, which led to Ballard hiring a team to help manage his activities across his military, academic, popular science and business endeavors. The third piece of advice has been a bit more difficult for Ballard to enact, as he said with a laugh: "The third thing is the one I'm having a little difficulty with: 'The next time a big project comes along, say no!' I've never said no. So I'm struggling with that one, and you'll have to check back in and see how I do it."

Mentors & Mentoring

Ballard counts his mom – who recently passed away at the age of 98, having cared for his handicapped sister her entire adult life – as his most influential mentor in his life. "I had a tough time; it was not easy to get where I got, and she was always the person that picked me up when I fell down." She was also the one who would help keep Ballard solidly grounded. Upon watching all of the international media hoopla surrounding his discovery of the Titanic, she congratulated him but said: "Too bad you found that rusty old boat, because you're a good scientist and now they're only going to remember you for finding that boat."

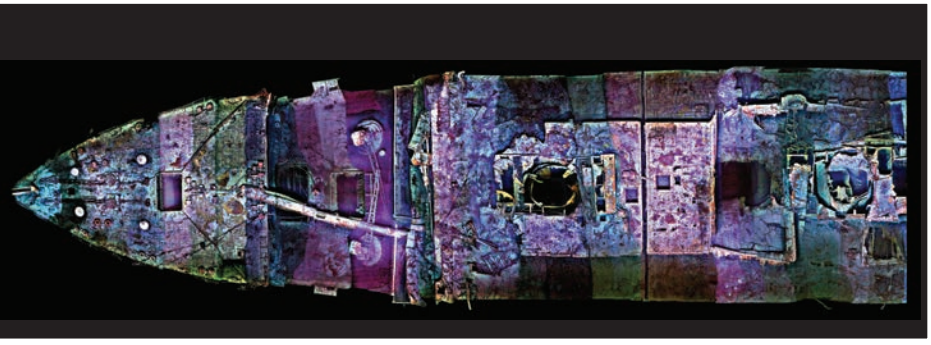
Mentoring has, and continues to be vitally important to Ballard, a lesson learned at an early age. As a boy growing up in Southern California, he had the opportunity to meet Scripps Oceanography Director Roger Revelle who is widely regarded for not only establishing the institution as an internationally prominent science center, but for solidifying the decades-long relationship between Scripps Oceanography and the U.S. Navy. Revelle served as an oceanographer for the U.S. Navy during World War II and was instrumental in the founding of the Office of Naval Research. Revelle worked at Scripps Oceanography before and after the war and served as its director from 1950 to 1964.

"When I met with Roger Revelle, he said oceanography is not something you take in undergraduate, that's a graduate program," said Ballard. "He said 'you really need to ground yourself in a basic science first."

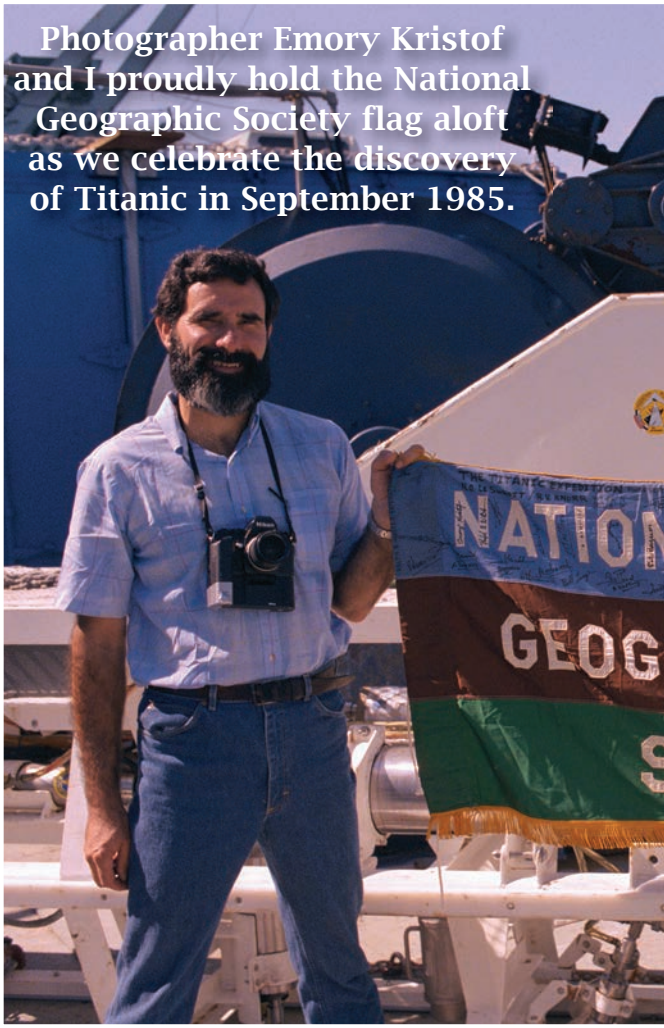
Taking his advice to the extreme, Ballard enrolled at UC Santa Barbara with quadruple major in chemistry and geology,

WHOI, Mosaic/Ballard Family

Mosaics of the Titanic deck in 1985 (black and white) and 2004 reveal damage over those 19 years. The crow's nest on the mast, near the bow, disappeared. The aft funnel (color) suffered significant damage. Some say time caused the damage, but I blame the numerous submersible dives since 1986, carelessly banging into the ship. **Visitors are literally loving Titanic to death.**



Hanumant Singh, WHOI, and IFE/IAO



Photographer Emory Kristof and I proudly hold the National Geographic Society flag aloft as we celebrate the discovery of Titanic in September 1985.

Emory Kristof/National Geographic Image Collection

with minors in physics and mathematics. "So I sort of became a Swiss army knife, master of nothing but pretty good at a lot of things. Today you don't get a job and retire and get a gold watch. You go through multiple evolutions. And I've been able to recast myself multiple times because I've had that really strong, broad based experience in math, physics, chemistry, and geology. So I'd say get a really broad base in the sciences."

Beyond "That Rusty Old Boat"

The list of discoveries under Ballard's guise is long and distinguished, and while the discovery of Titanic was his most acclaimed among the general population, it's not his favorite. "Everyone wants me to say Titanic. I like to say, 'Kids, my favorite discovery is the one I'm about to make,' because rumors of my death are greatly exaggerated.'"

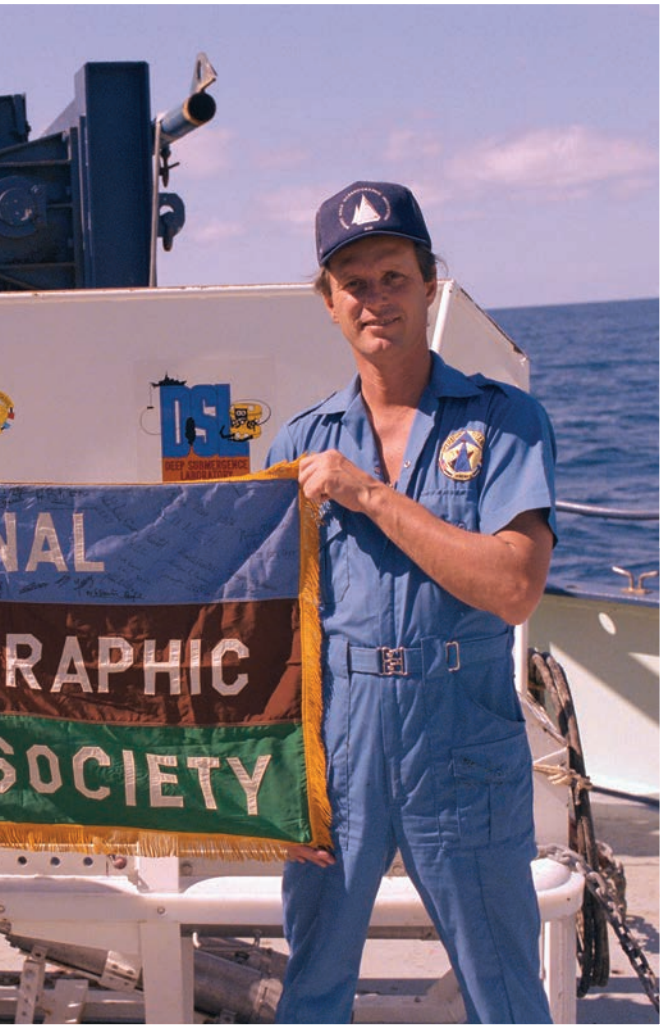
In fact, he has two favorite discoveries, but he calls the discovery of hydrothermal vents – Black Smokers – as the show-stopper.

"That rewrote the biology book, that was clearly one of the most significant discoveries ever made in the ocean," said Ballard. "Discovering hydrothermal vents and life system completely opened up prospecting for life throughout the universe and even within our own solar system."

Another favorite was the discovery of perfectly preserved ancient shipwrecks in the anoxic bottom waters of the Black Sea. "That was another home run," said Ballard.

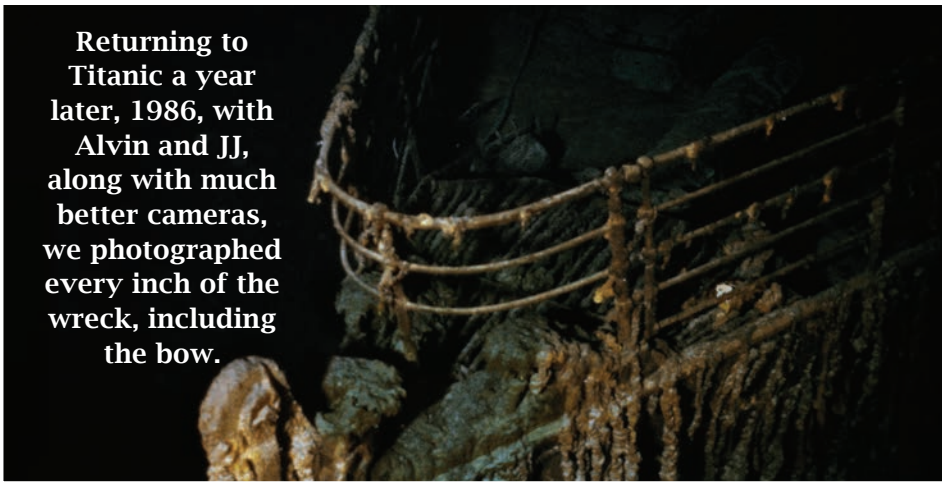
While Ballard has spent much time at sea, on and below the waters, he sees the future generation 'exploring' the oceans from the comforts of their own offices, labs and homes. Specifically, he sees the evolution of telepresence technology and autonomous systems as working collaboratively to help future scientists and explorers learn even more about what lies in the ocean.

"Now with the use of AUVs and autonomous surface vehicles, we have a whole cadre of tools we're using; we call them force multipliers … it's going to be autonomous everything," said Ballard. "I don't expect humans to go to sea much (in the future). I mean, I love horseback riding, but I don't ride a horse to work. We're going to be very much in the world of more and more intelligent autonomous vehicles."



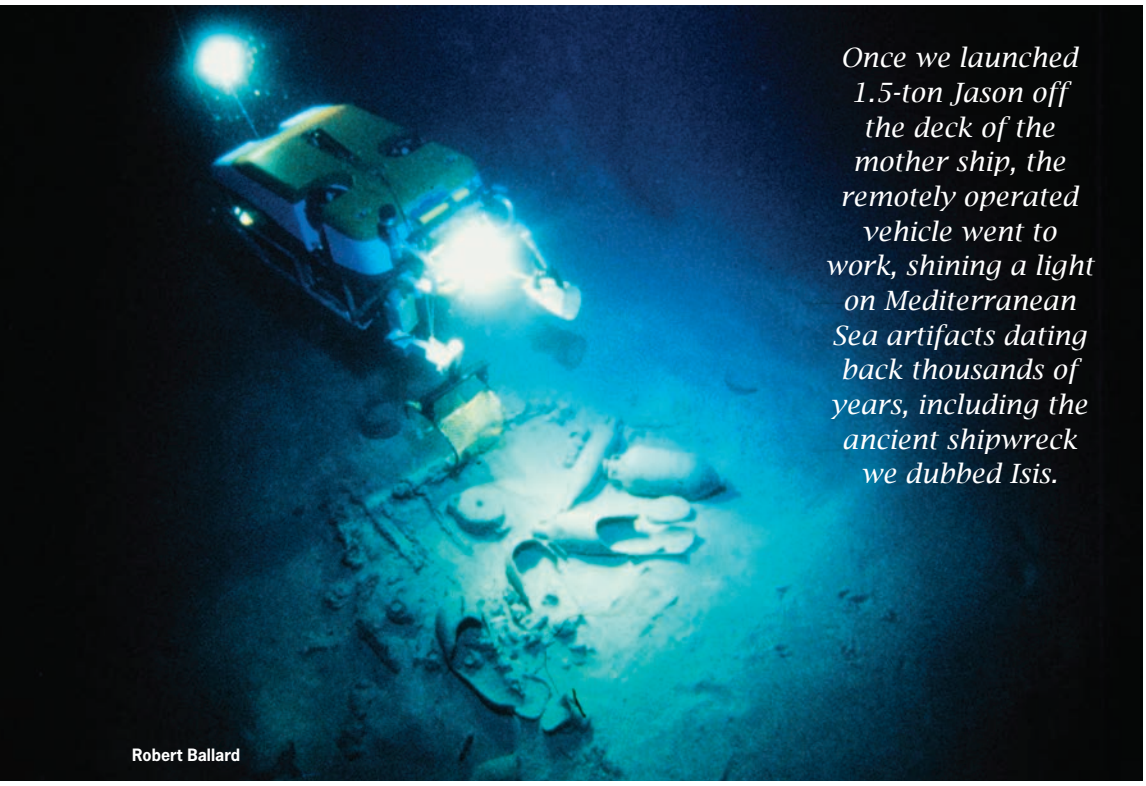
Emory Kristof/National Geographic

Memories of leisure and luxury strew the Titanic site, such as the wroughtiron sides of deck benches, their wooden seats long rotted away.



Returning to Titanic a year later, 1986, with Alvin and JJ, along with much better cameras, we photographed every inch of the wreck, including the bow.

Robert Ballard and Martin Bowen/Woods Hole Oceanographic Institution (WHOI)

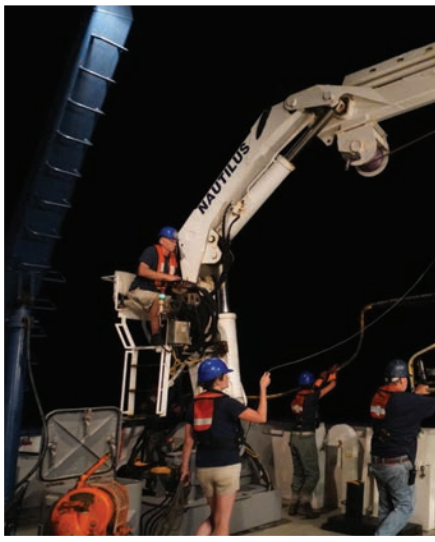


Once we launched 1.5-ton Jason off the deck of the mother ship, the remotely operated vehicle went to work, shining a light on Mediterranean Sea artifacts dating back thousands of years, including the ancient shipwreck we dubbed Isis.

Robert Ballard

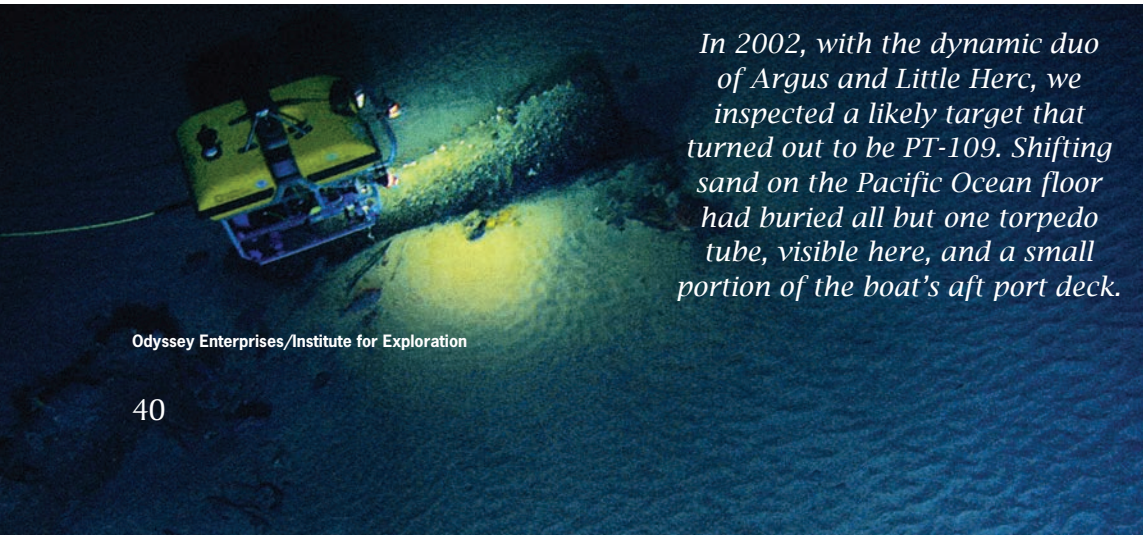
Drones filming from above reveal Hercules as it scours the ocean floor day and night for any sign of the famous aviator who disappeared in 1937.

Inset below: Jesse Goldberg/National Geographic Image Collection



Early in the 1989 search for Bismarck, **Argo snagged underwater cables**—*the black lines in this photograph, adding to the stress of the expedition.*

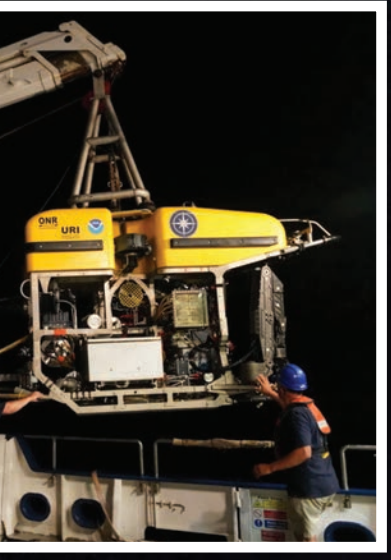
Joseph H. Bailey/National Geographic Image Collection

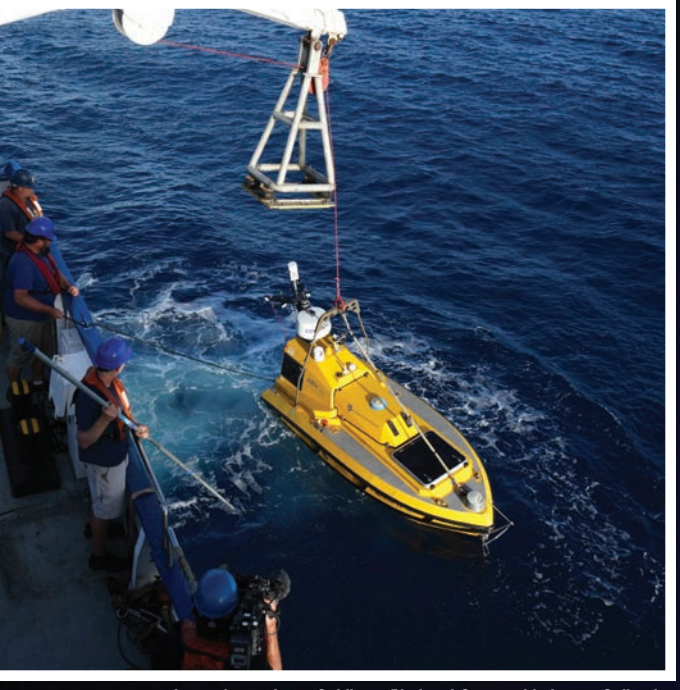


In 2002, with the dynamic duo of Argus and Little Herc, we inspected a likely target that turned out to be PT-109. Shifting sand on the Pacific Ocean floor had buried all but one torpedo tube, visible here, and a small portion of the boat's aft port deck.

Odyssey Enterprises/Institute for Exploration

Ernie Kovachs/National Geographic Image Collection





Inset above: Jesse Goldberg/National Geographic Image Collection

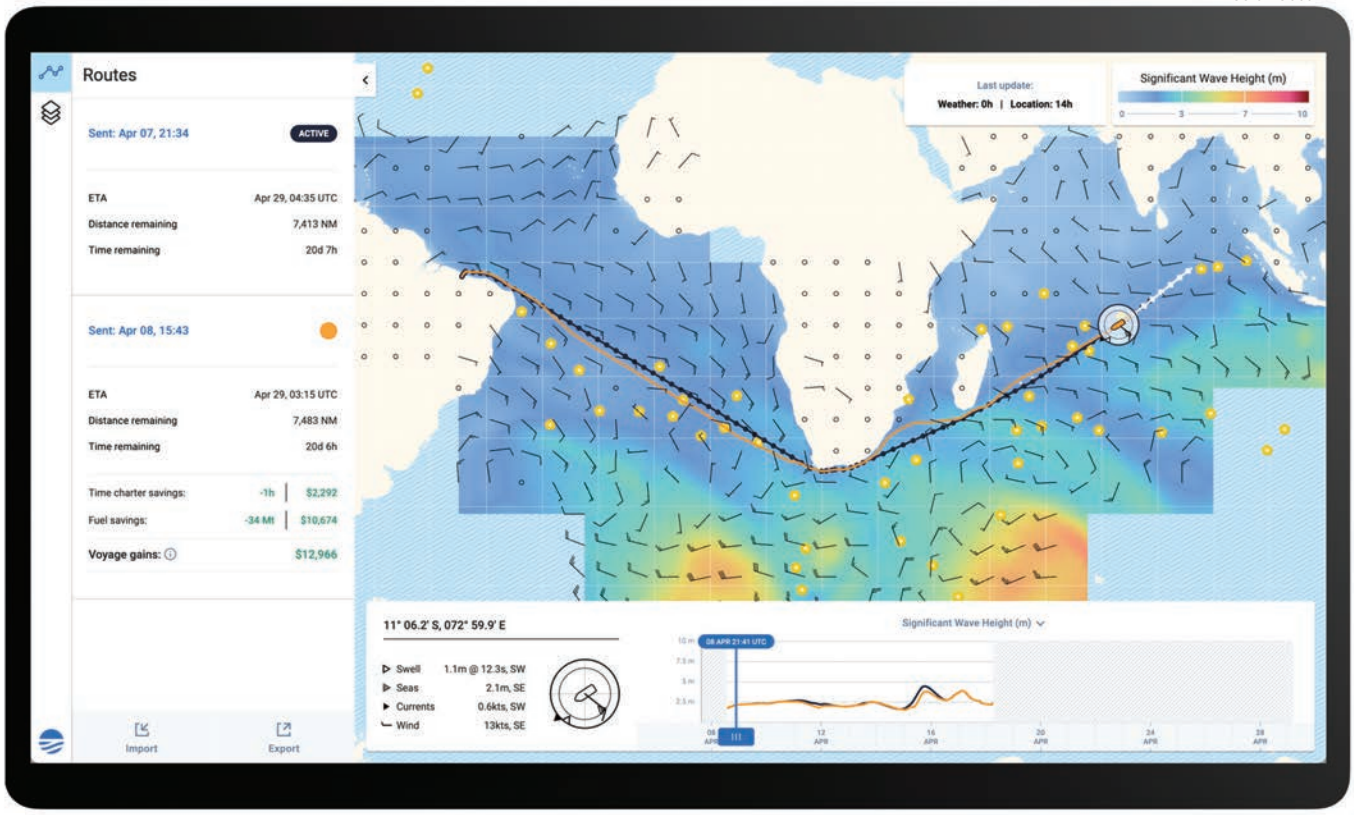
Rob Lyall/National Geographic Image Collection

The Forecast for Weather-Spotting Technology

By Celia Konowe

Sofar Ocean's free drifting Spotter buoy in open ocean water.

Sofar Ocean



Sofar Ocean Wayfinder vessel routing platform in action.

The upcoming UN Decade of Ocean Science for Sustainable Development (2021-2030) should herald an increase in marine exploration, aiming to better understand our oceans to reverse the declining health of ecosystems. Heightened knowledge about these waters means a stronger, more effective commitment to even further exploration and to mitigating the impact of weather systems on coastal communities and marine ecosystems.

Weather spotting and its related technologies are not a new industry, nor do they lack in notable achievements. Since the late 1800s, various strategies, including at-sea observations, buoys, satellites, and statistical and modeling predictions have been used to better identify and comprehend weather patterns, both short and long term. However, today we strive for quicker, more accurate and more detailed data for increasingly effective models. To do that, though, we must continue exploring ocean-atmosphere dynamics, which inevitably requires more observational data. Like our struggles with understanding the deep sea, our arsenal lacks data, which is often costly, time intensive and difficult to collect. One group, however, is pushing to change this norm by connecting the world's oceans together.

Sofar Ocean, a San Francisco-based creator of marine instruments for data collection and weather forecasting, is determined to increase the collection of and access to ocean data, as well as provide critical insights to scientists, communities and industries around the world. Its Spotter technology, designed to autonomously collect data on waves, wind and water temperature, as well as their Smart Mooring, a modular, real-time monitoring platform, play important roles in ameliorating the current shortage of information needed to address the

Dr. Mark Buckley of the USGS St. Petersburg Coastal and Marine Science Center holds a new Sofar Smart Mooring and Spotter Buoy that will be used to deliver high-fidelity, real-time wave, water level, and wind data. These data will be used to validate and improve the USGS/NOAA Total Water Level and Coastal Change Forecast, which provides real-time forecasts of water levels and coastal change along nearly 3,000 miles of the U.S. Gulf and Atlantic coasts.

health of our oceans. "We set out to deploy a global distributed sensor network of live weather sensors, driving real-time ocean weather data into models for better forecasts and situational awareness…we can now improve ocean wave forecasts by more than 30%," said CEO Tim Janssen. This is only the start, he added; by the end of the year, global coverage will be achieved with more than 2,000 live sensors at any given time.

In addition to sensory technology, Sofar Ocean designs modeling platforms, like the Wayfinder, engaging their created ocean networks and gathering "real-time observational data to reduce forecast uncertainty and generate open ocean weather forecasts." Wayfinder combines data collected from forecasts and live sensors with a "new approach" to ship routing, inspired by dynamic routing solutions on land like Google Maps and Waze. "For vessel routes, the Wayfinder optimization engine finds the best combination of waypoints and speed profiles from hundreds or millions of options, while accounting for economic and operational constraints (ETA, TCI, bunker price, fuel consumption, seakeeping, safety etc.)," Janssen explained.

Weather spotting represents a crucial element to achieve the larger goal of marine exploration and climate awareness. "We cannot manage what we do not understand. And we cannot understand what we do not measure or observe. We know more about the surface of the Moon than we do about our own oceans. And on a planet where our oceans cover more than 70% of its surface area, drive our weather and climate, and fuel over a trillion dollars in annual economic activity, we believe change is needed to enable a deeper understanding of this resource," Janssen said. Furthermore, such technology can improve understanding and awareness of real-time ocean conditions that impact sensitive ecosystems, like coral reefs. In partnership with Aqualink, an organization focused on ocean conservation technology, Sofar Ocean's Spotter and Smart Mooring equipment also do just that.

Helping the coral reefs

The plight of the world's coral reefs is well known to even the most amateur of marine fanatics. Damaging activities such as coral mining, pollution, overfishing and coral bleaching (due to warming water temperatures) have decreased reef populations in recent years, bringing alarm and a call to action to the forefront of marine crises. Aqualink, with the support of Sofar Ocean's technology, aims to create an accessible, up-to-date database of ocean temperature data collected by buoys around the world. The solar-powered and completely autonomous

Meaghan Faletti, USGS

Spotter is able to be deployed in remote locations and the buoys are "mounted along the mooring line, which doubles as a data hub, with one at one meter below the surface and the other just above the ocean floor," explained co-founder Drew Gray. To date, Aqualink has been able track even large ocean-atmosphere phenomenon like La Niña, a recurring climate pattern that brings cooler water temperatures and lower air pressure than normal (the counterpart to El Niño). Aqualink also encourages community contribution of survey imagery to complement temperature data, whether through an organization or as a citizen scientist. "Visual data offers the ability for scientists to make deeper assessments than they could on temperature data alone, such as the onset of coral bleaching," added Gray.

Coastal protection

Aqualink is one of many groups utilizing Sofar Ocean's technology in innovative ways. "We're excited to empower others," Janssen said, while pointing out other partnerships, like the University of Tokyo's use of the Spotter to better understand sea-ice interactions in the Arctic. The U.S. Geological Survey (USGS) has also begun work incorporating the buoys' abilities, this time working to protect a different kind of oce-

Meaghan Faletti, USGS

anic community—one that lives aside it, as opposed to in it.

Scientist Mark Buckley is a member of the USGS Coastal Change Hazards group, focused on improving predictions of wave-driven coastal flooding using field, laboratory and numerical modeling techniques. "As sea-swell waves (4-20 s. period) break on the coast, they transfer energy to lower frequency (infragravity; 20-250 s. period) waves and transfer momentum into the water column generating an increase in the time-averaged water level (wave setup). Sea-swell waves, infragravity waves and wave setup are the three components of wave-driven coastal flooding," Buckley explained.

During the last two decades, the USGS has invested in research that led to the development of the Total Water Level and Coastal Change Forecast (TWL&CC) model, a collaborative effort with the National Oceanic and Atmospheric Administration (NOAA) that covers about 4,700 km of open, sandy coastline on the U.S. Atlantic and Gulf of Mexico coasts. The TWL&CC Forecast Viewer is a web-based platform driven by simulations of tides, storm surge and offshore wave conditions and is used by the National Weather Service and many local emergency planners. "The TWL&CC Forecast Viewer is validated using camera systems that track coastal flooding, along with wave buoys and pressure sensors that measure wave and water level conditions offshore," Buckley said. Additionally, Sofar Ocean's Smart Mooring links a directional wave buoy and its communications system with a pressure sensor mounted on the sea floor. This saves precious time and effort, Buckley explained. "Whereas researchers would normally deploy pressure sensors for several months before retrieving and downloading the data, the data is now available in real-time."

Looking Long Range

The future of weather spotting and forecasting is one of necessity for impacted communities, ecosystems and industries. A stronger understanding of coastal hazards, as Buckley and the USGS strive for, will allow coastal managers and policy makers to make more informed decisions. The U.S. coastline is home to almost half of the country's population and extensive protected areas for coastal wildlife. Thus, changes there could have detrimental effects on lives, infrastructure and critical ecosystems, as Buckley pointed out. "Understanding how the coast will change in response to storms, waves and changing water levels can help coastal and resource managers predict and prepare for impacts to their coastal areas, enhancing resiliency in the face of a changing world."

This future vision is only achievable with more data, though, as Sofar Ocean's work reminds us. "One of the biggest advances in sensing on land and from space is the concept of distributed networks. For instance, instead of building a sin-

Ryan Born

Spotter and Smart Mooring installation in Mo'orea, French Polynesia.

gle, large and exceedingly expensive satellite with exquisite instrumentation, we build large networks of low-cost satellites with much simpler sensors," Janssen explained. The value of more data points certainly is hard to dispute. "Our goal is to use our technology to help others to help us grow our ocean data infrastructure," he added. "Our dream is for a future where interconnected, universally compatible ocean-sensing devices are a reality, ushering in a more sustainable future with universal access to ocean data and insights."

In a time of rapidly changing climatic patterns and increasing environmental anxiety, the implications of weather-spotting technology represent significant potential for saving and protecting communities, ecosystems and industries that are at the mercy of ocean-atmosphere dynamics. Advancing sensor and modeling technology, paired with innovative users and a ticking clock, will continue to enable meaningful discoveries, fulfilling our decade's dedication to ocean science and sustainable development.

MARINE TECHNOLOGY REPORTER

2021 Editorial Calendar

January 2021

Underwater Vehicle Annual

- Underwater Defense
- Manipulator Arms and Tools
- Autonomous Navigation GNSS MEMS
- Unmanned Vehicle Propulsion
- Hydrophones

Event Distribution:

Subsea Expo
February 23-25 Aberdeen, Scotland
Underwater Defense and Security
March 2-4 Southampton, UK
Ocean Business 2021
April 13-15 Southampton, UK

Digital Edition

MTR E-Magazine Edition: Oceanographic

March 2021

Oceanographic Instrumentation & Sensors

- Offshore Energy: O&G and Renewables
- Fiber Optic Cables, Connectors & Slip Rings
- Buoyancy Technology
- Scientific Deck Machinery / LARS

Event Distribution:

OTC
May 3-6 Houston, TX
Oceans Europe
May 17-21 Porto, Portugal
Underwater Technology Conference
June 2021 Bergen, Norway

May 2021

Hydrographic Survey Sonar

- Comms, Telemetry & Data Processing Software
- USV Platforms
- Magnetometers & Streamers
- GPS, Gyro Compasses & MEMS Motion Tracking

Event Distribution:

Seawork:
Jun 15-17, Southampton, UK

Digital Edition

MTR E-Magazine Edition: Hydrographic

July 2021

Autonomous Vehicle Operations

- Subsea Electrification & Residency
- ROV Technology: Work Class to Micro Systems
- Thruster Tech: Underwater Propulsion
- Underwater Tools & Manipulators
- Beacons, Flashers & Tracking Systems

Event Distribution:

Offshore Europe:
September 7-10 Aberdeen, Scotland
Oceans
September 20-23, San Diego

September 2021

MTR100: Focus on 100 Leading Companies, People and Innovations in the Subsea Space

- Interconnect: Underwater Cables & Connectors
- Offshore Inspection, Maintenance & Repair (IMR)
- Underwater Imaging: Lights, Cameras, Lasers & Multibeam Sonars

Event Distribution:

Europort:
Nov 2-5 Rotterdam, Netherlands

November 2021

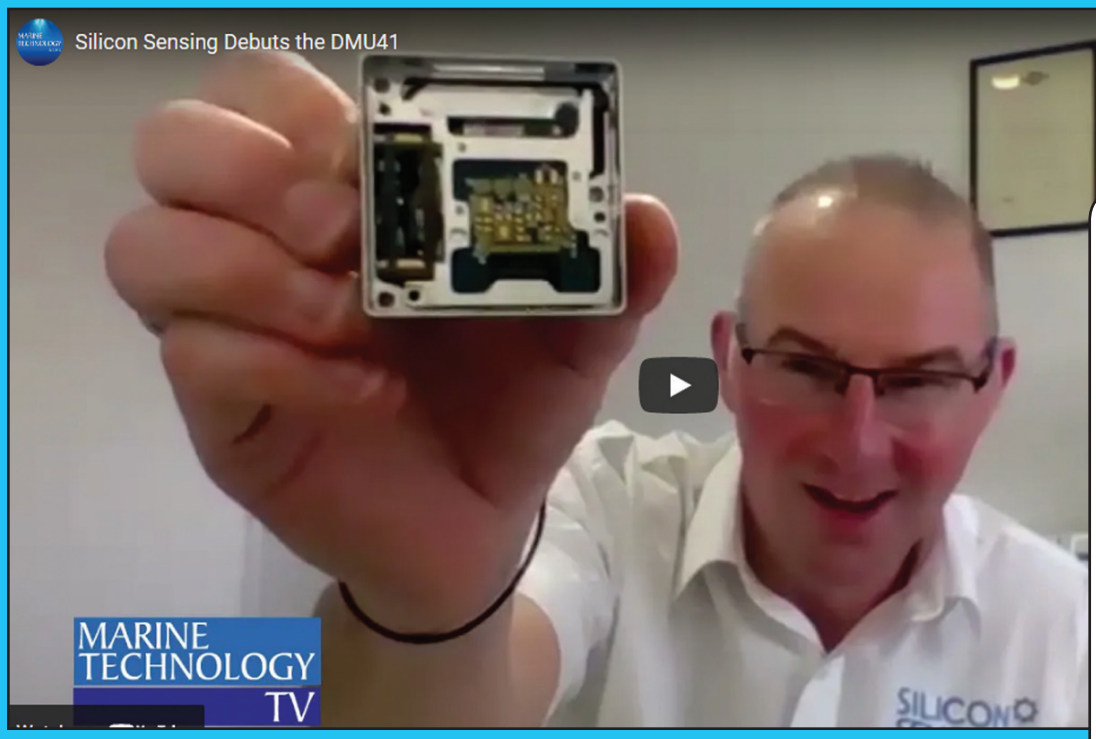
Ocean Observation: Gliders, Buoys & Sub-Surface Networks

- Acoustic Doppler Sonar Technologies ADCPs and DVLs
- Instrumentation: Profilers, Samplers & Sediment Corers
- Fresh Water Monitoring & Sensors
- Seafloor Mapping
- Geospatial Software Systems for Hydrography

Digital Edition

MTR E-Magazine Edition: Subsea Vehicles

Silicon Sensing Debuts DMU41



MARINE TECHNOLOGY TV
Watch the video @ bit.ly/3fMWczb

DMU41 Highlights

- 9 DoF inertial measurement unit
- Unit volume, weight and power consumption reduced 40%+
- 50 x 50 x 50mm
- Weighs 200g
- Typical power consumption of less than 1.5w

Last month Silicon Sensing Systems launched a new 9 degrees of freedom (DoF) inertial measurement unit (IMU) which offers a dramatic reduction in volume, weight and power consumption. ***Dr. Mark Marshall*** *(above) Consultant Engineer, Silicon Sensing, discusses the unit and the technology behind it.*

Obviously we're here to discuss the capabilities and the technical aspects of the new DMU41, but to start in the macro, what was the impetus? What were the market drivers to develop this new unit?

Basically we went and asked our customers (and prospects) what they required next, what they needed for their future products. It became very apparent that the customer wanted something a little smaller, equally as well performing as the DMU30, which is a very good product, but certainly smaller, lighter, lower power.

What do you consider to be the core? The key technical attributes of the DMU41 that make it stand apart?

That's certainly the performance of our sensors, and without a doubt delivering fiber optic type performance in a very small, low cost and robust body. This will now fit into even smaller spaces for certain customer applications, but still maintaining our high performance sensors and integrating now the magnetometer and barometer, which would open up even more potential markets for the product.

It appears that you certainly have packed a lot into a very small package. From an engineering and manufacturing standpoint, what were the key technologies or capabilities to achieving these targets?

We've used a lot of advanced manufacturing techniques. We've borrowed some ideas from the mobile phone industry and we've used some very high-performance processors within the package itself.

I'm sure the potential uses for the new DMU41 are broad. Can you give an overview of the industries or the specific vehicles that will benefit from this new technology?

You're correct, it is very broad. Wwith it being a lot lighter and smaller size and particularly the OEM version, and lower power, we'll be going after a lot of the autonomous applications now as well. I'm sure there'll be some that we haven't even considered, but also particularly the OEM where we can put that into someone else's package and make a sensor system which is even smaller.

Tech File

Innovative new products, technologies and concepts

MODUS Orders SPICE AUVs from Kawasaki

Kawasaki Heavy Industries received an order by Modus Subsea Services Limited (MODUS) in UK for an AUV called SPICE, **reported to be the world's first AUV equipped with a robot arm for performing subsea pipeline inspections.** SPICE was developed based on a fusion of submarine-related technologies and industrial robot technologies fostered at Kawasaki over many years. SPICE will be used for operations in the North Sea and other sea areas around the world after delivery to MODUS in 2021. MODUS has committed to acquire two units of SPICE from Kawasaki, of which first one was placed an order this time. A robot arm fitted with an inspection tool unit at the end enables SPICE to perform close-range inspections of subsea pipelines. In addition, it is operated using a docking station also developed by Kawasaki, which increases inspection operation efficiency and reduces cost requirements, while also benefiting crews working on a support vessel by reducing their burden and improving safety. After being submerged into the sea along with the docking station, SPICE launches itself, searches for the pipeline to be inspected, performs inspections, and returns to the docking station once its mission completes. As this entire process is handled autonomously, SPICE does not require a dedicated ROV operator or a highly sophisticated support vessel capable of dynamic positioning, unlike ROVs that used to be the standard pipeline inspection equipment.

SPICE comes equipped with an inspection tool unit fitted with close-range sensors at the end of the robot arm.

SPICE is capable of automated continuous detecting and tracking of subsea pipelines. It automatically avoids obstacles along the pipeline and continues inspections once the obstacle has been cleared. This enables uninterrupted continuous inspection operations.

After returning to the docking station under water, SPICE enables recharging the battery and sending collected data to the support vessel. SPICE can be launched and recovered underwater.

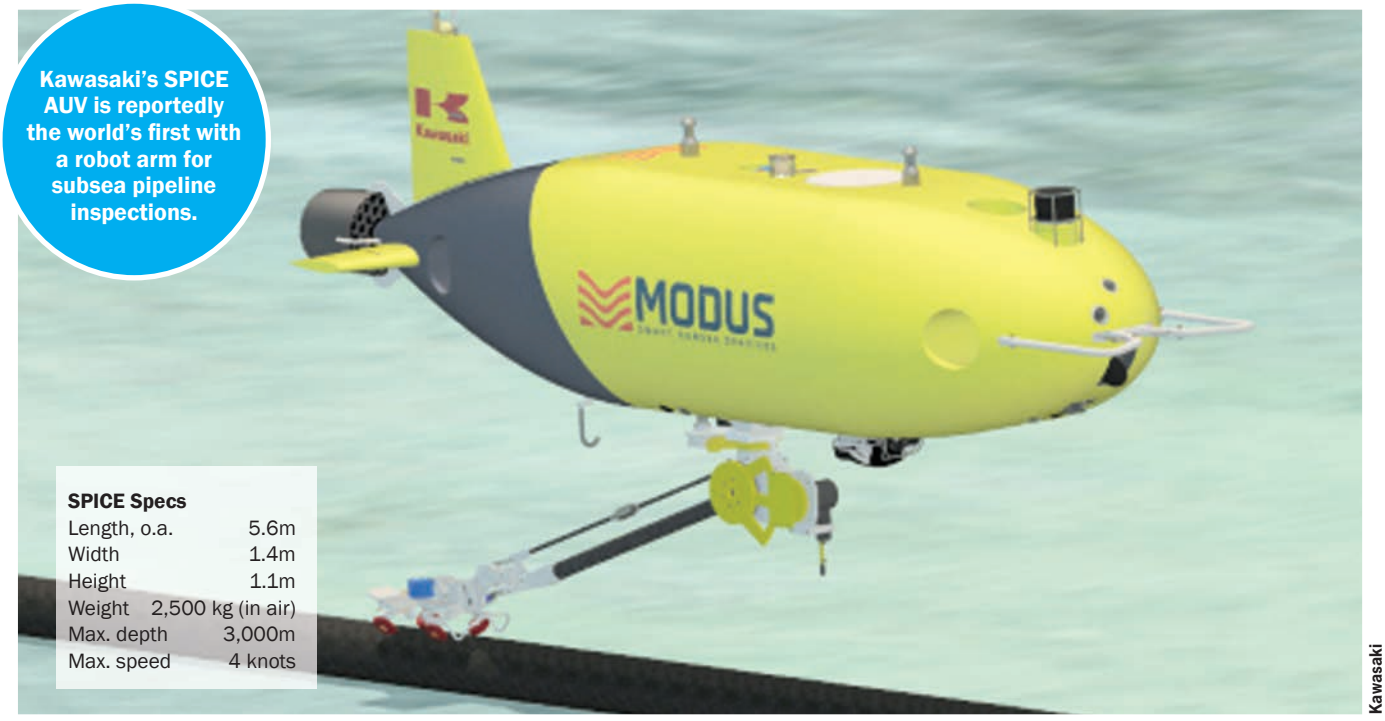
Hydromea Debuts Drone

Hydromea unveiled the prototype of a wireless underwater drone, a compact drone designed to fit into a backpack, be remotely controlled, and send HD video back in real time without any physical connection to the pilot. The unit is designed to deliver significant benefits in a number of inspection scenarios in confined flooded spaces, such as hydropower dams, closed waterways and ballast tanks on ships. "Our underwater drone works without a cable and sends full HD video stream back in real time," said Igor Martin, co-founder and CEO of Hydromea. "This eliminates risks of getting stuck in complex flooded spaces."

www.hydromea.com

Hydromea

Kawasaki's SPICE AUV is reportedly the world's first with a robot arm for subsea pipeline inspections.



SPICE Specs

Length, o.a.	5.6m
Width	1.4m
Height	1.1m
Weight	2,500 kg (in air)
Max. depth	3,000m
Max. speed	4 knots

Kawasaki

Tech File

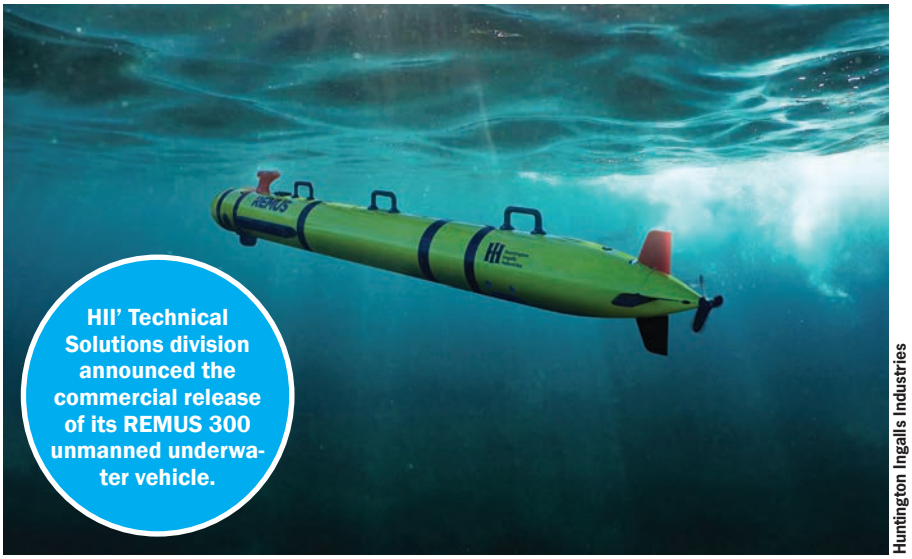
Innovative new products, technologies and concepts

HII Commercial Release of REMUS 300 UUV

Huntington Ingalls Industries announced the commercial release of its REMUS 300 unmanned underwater vehicle (UUV). This new, open architecture, small-class UUV can dive to depths of 305 meters (1,000 feet) and has endurance options up to 30 hours.

"The REMUS 300 combines everything we've learned from more than 20 years of development on our REMUS 100 systems with enhancements like advanced modularity and a more robust structure and sensors," said Duane Fotheringham, president of the Unmanned Systems business group in HII's Technical Solutions division. Modular energy sections allow for field replacement of 1.5, 3.0 or 4.5 kilowatt-hour lithium-ion batteries enabling up to 10, 20 or 30 hours of endurance.

www.huntingtoningalls.com



HII' Technical Solutions division announced the commercial release of its REMUS 300 unmanned underwater vehicle.

Huntington Ingalls Industries

Dive Technologies, Kraken Completes Sea Trials

Dive Technologies completed successful sea trials of Kraken's Miniature Synthetic Aperture Sonar (MINSAS 120) integrated onto Dive's Large Displacement Autonomous Underwater Vehicle (DIVE-LD). The DIVE-LD is also powered by Kraken's pressure tolerant batteries. "Over seven days we completed 30 missions and collected 1.3 TB of sonar data, processed in real-time onboard the AUV," said Bill Lebo, Dive Co-Founder. "The incredible imagery produced allowed our team to quickly locate and identify a variety of objects in the testing area, including abandoned lobster traps previously hidden amongst a boulder field, a number of shipwrecks and customer-specific targets of interest. The imagery collected of the wreck of the USS Yankee was particularly impressive. The use of Kraken's removable data storage module, the DataPod, also enabled us to demonstrate time-critical data exfiltration at the conclusion of the test missions."

www.krakenrobotics.com

Krakem/Dive Technologies

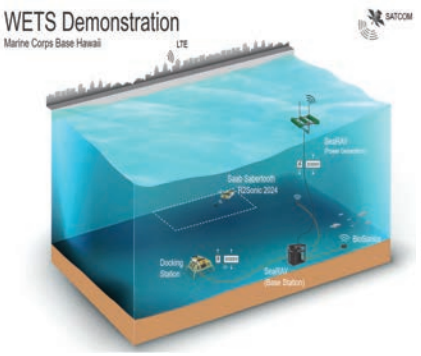
Wave-Powered Sabertooth Put to the Test

The 3000m rated Saab Seaeye Sabertooth is a roaming and hovering multi-role vehicle that can operate in both fully autonomous (AUV) and tethered (ROV) modes. Now it can operated from converted energy from waves operating in seabed residency mode, a renewable energy breakthrough with significant savings in support vessel costs and CO2 emissions. Pioneering the concept is C-Power's SeaRAY Autonomous Offshore Power System (AOPS), which provides offshore power, energy storage, and real-time data communications for resident marine systems. During trials, the Sabertooth owned by Hibbard Inshore and operated on behalf of C-Power, will repeatedly patrol pre-programmed areas to collect data, before returning to an underwater docking station for cloud upload and battery recharge. Included in the studies will be seabed analysis, fish densities, infrastructure monitoring and water-column data gathering.

The trials come in partnership with the U.S. Department of Energy's Water Power Technologies Office, together with the National Renewable Energy Laboratory and the U.S. Navy.

In particular, testing of the SeaRAY AOPS is included in the Navy's Coastal Trident 2021 program, which is the largest port and maritime security undertaking in the nation. For the trials, the Sabertooth will be equipped with an R2Sonic Sonic 2024 multibeam echosounder, 2G Robotics ULS-500 PRO Laser Scanner and camera, and the ASL AZFP 70,120 & 200 kHz Acoustic Zooplankton Fish Profiler.

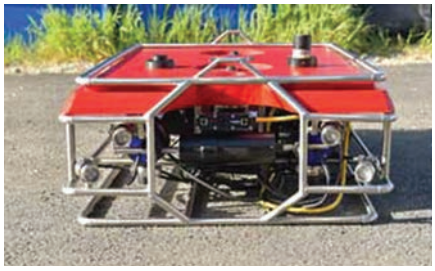
www.saabseaeye.com
www.cpower.co/searay



C-Power/Hibbard

Tech File

Innovative new products, technologies and concepts



Mariscope launches its new ROV Flunder

The new Flunder model from Mariscope was launched worldwide, an Observation Class/Light Work Class category ROV. The new model is based on the Commander MK III. The Flunder, in its standard version, incorporates six 400W thrusters, four horizontal, two vertical. and a modified control system. The power of the motors can be increased on demand up to 900W each.

These features, together with its low profile that reduces its hydrodynamic resistance (its dimensions are 100 x 120 x 40 cm), gives it a speed of 3-5 knots.

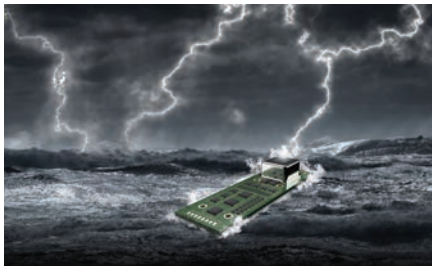
Flunder will come in standard 500m version, with a 1000m version available.

www.mariscope.de

Balmoral's Offshore Wind Cable Stability System

With recent publicity surrounding offshore wind cable failures, Balmoral Comtec says its integrated cable protection stability system offers up to 75% reduction in subsea cable movement helping prevent damage. The stability solution, which complements Balmoral FibreFlex, its patented cable protection system, offers enhanced tensile and creep performance by using weighted modules to improve cable curvature response while maintaining system geometry over life. Even in the most extreme environments a 50% reduction in subsea movement is achieved that more than doubles cable lifetime performance.

www.balmoral-group.com



New Gyroscope from Silicon Sensing

Silicon Sensing announced a new gyroscopes, the CRS39A which was designed for use in severe environments including downhole drilling ops. This upgrade of Silicon Sensing's established CRS39 gyro includes a move to a single board, from two. This has reduced the unit's mass by 40% and allows it to be installed far more easily in space-limited applications, such as the 25mm diameter cylinders typically used in downhole drilling equipment. CRS39A also incorporates upgraded micro electromechanical systems (MEMS) and electronics, including new drive electronics and improvements to the sensor head.

www.siliconsensing.com

Sonardyne's Gyro USBL completes the Ranger 2 package onboard the research vessel Atlantis.

Sonardyne

Tech File

Innovative new products, technologies and concepts

EdgeTech 2050-DSS Combined SSS & SBF

EdgeTech introduced a combined tri-frequency side scan sonar and high resolution sub-bottom profiling sonar system. The 2050-DSS is a tri-frequency side scan sonar system, where any two, operator selectable, frequencies can be operated simultaneously. The system can be provided with either a 120, 410 & 850 kHz towfish, or a 230, 540 & 850 kHz towfish. Both towfish options are equipped with a 2-16 kHz sub-bottom profiler, that use a PVDF panel receive hydrophone. Use of an area based receive hydrophone panel provides improved beam patterns and therefore improved signal to noise ratios.

www.edgetech.com

Digital Edge's EdgeArchive

Digital Edge has a new back-up solution for the Edge DVR, EdgeArchive, which handles the transfer of data from the internal DVR drives to client storage, either on a NAS a Raid, or a phased delivery to multiple external hard drives. This back-up solution uses an integral app within Edge architecture. Being a Native app, the data transfer ensures that the quality of Live recordings are not impacted by a third-party program trying to access the same file that the DVR app is currently using.

Archive can act as a simple data mirror of the correct internal drive data folders, or can be used to create multiple simultaneous backups of client deliverables.

EdgeArchive is an addition to the full Edge DVR Version 5 software suite: Edge Archive; Edge DVR - 3 Versions, Lite, Edge and Pro; Workpack Creator/Editor; Event Button Creator/Editor; Network Viewer (4 Channel); Client Viewer; Offline Editor; and Support Package.

"Clients transitioning to 4k or 4HD channels from SD has had an impact in data storage terms," said John Scott, Operations Manager. "Previously they would be able to get months of data on the internal hard drives which is no longer possible.

And as hard drive space becomes more of an issue, responding to our client's needs dynamically, Digital Edge has invested the last year of development into creating an Archiving application that allows clients to remove data from the DVR without threatening the integrity of the DVR project."

Using EdgeArchive ensures that access violations of "live recording" files do not occur when the data is transferred. It will be beneficial for clients in the field on extended campaigns."

www.digitaledgesubsea.com

Sonardyne's Ranger 2 upgrade for US RV Atlantis

Sonardyne's Ranger 2 Ultra-Short BaseLine (USBL) underwater tracking technology is to provide improved support to oceanographic work from the research vessel Atlantis, including science expeditions in the human occupied submersible Alvin. The most updated version of Ranger 2 provides greater precision, speed and range tracking and replaces the existing Ranger 1 system, which has been supporting research from the ship since 2009.

Additional upgrades include a new AvTrak tracking and telemetry instrument for Alvin, to support the increased depth rating of the submersible, from 4,500 m to 6,500 m. This bespoke 10,000 m-rated AvTrak meets the requirements for a 1.5 times safety margin for human-occupied submersibles.

The Ranger 2 system will support the Atlantis' work by enabling science teams to precisely monitor the position of submersibles and other underwater platforms deployed from the vessel, including remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), as well as tracking its CTD (conductivity, temperature and pressure sensor), towed sleds and dredges, in all water depths.

The team on the Atlantis will also be able to use Ranger 2 to communicate with scientists onboard the Alvin throughout every stage of a dive via the AvTrak using the secure Sonardyne Messaging Service (SMS) feature. The AvTrak can also act as a relocation beacon for the Alvin, as well as remotely operated vehicles (ROVs) deployed by the Atlantis.

The Atlantis is also upgrading its through-hull transceiver from a High Performance Transceiver (HPT) 5000 to a Gyro USBL 7000, complete with a new gate valve, flanges and sea chest. Gyro USBL combines the vessel heading, pitch and roll data that's critical to USBL system performance, with an acoustic transceiver – all in one housing. Atlantis will be equipped with the latest generation Gyro USBL, which it 30% shorter and 40% lighter than its predecessor. That means it's easier to handle and install so more vessels, including small vessels of opportunity and unmanned surface vessels, can get the best performance from their USBL system.

www.sonardyne.com

Tech File

Innovative new products, technologies and concepts

RBRquartz³ Q|plus Pressure Logger

RBR released the new RBRquartz³ Q|plus pressure logger. At the heart is an integrated Paroscientific Digiquartz pressure sensor for best-in-class initial accuracy, resolution, and low-drift performance. Intended for long-term autonomous or real-time observations, the RBRquartz³ Q|plus has high stability and can resolve water level changes as small as 100ppb at 16Hz sampling rate (for example, at 50m depth that would be a resolution of ±0.005mm). The RBRquartz³ Q|plus also comes standard with a ±0.002°C high-accuracy temperature sensor and may be configured with an optional three-axis tilt sensor.

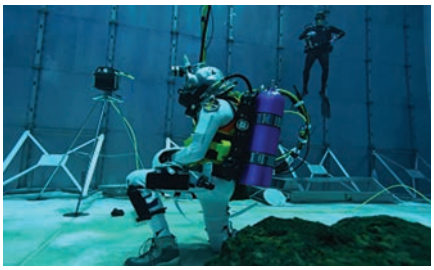
www.rbr-global.com

Electric Subsea Valve Actuator with a Safety Spring

Bosch Rexroth recently presented a disruptive innovation for electrically actuating valves in the subsea process industry. The new SVA R2 Subsea Valve Actuator is reported to be the world's first electric actuator that can replace conventional hydraulic cylinders with field-proven safety technology and without taking up additional space.

Thanks to condition monitoring and a safety spring, the SVA R2 satisfies Safety Integrity Level (SIL) 3 in accordance with IEC 61508 and IEC 61511. The use of internationally standardized interfaces means even more standardization in the subsea process industry.

www.boschrexroth.com



Echoscope4G C500

Coda Octopus released the Echoscope4G C500 Inspector system, designed as a modular, mobile platform designed to make sonar deployment simple and fast. The Inspector comprises a bespoke, lightweight integrated sensor platform supporting the ISAR rotator and the C500 sonar. The Inspector platform can be suspended and lowered from a single lifting point for near-surface temporary deployments or can be placed directly on the seabed using the extendable tripod legs included with the system. A single integrated sensor cable (ISC) connects the ISAR and C500 sonar to the 3D Connect integrated topside unit providing power, control and data.

www.codaoctopus.com

U.S. Army Corps of Engineers photo

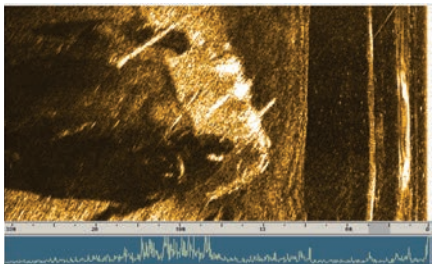
Tech File

Innovative new products, technologies and concepts

Birns 1V and 1B Coax Connectivity Solutions

Birns introduced new RF subsea connector with contacts capable of open face pressure ratings to 1433m, UHF insertion loss of ≤0.7 dB at signal frequencies to 3GHz and maximum UHF voltage standing wave ratio (VSWR) of 1.7:1. The newest product introductions with these features include the Birns 1V series, featuring a unique, compact coax contact that offers 75Ω impedance in the same footprint of a 50Ω contact. The 1V line is ideal for HD/SD video with signal frequencies to 3GHz. All coax pin configurations in the 6km-rated Birns Millennium series are now offered with this new compact coax contact.

www.birns.com



JW Fishers Helps to Find a Truck in the James River

The James River is a tributary of the Missouri River, and the Beadle County Office of Emergency Management (OEM) uses a JW Fishers side scan sonar system to help locate most anything lost underwater. It was deployed recenlty, as Tom Moeding, Beadle County's Emergency Management Director, explained. "We used our JW Fishers side scan sonar to pinpoint the location of a 2014 Dodge pickup." The driver ran the truck into the river in the middle of the night, but could not remember the location. After finding tire tracks the dive team and its JW Fishers system was deployed, and found vehicle.

www.jwfishers.com

WASSP S3 Gets Upgrade

WASSP released the latest version of its S3 dedicated Hydrographic Survey MBES with rollout of new Real-time Processing Module. WASSP S3 is a professional survey and mapping multibeam echosounder, designed to survey up to 10x faster than a single-beam echosounder. It combines data from a multibeam transducer simultaneously generating a 120 degrees swath with up to 100 pings per second. This functionality now incorporates advanced signal processing from the new Real-time Processing Module along with position, heading, motion and sound velocity to create an accurate bathymetric map meeting hydrographic survey standards.

www.wassp.com

Sound Shield Aims to Keep Asian Carp in Check

The U.S. Geological Survey (USGS), the U.S. Army Engineer Research and Development Center (ERDC) and partners installed a temporary, experimental underwater Acoustic Deterrent System, or uADS, at Mississippi River Lock 19 between Keokuk, Iowa, and Hamilton, Illinois, Feb. 3. The deployment is part of a study to understand how invasive Asian carp respond to acoustic, or sound, signals.

"If this uADS is successful in deterring Asian carp, it could have huge implications for invasive species management," said Dr. Marybeth Brey, a USGS research fish biologist and the project lead. "This new deterrent system is designed to be more selective and not affect native species, providing another tool for resource managers to deter Asian carp."

Personnel from the U.S. Army Engineer R&D Center and U.S. Geological Survey watch as a 350-ton crane lowers the 105-foot-long weldment, or underwater Acoustic Deterrent System, into the lock approach of Lock 19 near Keokuk, Iowa, Feb. 3, 2021. Laboratory-tested sounds that proved to be irritating to invasive Asian carp will be broadcast underwater from the weldment as part of a study to evaluate fish behavior.

Asian carp — including silver carp, bighead carp, black carp and grass carp — are harmful because they grow quickly and aggressively compete with native fish for food and habitat.

The multiagency team installed the experimental uADS in the lock approach to test, under field conditions, the potential for acoustic signals to deter both the Asian carp and native fish from moving upstream. The engineering, maintenance and logistical considerations associated with long-term operations of the uADS in an active navigation channel will also be assessed throughout the study.

The uADS is housed in a weldment — a 105-foot-long beam with 16 speakers — in the approach channel of Lock 19.

R/V David Packard

MBARI to build new Research Vessel

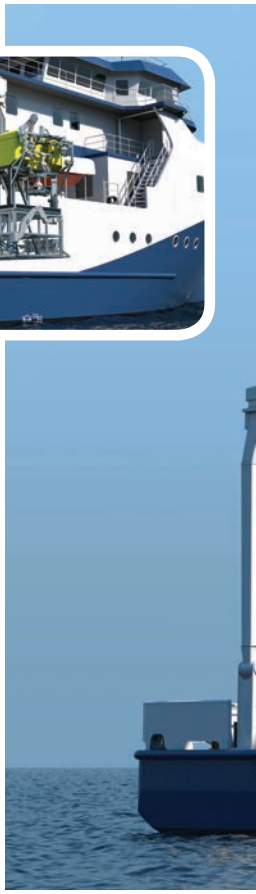
The Monterey Bay Aquarium Research Institute (MBARI) is embarking on a new chapter in its ocean research with the construction of a state-of-the-art ship, a research vessel named in honor of MBARI's founder, David Packard. Designed by Glosten and to be built at Freire Shipyard in Vigo, Spain, R/V David Packard will measure 164 x 42 ft. (50 x 12.8m) with a 12-ft. (3.7 m) draft. It will support a crew of 12, plus a science crew of 18. MBARI has selected, for the construction of the R/V David Packard.

"MBARI's mission to explore and understand the ocean is more important than ever, especially in light of the growing threats of climate change, overfishing, and pollution," said Chris Scholin, MBARI President and CEO. "This new state-of-the-art research vessel will expand MBARI's reach and enhance our research, engineering development, and outreach efforts."

The new research ship will enable continued exploration of the deep sea, from the midnight zone — the inky depths below 1,000m (about 3,300 ft.) — to the abyssal plain, with MBARI's deep-diving remotely operated vehicle (ROV) Doc Ricketts.

As the command center for the ROV Doc Ricketts, the David Packard will allow researchers to continue exploring the deepest reaches of the Monterey Canyon and beyond.

"To safeguard Earth's living ocean, we need to invest much more in science and exploration," said Julie Packard, Chair of MBARI's Board of Directors and Executive Director of the Monterey Bay Aquarium. "That's something my father understood when he founded MBARI in 1987. MBARI's new vessel



will be a powerful research and exploration platform. And it will help Monterey Bay Aquarium show people around the world the wonders of deep-sea life by supporting our upcoming exhibition, Into the Deep: Exploring Our Undiscovered Ocean. I'm excited about the potential the R/V David Packard can contribute to inspiring ocean education and conservation for decades to come."

R/V David Packard will replace MBARI's current flagship research vessel, the R/V Western Flyer, which will be retired in fall 2022.

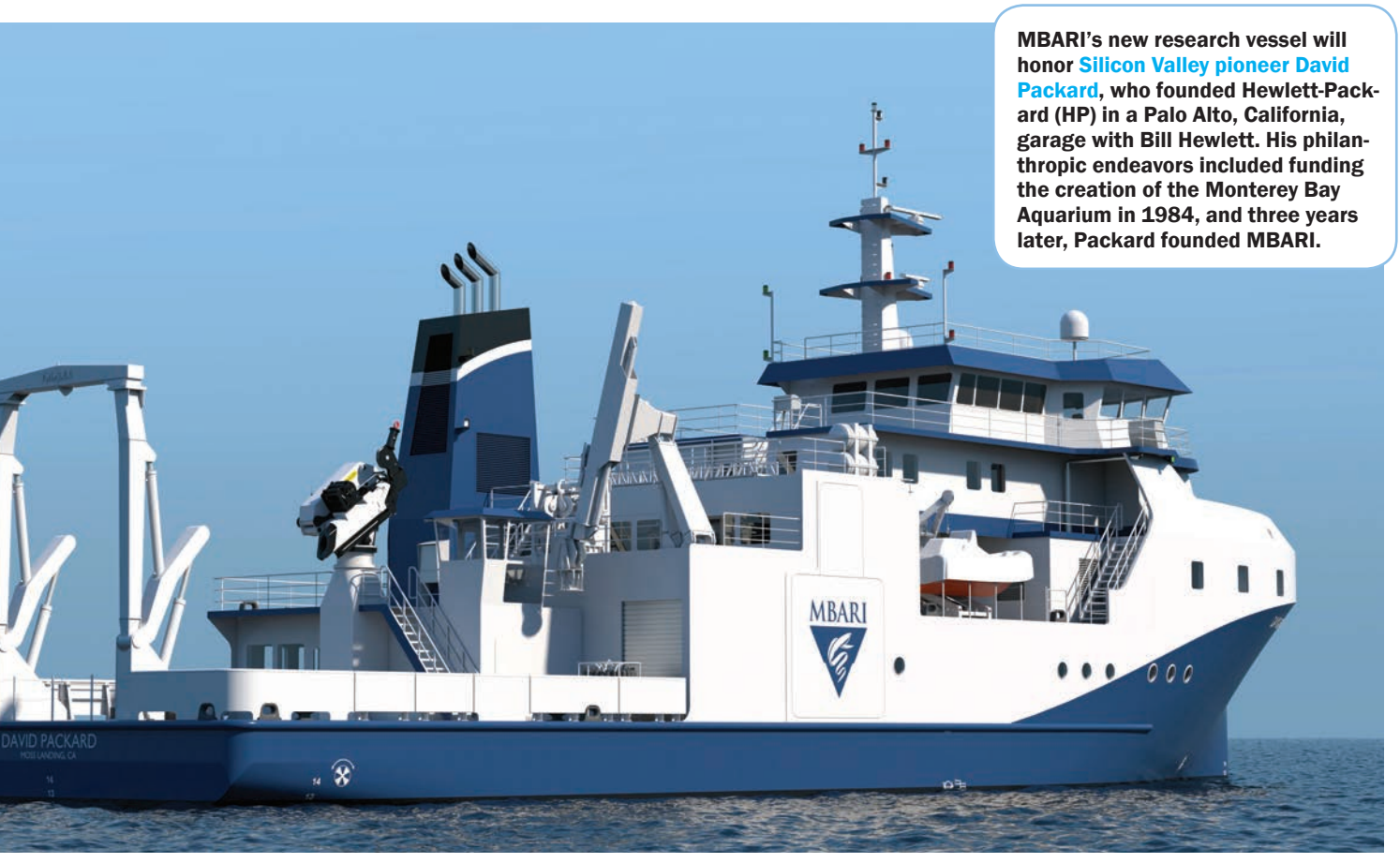
Silicon Valley pioneer David Packard founded Hewlett-Packard (HP) in a Palo Alto, California, garage with Bill Hewlett, and is largely credited with sparking the tech revolution. His philanthropic endeavors included funding the creation of the Monterey Bay Aquarium in 1984. Three years later, Packard founded MBARI as an independent institution committed to pursuing cutting-edge ocean science and engineering programs.

Planning for MBARI's acquisition of a new research vessel began in 2009. MBARI's marine operations team engaged Glosten for its expertise in naval architecture and marine engineering. For the past three years, MBARI's marine operations team has worked closely with Glosten's team of engineers to refine design specifications for the R/V David Packard.

Glosten provided the design and specification services for the shipyard bid package and assisted in the bid review process. As construction gets underway, Glosten will be the on-site construction team for MBARI, providing MBARI continuity through the life of the ship.

Freire will build the R/V David Packard at its shipyard in Vigo, a coastal town in northern Spain.

The final design will get underway this spring, with keel laying expected by November 2021 and the vessel's launch in September 2022. Construction should be complete in May 2023, when the vessel will depart Spain for its journey to its homeport of Moss Landing, California. MBARI's marine operations team will conduct the final fitting out and testing of the ship before science operations begin in fall 2023. The R/V David Packard will join MBARI's two existing research vessels, the R/V Rachel Carson and R/V Paragon.



MBARI's new research vessel will honor Silicon Valley pioneer David Packard, who founded Hewlett-Packard (HP) in a Palo Alto, California, garage with Bill Hewlett. His philanthropic endeavors included funding the creation of the Monterey Bay Aquarium in 1984, and three years later, Packard founded MBARI.

Who's News?

Latest People & Company News

Phoenix International

Salvage dive @ 19,075 ft.

Mocean Energy

Cameron McNatt and Mocean Energy's Blue X wave machine.

Phoenix, SUPSALV: Record-Breaking Salvage Dive

Phoenix International Holdings, Inc. (Phoenix), under the direction of the U.S. Navy's Supervisor of Salvage and Diving (SUPSALV), located and recovered the fuselage of a downed MH-60S Seahawk helicopter in the Pacific, near Okinawa, Japan, from a record breaking depth of 19,075 feet. The helicopter was located in March of 2020 using the U.S. Navy's Autonomous Underwater Vehicle "Trondheim" and then, a year later, Phoenix and SUPSALV returned to the site and recovered the helicopter on March 21, 2021 using the U.S. Navy's Remotely Operated Vehicle "CURV 21" and Fly Away Deep Ocean Salvage System. Both Trondheim and CURV 21 are rated to operate down to 20,000 feet.

www.phnx-international.com

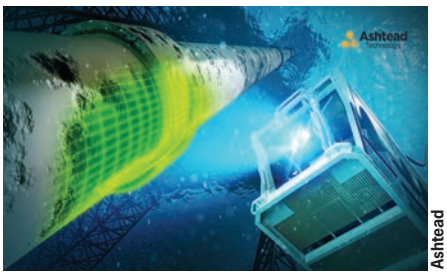
Mocean Energy Blue X Wave Machine arrives in Orkney

The Blue X wave energy prototype from Mocean Energy has been unloaded at Hatston Pier in Kirkwall, Orkney, Scotland ahead of summer sea trials. The wave energy device is 20 meters long and weighs 38 tons. Mocean Energy said Blue X will be tested in Kirkwall Harbor before being towed around Orkney to Copland's Dock in Stromness. The device will then be deployed at the European Marine Energy Centre's Scapa Flow test site for sea trials initially, and then later will move to EMEC's grid-connected wave test site at Billia Croo, on the west coast of Orkney. The Blue X wave machine was built in Scotland by Fife fabricator AJS Production and painted by Montrose-based Rybay Corrosion services. The University of Edinburgh who supplied their CGEN generator, Supply Design and Blackfish Engineering Design.

www.mocean.energy

Ashtead Funded for Unmanned Digital Twinning Project

Welaptega, an Ashtead Technology company, launched a $500,000 initiative to develop a product to enable digital twinning of underwater infrastructure without the need for offshore personnel. In collaboration with Whitecap Scientific, SubC Imaging, and Nova Scotia Community College SEATAC division, the new digital twinning technology will develop an intuitive bridge between Welaptega's and Whitecap Scientific's technology systems.



Ashtead

Japan, France Conclude AUV Mine Countermeasure Study

Mitsubishi Heavy Industries, Ltd. (MHI) concluded a research and prototype production contract with Japan's Ministry of Defense for next-generation mine-countermeasure technology, a France-Japan joint research project.

The research and prototype manufacturing project aims to combine the low frequency synthetic aperture sonar (LF-SAS) mounted in MHI's OZZ-5 autonomous underwater mine countermeasure vehicle with the high frequency synthetic aperture sonar (HF-SAS) from France's Thales Group, and by enhancing the precision of the automatic detection and classification function, together with signal processing technology development, achieve synthetic aperture signal processing in real time.

TCarta Satellite-Derived Bathymetry to NOAA

TCarta Marine has supplied the National Oceanic and Atmospheric Administration (NOAA) with satellite-derived bathymetry (SDB) validated by green laser altimeter data from the NASA ICESat-2 satellite for two U.S. shallow-water coastal areas. TCarta was the subcontrac-

Who's News?

Latest People & Company News

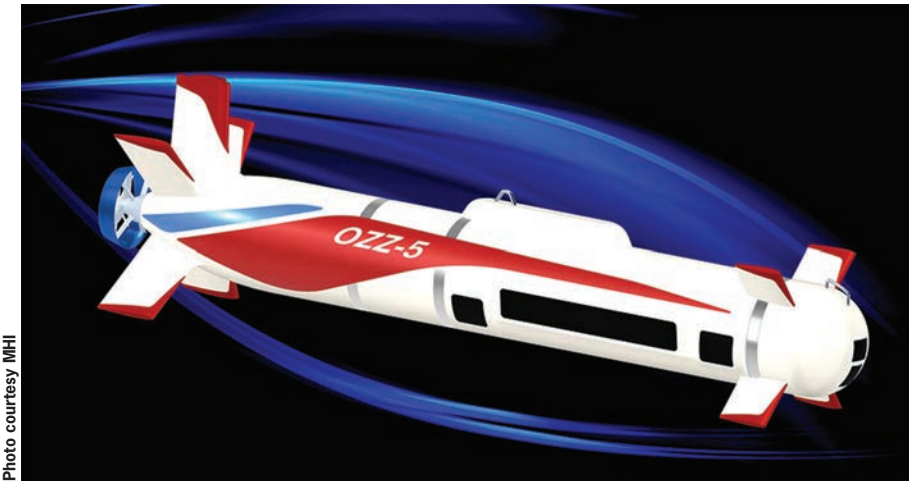
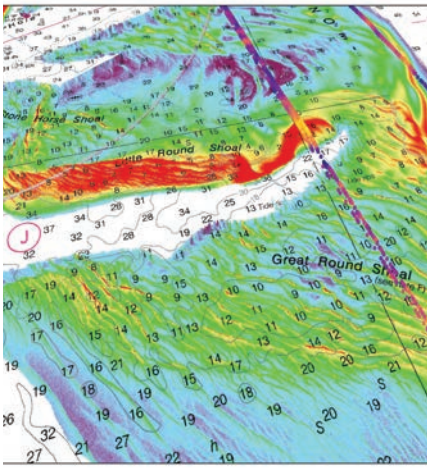


Photo courtesy MHI

Japan/France: OZZ-5, autonomous mine countermeasure vehicle.



TCarta Marine

Bathymetry data for NOAA.

tor on the prime contract awarded to Woolpert. The NOAA pilot focused on two shallow-water regions that were 3,000 sq. km in total area - one in the Green Bay area of western Lake Michigan and the other around Cape Cod and Nantucket Sound. Both areas experience natural forces that alter the underwater terrain faster than traditional bathymetric surveys can be completed.

Merchant Ship Earns DNV SILENT-E Notation

ONEX Peace, an Aframax tanker built by Hyundai Samho Heavy Industries and delivered to its owner ONEX, has become the world's first merchant ship to receive DNV's SILENT-E notation. The SILENT-E notation ensures ships do not exceed average-to-moderate Underwater Radiation Noise (URN) levels.

PanGeo Subsea Delivers SBI into Taiwan

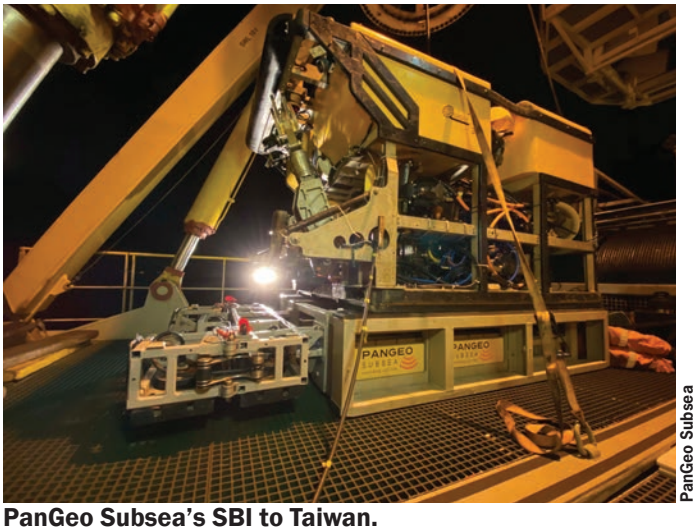
PanGeo Subsea announced the introduction of our patented Sub-Bottom Imager (SBI) to Taiwan to deliver sub-seabed imaging for Jan de Nul, in support of Formosa 2 Offshore Wind Farm Project. Initially, PanGeo plans to have one SBI unit resident in Taiwan with a plan to ship additional SBI units as operations dictate. PanGeo will be supporting the growing renewable markets in the region by providing acoustic imaging services for cable depth of burial specifically for Formosa 2 with plans to provide technology solutions to other developers in the region as more offshore wind projects are announced.

Express Engineering Opens New Assembly, Test Center

Express Engineering opened its new international assembly and test centre, an investment of approximately $5m in a 48,000-sq.-ft. purpose-built center in Gateshead in the North of England.

Photo courtesy HSHI

ONEX Peach is first with "SILENT-E" notation.



PanGeo Subsea

PanGeo Subsea's SBI to Taiwan.

Who's News?

Latest People & Company News

FarSounder Celebrates "20"

2021 marks two decades that FarSounder has been dedicated to developing their unique 3D Forward Looking Sonar technology (3D FLS). Today, this patented technology is deployed globally. Argos series of navigation sonars are used to detect shallows and obstacles in the water column. There is a broad range of vessel types that find these sonars invaluable. With a user interface showing real-time 3D imagery in up to a 120-degree field of view out to navigationally significant ranges, the benefits are abundant.

Impact Subsea Altimeter gains Queen's Award for Enterprise

Impact Subsea received a Queen's Award for Enterprise for Innovation for its ISA500 Altimeter, recognized as having a step-change impact within the field of underwater altimeters in terms of distance measurement range, accuracy and new functionality previously unseen in the market.

Nicola Offshore, Cyprus Subsea Partner

Nicola Offshore GmbH and Cyprus Subsea Consulting and Services C.S.C.S. Ltd (C.S.C.S.) have signed a commercial partnership agreement with the goal of sharing knowledge and resources to unlock new efficiencies for acquiring marine data using multibeam echosounders, subsea gliders and ocean monitoring instruments.

Valeport achieves 'Made In Britain' status

Valeport achieved the 'Made In Britain' accreditation for its range of innovative marine solutions that are developed, designed and manufactured at its UK headquarters in Totnes, Devon. The independent, family-owned business, which employees more than 90 people from state-of-the art facilities on the River Dart, designs and supplies precision sensors and probes to a worldwide customer base that includes: environmental, energy, construction, dredging, engineering, scientific research and military sectors.

Sonardyne wins Queen's Award for Unlocking the Secrets of our Restless Sea Floor

Sonardyne

Manufacturing Assembly Operator Ian Hall, prepares a seabed monitoring instrument at Sonardyne's headquarters in Yatelely, England.

A pioneering system developed by Sonardyne to study ocean floor movement has been recognized with a Queen's Award for Enterprise in Innovation. Developed over more than a decade and in use globally by the energy and ocean science sectors, Sonardyne's seabed deformation monitoring system is designed to provide engineers and scientists with new understanding of the seafloor and the physical processes that act upon it.

Using a network of autonomous, battery-powered instruments deployed on the seabed, the system measures horizontal and vertical seabed movement at a high level of precision

The instruments used in Sonardyne's seabed deformation monitoring system have been engineered using low power electronics and long-life batteries, all in pressure tolerant housings, enabling them to remain on the seabed for more than 10 years at a time.

They also contain Sonardyne's underwater digital acoustic communications technology, which won a Queen's Award for Enterprise in Innovation 2014. This allows hundreds of instruments to be deployed simultaneously and the data they gather to be wirelessly gathered using subsea robots and crewed or uncrewed surface vessels.

Users of Sonardyne's seafloor monitoring system include international energy company Shell and Earth research organisation Scripps Institution of Oceanography.

Shell's research geophysicist Dr. Paul Hatchell (retired) said: "Sonardyne's seafloor deformation monitoring technology was a complete game-changer for helping Shell to gain insight into their offshore reservoirs, located in very deep water, where direct access to the seafloor by people is obviously not practical.

"I worked closely with the Sonardyne team on this application from the very beginning. This award is highly deserved recognition of their dedication to technological innovation throughout our 15-year journey together and I am thoroughly delighted with today's announcement."

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