MARINE TECHNOLOGY REPORTER

November/December 2021
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A look inside Tim Janssen's & Sofar Ocean Technologies'

Epic Ocean Data Quest

SubSurface Networks
Swarm tech meets & greets the Seismic Challenge

USNS Walter Munk?
The call to honor 'America's Greatest Oceanographer'

Under the Microscope
Science supports the business of Offshore Wind

Meet NOUS
An underwater 'Artificial Mind'

Volume 64 Number 8

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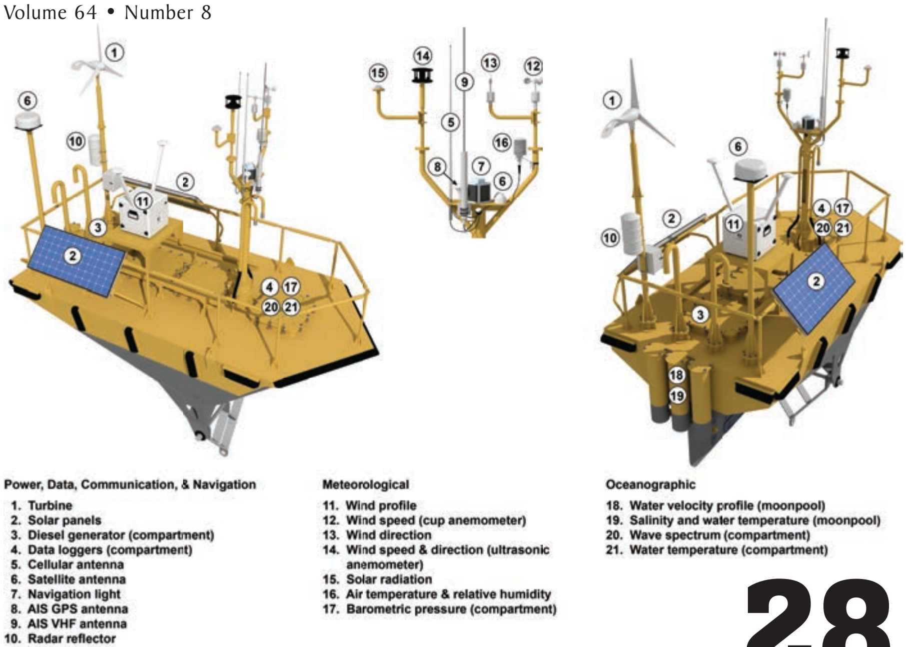

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Illustration by Mike Perkins, Pacific Northwest National Laboratory)

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National Technical University of Athens

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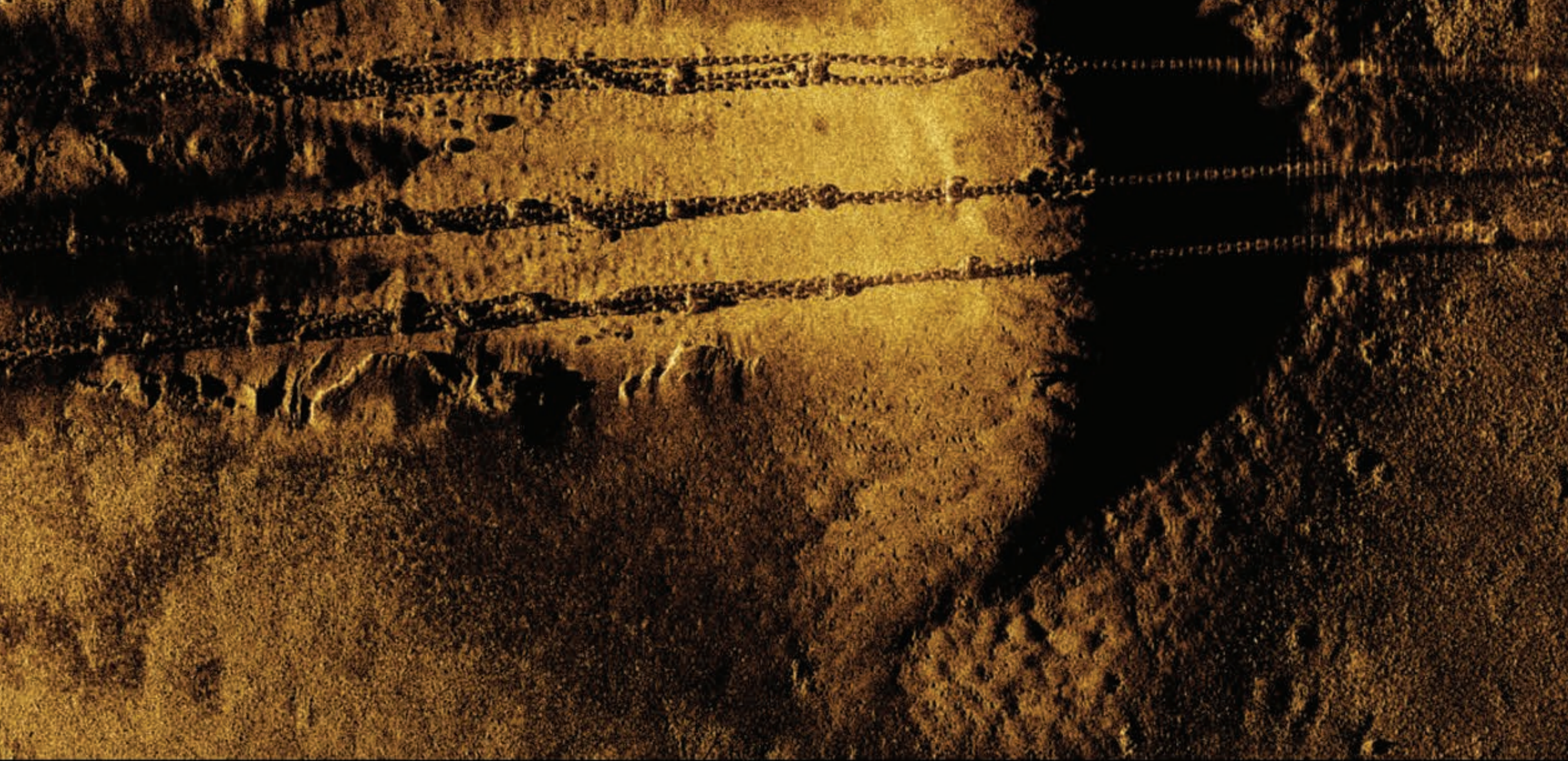
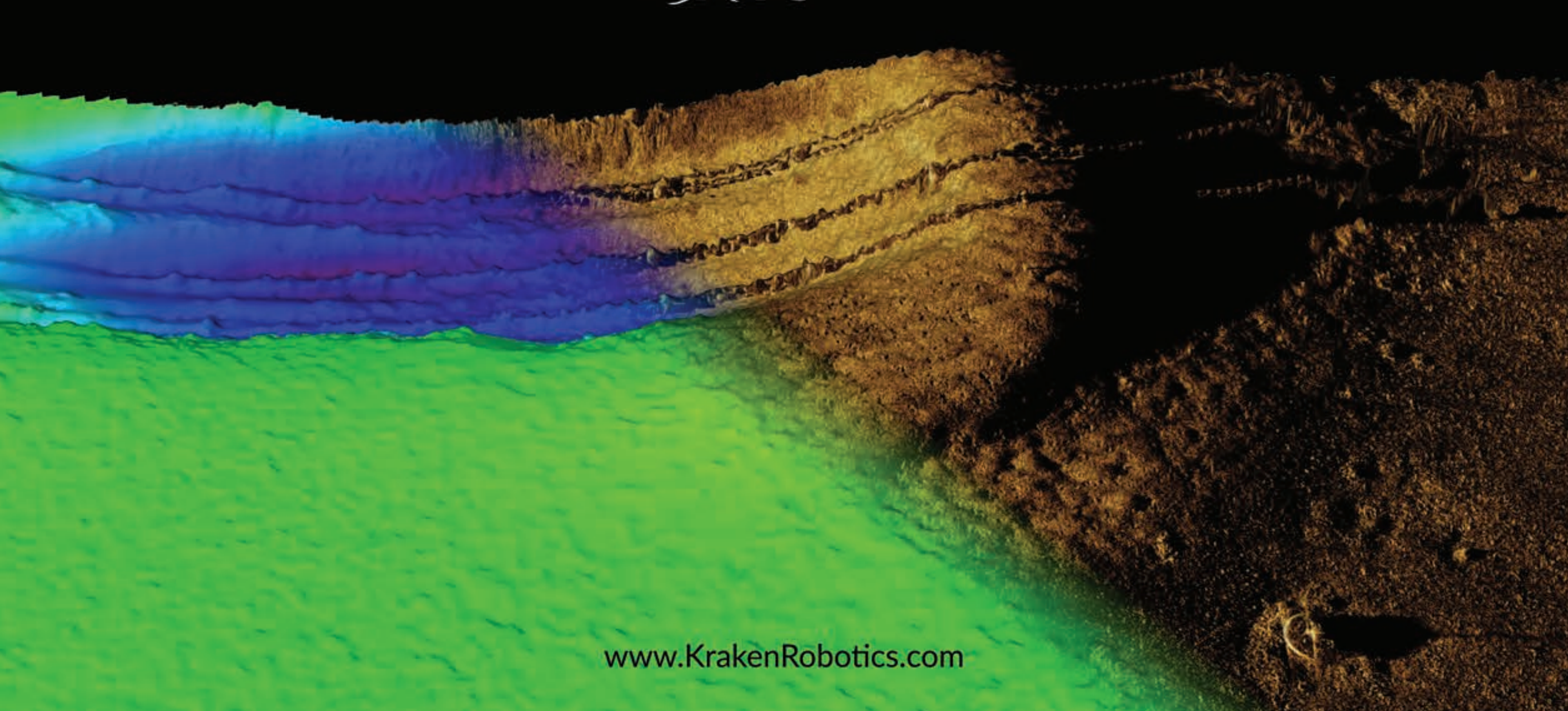
Sofar Ocean Technologies

On the Cover

Tim Janssen, CEO, Sofar Ocean Technologies. *Photo courtesy Sofar Ocean Technologies*





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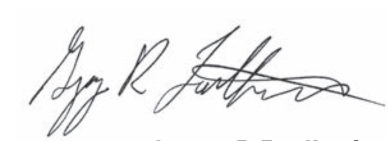
Editorial

2021 has gone by in a virtual blur, and as we head toward the turn it's interesting to note that a pair of markets – traditional offshore oil and gas and the burgeoning offshore wind industry – promise to make 2022 and beyond bountiful for all who read these pages. This edition is focused squarely on ocean observation, and with that we have a full line-up exploring different aspects. Starting with the cover story, we had the opportunity recently to spend some time via video with **Tim Janssen**, CEO of Sofar Ocean Technologies, to explore this tech start-up's quest to harness the mountain of ocean data. While the 'digitalization and data' story line is hardly new, Sofar has embarked on an epic quest to not only gather and distribute real-time data from the ocean cheaply and efficiently, but to help add real actionable value to various stakeholders in disparate industries. Our interview with Tim starts on page 46.

Regular contributor Elaine Maslin tackles the subsurface network topic, and in this regard she explores recent developments with Blue Ocean Seismic Services, which is melding swarms of underwater vehicles with the collection of seismic data. Her story starts on page 22.

Last, but certainly not least, I thank the trio of author from the Pacific Northwest National Laboratory for their contribution starting on page 28 which looks at buoy-based technology and its growing role in addressing offshore wind challenges.



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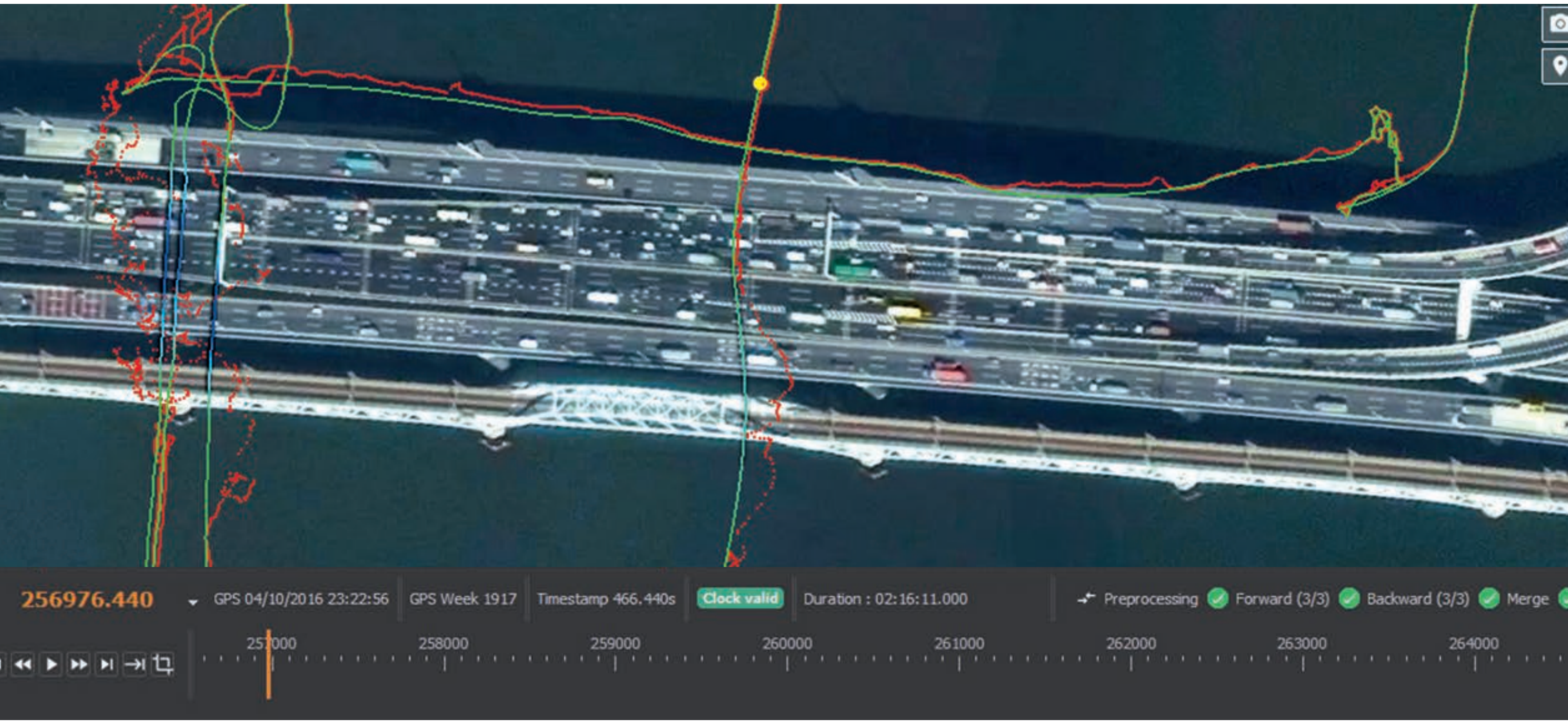
Qinertia

The Next-generation INS/GNSS Post-processing Software



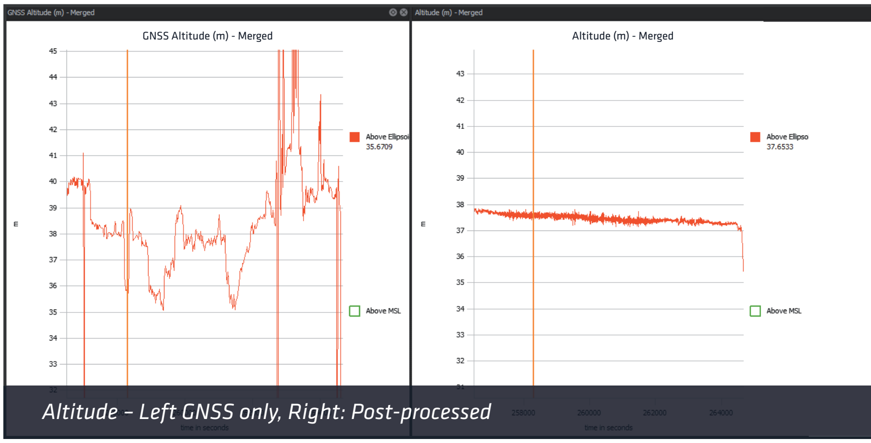
Quality: *Green -> centimetric position; Blue -> decimetric < 30cms; Red -> Raw GNSS data*

SURVEYING UNDER BRIDGES MADE EASY

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.

With Qinertia and its unique 100% in-house GNSS/INS tightly coupled forward / backward processing, data collected under the bridges are fully exploitable (blue / green trajectory).



Altitude – Left GNSS only, Right: Post-processed

The Fastest PPK Software

Log duration: 2h15
Processing Time: < 2 mins

Long GNSS Outages Handling

Example: up to 80 seconds *outages and multi-path effects*
95% positions < 2 cms
Max error < 30 cms

Easy & Powerful Exporter

Easy export to third party software (SBET/ ASCII)

Many thanks to Hydro Systems Development (HSD Japan) for their kind collaboration.

Full data available upon request at marketing@sbg-systems.com
www.sbg-systems.com

SBG SYSTEMS

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Peterson

Severy

Sheridan

White

Bae

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Gallaudet

Rear Admiral (ret) Gallaudet is the CEO of Ocean STL Consulting. From 2017-2021 he was the Acting and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA) and Assistant Secretary of Commerce for Oceans and Atmosphere. Prior to NOAA he served for 32 years in the U.S. Navy retiring as the Oceanographer of the Navy.

Mahon

Alicia Mahon is the Offshore Wind and Dynamics Team Lead at PNNL focusing on developing marine technology solutions to support offshore wind development.

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How to Honor America's Greatest Oceanographer?

CALL FOR THE USNS WALTER MUNK

By Rear Admiral Tim Gallaudet, Ph.D., U.S. Navy (retired)

Walter Munk (center) with the author (left) and his wife Mary (right) at Scripps in 2018

Photo courtesy the Author

In the 2021 National Defense Authorization Act, Congress established a commission to rename several military bases and ships that commemorate members of the Confederacy. One of these is the Naval oceanographic ship USNS Maury (T-AGS 66), named after oceanographer Matthew Fontaine Maury, who resigned his commission in the U.S. Navy to join the Confederacy at the outbreak of the American Civil War. The USNS Maury is an asset of the Naval Meteorology and Oceanography Command (NMOC), which I led from 2014-2017. I attended the ship's commissioning in 2017, where I praised Maury's recognition as the father of modern oceanography. I did the same on other occasions when I served as the Superintendent of the U.S. Naval Observatory, which Maury founded in 1842. Notwithstanding this association, I agree with others who have called it disgraceful for any military unit to be named after someone who fought against our government to maintain a system that enslaved other human beings.

The most appropriate individual after which to rename USNS Maury would be an American who made significant contributions to Naval oceanography and reflected the diversity of our population. Among the pantheon of our greatest ocean scientists, there is no better candidate than the renowned oceanographer Dr. Walter Munk. I first met Walter when I was a newly-minted Ensign in the Navy while earning a Master's degree at Scripps Institution of Oceanography, where he was a Professor and research scientist. This was over 30 years ago, long into his career which spanned nearly eight decades. Since then, I climbed a long ladder in ocean science and technology that carried me to multiple sea-going expeditions, brought me back to Scripps to earn a Ph.D., and led me to serve at the highest levels of the U.S. Government. At every step, Walter Munk served as a beacon, lighting the way and inspiring me along with many others. While volumes could be written about why a ship should bear his name, I share three points here that are both compelling and personal.

1

Walter's first contribution was to national security when he worked with Dr. Harald Sverdrup at Scripps during World War II to predict surf conditions for Allied landings in the Pacific theater. Walter actually enlisted in the Army before Scripps and the Navy found more effective applications for his talent. This began a highly impactful partnership with the Navy that lasted throughout Walter's life and saw him make critical advances in physical oceanography and underwater acoustics. These directly underpinned the U.S. Navy's competitive advantage in Antisubmarine Warfare against the Soviet Union during the Cold War. His accomplishments not only inspired me as a junior officer at Scripps, they were foundational for the resurgence of ocean science within the Navy that I led with the establishment of Task Force Ocean. This included advancements in ocean technology and unmanned systems and built upon similar work by the Navy to address climate change impacts on national security.

2

More remarkable were Walter's accomplishments in science as a whole. From unlocking the nature of ocean currents that is the basis of modern numerical models, pioneering research in ocean acoustic tomography and internal waves, developing modern methods of tidal time series analysis, to exploring unexplainable characteristics of sea level rise, the expanse of his impact on the field of geophysics is simply dizzying. When I was given the opportunity to steer National policy regarding ocean science and technology, I did not ignore the example of this iconic ocean champion. As the Acting and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA), I initiated and oversaw the development of a National Strategy and Plan to map and explore our oceans, as well as similar efforts to add new and expand existing marine protected areas (MPAs), address marine plastic pollution, combat coral disease, and advance ocean science and technology. Walter's legacy with Scripps also made notable contributions to the 2019 White House Summit on Ocean Science and Technology Partnerships, which spurred the signing of a trove of agreements between NOAA and partner organizations to move forward in areas such as ocean mapping, exploration, science, public understanding, countering illegal fishing, conserving coral reefs, and expanding the research and operational application of autonomous systems and artificial intelligence.

A third aspect of Walter's mark on America is the strength in diversity that he represented. Walter came to the United States from Austria-Hungary in 1937, and in response to Nazi Germany's annexation of Austria in 1938, he applied for and obtained U.S. citizenship in 1939. While discussions on diversity nowadays tend to focus on race, it is equally important to include our immigrant population. According to the U.S. Census Bureau, foreign-born citizens are the second largest minority group in America, tied with African Americans. As a non-native English speaker who rose to the equivalent of royalty in U.S. science, Walter embodied the American dream. I never lost sight of this while I served in the Navy and at NOAA, deliberately including our immigrant teammates in my outreach and recognition during diversity events with employees, partners, and lawmakers.

Several months after Walter passed away in February of 2019, his family asked me to be the Master of Ceremonies at a recognition event for him planned for October of that Year. This widely attended event was preceded by the Walter Munk Legacy Celebration hosted by Scripps the day before, and it was followed by a ceremony and paddle-out near the Scripps research pier the day after. Across the three days, the total measure of the man was summed by the extraordinary expanse, magnitude, and diversity of those who gave tribute to him. While the naming commission struggles to secure broad public support for their Congressional mandate, they can do no better in renaming the Navy's newest oceanographic ship after the loyal veteran, esteemed scientist, and naturalized citizen - Walter Munk.

Navy provides realistic, operationally-relevant test environment for innovative technology

ANTX answers the question: Will it Work?

By Edward Lundquist

U.S. Navy photo by Chief Mass Communication Specialist RJ Stratchko

The Naval Air Warfare Center Aircraft Division (NAWCAD) leveraged its ANTX events to demonstrate its Blue Water Unmanned Air System to deliver supplies to a ship at sea.

"**Synergy"** is an overused word. But in the case of the "Advanced Naval Technology Exercises" that are held around the country, ANTX is truly a sum greater than its parts.

ANTXs are conducted by the Naval Research & Development Establishment (NR&DE) and hosted at the various Naval Warfare Centers to demonstrate emerging technologies and innovations aimed at solving Navy and Marine Corps problems and addressing mission priorities and gaps. They are not so much exercises, which usually denotes training, but more like technology demonstrations. But while they culminate in a demonstration of these newly developed capabilities for stakeholders, those demonstrations are often months in the making involving the various teams.

According to the ANTX website (**www.antx.org**), ANTXs bring industry, academia, and government research and development organizations together to "align technical innovation with operational needs," and "evaluate the utility of new technologies before decisions are made on investment priorities."

ANTX can bring participants representing very different technologies and unique approaches together to form teams that can address larger problems.

The Naval Air Warfare Center Aircraft Division's (NAWCAD) recent ANTX featured more than 20 emerging warfighter technologies at its Naval Air Station Patuxent River headquarters.

According to Tony Schmidt, NAWCAD's director for rapid prototyping and experimentation, the ANTX aimed to answer the question, "Will this work?"

"NAWCAD successfully transitions much of its ANTX technology from demonstration to deployment because of our narrow focus on very specific capability gaps," said Schmidt. "We typically target a transition exit to the PEOs (program executive offices) and program offices, to deliver a capability for the fleet. We pose and define problems, and leverage cooperation, to rapidly deliver solutions with a near-term focus."

"We try to find technology that fills warfighting gaps and solves warfighting problems," said Schmidt. "We're looking for technology to get out to the warfighter and providing that forum for DOD, industry and academia to participate and showcase capabilities and how they would interface with a warfighting environment."

Schmidt said ANTX provides a realistic environment for experimentation. "We're very focused on technology. We want to solve a specific problem, and specifically determine if that system or solution will work, and do so in that warfighting environment for a Sailor or Marine."

Schmidt said the ANTX scenarios provide the opportunity to "take technology and see if it works."

"We have a test wing with four squadrons, 128 state-of-the-art labs, plus the Atlantic Test Range – thousands of square miles in the Atlantic Ocean – and its resources and instrumentation. NAWCAD provides a world class venue for experimentation and test that is replicated nowhere else in the world." Schmidt said. "We take advantage of Cooperative Research and Development Agreements. CRADAs let industry and academia use our test ranges and aircraft at no cost to them, and we get to see their technology in a realistic and operationally relevant environment – at no cost to the government."

"To test and fail is still a valuable learning experience," Schmidt said.

NAWCAD is experimenting with logistics Unmanned Aircraft System (UAS) commercial vehicles to prototype a long-range naval ship-to-ship and ship-to-shore cargo delivery system as part of the Navy's "Blue Water" UAS capability. The system was tested aboard the USS Gerald R. Ford (CVN 78) during ANTX 2021.

ANTX Coastal Trident 2021 (ANTX/CT21), held at Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) in California, encompassed more than 50 projects and 35 topics, and included more than a dozen live exercises occurring over a six-month period culminating in some demonstrations held onsite in Septembers. One of the challenges asked participants to examine the operational and technical capabilities of port and maritime security organiza-

Dave Gentile, Ion

Shoreside:
Team members collaborate to track and engage a high speed boat straying into an exclusion area.

Dave Gentile, Ion

tions to counter asymmetric threats to the U.S. Marine Transportation Systems (MTS) and its associated personnel, operations, and critical infrastructure.

In many cases, these demonstrations brought partners into teams that have previously never worked together. In one such event, a team consisting of Marine Arresting Technologies (MAT) of Tarpon Springs, Fla., SpotterRF of Provo, Utah, ION of Houston, Texas, and Theiss UAV Solutions of Salem, Ohio, collaborated to provide a solution to the issue of enforcing a maritime security and safety exclusion zone, and slowing or stopping a vessel from entering that restricted area without damaging the boat or harming its occupants.

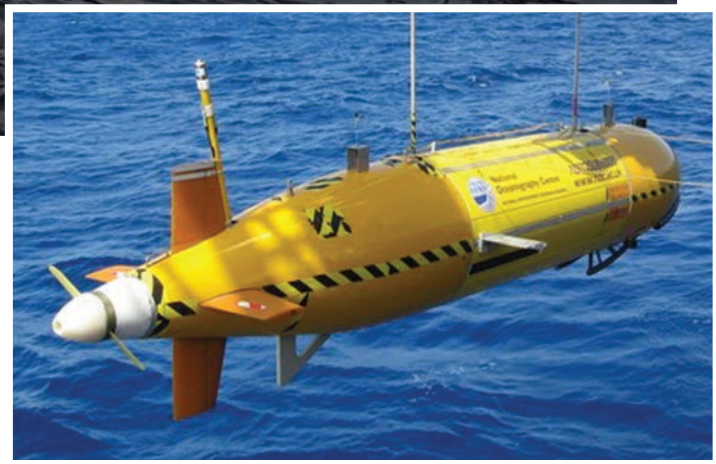
The Navy provided a target and the port provided a realistic operating environment. The industry team employed a small unmanned vessel as a force multiplier to provide an initial non-lethal response to a threat approaching the entrance to the Port of Hueneme, simulated by a Navy High-Speed Maneuvering Surface Target (HSMST) boat — that had to be slowed so security forces could get the boat to safely exit the area. These companies had not worked with each other before, but their solution successfully met the goals of the scenario. The demonstration took place during intermittent thick fog at the harbor entrance, underscoring the importance of executing the scenario together in a real-world setting, and with representatives of several warfare centers observing.

Each of the team members brough their own specialized technology and capability. SpotterRF's C550 perimeter surveillance radar detected and tracked a target and passed information to the command and control (C2) hub developed by ION, which used their Marlin platform technology to plan and execute the missions for the Theiss UAV. The UAV was fitted with a command-initiated device that discharged and arresting line in front of the vessel at the precise time and location computed the C2 system. The radar data enabled a constantly updated solution. The drone flew in front of the target and autonomously deployed the arresting line, which slowed the target boat. The UAV can be recovered and the system reloaded for subsequent missions.

There are a lot of good reasons for stakeholders to take part in an ANTX. The warfare centers that host an ANTX get in the middle of technical developments relevant to their areas of responsibility, gain insight into warfighter needs, and can engage with new and existing industry and academic research partners. Both large primes and small entrepreneurial businesses can be exposed to specific warfighter requirements and work with actual end-users in a low-risk, consequence-free environment.

NOC MARKS ITS 25TH ANNIVERSARY OF ITS FIRST AUV MISSION

Loch Ness Trial 2019



Autosub6000 will be mapping areas of the seafloor using sonar and photography

All Images courtesy NOC

This year, the National Oceanography Center (NOC) is celebrating the 25th anniversary of its first Autonomous Underwater Vehicle (AUV) mission.

Over the last quarter of a century, the NOC's underwater robots have been at the center of countless missions across the world in the most extreme marine environments to support scientific ocean research. As the world gathers in Glasgow at the COP26 summit, the NOC is marking its progress in technological developments, which now allow its scientists to reach new ocean depths, travel under ice, take readings in remote areas and collect data during high sea states to help our understanding of the ocean and threats of climate change.

In 1996, the NOC embarked on its first AUV mission in Portland Harbor, Dorset – a three-day program to demonstrate the transition of remote control autonomous operation with GPS and dead-reckoning navigation. A year later, the team and Autosub-1 were gathering oceanographic data off the Florida coast, and the following year off Bermuda. The inaugural mission was at the forefront of the scientific and technical credibility of autonomous underwater vehicles, and laid the foundations for the innovative global AUV operations and developments undertaken by the NOC team today.

After 25 years of development and the launch of its Marine Autonomous & Robotics Systems Group (MARS), the NOC's state-of-the-art robot submarines are paving the way for safer and more cost-efficient offshore operations. Oceanids – the NOC's latest program which aims to put the UK at the forefront of world-class autonomous technology development – saw the team pilot the latest version of the successful Autosub Long Range (ALR) vehicle to ensure its capabilities were ready for scientific deployments anywhere in the ocean. The newly developed ALR, better known as *Boaty McBoatface*, offers a step change in capability compared to the earlier model, enabling the UK's marine science community to use the robots in unexplored and technologically challenging under-ice and deep-ocean environments.

Discussing the NOC's technological developments, Dr Maaten Furlong, Head of the Marine Autonomous & Robotic Systems Group at the National Oceanography Center, said: "Since we first started developing AUVs in the late 80's and our inaugural AUV expedition 25 years ago, the combined science and engineering teams have made huge strides pushing the boundaries of how we explore the world's oceans. It's amazing to look back on our technological advancement and scientific achievements over the past 25 years.

"Looking forward, programs like Oceanids have meant we've been able to progress the AUV technology, pushing the UK's autonomous capability forward and creating the next generation of pioneering vehicles that will continue our history of exploration and crucially enable the transition towards

All Images courtesy NOC

The NOC's first Autosub mission in July 1996.

net-zero observations. Autonomous vehicles are a key technology to enable scientific research to move to net-zero emissions. I am excited to see NOC's Autosub developments playing a vital role in this change, and look forward to seeing the continued advancement of the technology and the associated scientific exploration."

Capable of being deployed for up to three months and reaching depths of up to 6,000m, the NOC's newest fleet of six ALRs will open new opportunities for lower cost shore-based scientific missions and under-ice exploration. Development of new navigation features will also allow scientists to research areas that could not previously be reached by boat, including the melting Thwaites Glacier, which will be visited later this year by the NOC team.

PROTECTING THE NAVY'S EQUIPMENT FROM THE ENVIRONMENT

After funding her doctoral studies at URI, the Naval Undersea Warfare Center hires first-generation college student as an engineer

For those operating equipment on, under or near the water for commercial or recreational purposes, the corrosive effects of saltwater can be costly. For the U.S. Navy, the ramifications could be much more severe.

As a doctoral student in mechanical engineering and applied mechanics at the University of Rhode Island, Irine Neba Mforsoh studied the long-term effects seawater and ultraviolet radiation have on the materials used to coat marine structures.

After earning her doctorate in spring 2021, the first-generation college student is now applying what she has learned as an engineer at the Naval Undersea Warfare Center Division Newport.

From Cameroon to Kingston

Originally from Cameroon, Neba Mforsoh moved to the United States in 2016 to be with her husband, who was a member of the United States Army serving on active duty in Germany at the time.

Staying with a relative in Iowa, Neba Mforsoh decided to enroll in a doctoral program, which is when she met Arun Shukla, professor of mechanical engineering at URI.

"Prior to moving to the United States, I was working as a lecturer at a university in Cameroon and pursuing a Ph.D.," said Neba Mforsoh. "It was critical for me to continue to expand my knowledge so that I could provide the best possible instruction to my students. I decided to continue my education at URI because the University accepted my international credentials and everyone I met was very welcoming."

Shukla was immediately impressed with Neba Mforsoh.

"Irine visited my Dynamic Photomechanics Laboratory at URI to discuss her intention to work under my guidance for her doctoral dissertation," said Shukla. "Her language skills were superior, her leadership qualities were evident, and I was impressed with the effort she made prior to our meeting to understand the type of research we conduct in the lab."

Shukla recommended that Neba Mforsoh apply for the Naval Engineering Education Consortium program, through which her studies would be funded by the Naval Undersea Warfare Center and she would get to work on a research project started by the professor.

Neba Mforsoh was accepted into the program and dove into her research.

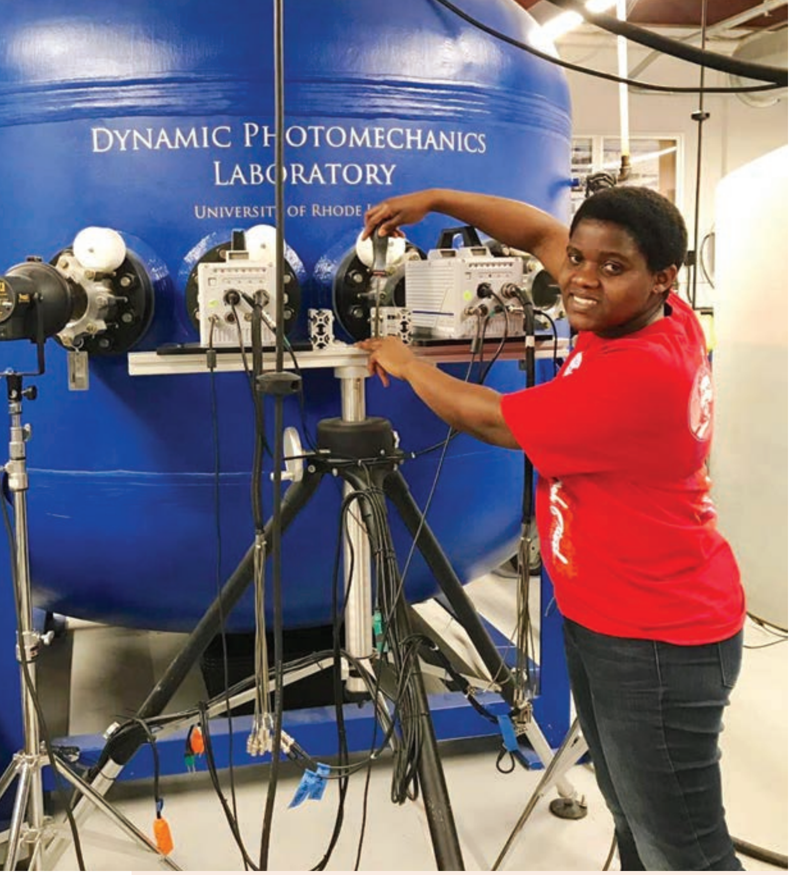
Identifying and Solving a Problem

"I quantified the changes to the mechanical properties of elastomers (a natural or synthetic polymer having elastic properties) after exposure to seawater and ultraviolet radiation," said Neba Mforsoh. "I studied the changes in elasticity, adhesion to surfaces and energy absorption capabilities."

In practical terms, Neba Mforsoh's research will help the Navy design more durable coated structures and help prevent equipment from failing prematurely.

"Marine structures will be designed with an understanding of material properties and the effects of extreme loading conditions in the ocean environment, increasing reliability," said Neba Mforsoh. "My research included diagnostics to determine why certain components in ships, such as cable connectors, fail prematurely at the interface. This research can be used to solve this problem and optimize future designs."

Once of Neba Mforsoh's mentors on the project was James LeBlanc, chief scientist of the Naval Undersea Warfare Cen-



***Irine Neba Mforsoh** performing an experiment in Professor Arun Shukla's Dynamic Photomechanics Laboratory at URI.*

Photos courtesy of Irine Neba Mforsoh

***Irine Neba Mforsoh** after the 2021 commencement ceremony for graduate students at URI.*

ter's platform and payload integration department.

"When presented with a problem of interest to the Navy, Irine designed experiments that would produce the results we were interested in," said LeBlanc. "Her testing was always well thought out and executed with attention to detail."

Besides her doctoral studies, which culminated with her dissertation, Neba Mforsoh has engaged with and impressed the Navy on several other occasions.

Neba Mforsoh was accepted into the prestigious Naval Research Enterprise Internship Program in 2020. When the 10-week program was canceled due to COVID-19, the Naval Undersea Warfare Center enabled her to do an internship at its facility in Newport during the summer of 2020.

"I worked on the adhesion behavior of polymers/metallic interfaces, material characterization, data analysis on the fracture behavior of saturated carbon/epoxy and glass/epoxy composites when subjected to low temperatures, battery testing and I assisted in marine mammal impact research," said Neba Mforsoh.

Later in the year, Neba Mforsoh was informed that she could do a virtual version of the Naval Research Enterprise Internship Program, which she did in November to December 2020 for the Naval Surface Warfare Center, Philadelphia Division.

Blazing a Trail

Shukla has mentored 105 graduate students at URI (30 of whom were doctoral students). According to the professor, Neba Mforsoh was the first female African American mechanical engineering doctoral student at URI. She finished her doctoral courses with a perfect 4.0 grade point average.

As an engineer at the Naval Undersea Warfare Center, Neba Mforsoh is contributing to the Navy's research on coatings and additive manufacturing.

"Irine has such a wealth of knowledge that she is able to work in many different technical areas at NUWC," said LeBlanc. "As an intern, she supported projects in material science, chemistry, and power/energy. More importantly, she is able to interact with senior researchers in a professional manner and has a continual desire to learn and grow as a NUWC employee."

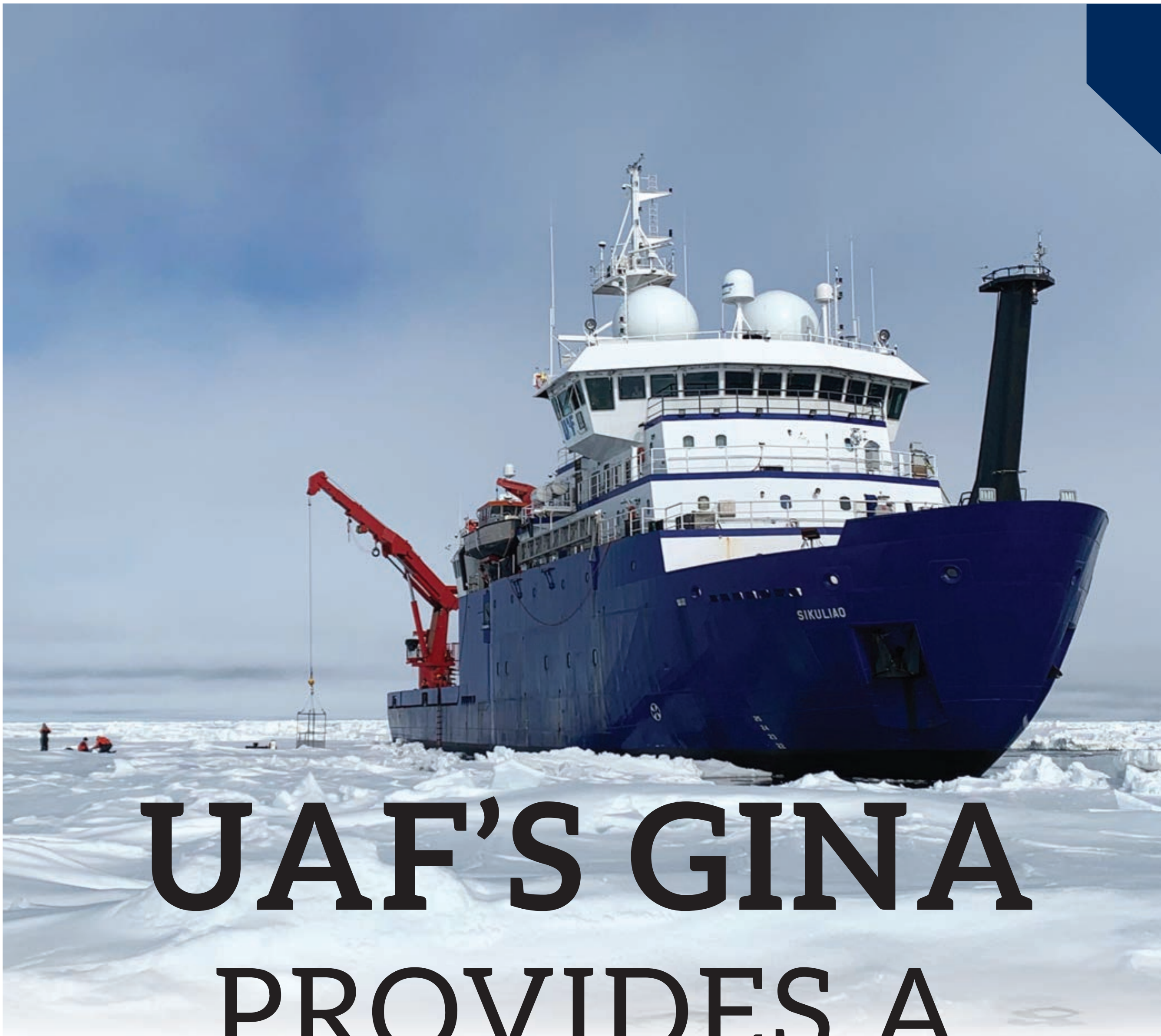


Photo courtesy Ethan Roth

UAF'S GINA PROVIDES A GUIDING HAND IN ARCTIC OCEAN RESEARCH

The Sikuliaq, a 261-ft. ice-capable research vessel operated by UAF, pauses in the Arctic Ocean in June 2021 during its fifth year of operation.

The research vessel Sikuliaq navigated among and around the chunks and slabs of Arctic sea ice above Alaska for several weeks on two voyages this fall, breaking through frozen slabs when it had to, just as its sturdy hull is designed to do. It's now on a third trip.

The Sikuliaq, a 261-ft. ice-capable research vessel operated by UAF, pauses in the Arctic Ocean in June 2021 during its fifth year of operation. A few months later, it traveled farther north than ever before — almost 500 miles beyond Point Barrow.

Satellite imagery produced at the Geographic Information Network of Alaska, or GINA, at the University of Alaska Fairbanks Geophysical Institute helps the Sikuliaq weave its way through the ice.

The satellite images, along with satellite data from other sources, show up on the Sikuliaq's bridge in an easy-to-use web-based map server. The map server has been on the Sikuliaq since 2013, when the ship was built.

Steve Roberts, the Sikuliaq's science systems engineer, got the idea for the map server while working aboard the USCGC Healy, the Coast Guard's icebreaker, and has refined his system over the years.

"I remember every day scientists on the Healy continually saying, "Where are we?'," he said from aboard the Sikuliaq as it sailed in ice-strewn waters about 350 miles north of Alaska. Ice occasionally banged the hull as he spoke. "There was nothing on the ship that provided information relative to the science missions. We need to know where we are relative to science stations and moorings.

"When you are working in ice, the ice controls where you are," he said. "Knowing where sea ice is at all times is critical."

Eyes in the Sky

Navigating sea ice is a burgeoning field of interest as shipping increases in the Arctic, which is becoming increasingly open though not entirely ice-free. Icebergs from coastal sources still bob along, and thick slabs of sea ice still drift.

The National Snow and Ice Data Center notes that satellites have only been continuously monitoring sea ice since 1979. Prior to that, captains had to rely on their crews' firsthand observations and on weekly ice charts based on airborne observations and reports from observers on the coasts and other ships.

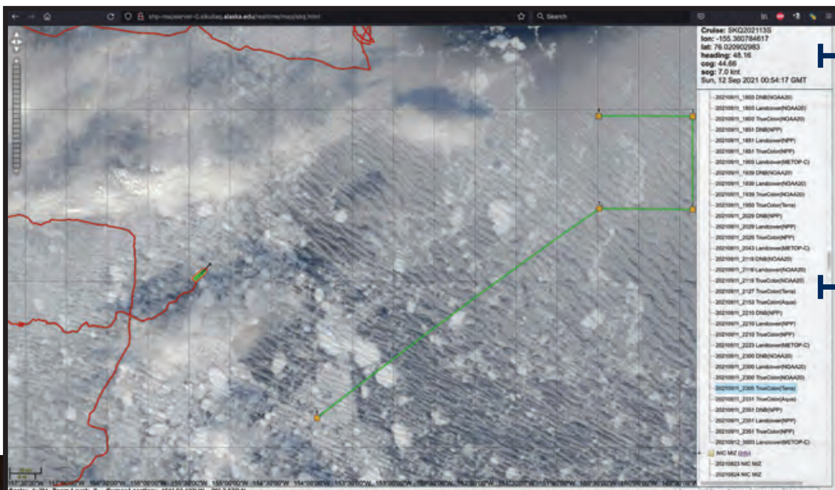
Avoiding the ice is often best for the scientists, who usually have a limited amount of time to get what they need from the open water. That was the situation on a seven-week research voyage UAF geophysics professor Bernard Coakley took into the Chukchi and Beaufort Seas and with a Navy-funded voyage in some of the same waters.

Satellite information retrieved from GINA and displayed in Roberts' tool, along with other information sources, also helps improve the safety, effectiveness and efficiency of the Sikuliaq's voyages. The National Science Foundation owns the Sikuliaq, a part of the U.S. academic research fleet, and the UAF College of Fisheries and Ocean Sciences operates the ship.

"There's tight interaction between the navigator and the scientists," Roberts said. "Scientists can determine where the ship goes, but a lot of times it's the ice that decides."

"Scientists need to maintain situational awareness of the conditions," he said. "And that's the purpose of this tool: to allow us to maintain situational awareness for scientists and for driving the ship."

Images courtesy Steve Roberts



GINA radar image: An image from the map server shows the Sikuliaq amid the sea ice on Sept. 12, 2021.

Scanning for ice: GINA images in the ship's map server can be viewed via an overhead monitor above the main console. This helps deck officers navigate in the ice pack by matching features visible in ice radar with the same features seen in the satellite imagery. Crew member Johna Winters, a master's student in marine resource management at Oregon State University, surveys the ice.

How it works

Satellite imagery is acquired by two fundamental types of sensors: passive and active.

Passive sensors monitor radiation in specific wavelengths continually emitted from the Earth, either at the surface or from the atmosphere.

Active sensors such as synthetic aperture radar emit signals that travel through clouds, bounce off the Earth's surface and return to the sensor.

Data from each type of sensor can be processed into different products for different uses.

GINA uses data from passive-sensor satellites in the National Oceanic and Atmospheric Administration's Joint Polar Satellite System.

Acquiring imagery through the GINA system in Fairbanks enhances the usefulness of Roberts' map server. Although the map server relies heavily on cloud-penetrating SAR imagery that shows the ice in great detail, SAR satellites image the same area just once every day or less often. Such infrequency means data from a dynamic Arctic Ocean can be quickly outdated.

Images via GINA can capture the same area more frequently because the images cover a wider area than those of a SAR satellite. But the surface in a GINA image sometimes might be obscured by clouds.

There's also the benefit of GINA being located in Fairbanks.

"We have antennas located in places like Interior Alaska and the technology to deliver these products right after the satellites fly overhead," said Jennifer Delamere, director of the Geographic Information Network of Alaska. "In previous years it would have taken hours or days to get the information."

"This is just a great example of UAF research helping the Sikuliaq get around in the ice. And it's taking advantage of local technology, both what Steve developed and GINA data, on the bridge of the ship," she said.

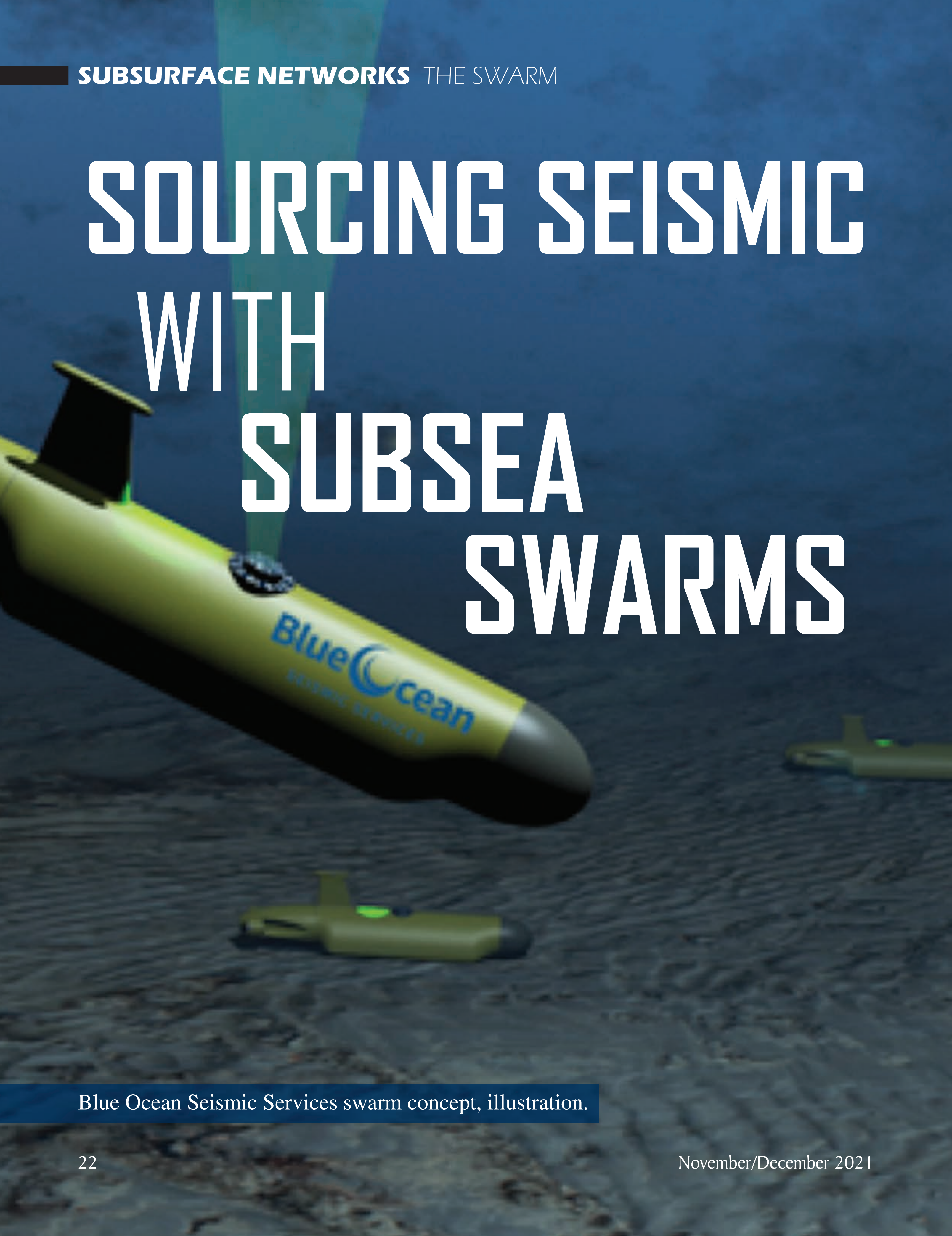
Delamere added that the Geographic Information Network of Alaska provides support for many operations in addition to those of the Sikuliaq.

GINA data is also used by the Alaska Sea Ice Program to analyze sea ice extent and characteristics, by firefighting agencies to show wildfire activity and by other agencies to show volcanic ash, river ice and flooding, and precipitation.

"GINA is ready to help whoever and whenever — whether it's for something on land, in the atmosphere, or way out at sea," Delamere said.

Excerpted with permission from the University of Alaska Fairbanks Geophysical Institute.

SOURCING SEISMIC WITH SUBSEA SWARMS



Blue Ocean Seismic Services swarm concept, illustration.

Swarm behavior of underwater vehicles has long been on the wish list. Couple that with collecting seismic data and you have an interesting challenge. The seismic industry has a track record for innovation – Blue Ocean Seismic Services is taking on the latest challenge. **Elaine Maslin reports.**

Image courtesy Blue Ocean Seismic Services

Seismic data acquisition isn't perhaps at the top of many lists when it comes to discussing innovation in the marine sector. Yet it's been an area that's seen leaps and bounds in innovation, from how the data is gathered to how it's processed, helping to reduce uncertainty for oil and gas explorers and increase understanding of how reservoirs are performing through field life.

Today, seismic streamer spreads cover thousands of square miles, there's automated cable-based seabed seismic-node deployment and the world's biggest super computers churn the data.

But now one of the latest innovations looks close to hitting the open seas. UK-based Blue Ocean Seismic Services, which only launched in 2019, just before the Coronavirus pandemic struck, has its goal set on commercializing self-locating ocean bottom seismic nodes to significantly reduce the time, cost and logistics footprint involved in seismic data acquisition.

Currently, ocean bottom nodes (OBNs), which contain hydrophones and geophones to pick up the seismic data reflected off the subsurface, have to be positioned using an ROV, or are deployed on a cable, which gets expensive and challenging in deeper waters. Instead, Blue Ocean Seismic Services' nodes will be able to fly themselves to pre-set locations, wait to gather data, as a seismic shot vessel passes overhead, then lift off and move to the next location, and so on.

The 700mm-long nodes are being built to operate for three months at a time down to around 2,000 m deep, before needing to be retrieved for recharging, data recovery and any maintenance before redeployment, with their support vessel (a standard offshore support vessel) also acting as the shot vessel.

It's a concept others have also been working on, but now Blue Ocean Seismic Services seems close to commercial reality, with pre-commercial trials planned for the North Sea and potentially the US Gulf of Mexico and off Australia next year. What's more, the company wants to provide these services not just to oil and gas companies, but also those involved in offshore wind, where "useful low cost high density seismic will be a novel way of characterising the seabed sub-structure," and carbon capture and storage (CCS).

"We've customers wanting product before we've delivered it," says Simon Illingworth, the company's managing director and CEO, who says the concept could cut costs by 50-60%. "bp and Woodside want as soon as it's available. It's exciting technology. It's substantially cheaper than traditional technology and a lot less carbon emissions, which is important now."

Illingworth has a background in developing start-up technology companies. Born in the UK, he moved to Australia where he founded and sold computer software firm SmartTrack in the early 2000s. Illingworth went on to work in telecommunications, satellite tracking and then petrophysical data evaluation before co-founding Blue Ocean Monitoring, a Perth, Australia-based start-up, in 2014, with co-founder and chief technology officer Ben Hollings, whose background is in maritime robotics development. Blue Ocean Monitoring's focus is using robotics and autonomous technologies to make data collection in the marine environment easier and with lower cost, risk to people and environmental footprint.

It's been working with Woodside, providing passive acoustic marine mammal monitoring during seismic surveys using Teledyne Webb Research Slocum Gliders (see *MTR*, October 2018). Illingworth takes up the story: "In 2017, the question arose that, if the gliders, as lander-gliders, could also be used to gather the seismic data." The Blue Ocean Monitoring team thought it could, so "Woodside then funded a development program to a tune of AUS$4 million," he says. "We're also a vendor to bp and they got wind of the idea and we cleared a series A funding with bp Ventures for £10 million at the end of

One of the latest node prototypes during trials.

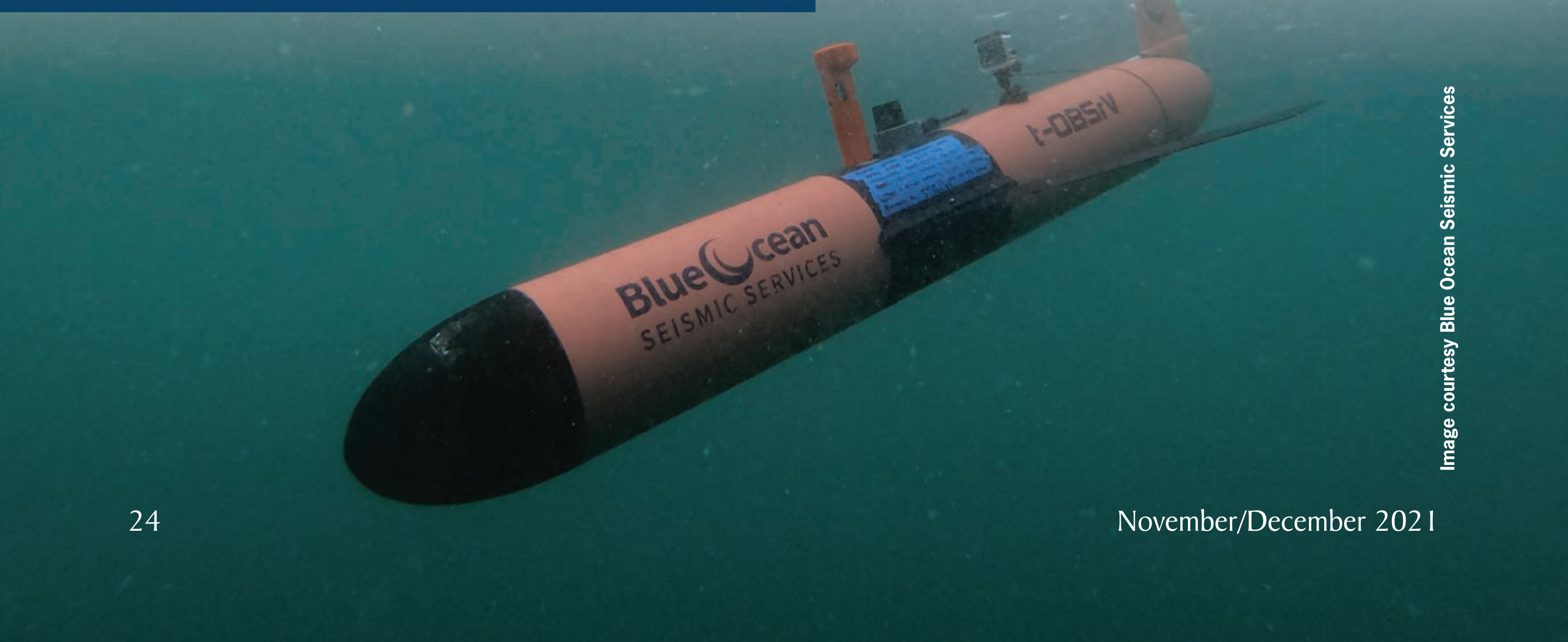


Image courtesy Blue Ocean Seismic Services

2019. Blue Ocean Seismic Services was then formed and we started development operations in the UK."

The team chose to have a small office in Perth, but its main base in Farnborough, a town west of London, to be close to its customers in London, but also due to access to suppliers and engineering talent in the area. Farnborough has a strong engineering heritage, having been home to the Royal Aircraft Establishment, a UK defense research group set up in the early 20th century (whose alumni include the likes of Geoffrey de Havilland of de Havilland and the Comet fame). Now, despite the pandemic and having only been running less than two years, the company has more than 35 staff, and growing, mostly in the UK.

More importantly, having designed the vehicle, electronics, command and control itself, it's now also chalked up some key system trials. Up until last year, work mostly focused on the OBNs and their buoyancy, to enable landing on the seabed. Late last year, in Australia, they tested the vehicle's command and control systems, which have been built by the company, and swarm control, using acoustic positioning and communications, work. The latter have proven to be able to accurately position the nodes in deepwater to within 2m, Illingworth says. The "testbed ocean bottom seismic robotic vehicle" (or tOBSrV) successfully traversed a series of waypoints, while providing status updates to a master vessel. It logged flight and engineering data, which is being utilized for further systems development and optimization.

Then, this year, off Blyth, on the UK's North Sea east coast, it's been testing coupling on the seabed – a critical element for gathering subsurface data. For a week, they repeatedly deployed six nodes, the pre-alpha nodes, as they've been called, and a traditional OBN, via a ship's crane and an ROV, and compared the data. "They were comparable," says Illingworth. "We're on a really good track now. We collected some

The concept could cut costs by 50 to 60%, said Simon Illingworth, CEO, Blue Ocean Seismic Services. *"bp and Woodside want as soon as it's available. It's exciting technology. It's substantially cheaper than traditional technology and a lot less carbon emissions, which is important now."*

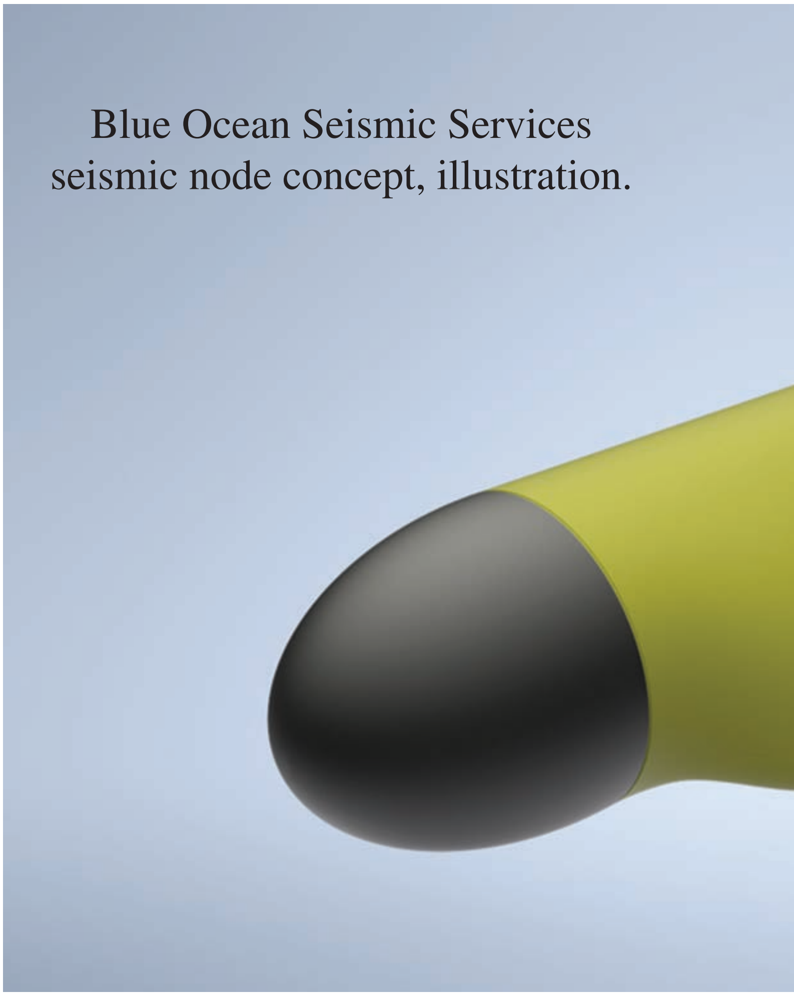
really good seismic and engineering data, how stable they are on the seabed. Testing next year will be autonomous, they will be swarming themselves." Next year will also see scale up, with the alpha prototype be tested "in the tens", then pre-commercial nodes tested in hundreds.

"We're going to have many of these on the seabed at any one time," says Illingworth. It's likely that crewed vessels of opportunity will be used initially, with the nodes deployed in their thousands via containerised systems that are as automated as possible and, because there are so many and they will be spread out over large areas, their acoustic positioning and communications will be supported by uncrewed surface vessels (USVs), as force multipliers.

Next year will also be about developing the launch and recovery system. Recovery is tricky, says Illingworth, but they've developed a technology for this, which includes being able to identify anything that's not one of their nodes automatically and putting it back over the side. It's currently not patented, so he couldn't say more. Next year's testing will be in the North Sea, probably also off northwest Australia at the


An over-the-side transceiver deployment during trials.

Images courtesy Blue Ocean Seismic Services

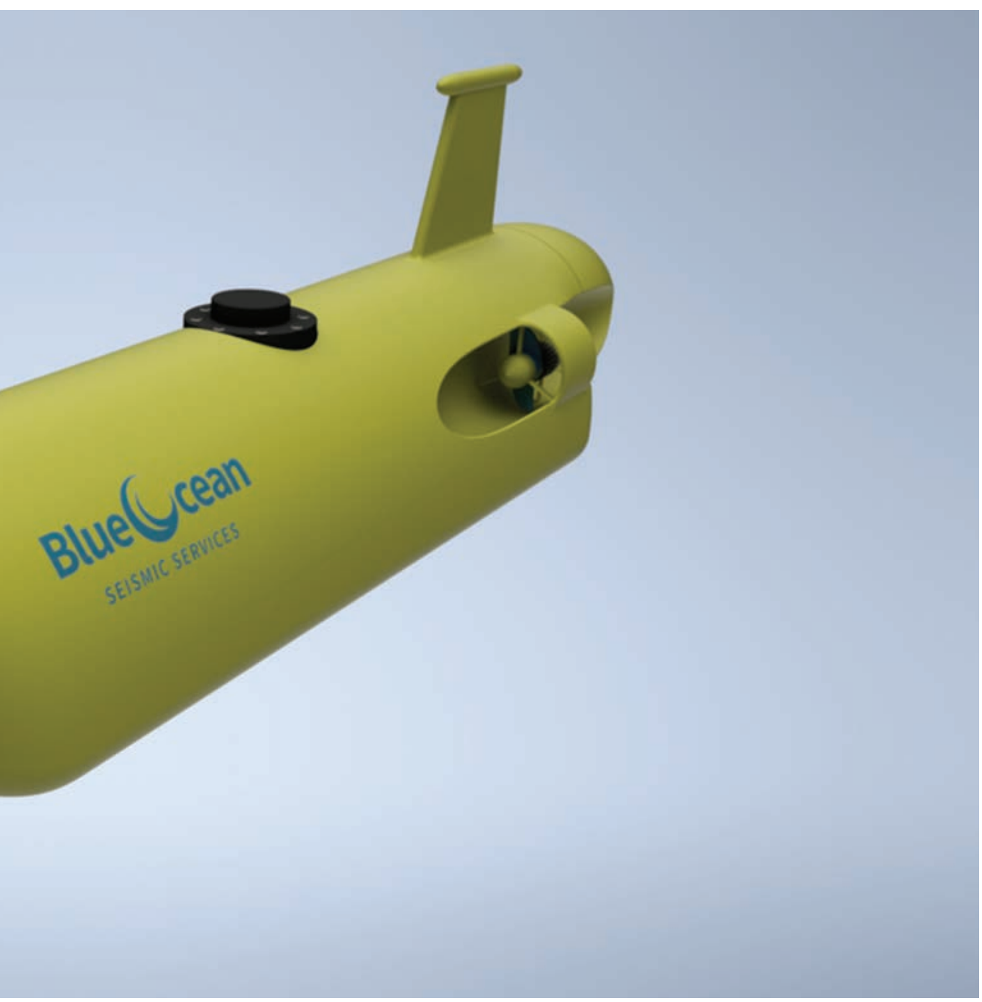

Blue Ocean Seismic Services seismic node concept, illustration.

end of Q2 and probably also in the US Gulf of Mexico.

Eventually, the nodes will also be communicating with other. "In the future, it will all be fully autonomous," says Illingworth. "Fully autonomous solution is a clear pathway for us. Autonomous vessels (including the source vessel) and nodes, doing their own thing. A fully autonomous solution is a clear pathway for us." There's likely to be evolution in the type of battery used, with lithium-ion used now, but a lot happening in batteries that this could change – although induction charging, which they'll use to limit having to open the units, will likely remain key.

The focus now, however, is building up the company with a goal to be running commercial operations in 2023-2024. "We're now starting to build up an operations team," says Illingworth, "transitioning from a technology company to an operating company and planning scale up manufacturing." The next step is likely opening an operations office, to cover the North Sea, also an office in Houston, to support Gulf of Mexico, Mexico and Brazil, with an operations hub, probably in Louisiana, after that.

"The Gulf of Mexico is a very important part of future," says Illingworth, especially as one of its key supporters, Woodside, is moving to merge with BHP, giving it more focus in that region. The key takeaway? Blue Ocean Seismic Services is one to watch in 2022.



Ocean Tech Services, LLC and Pacific Northwest National Laboratory

From Sea to Shining Sea

Addressing Offshore Wind Challenges with Buoy-based Technology

Facilitating meteorological and oceanographic data collection using validated methods to support the U.S. offshore wind industry

By Alicia M. Mahon, Lindsay M. Sheridan, and Mark Severy – Pacific Northwest National Laboratory

Buoys off Martha's Vineyard, Massachusetts undergoing validation in January 2020.

Offshore wind development planning and deployment are accelerating in the United States in pursuit of national and regional decarbonization goals. However, development is currently challenged by a lack of long-term observations of meteorology, particularly above the immediate ocean surface and including the rotor heights of offshore wind turbines. Such observations are needed not just by the wind industry to support specific developments but also by the research community to fill knowledge gaps regarding physical processes that affect the accuracy of computer models. Researchers need observations over annual cycles or longer to validate models under the full range of meteorological and oceanographic (metocean) conditions that wind turbines will experience. Additionally, information on the potential environmental effects of offshore wind energy development is needed to enhance our understanding of potential wind-wildlife interactions to support siting and permitting.

Measurement of metocean conditions in remote, complex offshore environments is challenging enough, and the offshore wind community endures the additional complexity of needing information at turbine hub heights hundreds of feet above the surface of the water. To address this challenge, researchers at the Pacific Northwest National Laboratory (PNNL) manage two buoys for the U.S. Department of Energy that are equipped with instruments, including Doppler lidars, to measure and make publicly available site conditions for the offshore wind community. Available on the U.S. Department of Energy's Data Archive and Portal (**https://a2e.energy.gov/data**), which is also managed by PNNL, buoy metocean data are freely accessed and used by offshore wind developers, consultants, regulators, and researchers to validate wind models, improve the understanding of air-sea interactions, reduce uncertainty and risk in characterizing wind resources, and support offshore wind siting and design.

Data Collection and Analysis

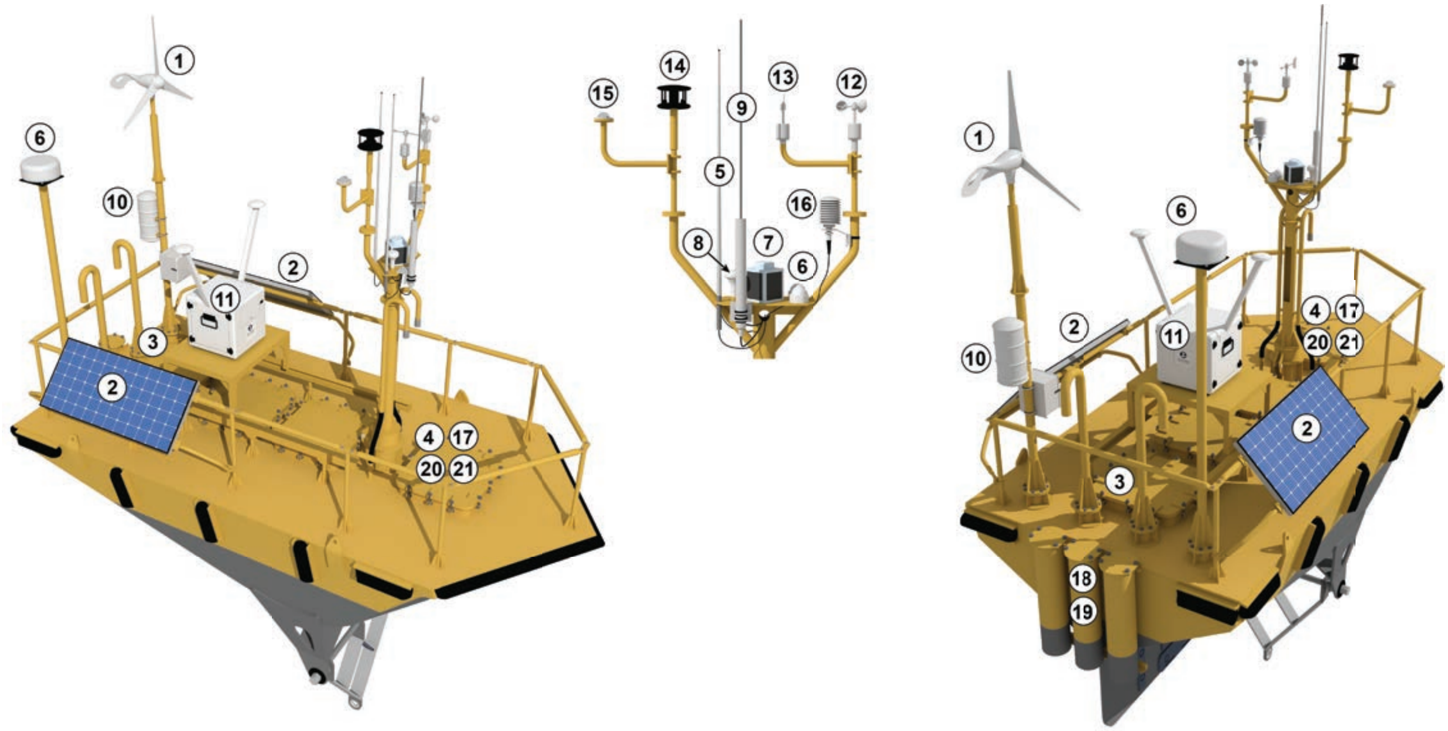
The lidar buoys collect a comprehensive set of metocean measurements needed for offshore wind resource characterization. The centerpiece of the instrumentation suite for each buoy is a motion-corrected lidar system that provides profiles of the wind speed and direction up to 250 meters above the sea surface. In addition to a lidar, each buoy collects complementary oceanographic and near-surface meteorological data, such as ocean current profiles and air and sea temperature.

The buoys provide a cost-effective, innovative, and mobile solution for gathering the long-term observations needed to comprehensively characterize the wind resource at diverse locations of offshore wind development interest.

After procurement in 2014, the buoys underwent testing at PNNL's Marine and Coastal Research Laboratory in Sequim, Washington. The goal was to assess the performance of all sensors, power systems, and communications links with the buoys deployed in a location representative of a real operational environment.

Schematic of lidar buoy instrumentation

Illustration by Mike Perkins, Pacific Northwest National Laboratory



Power, Data, Communication, & Navigation

1. Turbine
2. Solar panels
3. Diesel generator (compartment)
4. Data loggers (compartment)
5. Cellular antenna
6. Satellite antenna
7. Navigation light
8. AIS GPS antenna
9. AIS VHF antenna
10. Radar reflector

Meteorological

11. Wind profile
12. Wind speed (cup anemometer)
13. Wind direction
14. Wind speed & direction (ultrasonic anemometer)
15. Solar radiation
16. Air temperature & relative humidity
17. Barometric pressure (compartment)

Oceanographic

18. Water velocity profile (moonpool)
19. Salinity and water temperature (moonpool)
20. Wave spectrum (compartment)
21. Water temperature (compartment)

East Coast Deployments

In December 2014, one buoy was deployed 42 km off the coast of Virginia, and in November 2015, the second buoy was deployed 5 km off the coast of New Jersey. Each buoy collected over a year's worth of continuous metocean data, providing the first open-ocean observations of hub height wind speed and direction over a full annual cycle in the United States. The buoys diligently collected data during conditions that are experienced by East Coast offshore wind farms, ranging from gentle winds and seas to hurricanes and nor'easters.

Observations from the East Coast buoy deployments propelled offshore wind energy research in a variety of impactful directions. First, researchers thoroughly characterized and examined the wind resource at the two locations of offshore wind energy development according to seasonal and diurnal trends, origin of the wind resource, and an assortment of metocean conditions such as atmospheric stability and wave age.

Once researchers established the behavior of the wind resource off Virginia and New Jersey, they employed the buoy observations to validate theoretical wind speed profile assumptions, such as the logarithmic wind profile from Monin-Obukhov Similarity Theory, and reanalysis models that incorporate them. Reanalysis models are commonly engaged in setting wind energy project performance expectations, and the East Coast buoy observations revealed a slow wind speed bias in these models, which translated to simulated gross capacity factors up to nine percentage points lower than the capacity factors suggested by the observations. These findings inspired further research into potential improvements in wind resource simulations through high-resolution models with coupled atmospheric and oceanic feedback.

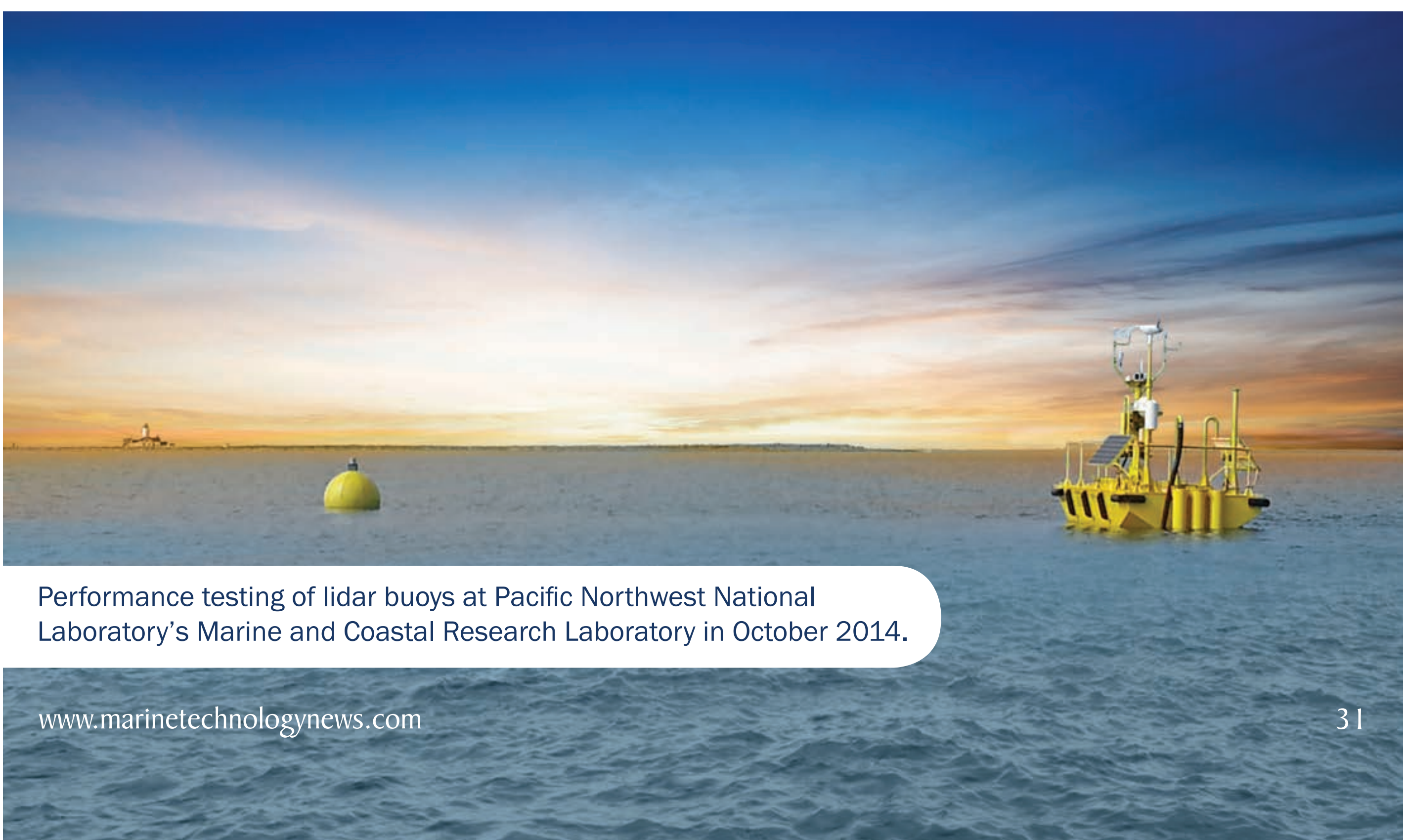
Buoy Upgrades and Lidar Validation

Following their East Coast mission, the buoys were outfitted with upgraded lidar systems that better capture wind data at extended heights above the sea surface, allowing for improved understanding of wind behavior at increasing hub heights and across the large rotor-swept area of offshore wind turbines. The buoys returned to Atlantic Ocean waters in 2019, this time off the coast of Martha's Vineyard, Massachusetts to validate the new lidar systems using the observational technology available at Woods Hole Oceanographic Institute.

Validating the readings from the lidar buoys through an offshore measurement campaign helps evaluate the accuracy and uncertainty of the subsequent wind resource measurements. The validation process involves deploying each lidar buoy near a trusted reference source for comparison. The lidar must collect measurements across a range of wind conditions, including low- and high-wind speeds, that can be evaluated against the reference source. A typical validation process can take between four and eight weeks to capture enough measurements across the required wind speed range. Guidelines for validating the performance of floating lidar systems have been published by the Carbon Trust, including their Roadmap for Commercial Acceptance of Floating Lidar Technology and a set of Recommended Practices for Floating Lidar Systems, which was later published by the International Energy Agency Wind Technology Collaboration Program.

West Coast Deployments

After a successful validation campaign, the buoys were deployed in September and October 2020 off the northern and central California coasts to support gathering metocean mea-



Performance testing of lidar buoys at Pacific Northwest National Laboratory's Marine and Coastal Research Laboratory in October 2014.

Image courtesy of Pacific Northwest National Laboratory surements that will inform decisions on potential leasing of wind energy sites in the Pacific Ocean. In addition to gathering valuable metocean data to better understand wind energy potential off the West Coast, a PNNL-developed stereo-vision wildlife tracking technology, called ThermalTracker-3D, was installed on one of the buoys to validate the system for tracking bird and bat behavior around remote wind turbines. Using a pair of thermal video cameras, the technology remotely senses movement of animals and objects, day and night, near critical assets such as offshore wind turbines. ThermalTracker-3D is designed to provide data to help inform siting and permitting decisions for wind turbines, and it allows monitoring of bird and bat behavior following offshore wind farm construction to help fill gaps in the understanding of avian-wind technology interactions.

Investigation is underway using the West Coast data to establish wind project performance potential and to understand the impacts of Pacific metocean conditions on the available wind resource and the theories and models that simulate it. In addition, the current buoy deployment allows researchers to perform an East Coast versus West Coast comparison of model hub height wind speed accuracy. Model errors are being classified according to conditions observed in both diverse environments of offshore wind development interest, such as stable boundary layers, and according to conditions unique to each coast, for example the coastally trapped wind reversals that occur on the West Coast. The results of the analyses will set expectations of uncertainty for model users along with identifying areas for improvement for future model development.

Research & Development

The current and foreseeable expansion of offshore wind energy deployments in the United States necessitates the development of new, innovative instruments for resource characterization and environmental monitoring. Building on the success of the East and West Coast buoy deployments, PNNL is developing an instrumentation test buoy that will serve as an offshore platform to evaluate the performance of new instrumentation under development for offshore metocean and/or wildlife monitoring. Possible test sensors for the platform

Buoy stationed off Morro Bay, California for deployment in September 2020.

Image courtesy of AXYS Technologies, Inc.

include radar wind profilers, temperature profilers, surface atmospheric turbulence measurements, weather and precipitation measurement, and wildlife tracking and monitoring instrumentation. The test buoy is being designed to accommodate a range of future sensors both above and below water and to have additional capacity for weight, electric power, mounting locations, and data storage and transmission. The buoy will have the ability to adapt to the needs of new instrumentation and expand systems to meet power and data requirements for test instrumentation.

One such piece of new instrumentation that will be tested on the test buoy is an eddy covariance flux system under development by the University at Albany's Atmospheric Sciences Research Center. The eddy covariance flux system is being designed to integrate with a lidar buoy to measure turbulence momentum and buoyancy fluxes near the sea surface. Deploying the eddy covariance flux system alongside a Doppler lidar will allow the continuous in situ characterization of the atmospheric surface fluxes, turbulence, and wind profiles that influence wind power generation potential and fluctuation of turbine loads. Researchers can use these measurements to evaluate and refine wind resource assessment and short-term to medium-range forecast models.

The Future: 30 GW by 2030

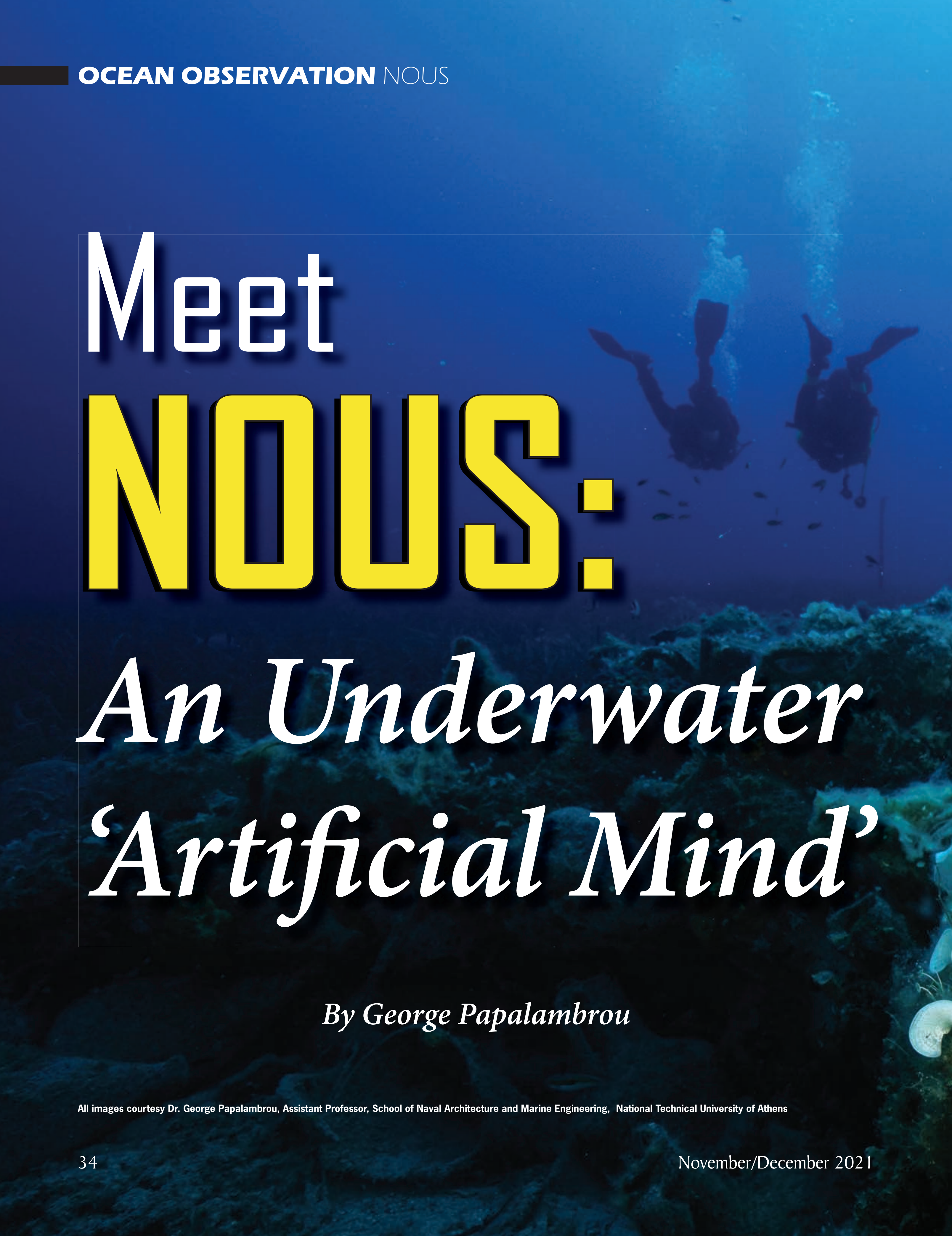
The U.S. offshore wind development and operational pipeline stands at a potential generating capacity of 35.3 GW, according to the 2021 Edition of the U.S. Department of Energy Offshore Wind Market Report, a capacity that is poised to support the 30 GW by 2030 national offshore wind energy goal announced by the Biden Administration. With strong winds prevalent over our country's largest bodies of waters, the U.S. wind energy industry is pursuing energy development in the Atlantic and Pacific Oceans and the Great Lakes. To design wind farms and select the most appropriate locations, engineers and decision makers need to understand the offshore wind and ocean conditions that impact energy production expectations, equipment reliability, safety, and project costs.

With support from the U.S. Department of Energy, PNNL manages the deployment of lidar buoys to facilitate offshore measurement campaigns that advance our understanding of the offshore environment and provide the observational data needed for model validation, particularly at hub height where offshore observations are particularly lacking and difficult to obtain. The metocean data collected by the buoys support the estimation of annual energy production, economical and reliable integration of wind energy, and characterization of turbulence for developing and applying design load criteria. The data also provide a better understanding of the offshore development environment that can improve siting, optimize designs, improve reliability and performance, increase safety, and reduce capital and operating costs.

Providing offshore wind stakeholders with open access to the buoy data facilitates the informed decision-making needed to catalyze development in support of sustainable, equitable offshore wind energy.

About Pacific Northwest National Laboratory

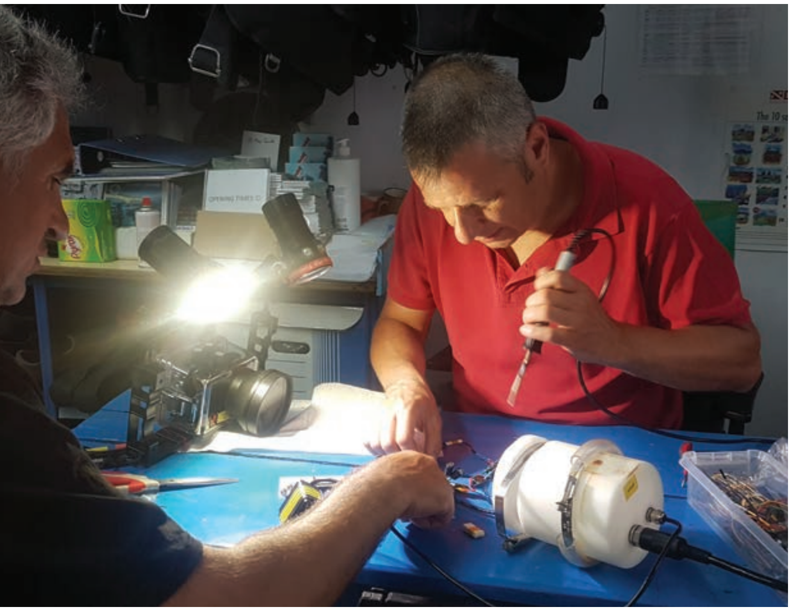
Pacific Northwest National Laboratory (PNNL) draws on its distinguishing strengths in chemistry, Earth sciences, biology, and data science to advance scientific knowledge and address challenges in sustainable energy and national security. Founded in 1965, PNNL is operated by Battelle for the U.S. Department of Energy's Office of Science, which is the single largest supporter of basic research in the physical sciences in the United States. The U.S. Department of Energy's Office of Science is working to address some of the most pressing challenges of our time.

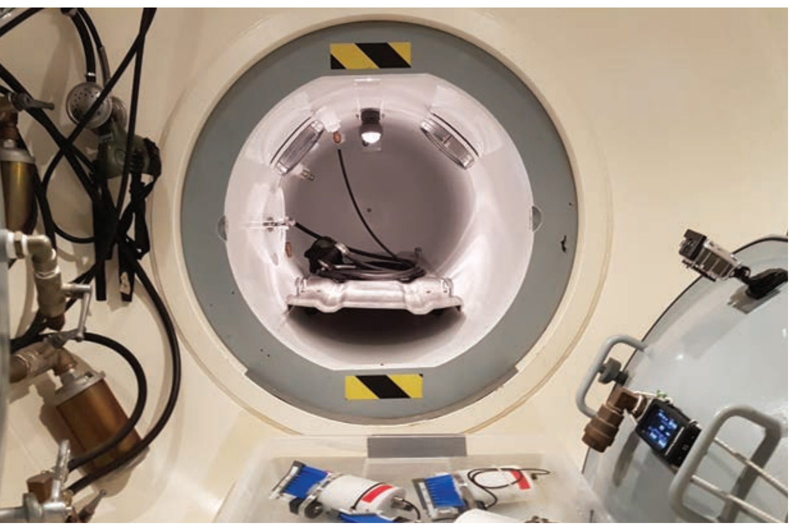


Meet NOUS: An Underwater 'Artificial Mind'

By George Papalambrou

All images courtesy Dr. George Papalambrou, Assistant Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens





The establishment of Maritime Protective Areas (MPA) and marine archaeological sites has been an objective of the Ministries of Culture and Environment in Greece for a long time. One of the main problems that delayed the implementation specifically of the "underwater museums", was the way they were protected. Usually in ancient shipwrecks, only their cargo is preserved, which is mostly amphorae, that can be easily stolen.

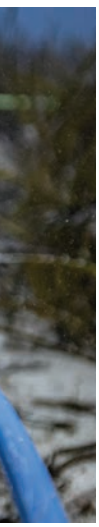
Therefore it was both a necessity and a requirement for a system which should be self-powered (since in most of the places where wrecks are located there is no electrical power supply), able to connect to the internet with all available technologies for communication and remote control, have sensors which can monitor the site of interest continuously and alert appropriately in case of violations, tampering or other events.

Such a system could have many useful applications, such as monitoring and surveillance of marine protected parks, diving parks, sea farms; make real-time scientific observations throughout the day and over long periods of time and monitoring of biodiversity and climate change.

At the beginning of 2019, the design of the Underwater Visual Observation System "NOUS" (uNdersea visiOn sUrveillance System, which in Greek means "mind") was launched, which was successfully completed a year later.

"NOUS" allows continuous (24/7) monitoring and protection of an underwater site using machine learning and image and sound processing algorithms.

Briefly, it is a system consisting of an underwater array of self-cleaning cameras and microphones, which are either connected by optical fiber and electrical power conductor to the nearest shore, or to a floating platform on the sea surface. On the shore or on the platform there is a photovoltaic panel pow-



All images courtesy Dr. George Papalambrou, Assistant Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens

er supply and communication devices for Internet connection.

On the occasion of the successful completion of the initial operation phase of the "NOUS" system in Alonissos, more detailed information and perspectives are presented in this article.

The system was installed in February 2020, at the ancient shipwreck of Peristera, at Alonissos island, Northern Sporades, Greece, providing for the first time worldwide the capability for continuous monitoring of an underwater museum. The wreck is located 200 meters from the rocky islet of Peristera and at a depth of 21 to 33 meters. It is a merchant ship loaded with thousands of amphorae from Mendi (the ancient city of Halkidiki) and Peparithos (today's Skopelos), areas known in antiquity for their wine. The pile of amphorae, which extends over a length of 25 meters, gives a sense of the contour and large dimensions of the ancient merchant ship. The ship is described as one of the largest of the classical period in ancient Greece. It is estimated that it could carry about 4,000 amphorae and had a displacement of 120 tons. The pointed bottom (oxypythmenos in Greek) amphorae are the most common commercial transport vessels of antiquity, weighing about 8-10 kg and having a capacity of 15-25 liters. They are perhaps one of the most ingeniously invented and practical vessels of antiquity, having two handles to aid transportation, a narrow high neck and a sharp end to allow them to be safely stowed in the hold. The spectacular shipwreck proved that large merchant ships of over 100 tons were already sailing in the Mediterranean in the 5th century BC.

The prototype system in Peristera started its pilot operation in March 2020. The project was commissioned and funded by the Ephorate of Underwater Antiquities / Ministry of Culture & Sports under the European program "Bluemed MED 2014-2020".

All images courtesy Dr. George Papalambrou, Assistant Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens

After the opening on August 3, 2020, divers from Greece and around the world can now dive in Greece's first underwater museum in Alonissos.

The system consists of an onshore section at Peristera and an underwater section at the wreck site. Between the two sections there is an interconnection consisting of an optical fiber and a copper power supply.

Onshore section

The electricity of the system is provided by a fully autonomous system of photovoltaic panels and batteries, installed in Peristera. The sizing of the PV system was based on load requirement estimates, meteorological data for the area and the requirement for electrical autonomy for at least up to 7 days.

In terms of communications, WiFi at a frequency of 5 GHz is currently the main form of interface with the remote control station and is carried out via a point-to-point link between Peristera and Steni Vala.

At the land station, visual monitoring of both the site and the sea surface of the wreck is carried out by means of a remote-controlled infrared camera. In addition, there is a meteorological station for measuring atmospheric parameters such as air temperature, barometric pressure, relative humidity, wind speed and direction.

There is also an appropriate electrical power distribution and protection circuit and devices for measuring the voltage and current of the power lines, all monitored by the local computer.

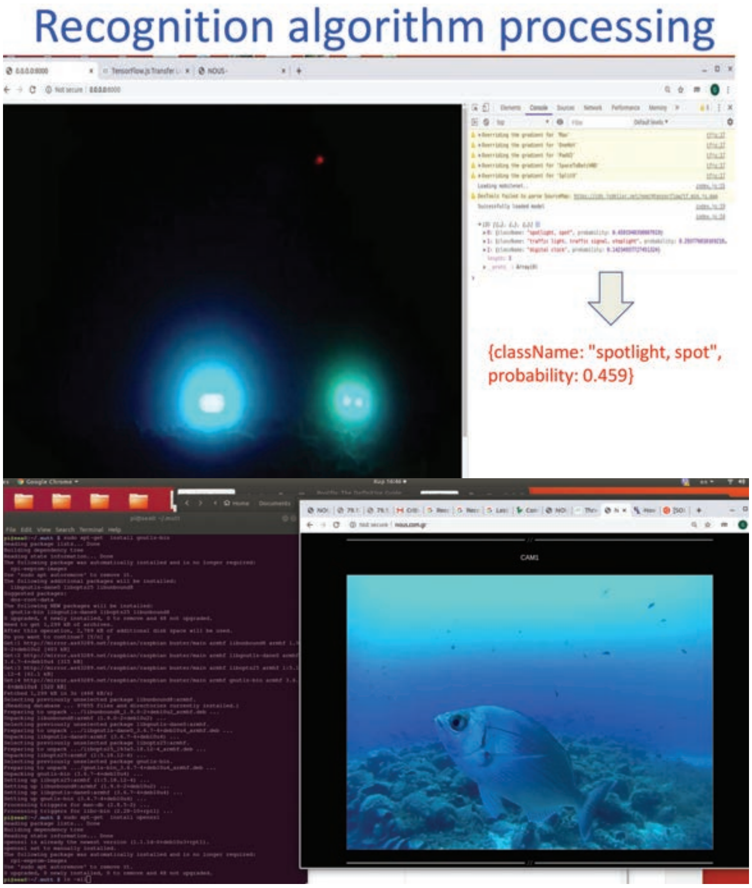
Underwater section

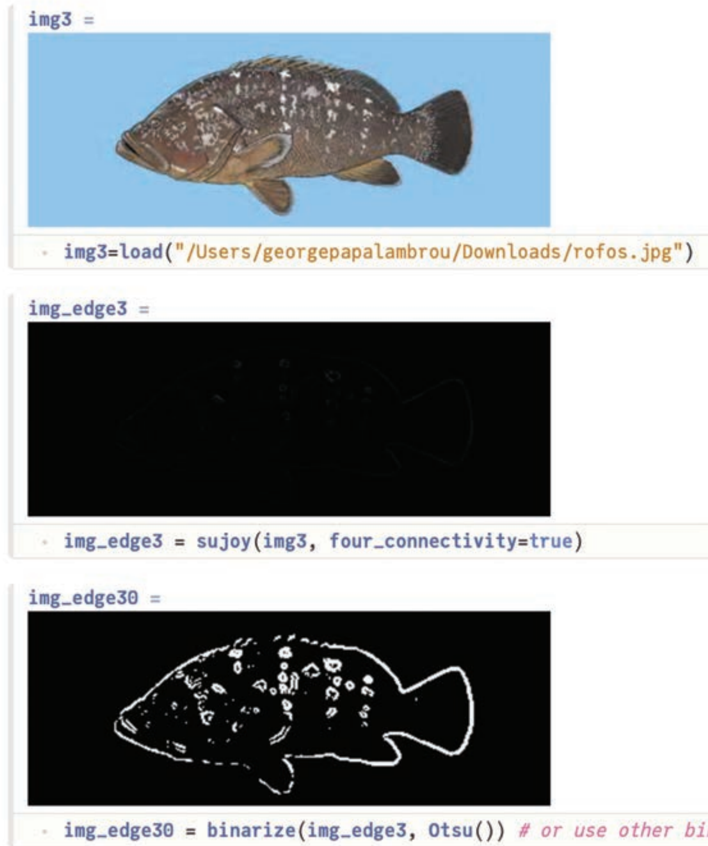
The underwater image transmission system consists of five cameras and one network switch. Each camera is easily adjusted in height and bearing so that it covers ("sees") the area of interest during the underwater installation. All cameras send video (stream) in real time over the network for processing to a remote station via the internet.

The underwater cameras are digital, color, state-of-the-art, with high-resolution technology and have a wide-angle lens. Each camera is connected to a local computer, which uses appropriate software to monitor its operating parameters. It is also possible to install additional instruments such as measuring sensors for the abiotic environment, underwater lights for night observations, lasers, infra-red cameras, etc.

The computer communicates via an Ethernet network with the other devices in the system, for transferring images and measurements (ie. electrical quality, speed and network status, etc.). It has a Linux operating system which allow to add applications, change settings remotely and secure access via ssh protocol. The computer has a custom electronic circuit designed for voltage and current measurements, both on the power line and on other consumers (wiper, lights, etc.).

The camera, lens and electronic parts are mounted in a wa-





tertight housing (camera housing). The housing is made of thermoplastic, with a removable front part made of transparent crystal and an O-ring seal. The ethernet switch and the fiber-to-copper converter are also located in a sealed hub housing.

The removal of all individual parts is by design easy, allowing for on-site maintenance or replacement of parts of the system without having to lift out of the sea the entire installation.

Wet plugs suitable for the marine environment have been fitted, allowing the cables to be connected and disconnected in the water. The two enclosures were designed entirely for the needs of the project, taking into account parameters such as depth, mounting, oxidation, cathodic protection and resistance to ultraviolet (UV) radiation.

Particular attention was paid to the ability of disconnection, cut-off of the system. So in case that a fishing gear gets entangled in one of the cameras (housing), or "catches" a cable branch, then by the tensile force exerted, this particular branch can be disconnected from the rest of the overall installation without pulling apart and eventually losing the whole system.

An automatic cleaning function of the crystal has been provisioned in the camera housing that removes marine deposits that develop over time and reduce the effectiveness of the optical system. Thus, a wiper system made for the needs of this particular housing was installed, consisting of a sealed servo motor and a cleaning arm with a rubber cleaning material. The cleaning system is fully and autonomously controlled (via image processing algorithms and optical system quality diagnostics) by the camera computer. During the design phase, the practice of 3D-printer manufacturing was followed for all components to ensure full size functionality.

Software application

The "NOUS" system has a wealth of automatic monitoring and protection capabilities through machine learning algorithms and image and sound processing. It is thus possible to detect any presence in the area of interest, such as divers, remote-controlled robots-ROVs, as well as the slightest light source in the dark. In particular, any alteration of the area of interest can be identified. In addition, an appropriate algorithm counts and detects the slightest change in the image on the camera housing crystal and, if necessary, immediately activates the wiper.

In all the above cases, an appropriate message is sent to selected recipients to evaluate the change in the area and carry out further investigation.

The machine learning algorithms used allow both the recognition of the object and the determination of its position in the image (object detection). They can also identify and classify their findings into specific categories (classification).

The Artificial Intelligence (AI) system on the "NOUS" uses

All images courtesy Dr. George Papalambrou, Assistant Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens

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[2] M. Atmatzidou, Diving into Greece's first underwater museum, National Geographic, 2/12/2020, https://www.nationalgeographic.com/travel/article/diving-into-the-first-underwater-museum-in-greece?cmpid=org=ngp::mc=social::src=facebook::cmp=editorial::add=fb20201202travel-greeceunderwatermuseum::rid=&sf240674775=1&fbclid=IwAR2PjCSz2WoJF0V1pgg1YsWl9ILtjy3M4r916F_rH_IPw0p-KVikgQINNuU

[3] Y. Elafros, Science Culture, "Shipwreck surveillance gets Microsoft funding", Kathimerini, 27/4/2021, https://www.ekathimerini.com/culture/1160037/shipwreck-surveillance-gets-microsoft-funding/?fbclid=IwAR27xKef-CL6jDZa8m–j1yBVhBfR0CNOY3tgwG_Fc-5uJ3Q0iV0UOF0twQ

neural networks that during the "training" phase were adapted to the data of the environment of the wreck monitored in Peristera, the land area of the equipment installation and the marine area on the surface of the wreck. Different operational scenarios in the wreck area were tested and video and image footage was collected in different phases, such as in calm conditions, with sea turbulence, during daytime and night diving, with use of lighting, ROV passage, different water column turbidities, with creation of debris on camera lenses, the passage of boats and other floating objects.

Perspectives

After the inauguration (August 2020) there has been intense interest from Greek and international stakeholders, both from the diving public that visited the marine museum and from scientists about the potential of "smart" monitoring of marine life which can be continuous and in real time. The topic was covered by the world's major news agencies and media [1], [2], [3].

After about one year of pilot operation, the system is gradually moving into the second phase of its development, during which it will be enriched with new classes: fish fauna and protected species living in the National Marine Park of Alonissos Northern Sporades (N.M.P.A.N.S.), with the prospect of extending the EEAX Peristera at Stratoni, Halkidiki. In this direction, image processing and classification tests for the fish fauna observed at the wreck site have already started.

In April 2021, Microsoft has chosen to support the biodiversity conservation effort through "NOUS" by providing technical support on AI issues and access to its computing infrastructure in the form of a grant, supporting the proposal "Machine Learning and Real Time Monitoring for the conservation of marine life with emphasis on seahorses."

LESSONS LEARNED IN SETTING UNDERWATER RADIATED NOISE TARGETS:

A BC FERRIES CASE STUDY

*By **Greg Peterson** BC Ferries, Director of Engineering, **Chanwoo Bae**, BC Ferries, Engineering Manager (Naval Architecture), and **Derek White,** Vancouver Fraser Port Authority, ECHO Program Project Manager*

In a typical year, the waters surrounding British Columbia's Port of Vancouver host approximately 3,000 deep sea commercial vessels and 19 of the 35 ferries operated by BC Ferries, one of the largest ferry operators in the world. These waters are also home to a wide variety of aquatic wildlife, including the southern resident killer whales (SRKW), which have been listed as endangered in Canada since 2003.

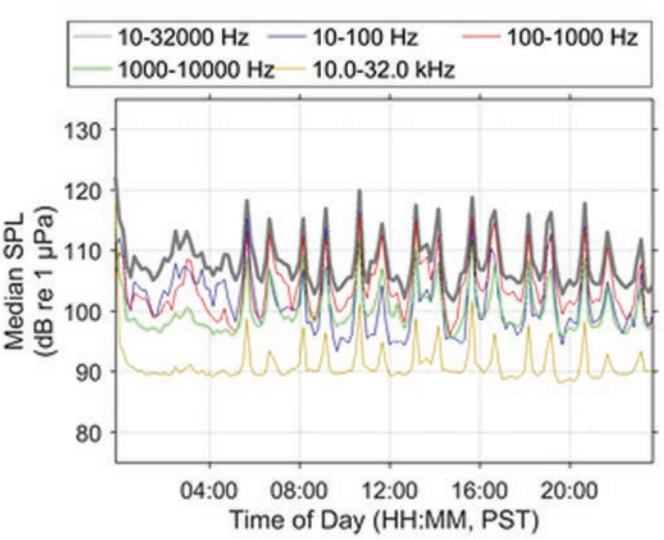


FIGURE 1: Sound Pressure Levels measured in the Strait of Georgia during a typical day.

With vessel-generated acoustic disturbances identified by Fisheries and Oceans Canada as one of four key threats to the SRKW, the Vancouver Fraser Port Authority launched the Enhancing Cetacean Habitat and Observation (ECHO) Program in 2014 to better understand and manage the impacts of commercial vessel traffic on at-risk whales, with a particular focus on vessel-generated underwater noise.

In moving towards this goal, in 2015, the ECHO Program began monitoring underwater noise through a cabled hydrophone system installed in the Strait of Georgia, near the international shipping lane. The hydrophone system continuously measured underwater noise, showing that peak noise levels strongly correlated with BC Ferries' ferry schedule between Tsawwassen and Nanaimo (Figure 1). This initial study compelled BC Ferries—one of the ECHO Program's founding advisory working group members--to undertake research to better understand the underwater noise contributions of its fleet.

MEASURING AND SETTING TARGETS FOR UNDERWATER NOISE LEVELS

Between 2015 and 2017, BC Ferries contracted dedicated vessel sound trial measurements in addition to measurement opportunities via the shipping lane hydrophone system. As part of this baselining effort, an unusual trend was noted in BC Ferries' larger vessels: its C-Class (Queen vessels), Spirit Class and Celebration Class vessels. In each case the radiated noise levels (RNL) level did not change, or even increased, as vessel speed was reduced. This finding is unlike the trend observed in most vessels, where a decrease in speed has a significant impact in reducing underwater radiated noise.

Following this baseline effort, BC Ferries identified underwater noise reduction as an objective and set an ambitious fleet-wide target of a 50 percent reduction in underwater noise based on typical sound levels from ferries crossing Strait of Georgia in the 2016 measurements.

In 2018, BC Ferries advanced this effort by including underwater radiated noise (URN) performance requirements in the specifications for a new major vessel procurement intended to replace its existing C-Class ferries.

To address the frequency ranges of greatest sensitivity to SRKW, BC Ferries developed specific targets based on the frequency ranges used by the whales. This resulted in three spectrum based underwater radiated noise targets: a general broadband target, a SRKW communication band target, and a SRKW echolocation band target (Figure 2).

Despite the fact that the planned replacement vessels are intended to be larger and faster than the previous C-Class ferries, BC Ferries set a very aggressive broadband underwater radiated noise targeted reduction of 14dB. This equates to a 97 per cent reduction in total under water radiated sound intensity (Table 1).

In addition to the BC Ferries URN criteria, a Classification Society URN notation was also specified; this ensured the contracted Class (ABS) was engaged in the URN design process.

Underwater noise targets are only one performance metric stated in the new ferry build requirements and needed to be considered in conjunction with BC Ferries' other required performance characteristics. There was limited research available about how underwater radiated noise limits might be accomplished in concert with other critical performance requirements like speed and operational efficiency essential to maintaining a scheduled ferry service.

BC Ferries contracted Det Nortske Veritas (DNV) as its third party expert in underwater radiated noise. In 2019, BC Ferries also released a global Request for Expressions of Interest (RFEOI) for the Major Vessel Replacement Program to solicit interest, capacity and capability to be considered for the procurement. For many shipyards, this would have been the first set of performance requirements for a ferry build that included underwater radiated noise targets and requirements.

In a design build contract, the shipyard would shoulder the primary risk in meeting the underwater noise requirements. Unlike some other performance requirements, achievement of the URN contract requirement might not be possible to fully assess at the design stage. Once measurements are obtained during sea trials following construction, there may be little opportunity for the shipyard to apply corrective solutions. Thus the development of design tools (software and databases) is a critical element to achieve the program goals.

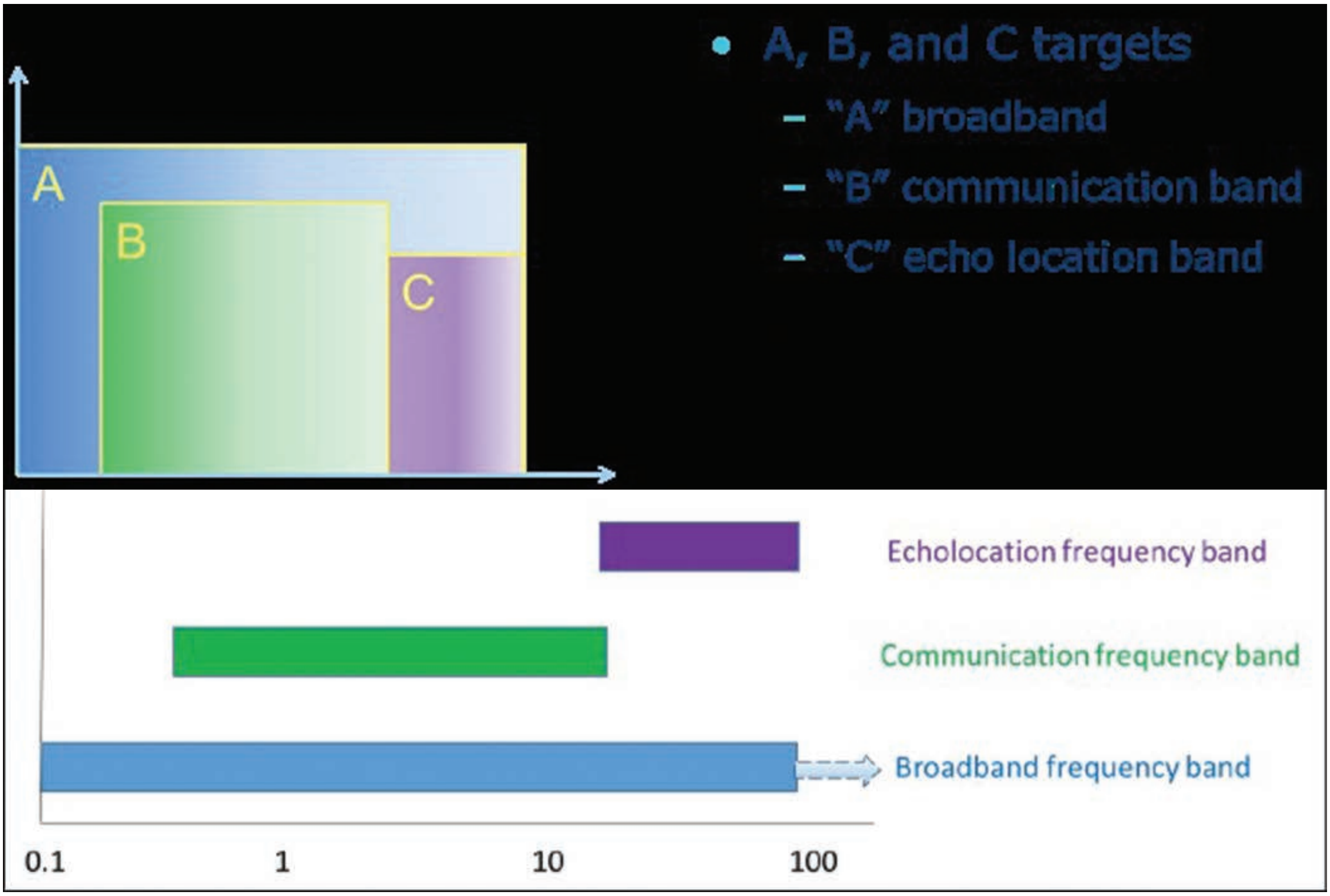
ASSESSING PROPELLER DESIGN AND PROPELLER SYSTEMS AS CONTRIBUTORS TO UNDERWATER NOISE

With support from Transport Canada, BC Ferries and DNV conducted a study to understand how underwater noise could be reduced in the current fleet by modelling propellers using the latest numerical tool and altering design parameters to observe change in URN signatures. Studies have estimated that up to 80 per cent of the underwater noise a ship produces comes from cavitation at the propeller; therefore the study focused on propeller design (Figure 3). Cavitation is caused when low pressure regions created during propeller motion create vapour bubbles which implode or pop and can generate high intensity sound waves over long distances. This action occurs at much higher frequencies than other ship-sourced

Vessel Particulars	New Major Vessel	C-Class Vessels to be Retired
Vessel Type	Double-ended Ro/Pax	Double-ended Ro/Pax
Length	167-172m max	139m
Beam	28.2	27.1
Speed (max)	21 knots service speed	20.5 knots
Power Plant	TBD	Diesel gearbox
Propulsion	CP Prop combinator; or Azimuthing thruster/pods with Fixed Pitch Props	CPP combinator
Capacity	360 vehicles, 2100 pass/crew	315 vehicles, 1494 pass/crew
URN Level	175 dB	189 dB

TABLE 1: Comparison of new major ferries and C-Class ferries they are scheduled to replace.

FIGURE 2: **Underwater Radiated Noise Targets as a function of Frequency.**



noise (e.g. propeller blade pass, engine firing rates) and therefore is of greatest concern when mitigating impacts on the SRKW population.

By exploring options to redesign the existing propellers that were optimized primarily for propulsion efficiency, the study by BC Ferries, Transport Canada and DNV showed that careful design could reduce underwater emitted noise from the propeller and hull arrangement. The study also showed that a propeller designed to minimize underwater radiated noise will sacrifice some power or efficiency resulting in reduced speed and/or increased fuel consumption. Key lesson learned are that underwater radiated noise needs to be balanced with other requirements and variations in the operational profile of the vessel and must be considered in the process to optimize a new vessel design.

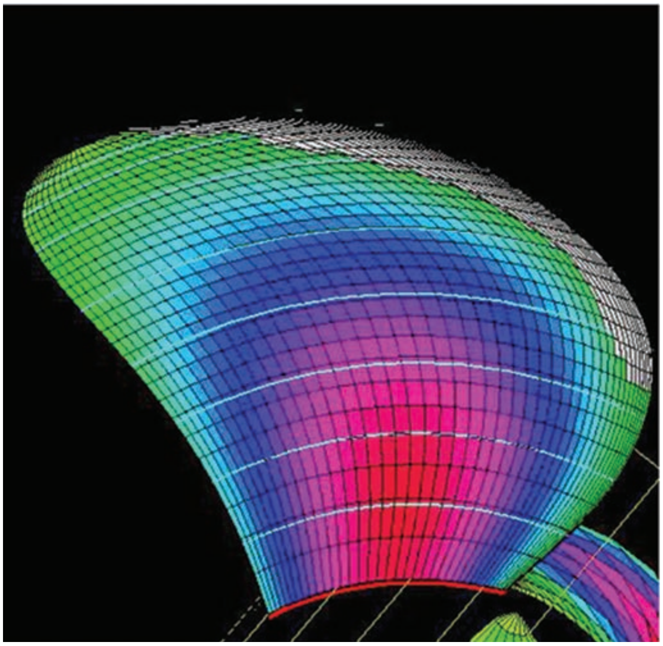
Beyond the study on propeller design, BC Ferries also undertook preliminary consultation with key vendors to determine how propulsion systems could be best optimized for the quietest operation. One potential opportunity with electrically-driven ferries, for example, is to combine a variable frequency drive (VFD) with a conventional controllable pitch propeller design, which would allow the propeller shaft speed to be matched with propeller pitch to minimize unwanted cavitation at slower speeds. As with any potential solution, there are performance impacts beyond underwater radiated noise that must be considered.

The vessel noise emission profile data and research initiatives described above can be shared with the successful shipyard. In any future project, BC Ferries intends to work directly with the shipyard and the ship classification society through the design and build phases, to improve the likelihood that the design targets can be achieved in sea trials.

LESSONS LEARNED

In 2021 the ECHO Program contracted West Pacific Marine to work with BC Ferries to prepare a case study report to capture the findings and learnings summarized in this article. While the New Major Vessel Replacement Program procurement process has been delayed due to COVID-19 impacts, the case study report illustrated that the initial phases of work undertaken by BC Ferries have led to some key learnings for other vessel operators considering the implementation of un-

FIGURE 3: Propeller cavitation simulation modelling.



derwater radiated noise targets:

- *Obtain baseline measurements of your fleet to determine where your starting point is before setting underwater noise reduction goals;*
- *Make design decisions in consideration of the larger system. Underwater radiated noise is a function of many complex interactions within a vessel, and as such, it is important to design the propeller and propulsion systems in concert with the hull design to ensure that functional requirements are accounted for;*
- *Engage an underwater radiated noise expert to assess design impacts and conduct trade-off analysis. Ensure the expertise is available when working closely with the selected shipyard throughout the detailed design and build process;*
- *Anticipate conflicting requirements as a part of the design optimization process. For BC Ferries, for example, meeting underwater radiated noise reduction requirements while achieving improved energy efficiency is a balancing act that requires careful consideration.*

Underwater radiated noise is still a nascent field in the commercial shipping sector, but one that is gaining attention and focus. A collaborative work environment between the operator, owner, shipyard, naval architect and ship classification society is vital. As we continue to improve our understanding of quiet vessel design's possibilities and limits, we expect underwater radiated noise targets to be included in a growing number of new vessel builds. Understanding and managing the risk is necessary to encourage innovation.

MARINE TECHNOLOGY TV
Watch the interview
@ bit.ly/3rl6a2f

Inside Sofar Ocean Technologies

Epic Quest to Open Ocean Data

Tim Janssen, CEO, Sofar Ocean Technologies, discusses this real-time ocean intelligence platform's quest to collect, network and distribute vast amounts of ocean information and insight, essentially creating the 'nervous system for the oceans.'

By Greg Trauthwein

Tim, to start, please give us a by the numbers look at your company?

We are a startup, with 50 people in our San Francisco office, and 50 on the water. We have more than 1,200 live sensors right now, one of the largest networks ever created for ocean sensing. We have more than 5 million ocean hours on our platform and we collect more than 100,000 data points daily. What that data does is it allows us to improve weather forecast over the oceans, and particularly for instance, our wave forecast; we can get 30 to 50% improvements for every operational cycle. Also, we deliver insights for shipping, route optimization. We're trying to use sensor information to create insights that were previously not available.

We talk about getting information from the ocean and turning it into actionable data on a daily basis. What is unique about the Sofar approach?

"Ocean intelligence" is new, and as a result, it has to be inherently full stack. Data in itself is relevant for experts, but that data in itself is not that relevant for the everyday user. You need to be an expert to understand how that (data) changes forecasts. We create the insights from our sensors, and our sensor network is basically the central nervous system of our oceans. What we do is drive (data) into forecast models to translate it into better (weather and forecast) insights, (helping to) reduce the uncertainty around, for example, what waves and winds are going to be doing over the ocean. Specifically

"We're building standardization to enable a rapid expansion of sensing in the ocean. *(Traditionally) every sensor, every piece of hardware is different, with a different protocol, and a different connector. If you try to put them together, things get ugly quick, and everything turns into an engineering project.* **Engineering projects are great for engineers, (but) they're bad for almost everybody else (because) they cost a lot of time and money."**

Tim Janssen, CEO
Sofar Ocean Technologies

for maritime shipping, we deliver better options for routing their vessels for both safety, efficiency, and reducing emissions.

I know you've already given me a couple of key statistics, but I'd if you would to put a little more meat on the bones.

First off, I think an important difference between what we do and what we have been doing in our oceans is that we are switching to a distributed paradigm. This is fundamentally not that different from what has been done in space over the last two decades, where you see a shift from single exquisite platforms that are incredibly expensive and mostly government-owned, to networks of lower cost nodes. Together all of those lower cost nodes can provide much more information, much more synoptic insight as to what's actually going on. Basically, we are taking that same idea and bringing it to the ocean, where we've been mostly pretty bad at doing that; stuck to building large platforms that require large operational support; needing a PhD in oceanography operate the instrument. As a result, (that type of network) does not scale.

Why is scale important?

Scale is fundamental to what we do. Everything has to be global scale, thousands of sensors, lots of data. The platform that we use is the Spotter platform, which is a solar powered,

All images courtesy Sofar Ocean Technologies

satellite connected, metocean buoy. In addition, and this is really critical, we're building standardization to enable a rapid expansion of sensing in the ocean. (Traditionally) every sensor, every piece of hardware is different, with a different protocol, and a different connector. If you try to put them together, things get ugly quick, and everything turns into an engineering project. Engineering projects are great for engineers, (but) they're bad for almost everybody else (because) they cost a lot of time and money. What we want to do is create large, heterogeneous networks of sensors that cover much more than we've ever been able to do before. Creating a standardization discipline is not just for us; this going to be completely open to the community to enable faster innovation on the sensor level and integration into platforms like ours to create broader capability. What it does immediately for us is that it enables us to integrate subsurface sensors, so our Spotter platform now can also measure water levels, salinity, temperature, etc.; and any other subsurface sensors that could benefit from having a real time connectivity platform associated with it. So fundamentally in terms of cost, what's really important is that the cost of the nodes has to become incredibly small. To be successful and at scale, thousands, tens of thousands of sensors, complete planetary coverage, we have to bring the cost down of the individual nodes radically.

That's basically what we're working on in order to drive the scale. (So today we're) focusing on scale first, being disciplined around the hardware that we're building and trying to enable the community to drive the innovation needed to grow faster.

What do you consider to be the biggest challenge to keeping this network functional and growing?

I think the most important thing about maintaining something like this is to show its value. Fundamentally what we're focusing on is in creating value out of this data, creating insights that haven't been available before. So there are two parts to this. One is broad application: driving innovation and standardization across the community, because with that, ev-

“The platform that we use is the Spotter platform, which is a solar powered, satellite connected, metocean buoy.”

erything we build becomes more valuable. For example, communication standardization specifically designed for marine connectivity so the integration of components into platforms, (such as) our Spotter platform, helps the entire industry innovate faster and more efficiently.

The other part of it is focused insight. (An example of this is) Wayfinder, our maritime shipping route optimization capability, driven and powered by the fact that we have all this additional and unique information across the ocean.

When you look at the market today, which technologies do you could believe could be the most transformational to help gather and deliver better ocean information faster and cheaper?

‘Cheap’ is a means to an end; it’s really scale that matters. The capabilities that we have developed to date were enabled by advances across multiple technologies. The challenges that you have in collecting ocean data; one, it’s the ocean, so it has salt water and storms and anything electronic generally doesn’t like that very much. (But to answer your question): communications have traditionally been very expensive through monopolies in satellite communications, and that’s changing rapidly. Power. Advances in battery technology and solar capture has made it possible for us to build a low cost completely autonomous system that can stay out in the ocean forever and provide useful information. More generally, advances in IOT technology, the ability to build something extremely low cost that is as capable as maybe your home computer was 20 years ago.

Other things like material sciences, are also obviously important. But the point being is that it’s not a single innovation that makes it possible to do what we do today, and I don’t expect it to be a single innovation that’s going to basically, fundamentally change what we’re going to be doing in the future. I think one of the things that has been missing is standardization. Nobody else was doing it, (so) we figured we have to do that. I see (radical standardization) as the single most important advancement in the industry.

Can you give us some detailed insights on organizations that are using your services today?

Basically we have three things that we sell and provide to customers. One is hardware, to enable folks to collect data from the ocean, democratizing access to ocean data. One example is Aqualink, a philanthropy that's focused on monitoring in real time the health of coral reefs, and particularly looking at reef bleaching induced by heat waves in the ocean.

The second part of what we deliver is large amounts of unique data. That's a very different type of customer, and you can think about large government agencies that run their own forecasting systems or intelligence agencies that would like to have unique information around what's going on in the ocean right now.

And finally, insights. The shipping industry is our last customer layer, and an example there is Berge Bulk which has been using our system to improve the efficiency of their largest vessels shuttling between Brazil and China.

What's next for Sofar Ocean Technologies?

A lot, as we have just scratched the surface. The whole space, the maritime space, the ocean space, is very young, and we have a long way to go to take this to the next level. And we have to, because the pressure is on, as it is pretty clear to everyone that ocean dynamics is critical for understanding global weather and climate.

We've just closed our series B financing, which for a start-up is a big deal. Our current round, led by Foundry Group and Union Square Ventures, is an important step, but the excitement (for this type of environmental and ocean intelligence) in general in the investor community is massive.

We have got to get better and faster at what we're doing. We've learned a ton, but we've also learned everything we shouldn't do. (We have to) get better at figuring out better ways to deliver real value from ocean intelligence to our customers. Finally, the biggest hurdle to get to large distributed heterogeneous networks of sensors around the world is standardization. And this is not just impacting us; this is impacting every startup in the space, whether you build an autonomous surface vehicle, a glider, or another sensor platform. Aggressive standardization will help the entire community advance to the next stage.

** This interview was edited for clarity and brevity.*

Wayfinder is Sofar Ocean Technologies' maritime shipping route optimization capability.

All images courtesy Sofar Ocean Technologies

Sofar Ocean Technologies

Who: Sofar Ocean Technologies is a real-time ocean intelligence platform based in San Francisco, California.

What: Sofar has a global distributed network of thousands of sensors designed to capture data to drive unique weather forecasts and enable dynamic vessel routes. Cumulatively, these sensors have already racked up over five million ocean hours. Where Sofar seeks to differentiate itself is in its interconnected and global network and the vast amounts of data collected, leveraging scale and accessibility. Sofar devices are designed to be 'cost-effective' and scalable depending on customer needs. From the Southern Ocean to the kelp forests of California and the coral reefs of Australia, Sofar is delivering more than 100,000 unique ocean data points daily.

Why: While the oceans cover over 70% of the Earth's surface, we currently have an underwhelming amount of data about it, even though 3.5% of the world's GDP, which is close to $3 trillion, happens on the ocean's surface. To better predict the future state of weather and climate over our oceans, data density is critical.

Milestones:

- June 2021: Sofar opened access to its proprietary data platform to all scientists.
- September 2021: Sofar introduced a new marine hardware standard, Bristlemouth, aimed at catalyzing more collaboration, research and innovation for big data from the oceans with partners DARPA, the Office of Naval Research & Oceankind.
- November 2021: Sofar announced a $39 million Series B syndicate round with Union Square Ventures and the Foundry Group.

Saab Seaeye eWROV

Welcome to the (Ocean Infinity) Fleet

Image courtesy Saab Seaeye

Saab Seaeye agreed on a deal to sell 10 of its new electric work remotely operated vehicles (eWROV), including further options, to Ocean Infinity. Due to this and further future contracts Saab Seaeye is also to expand by 70% to an additional 3,236-sq. m. site in Fareham, UK, by March 2022 and is currently recruiting. The new eWROV product will be built in Saab Seaeye's new facility in Fareham within the Solent Freeport.

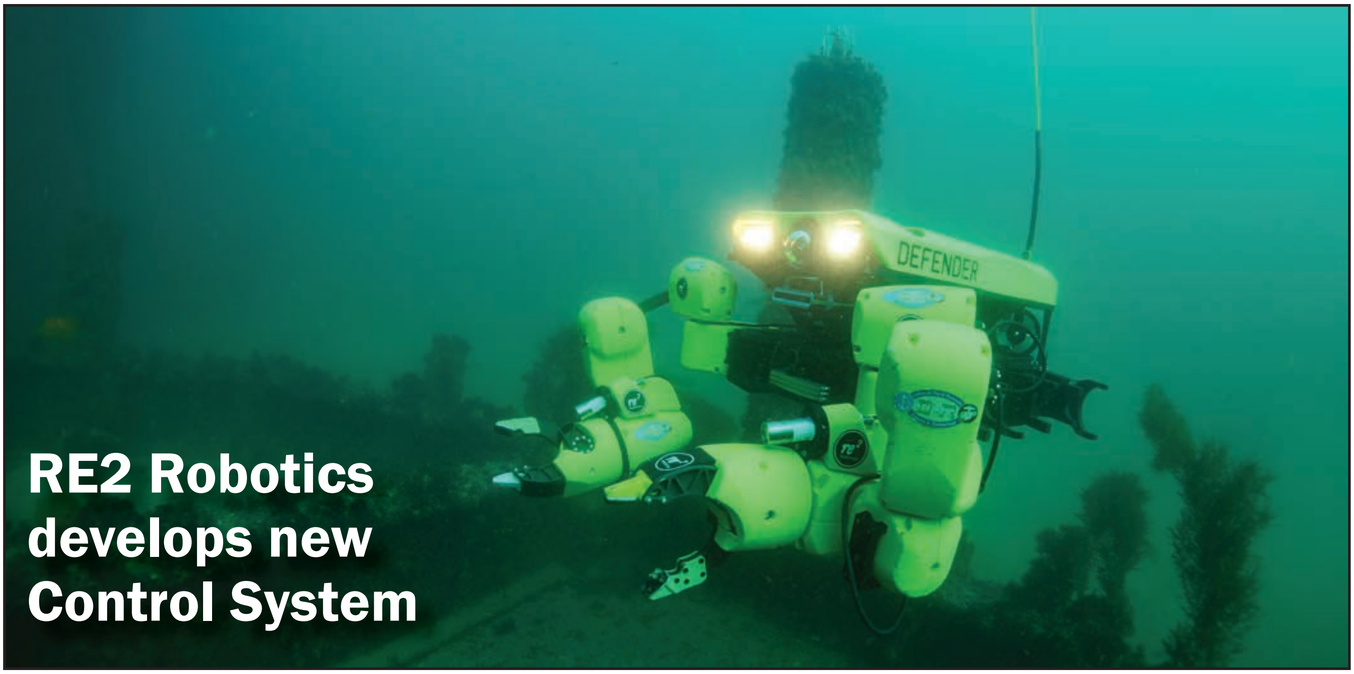
The eWROV is the latest addition to Saab Seaeye's underwater portfolio used across a variety of offshore energy sectors, ocean science and defence. It is the culmination of four years of research and development, resulting in a larger and more powerful ROV. Saab Seaeye is among the first companies to produce a full-size electric work-class vehicle that can deliver the same overall performance as a 250 horsepower hydraulic vehicle, while offering a lower lifetime cost and reduced environmental impact. Ocean Infinity is developing the world's largest fleet of uncrewed robotic vessels and will be the eWROV's launch customer. The eWROV will play its part in Ocean Infinity's mission to use innovative technology to transform operations at sea, enabling people and the planet to thrive. Armada is set to revolutionize the maritime industry, delivering sustainable services that offer up to 90% emissions savings over a conventional vessel performing a similar offshore task.

The eWROV's electrification is the key to its improved performance and sustainability-related attributes. As well as being more efficient, electric systems use little or no oil, making the eWROV significantly more environmentally friendly.

The eWROV also benefits from Saab Seaeye's iCON intelligent system architecture, making it capable of fully autonomous operation. "Ocean Infinity's order is the largest in Saab Seaeye's history and highlights the need for intelligent, adaptable and flexible underwater robotics," said Magnus Lewis-Olsson, Chairman of Saab UK.

"Lessening the environmental impact of operations at sea is the main driver behind the development of Armada. The all-electric eWROV, in addition to our already low-emission vessels, will enable us to support our customers with infrastructure integrity projects in the most environmentally responsible way," said Dan Hook, CTO, Ocean Infinity.

Innovative new products, technologies and concepts



RE2 Robotics develops new Control System

Image courtesy RE2 Robotics

RE2 Robotics received Phase I Small Business Innovation Research (SBIR) funding from the U.S. Navy to develop a system that enables "coupled control" of a remotely operated vehicle (ROV) and robotic manipulator through a single control system. The project, called *Coupled Locomotion And Manipulation System (CLAMS)* will combine the robotic arms' control system and the ROV control system into one unit, improving coordination of the underwater manipulator and the ROV's movements.

CLAMS will enable topside operators to control a system's robotic arms and ROV simultaneously using one control station by combining the Company's newly developed Coupled Remote Link Software (CTRLS) and the System Unification Model (SUM) to enable interoperability between ROV and robotic arm systems. CTRLS allows the topside ROV operator to send mission goals to the SUM module located on the vehicle. This enables the vehicle and robotic arms to quickly and efficiently achieve those mission goals, improving the ease of operators completing complex, underwater tasks.

"Currently, robotic arms and ROVs are controlled with separate control systems. CLAMS will enable both the robotic arms and the mobile platform to be operated with a single control unit," said Jorgen Pedersen, president and CEO, RE2 Robotics. "Integrating these platforms will enable users to increase efficiency by eliminating the need for an operator to monitor two separate control stations while completing a mission."

In addition to defense applications, CLAMS will benefit industries that use underwater manipulation systems to conduct routine inspection and maintenance tasks, such as the oil and gas and renewable energy industries.

Sonardyne, Wavefront Demo Obstacle Avoidance

Underwater obstacle avoidance tech from Sonardyne and Wavefront, was demonstrated on board an extra-large, uncrewed, underwater vehicle (XLUUV) built and operated by Plymouth-based MSubs Ltd. The demonstration of the Vigilant forward looking sonar was part of the first phase of the UK's Defense and Security Accelerator's (DASA) 'Uncrewed Underwater Vehicle Testbed – Opportunity to Integrate' competition, run jointly with the Royal Navy and the Defense Science and Technology Laboratory (Dstl). Vigilant, developed by Wavefront and manufactured and commercialized by Sonardyne, is a navigation and obstacle avoidance sonar for ships, uncrewed surface vessels (USVs) and underwater vehicles.

The system has two operating modes. In 3D mode, Vigilant produces accurate 3D bathymetry and color-coded depth imagery out to 600 m and to depths down to 100 m. In Sonar mode, Vigilant processes the intensity of the acoustic data to extract long-range positional data out to 1.5 km and over a 120-degree field of view. The sonar returns are used to generate alerts highlighting the presence of a navigationally relevant obstacle.

For the trial, the system's sonar projector and receiver array were mounted in the bow of the 9 m-long MSubs' S201 XLUUV. At just 31 cm-wide and weighing only 14 kg in air,

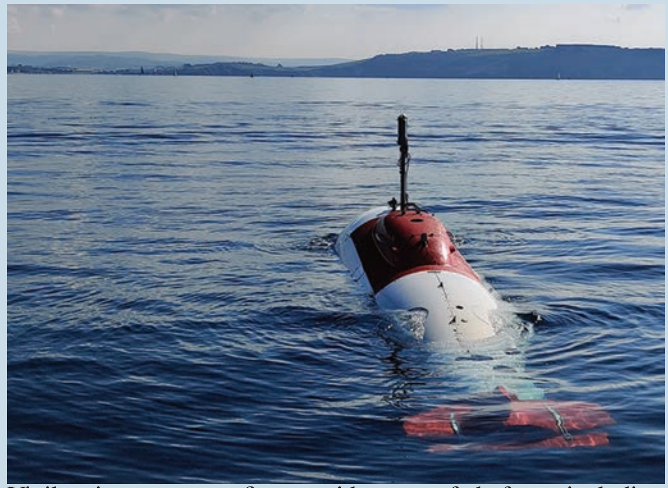


Image courtesy Sonardyne

Vigilant is easy to retrofit on a wide range of platforms including ships, USVs or, as in this case, an XLUUV. As part of the demonstration, the XLUUV was programmed to travel beyond the breakwater outside Plymouth sound. Vigilant was used to create a bathymetric map that was used by the XLUUV to navigate. The data was also overlaid over existing charts of the area, demonstrating the higher resolution provided by Vigilant.

Kongsberg Launches Blue Insight

Kongsberg Maritime (KM) launched Blue Insight, a cloud-based digital toolbox to enable state-of-the-art collection, visualization, contextualization, management and distribution of ocean data, focusing on marine and meteorological information.

Blue Insight is designed to provide an open, modular platform for the processing, visualization and sharing of ocean data. The core module contains the cloud framework – which has been built to the highest cyber security standards – and an application-specific dashboard, teamed with data storage and management functionalities. Additional modules can be added to this framework to tailor Blue Insight's functionality to suit all projects, however large or small. Key to Blue Insight's data-streaming functionality is the concept of sensor fusion, by which data is streamlined from various onboard sensors and a local database for seamless transmission into the cloud. In addition, the module serves as a link with KM onboard sensors for remote operation.

Data can be collected from any platform. Through ongoing delivery projects, several modules already exist to assist customers in obtaining the best results from Blue Insight, including Remote, a module that enables remote access to a KM echosounder via a web interface; Ocean View, a web-based visualization tool for historic and real-time sensor or database data; and Data Forwarder, enabling data conversion into any common format and

Image courtesy Kongsberg

automated data forwarding to external cloud systems or databases. Science Analytics supplies an infrastructure for more in-depth data-handling capabilities, such as the implementation of machine learning and AI-enhanced data analysis on board or in the cloud. As an example, one of the first delivery projects has seen the module providing a framework on unmanned surface vehicles for the automated onboard classification of fish. The portfolio of modules and support for specific instruments will be continuously expanded, consistent with KM's aim to provide customers with unprecedently swift access to data, even in heterogenous environments.

Mooring Tech for Floating Tidal Energy Array

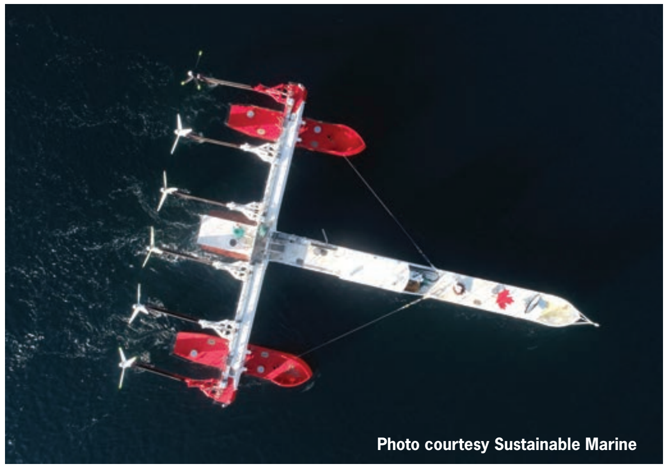


Photo courtesy Sustainable Marine

This year, Scottish Sustainable Marine will deliver the first development phase of the Pempa'q In-stream Tidal Energy Project – touted as the world's first floating tidal power array. When completed, the project will provide up to nine megawatts of electricity to the province's power grid.

The first phase consists of a 420-kW PLAT-I tidal energy platform, and Seasystems AS has been commissioned to supply adjustable mooring tensioners. Lying on the seabed, these are attached to the anchors that hold the power station in place in the strong tidal current – connecting the anchor chains with the anchors.

For the past five years, the company has adjusted its strategy from being purely a supplier of equipment to the oil and gas industry to focusing on deliveries to aqua culture and floating renewable energy.

In 2020, Seasystems secured a contract to supply mooring equipment to Hywind Tampen, Equinor's new floating wind farm, marking the firm's first hardware contract in the floating wind power market.

Seasystems has joined forces with Swift Anchors, a division of Sustainable Marine, in developing a unique hybrid mooring connector and anchor solution, specifically targeting wave, tidal, floating wind, floating solar, ocean thermal energy conversion, deep water aquaculture and other challenging anchor applications. This new solution, applied to the Pempa'q project, involves the integration of Seasystems' adjustable mooring tensioners with Swift Anchors' broad anchor product portfolio – including groutless rock Anchors, screw anchors, drag embedment anchors and grouted self-drilling piles.

Argeo selects Eelume 'Snake Robot' solution

Image courtesy Eelume

Argeo AS, a survey and inspection company focused on subsea data acquisition and visualization, selected Eelume's autonomous 'snake robot' to assist in its operations in the first commercial contract to be signed for this technology. Eelume's robotic solutions have been developed with the assistance of Kongsberg Maritime, a majority shareholder in the venture, and has been actively involved in Eelume since the company was founded in 2015, bringing nearly 30 years of experience gained from their HUGIN AUV to the development of the Eelume snake robot.

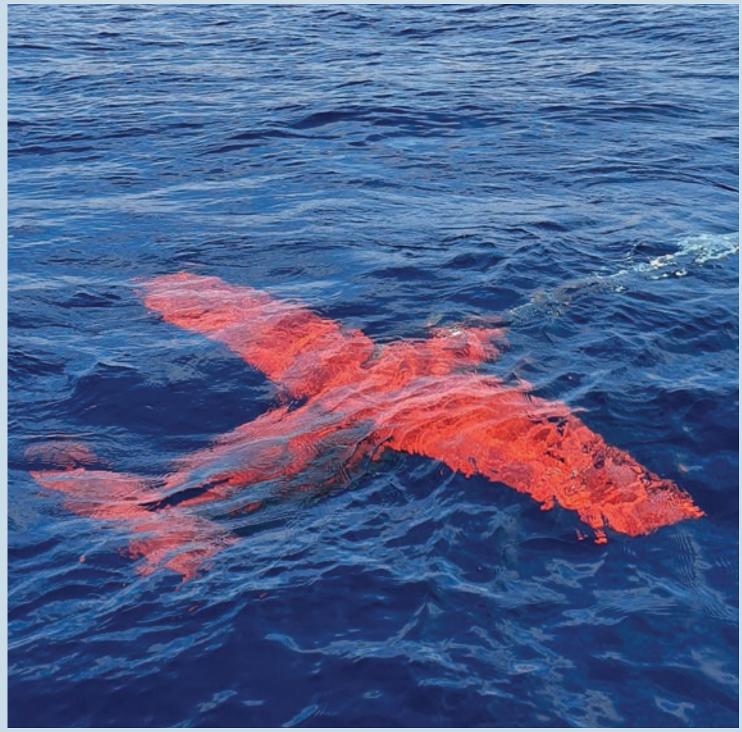
Argeo's aim is to transform the ocean space inspection industry through robotics, sensors, and data analytics technology. "We believe that this is just the beginning of a major shift in how the industry conducts underwater operations. There is a need in the market for this type of solution, and we anticipate a significant requirement for more robots of this type in the long term," said Trond Crantz, CEO, Argeo. "In addition to lowering carbon footprint and increasing efficiency, Eelume technology will enable Argeo to significantly reduce the costs related to inspection, light intervention and monitoring (IMR) of subsea assets and infrastructure. Currently, 90% of these costs are vessel-related. Implementing Eelume as a resident inspection tool for Offshore Wind and Oil & Gas will replace up to 70% of vessel activities." In operation, one Eelume robot can typically provide a serviceable footprint of 50-75 sq. km. Argeo propose matching the technology with its Unmanned Surface Vessels (USV), making the Eelume an effective mobile survey solution complete with deployment and recovery system.

FlipiX: iXblue Launches ROTV

iXblue launched its first Remotely Operated Towed Vehicle (ROTV): FlipiX. Designed to be operated autonomously from iXblue DriX Uncrewed Surface Vehicle (USV) or from a light vessel, FlipiX enhances autonomous survey capabilities and allows to conduct multi-sensor operations in a single run, ultimately offering unmatched operational efficiency.

Leveraging advanced motion control and a reduced operational footprint, FlipiX is a unique conveyance platform for Side Scan Sonars (SSS) and magnetometers. Operating at towing speeds up to seven knots, the FlipiX ROTV altitude, pitch and roll are autonomously controlled to maintain measuring instruments at a fixed altitude and constant attitude. This active motion control bestows the ROTV with increased stability and maneuverability, even during U-turns, resulting in enhanced measurement quality in the most challenging maritime environments and in reduced survey time.

When combined with the DriX USV, FlipiX can operate down to 50 meters water depths in its standard version and provides optimal positioning of measurement instruments for a data acquisition as close to the seabed as needed.



FlipiX

NOAA Analyses aids Aquaculture Siting

Photo courtesy Jeffrey Milisen/NOAA

NOAA released two Atlases compiling the best available science to inform the identification of Aquaculture Opportunity Areas (AOAs) in the Gulf of Mexico and Southern California.

NOAA previously identified these regions for their potential to host sustainable commercial aquaculture development in the United States. Areas in the Atlases will have characteristics expected to support multiple types of aquaculture industries including finfish, shellfish, seaweed, or some combination. “The aquaculture Atlases apply the latest ocean data and information to advance sustainable business development,” said Gina M. Raimondo, U.S. Secretary of Commerce.

“These are the most advanced spatial analyses ever performed for any U.S. ocean regions,” said Nicole LeBoeuf, Assistant Administrator of NOAA’s National Ocean Service. “The Atlases are powerful scientific tools that will help advance food security for all Americans and improve sustainable food production, which is critical for the economic and environmental resilience of our coastal communities.”

NOAA’s National Centers for Coastal Ocean Science developed each Atlas using more than 200 data layers accounting for key environmental, economic, social, and cultural considerations, including fishing interests and marine protected areas. The studies identified nine areas in the Gulf of Mexico and 10 areas in the Southern California Bight that may be suitable for aquaculture, while also reducing conflicts with other ocean uses.

New Products

MacGregor Delivers

MacGregor will deliver a suite of overboard handling systems for the new oceanographic research vessel David Packard owned by Monterey Bay Aquarium Research Institute (MBARI). MacGregor will be delivering a traction winch system and overhead crane that will constitute the ROV Launch & Recovery System (LARS), a deck mounted davit and winch.

Macgregor.com

Birns Millennium

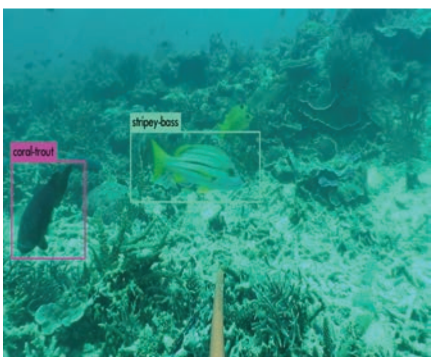
Birns offers a new reverse-gender (RG) contact configurations in its 6km-rated Birns Millennium connector series, which provide flexibility and enhanced safety and security options for subsea system designers who prefer that a power source use sockets versus pins in the receptacle. These new solutions fit the same mounting footprints as non-RG receptacles.

Birns.com

Tritech USBL Tracking

Tritech offers the MicronNav 200 UltraShort Base Line system designed for small underwater vehicles and diver support applications. New features: data transfer interleaved with USBL positioning, software integration into Google Maps, improved magnetic compass accuracy by one degree (1°) and compatibility with the new Micron Battery Modem.

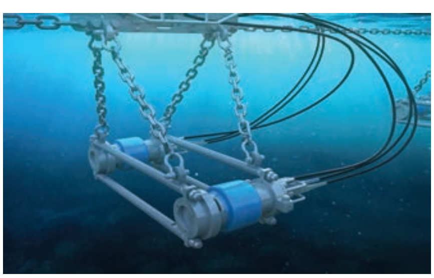
Moog.com



Automated Fish Counting

Researchers from the Curtin Institute for Computation (CIC) will use the latest in data science to develop an automated fish detection and counting solution. The CIC is part of a consortium that has been awarded $1 million in Federal funding to continue developing the AFID (Automated Fish Identification) system, which uses machine learning and Artificial Intelligence (AI) to automatically gather information about fish, including species and size.

Project lead and CIC Lead Data Scientist Dr Daniel Marrable said the technology aimed to accurately, efficiently and more cost-effectively gather data in order to gauge marine and coastal ecosystem health, which would benefit Australia's multi-billion dollar fisheries and aquaculture industries.



Bluepulse from Sercel

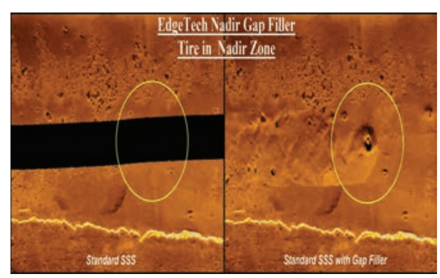
Sercel launched Bluepulse, a marine acoustic source that is a purpose-built to help protect marine wildlife from high-frequency emissions while maintaining highly accurate and reliable results for seismic acquisition. It is compatible with all existing peripherals, and existing G-Source and G-Source II units can be upgraded with Bluepulse technology.

Sercel.com

New Valeport Instruments

Valeport recently launched several products: **Bathy2** (pictured) – an enhanced, robust integrated instrument to provide density corrected depth data up to 6000m; **miniIPS2** and **uvSVX** – with interchangeable pressure heads; and **SWiFT CTD** and **SWiFT CTDplus** – designed for a seamless workflow, these profilers deliver improved accuracy and versatility.

Valeport.co.uk



New Sonar, Software

EdgeTech introduced a new method to provide nadir gap coverage on the EdgeTech 2205 sonar platforms. Complementing this new technology is SonarWiz from Chesapeake Technology, providing a software solution to support processing and mosaicking the new gap fill solution, available in a number of dual and tri-frequency configurations.

www.edgetech.com
www.chesapeaketech.com

MARINE TECHNOLOGY REPORTER

2022 Editorial Calendar

January/February 2022

Underwater Vehicle Annual

- Underwater Defense
- Manipulator Arms and Tools
- Autonomous Navigation GNSS MEMS
- Unmanned Vehicle Propulsion
- IMR: Offshore Inspection, Maintenance & Repair

Event Distribution:
Subsea Expo
February 22-24 Aberdeen, Scotland

Digital Edition

MTR E-Magazine Edition: Oceanographic

Special Report on
Coastal Zone Management

March/April 2022

Oceanographic Instrumentation & Sensors

- Fiber Optic Cables, Connectors & Slip Rings
- Buoyancy Technology
- Environmental Testing Equipment
- Underwater Communications
- Underwater Battery Technology

Event Distribution:
Oceanology International:
March 15-17, London, UK
IPF:
April 26-28, Atlantic City, NJ

May/June 2022

Offshore Energy: O&G & Renewables

- Hydrographic Survey Sonar
- Sonar, Telemetry & Data Processing Software
- USV, ROV & AUV Platforms
- GPS, Gyro Compasses & MEMS Motion Tracking
- Interconnect: Underwater Cables & Connectors

Event Distribution:
OTC:
May 2-5, Houston, TX

July/August 2022

Autonomous Vehicle Operations

- ROV Technology: Work Class to Micro Systems
- Thruster Tech: Underwater Propulsion
- Underwater Tools & Manipulators
- Scientific Deck Machinery

Event Distribution:
MATE ROV Competition:
July 2022

Digital Edition

MTR E-Magazine Edition: Hydrographic

Special Report on
Offshore Wind Field Surveys

September/October 2022

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

Event Distribution:
Oceans 2022:
October 17-21, Hampton Roads, VA

November 2022

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
- Underwater Imaging: Lights, Cameras, Lasers & Multibeam Sonars

Digital Edition

MTR E-Magazine Edition: Subsea Vehicles

Special Report on
Autonomous Defense Vehicles

Who's News?

Latest People & Company News

NOAA

Craig McLean, NOAA, to Retire

NOAA

Nancy Hann, NOAA

Director of NOAA Research to Retire

Craig N. McLean, assistant administrator of NOAA Research, who began his NOAA career as a uniformed officer in the NOAA Corps four decades ago and rose to lead the agency's research division and become a champion of ocean exploration, scientific integrity and science diplomacy, has announced his plan to retire from public service on April 1, 2022.

"Craig has been a passionate leader aboard our ships and more recently a champion of NOAA research to advance our mission to serve the nation," said Rick Spinrad, Ph.D., NOAA Administrator. "Like the best of ship captains, Craig has steered NOAA through rough waters, always upholding scientific integrity, advancing science and technology, forging strong partnerships at home and abroad."

McLean joined NOAA as a member of NOAA's commissioned corps in 1981, where he served for nearly 25 years aboard fisheries, oceanographic and hydrographic ships, retiring from the NOAA Corps at the rank of captain. He then went on to serve the last 16 years in NOAA senior leadership positions. He has served as the NOAA assistant administrator for Oceanic and Atmospheric Research (NOAA Research) for nearly seven years, as well as NOAA's acting Chief Scientist for most of the past five years.

As leader of NOAA Research, McLean has raised the public profile of NOAA's ocean, weather, climate and Great Lakes research. He has strengthened collaboration with NOAA's National Weather Service and across NOAA, and quickened the pace of using new research to improve NOAA's forecasts and other products that serve the public.

"I have been proud to wear the NOAA jersey for 40 years and work with so many amazing people who perform tirelessly to understand and protect our planet, " said McLean. "What I learned from my experiences early in my career is that leadership has the responsibility to do everything you can for your people, advocate for your people, and when you have chosen the right people, the mission will flow."

McLean grew up on the Passaic River in Rutherford, NJ, received a bachelor of science degree in zoology from Rutgers University and later received a law degree from Quinnipiac College School of Law.

Hann to lead NOAA OMAO, Corps

The U.S. Senate confirmed President Biden's nomination of NOAA Rear Admiral Nancy Hann to lead the NOAA Office of Marine and Aviation Operations (OMAO) and NOAA Commissioned Officer Corps (NOAA Corps), one of the nation's eight uniformed services.

"From flying into hurricanes to crewing remote explorations to the deepest depths of the ocean, the NOAA Corps drives NOAA's science forward," said U.S. Secretary of Commerce Gina M. Raimondo. "Rear Admiral Hann's leadership will continue to advance how we understand our planet through key observational platforms."

As director of OMAO and the NOAA Corps, Rear Admiral Hann will be responsible for NOAA's fleet of 15 research and survey ships, nine aircraft, and the uncrewed systems operations program, as well as guiding the approximately 330 uniformed officers and 1,000 civilian personnel assigned to OMAO and the NOAA Corps.

"Rear Admiral Hann is a highly qualified and capable leader with an impressive record of achievement," said Richard Spinrad, Ph.D., NOAA administrator.

Who's News?

Latest People & Company News

Stephen Fasham, CEO, Covelya Group

BV AIP for USV DriX

DOF, Ocean Floor Geophysics

Sonardyne Group Changes Name

Sonardyne Group Limited, a family-owned global group of companies comprising Chelsea Technologies, EIVA, Sonardyne, Voyis and Wavefront, announced today that it is rebranding as Covelya Group Limited. Alongside the name change, the company announced that Simon Partridge will succeed Ralph Rayner as company Chairman with immediate effect. Ralph will remain on the board in a non-executive capacity. The announcement was made by Covelya Group CEO, Stephen Fasham.

BV AIP for USV DriX

Bureau Veritas (BV) delivered an Approval in Principle (AiP) to iXblue for its Unmanned Surface Vessel (USV) named DriX. This AiP addresses the safety requirementsof the marine drone, which operates under the novel concept of remotely supervised autonomy.

DOF, OFG form Alliance

Ocean Floor Geophysics Inc. (OFG) and DOF Subsea AS (DOF) have entered into a strategic alliance for Autonomous Underwater Vehicle (AUV) services to the global offshore industry.

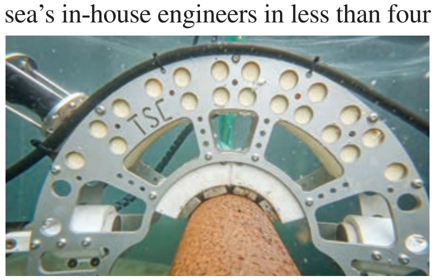
The partnership will effectively leverage the two businesses' recent collaboration in the development of the OFG AUV non-contact integrated Cathodic Protection (iCP) inspection system and enable the sharing of resources on several pipeline inspection and geohazard surveys. It will also provide the framework for a coordinated response to the increasing demand for AUV surveys.

Boxfish Luna New Feature: ProRes RAW Video Capture

Boxfish Research announced that its next-generation cinematography drone, the Boxfish Luna, now allows professional underwater videographers to capture full-frame 4K ProRes RAW video at 30 frames per second. This new product feature boosts the capacity of filmmakers to capture stunning underwater imagery with ease.

New Tool from TSC Subsea

TSC Subsea designed the ART vCaliper to inspect ovality and wall thickness in constricted locations. This customized tool was designed and built by TSC Subsea's in-house engineers in less than four weeks to meet the precise requirements of a project in the Gulf of Mexico. A client needed to perform ovality and thickness checks on a potential hot tapping location on a gas pipeline of its' semi-submersible platform.



New Tool from TSC Subsea

Seatronics, RTSYS sign Deal

Seatronicsa nnounced a global distribution agreement with RTSYS for its autonomous underwater vehicles (AUV) and passive acoustic monitoring (PAM) product lines. The Comet-300 AUV is designed to cover large underwater areas quickly and with high accuracy by offering precise real-time tracking and positioning and has high-definition sonar imaging capabilities. RTSYS also manufactures an alternative micro-AUV solution named NemoSens *(pictured below)* which is a cost-effective, lightweight and modular vehicle. Both AUVs will be available through Seatronics global bases along with the RTSYS range of PAM sensors, including underwater recorders, data buoys and remote stations.

Seatronics, RTSYS sign Deal

UNITED STATES POSTAL SERVICE

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12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☑ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months (Publisher must submit explanation of change with this statement.)

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14. Issue Date for Circulation Data Below: September 28, 2021

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a. Total Number of Copies (Net press run)		9704	12315
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	(4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g., First-Class Mail®)	1036	698
c. Total Paid and/or Requested Circulation (Sum of 15b (1), (2), (3), and (4))		9408	11699
d. Non-requested Distribution (By mail and outside the mail)	(1) Outside County Nonrequested Copies Stated on PS Form 3541 (include sample copies, requests over 3 years old, requests induced by a premium, bulk sales and requests including association requests, names obtained from business directories, lists, and other sources)	0	0
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	(4) Nonrequested Copies Distributed Outside the Mail (Include pickup stands, trade shows, showrooms, and other sources)	29	200
e. Total Nonrequested Distribution [Sum of 15d (1), (2), (3) and (4)]		79	247
f. Total Distribution (Sum of 15c and e)		9487	11946
g. Copies not Distributed (See Instructions to Publishers #4, (page #3))		217	369
h. Total (Sum of 15f and g)		9704	12315
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)		99.2%	98%

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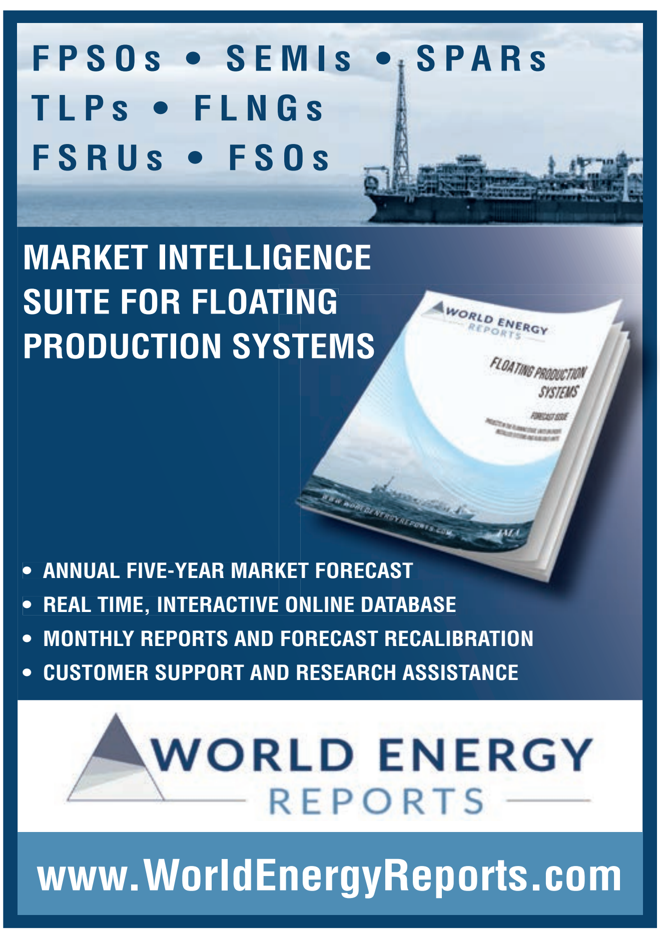

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c. Total Requested Copy Distribution (Line 15f) + Requested/Paid Electronic Copies (Line 16a)	23864	28741
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b divided by 16c × 100)	98.2%	99.1%

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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the November/December 2021 issue of this publication.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: Kathleen Hickey
Date: 9/28/2021

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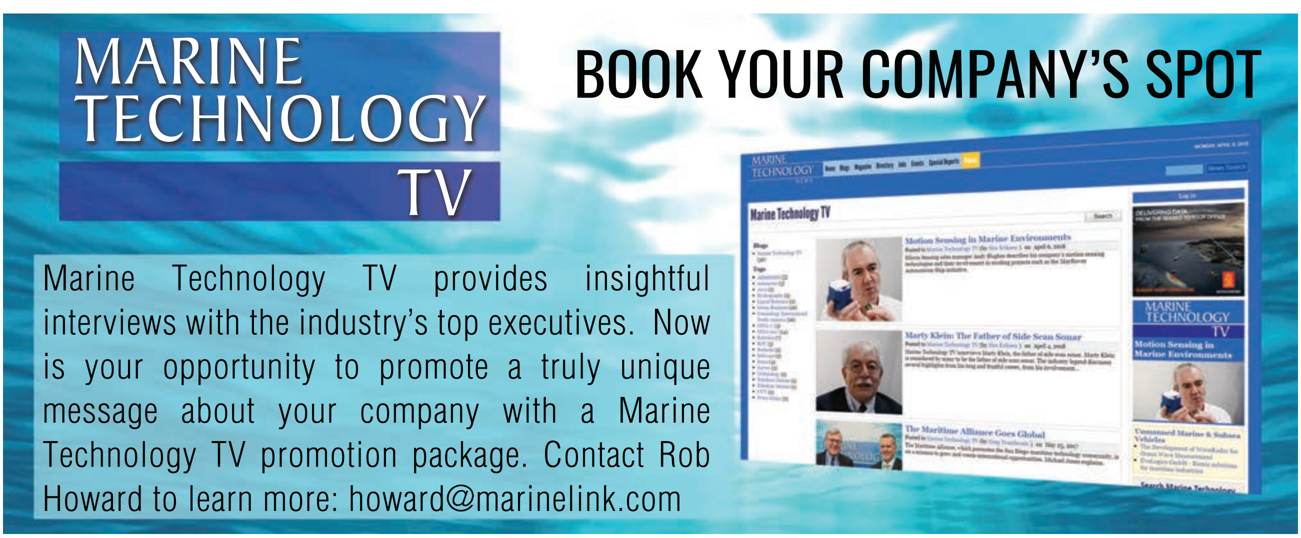

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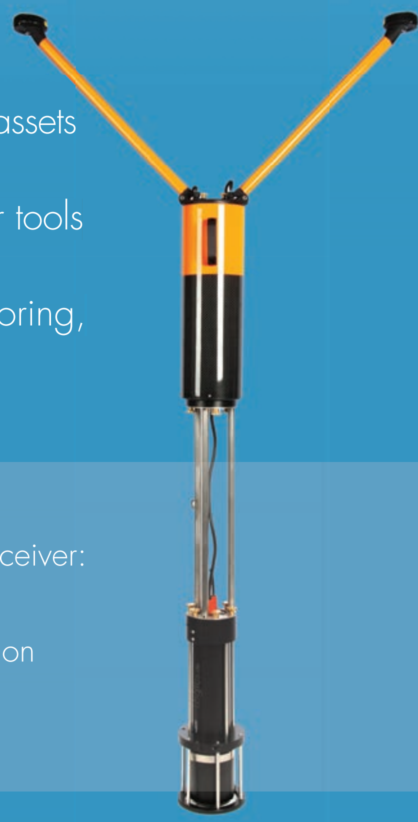


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