MARINE TECHNOLOGY REPORTER

October 2020

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Interview

U.S. Navy RDML John A. Okon

Commander, Naval Meteorology & Oceanography Command

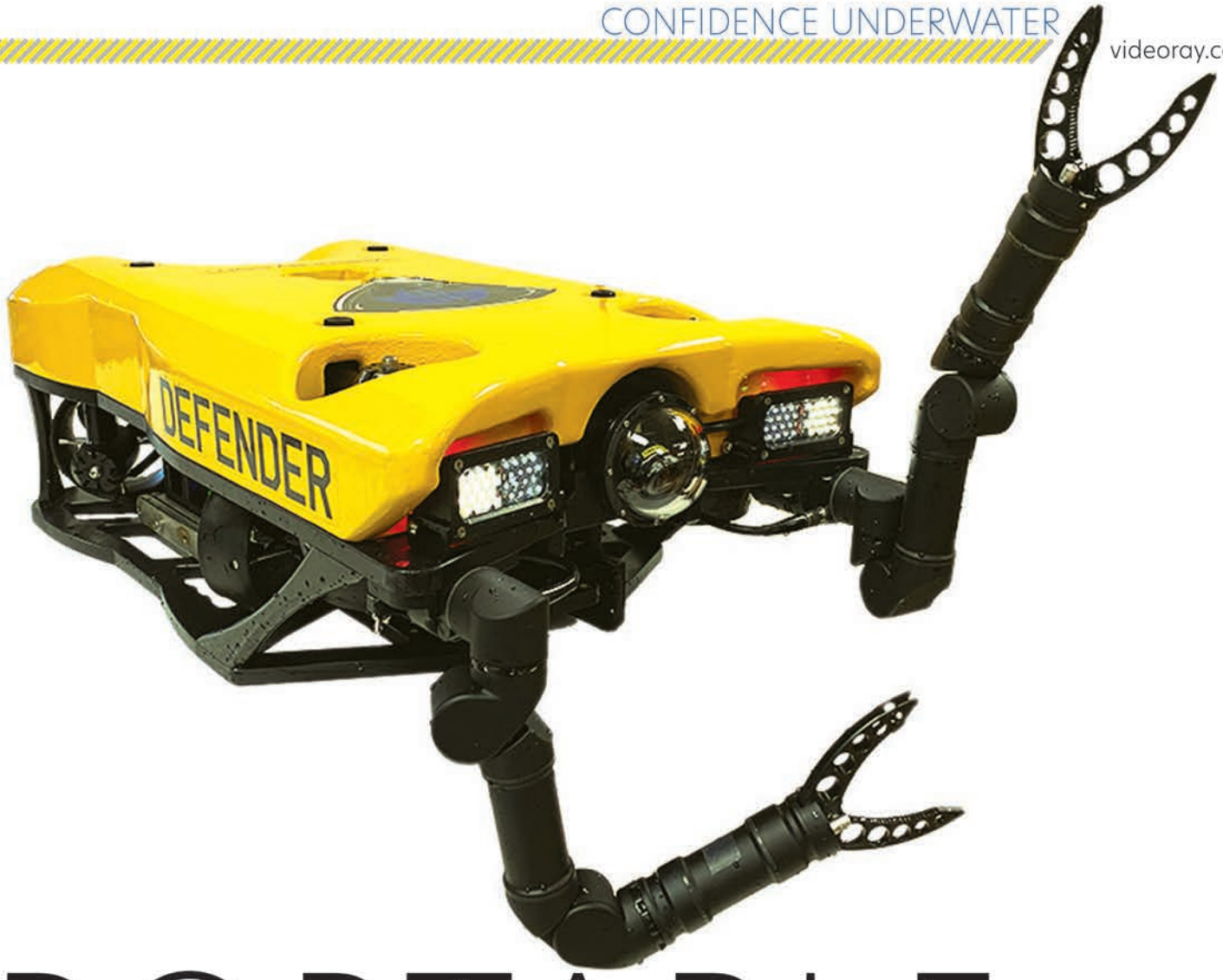
Seismic Survey

if Nodes Could Fly

Renewable Energy

CorPower Takes Wave Energy to the Bank

Volume 63 Number 8



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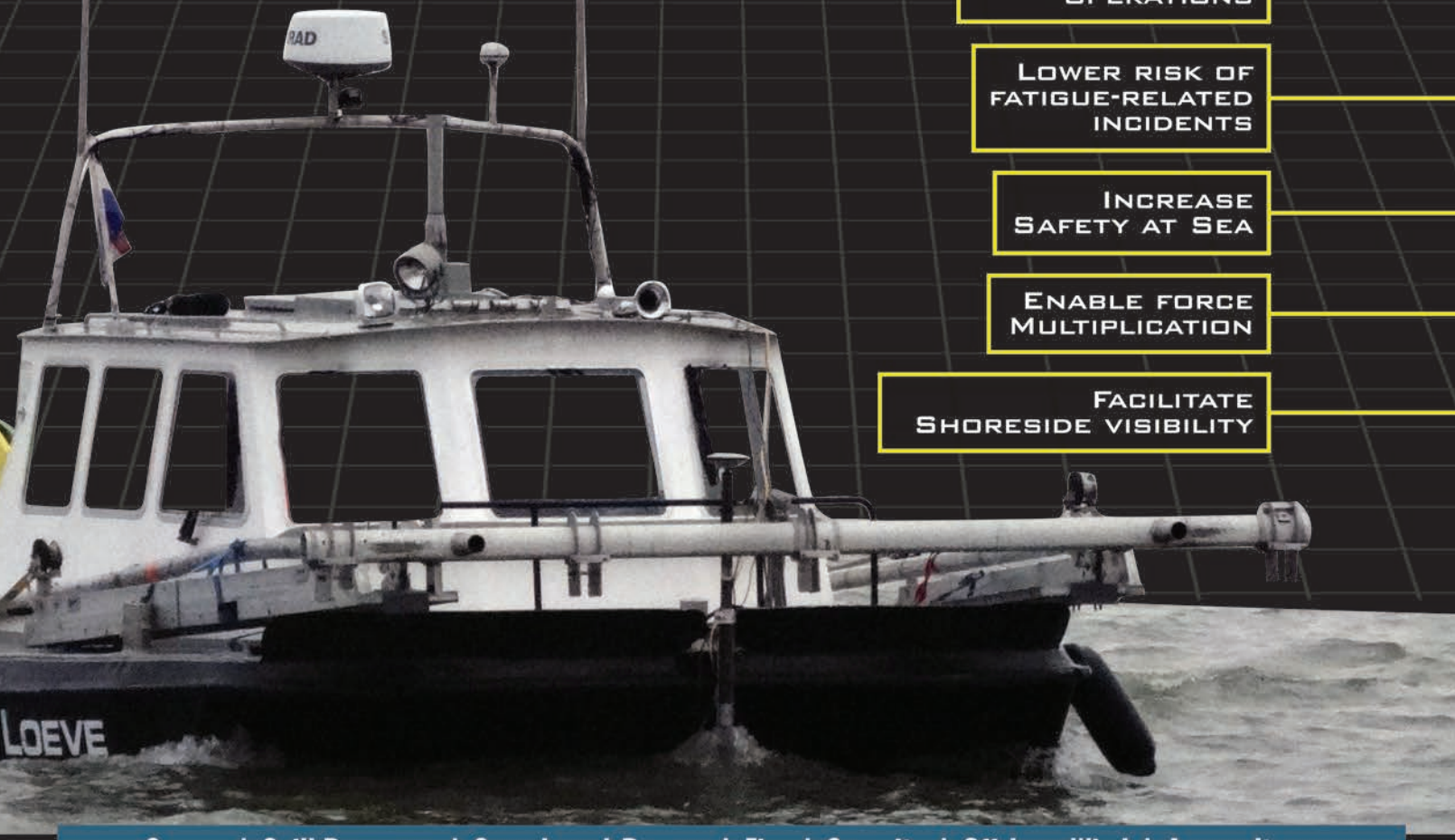

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October 2020
Volume 63 • Number 8

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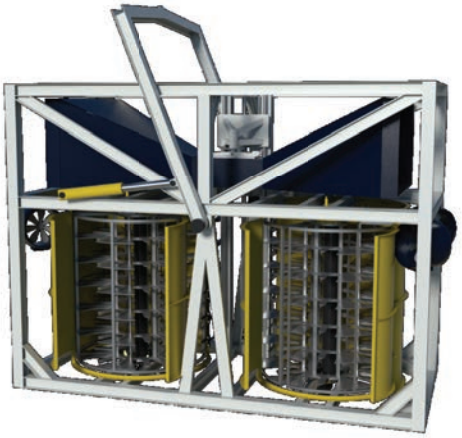

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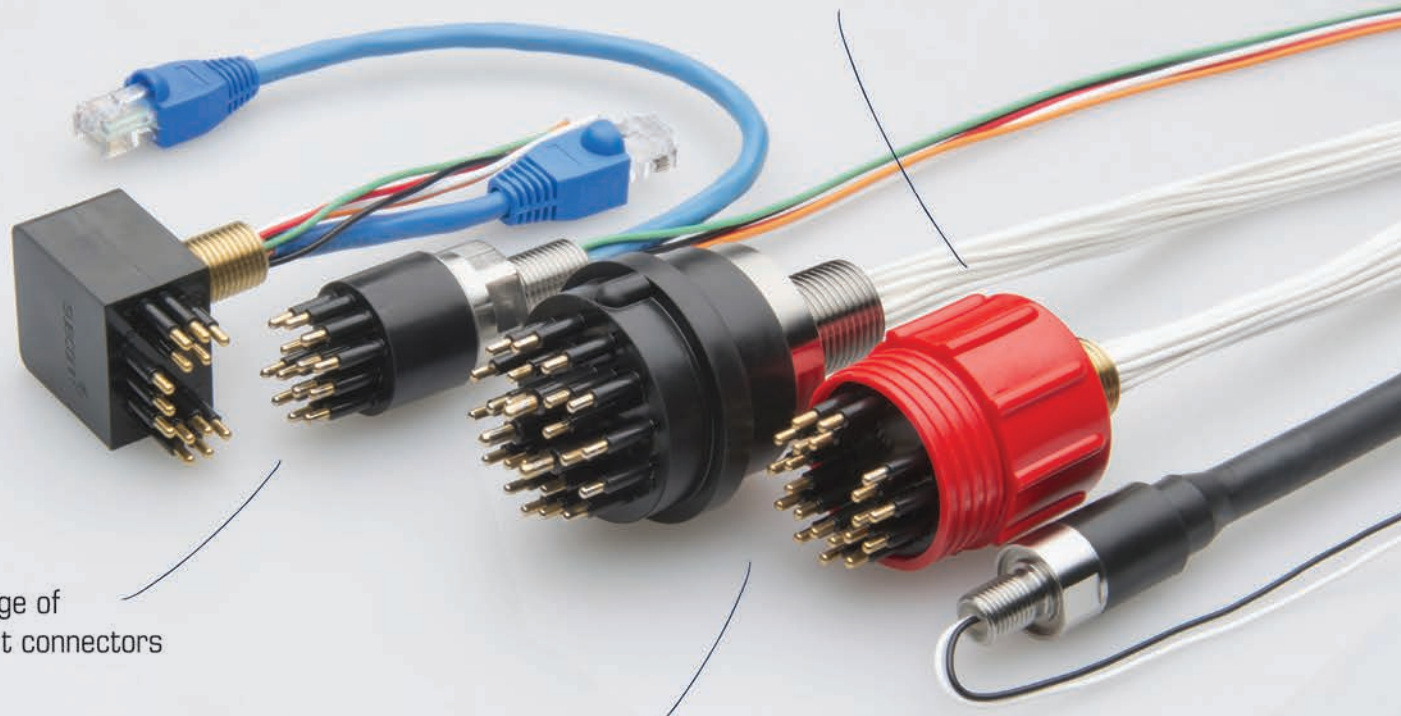

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Editorial

For this, the ocean observation edition of *Marine Technology Reporter,* we could not be more thrilled than to present our interview with **RDML John A. Okon**, Commander, Naval Meteorology & Oceanography Command, as he and his team have a vast scope of responsibility:

> *The United States Naval Meteorology and Oceanography Command (NMOC) provides critical information from the ocean depths to the most distant reaches of space, meeting needs in the military, scientific, and civilian communities.*

The targeted focus of our interview with RDML Okon, which starts on page 24, is a look inside how the command currently, and in the future, will increasingly use unmanned assets to help accomplish the vast scope of its work. Many of you reading this already know full well some of the subsea technology needs from this command, but I think you'll find RDML Okon's responses to our questions enlightening.

A different aspect of 'ocean observation' is a look inside **Emily Penn's** eXXpedition. This insightful feature profile looks at Penn's mission to meld art and science to help uncover some of the ocean's more vexing problems. The feature is written by MTR's summer intern **Celia Konowe**, who has a keen interest in hydrology, ecology conservation and marine ecosystem threats. She continues to contribute to our pages as she simultaneously finishes her final year at the University of Rochester.

From the business side of ocean observation **Elaine Maslin** looks inside the activities of Autonomous Robotics Ltd., and its work on "Flying Nodes," a system designed to speed up deployment and enable more flexible survey geometries compared to cable-based deployment.

Finally, we had a pair of interesting video interviews recently. The first is with **Patrik Möller**, CEO of CorPower Ocean, which is gearing up to deliver 'bankable' wave power renewable energy to the world by 2024. The second – topical as we endure the most active hurricane season in the U.S. ever – with **Olav** and **Oliver Hollingsaeter**, with via their company OceanTherm are examining how to morph proven 'bubble curtain' technology used to keep Norwegian fjords ice-free into a system that could effectively help to temporarily reduce the sea surface temperature and the power of hurricanes.

Gregory R. Trauthwein
Associate Publisher & Editor

MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 63 *No. 8*
ISSN 1559-7415
USPS# 023-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

Marine Technology Reporter (ISSN 1559-7415) is published monthly except for February, August, and December by New Wave Media, 118 E. 25th St., New York, NY 10010-1062. Periodicals Postage Paid at New York, NY and additional mailing offices.

POSTMASTER: Send all UAA to CFS. NON-POSTAL AND MILITARY FACILITIES send address corrections to Marine Technology Reporter, 850 Montauk Hwy., #867, Bayport, NY 11705.

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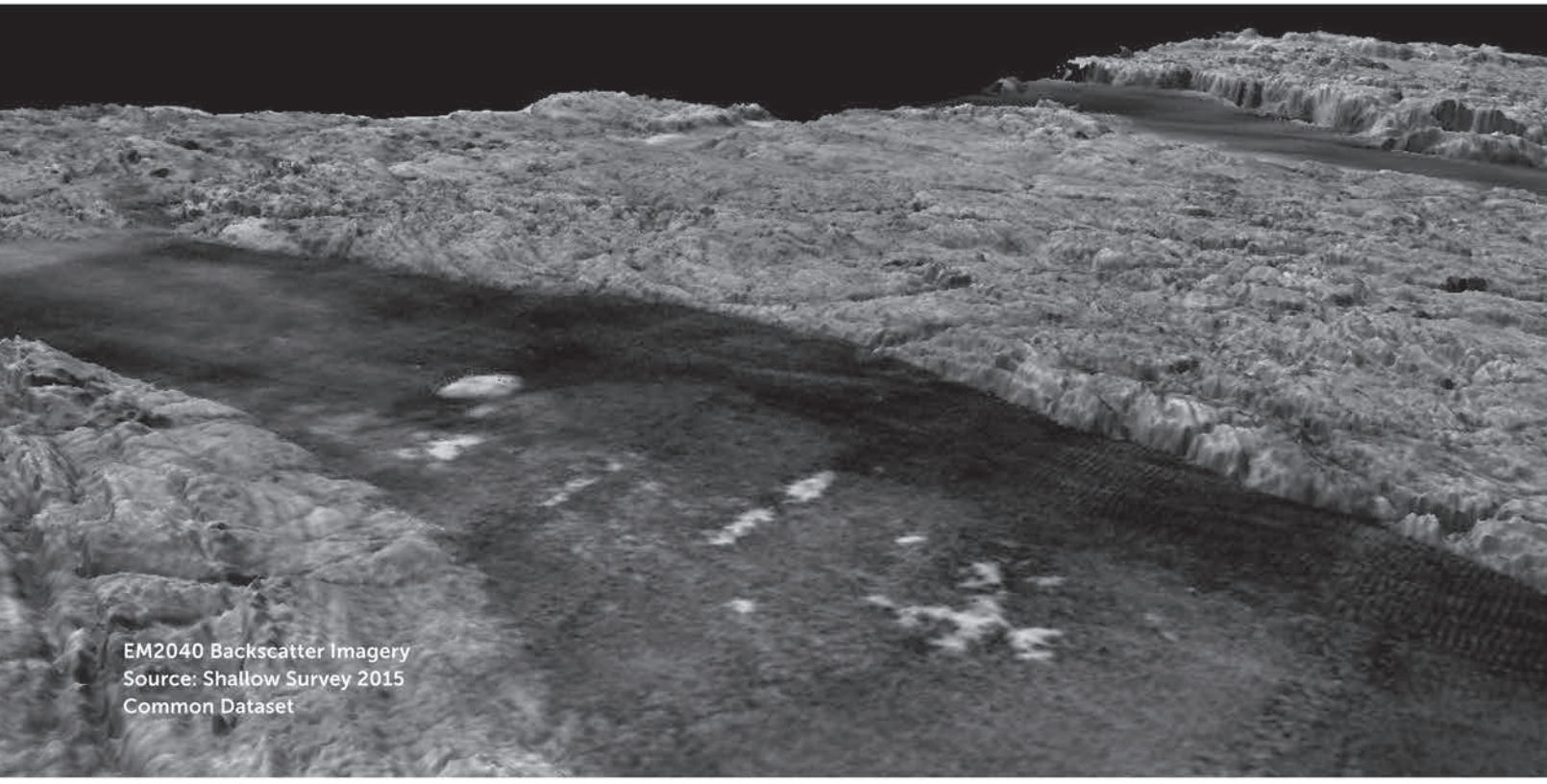

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Konowe

Celia Konowe is a rising college senior from Reston, Virginia, majoring in environmental studies at the University of Rochester with minors in French and theatre. This past semester, prior to the COVID-19 lockdown, she studied abroad in Ecuador through the Universidad de San Francisco Quito as part of its GAIAS (Galápagos Institute for the Arts and Sciences) program. Her time abroad was split between Quito and the Galápagos Islands while studying evolution, ecology and conservation. Her main environmental interests include hydrology, ecology conservation, marine ecosystem threats and food systems. She covered the 2019 Paris Air Show, aviation's largest industry event, and is a student member of the National Press Club.

Lundquist

Edward Lundquist is a retired naval officer who writes on naval, maritime, defense and security issues. He is a regular contributor to Maritime Reporter and Marine Technology Reporter.

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Shea

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Dr. Blair Thornton is an Associate Professor of Marine Autonomy at the University of Southampton in the UK with an adjunct position at the University of Tokyo in Japan.

West

Geraint West is Sonardyne's Global Business Manager, Ocean Science.

"Quotable"

"People often tout power management as the greatest limitation ... in reality, true autonomy and extended communications remain the barriers to broad ocean unmanned operations."
Rear Admiral John A. Okon, Commander, Naval Meteorology and Oceanography Command

"The structural efficiency of wave energy is being improved by a factor of five (10MWhr/per ton of equipment installed in the ocean). That is in line with the best floating wind concepts out there."
Patrik Möller, CEO, CorPower Ocean

Mitigating Underwater Noise

Noise Control Engineering (NCE) recently completed an underwater noise study for Washington State Ferries. Jesse Spence, President, NCE, discusses the growing mandate to mitigate noise from commercial vessels.

Noise Control Engineering, LLC (NCE), of Billerica, Massachusetts, recently completed an underwater radiated noise study for Washington State Ferries (WSF), a study which entailed measurement of nine vessels representing all seven operating classes of WSF vessels, quantifying noise, potential impacts to orcas and other marine life, and methods of reducing noise.

"With the increasing awareness of underwater noise impacts on marine life, both globally and locally in the Northwest, WSF is interested in learning more about how their operations may impact marine life," said Jesse Spence, President, NCE. "They are also interested in learning what aspects of their vessel designs cause underwater noise, and if they can reduce their impacts through procedural changes as well potential improvements to the design and engineering of their vessels."

"This work provides the information that WSF needs to take the next steps towards operational and engineered mitigation measures to reduce the impact of underwater radiated noise from our vessels on marine life, particularly the critically endangered Southern Resident Killer Whale," said Kevin Bartoy, Environmental Stewardship & Sustainability Program Manager, Washington State Ferries.

NCE used its Buoy Acoustic Measurement System (BAMS) to perform vessel noise measurements in general accordance with ANSI S12.64 while allowing the vessels to maintain their normal operating schedule. Simultaneously, vessel operational and environmental data was collected allowing for assessments of noise at varying propeller RPMs, operating powers, and speeds. This information was compiled into a database which was used to calculate 'source levels' and identify impacts to marine life using NMFS guidelines. The measurement data was also used to identify causes of noise ranging from propeller cavitation to specific machinery items. NCE's decades of experience in quiet ship design was used to identify potential methods of reducing underwater noise.

Cutting Ship Noise

While emissions from ship exhaust has been the main target of regulators to reduce shipping's impact on the environment, the matter of noise mitigation with a focus on its impact to wildlife has been a long-running concern, growing in stature in recent years as the overall health and well-being of the ocean and ocean issues have risen in the public conscience. As Spence co-wrote in a paper for The 23rd International Congress on Sound and Vibration, 2016):

> "Airborne noise on ships has been a concern for decades; airborne noise limits such as those adopted by the International Maritime Organization (IMO) [1] have been implemented on many vessels to improve communication and reduce hearing loss among crewmembers. Underwater noise from ships has historically been less of a concern (with the exception of military applications) until recently when its possible impact on the marine environment has become more obvious. In 2004 the U.S. National Oceanographic and Atmospheric Administration (NOAA) held a symposium to discuss underwater noise from shipping, including causes, effects, and possible mitigation approaches [2]. This was followed in 2007 by a second NOAA symposium [3], and a workshop in 2008 organized by Okeanos [4]. These events were attended by representatives from government, shipping industry, oil and gas industry, biologists, marine acousticians and designers, and others. Similar events have followed in subsequent years, and groups ranging from Green Marine to IMO have been working to increase awareness of underwater noise in the marine community. It appears that the marine community is listening; in 2014 IMO announced (non-mandatory) guidelines for reducing underwater noise from commercial ships which discusses possible approaches to reducing underwater noise from ships [5]."

"Also, early in 2019 there was a meeting held at the IMO offices in London, organized by Transport Canada, to attempt to quantify what we should do regarding underwater noise

limits and quantifiable approaches to noise mitigation. These meetings have all been in response to the rising recognition of our impacts to marine life, with respect to noise," said Spence. "Looking forward, I believe there will be greater acceptance of established noise criteria as independent operators design vessels that meet these criteria and modify existing vessels to reduce underwater noise. This issue has been discussed for nearly (or possibly more than) 20 years, and the momentum is building."

Drivers and Solutions

According to Spence, there are efforts to put more regulations in place, particularly for newbuilds, as a focus on shipborne noise continues to grow. "The marine vessel operator community is generally aware of the issue, and some are concerned that if the community does not take action to reduce noise emissions on their own, then tough limits will be set for them. One of my main takeaways from the 2019 IMO/Transport Canada meeting is the technology is available to reduce noise on commercial vessels. However, the desire and need to have reduced noise must be stated clearly in the vessel specification or it will not get implemented."

With the wide variety of private, commercial and government vessels plying the world's waterways, there is no single 'silver bullet' solution used to mitigate noise from boats and ships. "Every vessel is different, and there is no 'one size fits all' solution for underwater noise," said Spence. "However, propeller cavitation is a prominent feature of underwater noise for most commercial vessels. Machinery noise will also play an important role, particularly propulsion engines, gensets, gearboxes, and other large equipment."

When asked define 'top tips' to mitigate underwater noise, Spence admitted "Really, I have one. Put a limit in your vessel specification and require the vessel to be designed to meet it. There currently are a variety of underwater noise classifications from ABS, Lloyds, DNV GL, and others. Environmental' limits are available which are aimed at reducing underwater noise emissions without imposing onerous design limitations and the need to put damping on every panel, stiffener, dinner plate, etc. The more these limits are used the more we will learn about what it takes to meet them (with the associated confidence that they can be met), and what this all means to marine life. The limits will likely change over time, as we learn more and refine our understanding of quiet ship design and impacts to marine life. But without the first step of stating "I want lower noise," no progress will be made."

Hurricane Mitigation via the 'Bubble Curtain'

OceanTherm Aims to Decrease the Impact of Hurricanes by Temporarily Reducing the Sea Surface Temperature

By Greg Trauthwein

In maritime and offshore, Norway is hallowed ground for innovation. The latest entrant is OceanTherm, a team of scientists and innovators that propose its 'Bubble Curtain' Technology could effectively help reduce the power of hurricanes. We recently spoke with ***Olav*** *and* ***Oliver Hollingsaeter*** *for insights on the pace and direction of the research and development.*

According the U.S. Congressional Budget Office (CBO) April 2019 report, hurricane damage is expected to exact an annual economic loss of around $54 billion to the U.S. economy, exacting a heavy toll on households and commercial businesses, particularly the coastal maritime and offshore oil and gas infrastructures. In the midst of a historic 2020 Atlantic hurricane season, which at press time included an unprecedented 24 tropical or subtropical cyclones, 23 named storms, eight hurricanes, and two major hurricanes, those costs can be expected to rise.

Enter OceanTherm and its innovative 'Bubble Curtain' technology, a technology which has been used in smaller scale in Norway for more than 50 years to keep from fjords from freezing over; a technology which when scaled up offers promise to temporarily reduce hurricane severity by effectively reducing the ocean's surface temperature.

"To our knowledge, OceanTherm is the only company that is seriously pursuing the idea of finding a solution on the increasing hurricane challenge in the world," said Olav Hollingsaeter, CEO, OceanTherm. "Our research so far shows promising results, and we feel an obligation to go the distance needed to find out if our solution can be proved at scale."

Founded in 2017, OceanTherm is aiming to use the same technology to lower the sea surface temperature for a short time to prevent devastating natural disasters. Hurricanes are generated when masses of hot and cold air collide above warm ocean water, and hurricanes obtain their energy from the ocean surface when the surface water temperature is above 80 °F.

The bubble curtain works by lifting colder water from an optimal depth, de-

pending on the temperature, and mixing it with the warm surface water, effectively reducing the sea surface, aiming for a temperature below 80°F, temporarily. By cooling the surface water, the bubble curtain would potentially deprive the hurricanes of a critical energy source, potentially minimizing its strength and de-energizing the destructive storms before they make landfall.

How Does it Work?

A "Bubble Curtain" is a perforated pipe lowered in the water, placed across a stretch of ocean (such as as a narrow straight) and works by supplying bubbles of compressed air to the deep. When the bubbles rise, they bring the cold deep-sea water to the surface, and this cold water cools the warm ocean surface for a short period of time.

Strong ocean currents can be considered the engine of the solution. By placing a system in strategic positions, based on research, the colder water will spread out with the help of the currents and influence a larger area, like the coast of Florida.

The system could be permanently installed, with a projected lifespan of 50 years according to Olav Hollingsaeter, or it could be deployed as a mobile solutions.

The fixed system would be permanently installed across a narrow straight, would cost approximately $550 million for 30 miles of bubble curtain installed at a depth of 500 ft.," according to Oliver Hollingsaeter, Business Development, OceanTherm. This solution would include 1GW of compressors – or 20 50-MW compressors, with a cumulative OPEX of about $80 million per year.

The Mobile solution would depend on a fleet of up to 20 rental vessels, a modular solution that could cost anywhere between $100 and $300 million OPEX depending on the size, location and duration of the operation. According to the Hollingsaeter team, a prime area for the system could be the stretch between Florida and Cuba.

While much study and development remains to be done, particularly in respect to its impact on the environment, Oliver Hollingsaeter points out that the bubble curtain only changes the water temperature for a short period of time, minimizing long-term effects of sea-level temperature change and surrounding ecosystems.

Current partners include SINTEF Norway, an independent research organization; Research Council of Norway a Norwegian government agency; Innovation Norway a state-owned company and a national development bank, and MTI Startup, an early stage investment company and a part of MicroTech Innovation's system based in Vestfold.

OceanTherm is in the midst of arranging investors and research partners in the U.S. to participate in the project.

The fixed system would be permanently installed across a narrow straight, would cost approximately $550 million for 30 miles of bubble curtain installed at a depth of 500 ft."

– Oliver Hollingsaeter, Business Development, OceanTherm

Cloud Computing – The Next Big Bang for Seismic

By Bill Shea, CEO, Sharp Reflections

It is premature to analyze or try to predict what the final impact of Covid-19 will be on the wider seismic ecosystem at this early point in the crisis. However, we can make some educated guesses. Ongoing projects that are generating new data will continue, unless pre-commitments are cancelled. Some new projects that are "ready to sail", such as PGS' new Geostreamer X multi-azimuth marine seismic survey in the North Sea, will also go forward. Most upcoming projects still in the planning stage will be postponed or otherwise delayed. This is the result of a natural reigning in of spend that happens when shock waves hit the sector.

Disruption a driver for change

The seismic sector was poised for some change ahead of Covid-19, with seismic vendors announcing plans to migrate a percentage of their data processing to the cloud in 2020. This was the start of a new but incremental approach, which would take years to drive real change in terms of how seismic data is processed and delivered to oil companies.

Covid-19 has already disrupted normal workflows and processes. With companies across the globe embracing remote working out of necessity, it is clear that we are not going back to how things were before. Covid-19 has created a vacuum, creating opportunities for new processes and technologies to show their value. Disruption can be an impetus for change, and a natural result is that the seismic sector will use this time to restructure and evaluate to ensure its long-term survival.

Future proofing the seismic market

The oil and gas sector is often slow to adopt new habits. Remote access to technical computing is a relatively new trend. After Covid-19, the transition will have to happen quicker. Today, seismic delivery is a slow approach requiring the vendors to transmit large data files to oil companies, which in turn need to be manually uploaded to the company's expensive inhouse data storage infrastructure. For pre-stack data sets, this is still done using physical media. It can still take weeks (or months) for a new order to reach the interpreters workstation – delaying the analysis work.

Huge public clouds, such as Amazon Web Services and Microsoft Azure, will almost certainly disrupt seismic delivery. New field data will go directly to cloud computers for processing, allowing large-scale data projects to be shared instantly from vendor to company, effectively jump starting the interpretation program. Provided data analysis also transitions to cloud-based software, real advantages exist for the seismic customer. This requires wide-scale adoption of cloud technology by both oil companies and vendors.

Why is cloud the likely trend of Covid-19?

Covid-19 has resulted in companies across all sectors and countries taking

stock of current processes, with most forced to quickly implement new ones to keep their business afloat. Issues, such as computing system capabilities and the security of online conferencing platforms, widely became shared concerns at the start of lockdown, with IT departments put on the backfoot. This created a vacuum needing to be filled. New technologies entered common parlance and became the overnight solution to many companies' remote working needs.

Investing in more flexible and elastic computing infrastructure no longer seems like something that can wait until current systems are obsolete. This is likely to result in faster adoption of cloud computing following Covid-19, and there are a number of drivers which will help this:

Increasingly complex algorithms and higher volumes of data

The volume of seismic data available is growing exponentially, and there are increasingly complex imaging algorithms, such as Reverse-Time Migration (RTM) and Full-Waveform Inversion (FWI), to cope with these bigger data loads. The seismic vendors are improving their offering to oil companies. However, these algorithms require high-scale computing infrastructure by the oil companies to work at their most efficient level.

With the current situation putting pressure on oil companies to reduce spending, new seismic purchases or full-scale reprocessing projects are likely to be cut for the short-term. However, E&P companies still need to honor license commitments and progress seismic work programs during the downturn. This makes pre-stack data conditioning and

interpretation, to extract fresh insights from existing data libraries, a low-cost workstream. The value is especially high for multi-client datasets, which are not always processed to the standard required for quantitative interpretation. Cloud computing allows for larger pre-stack data sets to be processed in a shorter space of time compared to normal computer infrastructure.

The use of pre-stack data allows users to leverage 100% of their existing seismic data library. By undertaking in-house reprocessing and seismic inversion on existing data via the cloud, operators can mature prospects and optimize drilling locations during a downturn. This activity could be looked on favorably by governments as a low-cost, efficient workstream.

Remote working

Covid-19 has shown companies that having a remote workforce is possible. Public clouds offer a new way to work. Transitioning to cloud-based computers, will remove a degree of business uncertainty. It will guarantee companies, and their respective boards and investors, that the systems they have in place can support an army of remote workers should another large-scale incident occur in the future. This level of insurance will mean companies are more likely to adopt the cloud transition with a big bang, rather than via a slow evolutionary process.

Often, the attitude was that one would learn new skills when they had the time to do it. Coronavirus has presented the sector with that time to drive big changes forward now.

Cost savings

Existing computing infrastructures are a sunk cost for oil companies. Maintaining existing computer systems requires budget every year and, at some point, oil companies will also need to invest in high-performance computer software to improve efficiency. If the new system is not embraced in one go, companies will be forced to support two systems – the new one and the legacy one. This will drive up costs. Further to this, regardless of when the new system is implemented, staff will require training, and the expense of installing new processes will need to be made. While there is an appetite for embracing new technologies now, companies would do well to make use of this.

New architectures, new technologies

Embracing cloud can further facilitate growth and other innovations, such as machine learning and artificial intelligence, to become embedded within the company. Expanding elastic computing infrastructure and the cloud, allows companies to explore the potential that newer innovations can have and ensures the company is set up for when these technologies become the norm.

Legacy applications that are retained will need to be rewritten from scratch to take advantage of client-server computing capabilities. This will create opportunities for new entrants in the geoscience computing market.

Collaboration

Regardless of whether staff are working from home or the office, collaboration with partners and external third parties is a requirement of the seismic sector. When data is stored on a public cloud, data can be shared quickly and easily among partners with equal access possible for all involved in the project.

With data security an executive-level concern, companies need to know that, when employees are working on a project with a partner, the system is secure. The cloud is a natural collaboration tool and easily facilitates the safe and secure sharing of data by allowing the analysis of data to be undertaken where the data is stored.

The current climate

As we are entering the next phase of Covid-19, it is helpful to look at what has happened in the seismic sector. While there have been casualties of the crisis, not all projects have been shut down. Some, more innovative oil companies, are still pursuing transformation initiatives with cloud vendors. Employees across the board are open to exploring new work methods and technologies, and are keen to learn. With Rystad Energy stating there has been ‘a clear growth in cost-saving remote work technologies’ during this time. This is the natural reaction to a sector that has already acted fast to embrace webinars and other online learning platforms to replace the traditional conference circuit, for now.

The Rystad Energy report provided further hope that this time is one of re-evaluating priorities, stating that:

“Given the limited options of low-hanging cost savings in the current downturn, operators and suppliers are looking towards digital technologies to realize cost efficiencies.”

However, with the above opportunities to a develop a more agile and modern sector, there comes with them a humbling thought. This is not a temporary blip and it will last, at least, until there is a vaccine. What can be done is to implement clever changes into business models now, so that they are setup to cope with challenges such as this one, and others, into the future.

It will take 1-2 years to know fully the extent of Covid-19, but one thing is certain. Those companies that acted fast to adapt to the changing landscape will be better equipped to thrive over the years to come.

TAKING WAVE ENERGY TO THE BANK

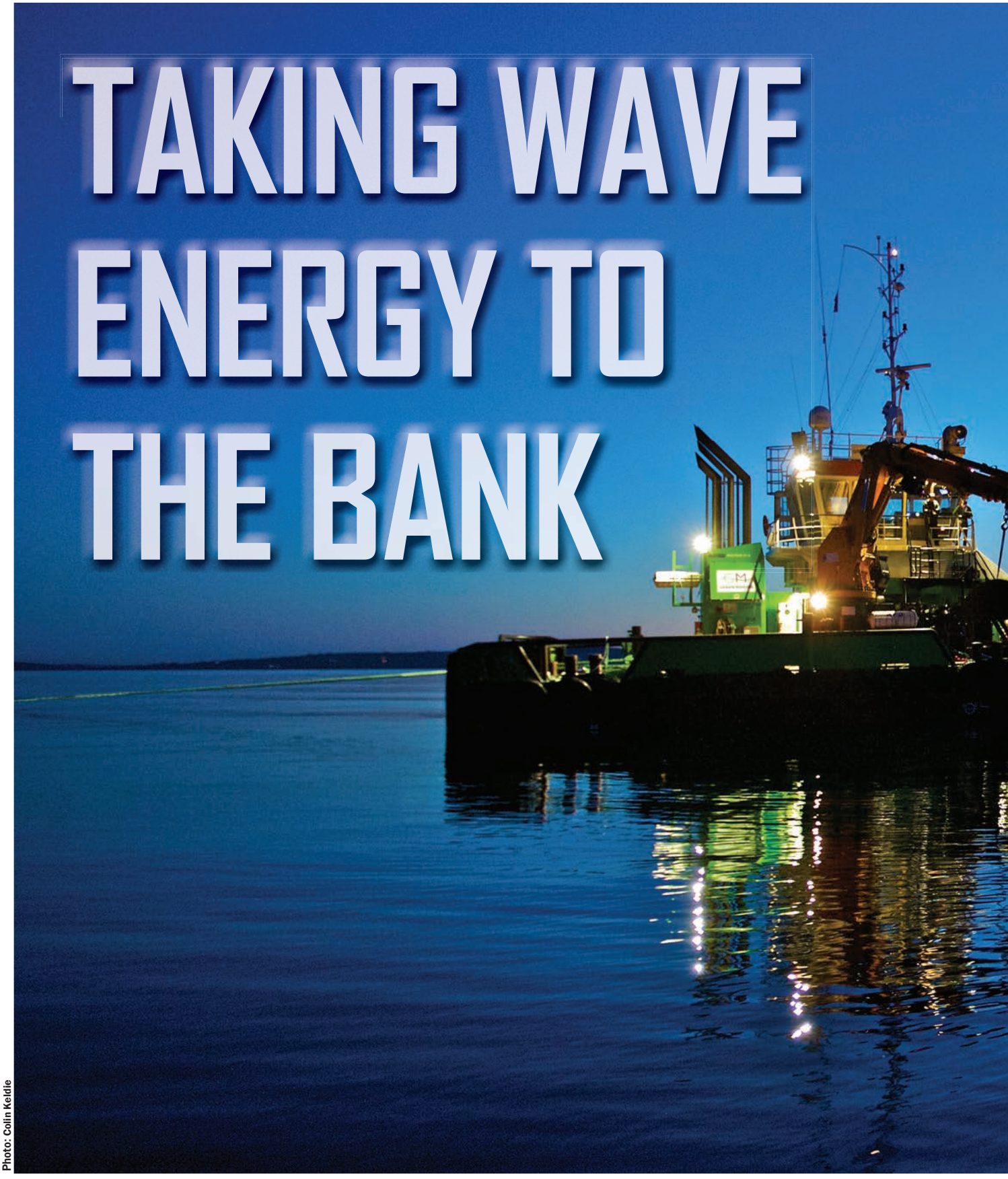
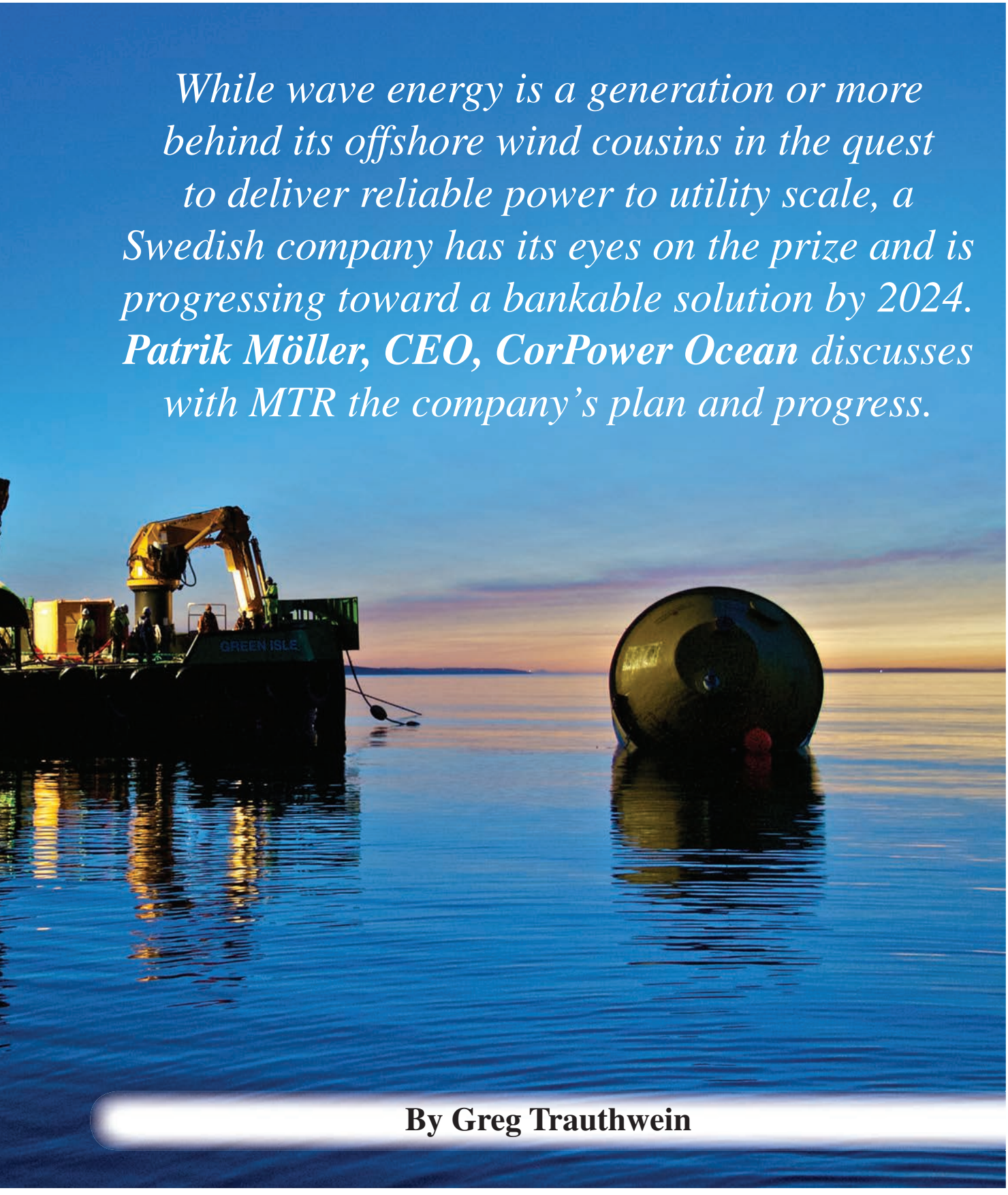


Photo: Colin Keldie

While wave energy is a generation or more behind its offshore wind cousins in the quest to deliver reliable power to utility scale, a Swedish company has its eyes on the prize and is progressing toward a bankable solution by 2024. ***Patrik Möller, CEO, CorPower Ocean*** *discusses with MTR the company's plan and progress.*



By Greg Trauthwein

"The structural efficiency of wave energy is being improved by a factor of five (10MWhr/per ton of equipment installed in the ocean). That is in line with the best floating wind concepts out there."

Patrik Möller, CEO, CorPower Ocean

CorPower is seeking success in the wave energy production arena, arguably the most challenging 'renewable' energy arm due to the hostility, unpredictability and instability of working in the corrosive ocean environment. A successful system must be rugged enough to survive the ocean's toughest conditions, yet flexible to generate power when conditions are calm.

At CorPower, Möller is leading a team that is purposefully taking its time to prove the concept, the technology, aiming to become a leading OEM and deliver a system that is both attractive to the investment community, providing utility scale production.

Since 2012 CorPower has been embarked on a five-stage process to design, test and deliver its Wave Energy Converter (WEC) solution. Currently in 'stage three,' Möller said the company to date has gotten funding of about $38 million, and will require an additional $65 million to complete stages four and five and bring the system to market in 2024.

"Wave energy has not followed the same curve of acceleration as offshore wind," Möller readily admitted. But he sees promise in the broad uptake of offshore wind, as well as the interest building around floating wind production. "It's fantastic to see the level of deployment of offshore wind, particularly floating wind coming on line in recent years as a bankable technology. It's really amazing."

In evaluated the wave energy industry as a whole, Möller estimates that there have been two tall hurdles to cross to bring the technology online as a significant contributor to power the world.

Historically, the devices have either broken in storms or they've just not produced enough electricity to make it a viable business case, said Möller. Regarding survivability, CorPower is introducing a new way to protect devices in the largest waves he said, introducing a function to wave energy similar to wind energy; pitching the blades in storms. "Every commercial wind turbine has the capacity to pitch the blades to protect from over-

Photos: Colin Keldie

spinning in the fiercest wind conditions," said Möller. "That has been a capability that has been missing in wave energy, so we're now adding that to our devices. The second challenge is advanced phase control technology that strongly amplifies the response to the regular waves. By amplifying the response to wave to enhance the power capture."

If his teams calculations are correct, and they are presently building a full-scale model, the C4 buoy which is a 9m diameter device designed to generate 300 kW, the result will be a system that, on average, captures five times as much energy over the year compared to the amount of machinery installed in the ocean.

"The structural efficiency of wave energy is being improved by a factor of five," he said. That's 10MWhr/per ton of equipment installed in the ocean which Möller believes is "in line with the best floating wind concepts out there."

We have completed three stages; in the third stage we built a half-scale system that we demonstrated in the Orkney Islands in norther Scotland

HOW CLOSE IS CORPOWER'S TECHNOLOGY TO COMMERCIALIZATION?

Corpower is currently fabricating our first commercial scale system, which will be dry-tested in a bespoke test rig with simulated wave loading in Stockholm before being deployed in the ocean during second half of 2021. We recently

launched a $18.8m project in northern Portugal with plans to develop an research and development, manufacturing and service center. mission is to successfully introduce certified and warrantied WEC products to the market by 2024, making wave energy a bankable technology that can attract mainstream renewable project finance. Corpower's knowledge center in Viana will drive the development and mass fabrication of WECs, laying foundations for future high-volume operations. Over the coming years we will collect substantial amounts of data to 'prove' our technology, with an overall aim of successfully complete the HiWave-5 demonstration phase with a competitive and certified product.

WHAT KIND OF LCOE DO YOU FORESEE?

Corpower has a clear path to a LCOE below $35/MWh. From first pre-commercial installations in 2024/25, the LCOE is projected to drop below $118/MWh after 150MW installed, and $70/MWh after 600MW installed by 2030.

HOW WILL CORPOWER SUCCEED IN WAVE ENERGY WHEN SO MANY OTHERS HAVE FAILED?

Corpower is confident in its ability to commercialize this new class of WECs. Our structured five-stage product verification program is recognized as best practice in the sector. The program involves a step-by-step verification process ensuring the business case is supported by the physical and economical metrics in each stage from small scale models (2012) to full scale array product (2023). This provides a clear path to reach a bankable product. A key part of the strategy involves dry testing each machine in controlled simulated wave loading on-land, to fully debug and stabilize the machines prior to ocean deployment. The WECs will undergo a further certification process with DNV-GL and independent third-party performance validation from EMEC and WavEC.

WHAT'S YOUR TIMEFRAME?

In line with Corpower's LCOE forecast, we expect our new class of WECs to be highly competitive with existing ocean technologies within the coming decade and with wind and solar by 2030.

THAT IS, OF COURSE, THE IDEAL. WHAT NEEDS TO BE DONE TO GET THERE?

Ring fenced revenue support for ocean energy is essential to accelerate deployment of the first 100s' of MWs by 2025-3030. This comes at a low cost, benefiting countries supporting the development such as the UK, Ireland, Portugal, France, U.S. and Norway. The technology also requires validation from independent academic and scientific spheres combined with strong support of energy developers to demonstrate market confidence. Corpower's technology is already receiving broad support across Europe from organisations including InnoEnergy, the Swedish Energy Agency, European Commission and Wave Energy Scotland. Major players within industry are also engaging including EDP, Simply Blue Energy, ENEL, and ABB.

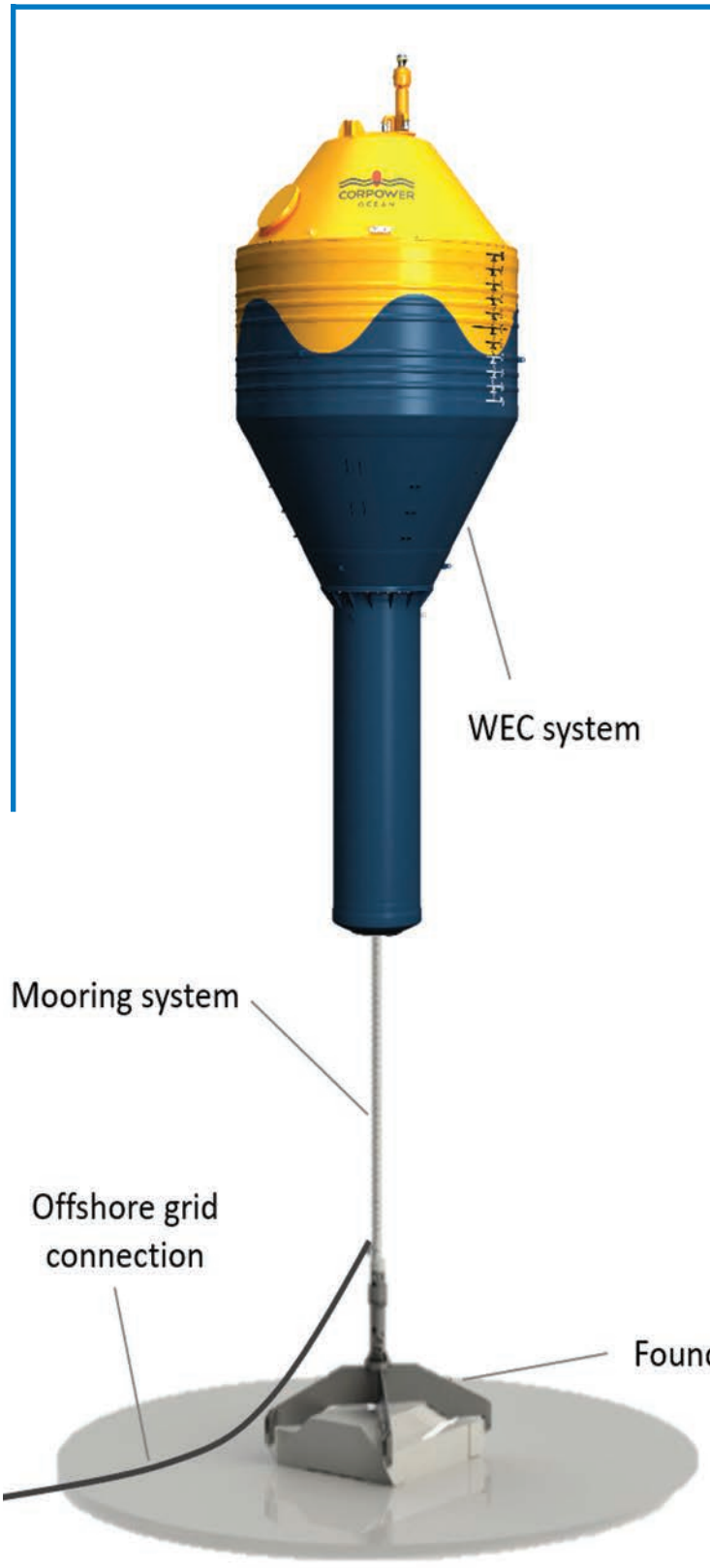


Photo: CorPower

Inside the CorPower's WEC

According to Patrik Möller, CEO, CorPower Ocean, it remains incredibly challenging to harness wave energy or convert it into electricity in large volumes. Waves not only roll past devices, they also bob up and down and converge from all sides in unpredictable seas. The hostile ocean environment with huge swells, destructive waves, high winds and corrosive saltwater also present major challenges for wave energy developers. A successful wave energy generator must prove to be both durable and reliable. There have been many attempts to design a device which effectively captures wave energy including writhing snake-like attenuators and devices mounted on the ocean floor.

Wave energy devices have historically either broken in storms, or they have not produced enough electricity compared to their cost to make it a viable business case. By introducing this new class of phase-controlled WECs, we are changing that picture. CorPower WECs can produce five times more electricity per ton (10MWh/t) than any other known wave technology by combining:

- *Storm survivability by a novel protection mode making the device transparent in storms, similar to a wind turbine pithcing the blades in storms; and*
- *Strongly amplified power capture in regular sea conditions by advanced phase control technology.*

CorPower's WECs provide a unique solution. Our WECs are essentially heaving buoys which float on the surface absorbing energy from ocean waves. The buoy is connected to the seabed using a tensioned mooring system. Special technology is used to make the compact devices oscillate in resonance with the incoming waves, strongly amplifying the motion and power capture and harnessing energy from the rise and fall as well as the back and forth motion of waves.

The resonant WEC has four significant patented features:

1. *Pneumatic pretension system. Makes the device transparent to storm waves, and brings down the required materials by 40% compared to a conventional gravity-balanced WEC, reducing CAPEX;*
2. *WaveSpring phase control technology, providing 300% increase in Annual Energy Production (AEP) for a given buoy size;*
3. *Cascade gearbox technology, enabling robust conversion of the amplified linear motion into rotation with low losses;*
4. *Composite hull technology, eliminating corrosion issues from salt water and provides long lifetime.*

CorPower WECs can further harvest the same AEP from a buoy with 1/10 volume compared to conventional point absorber WEC. By comparison, a 300kW CorPower WEC has a size of 9x18m and weighs 60 tonnes, where other wave devices may have dimensions of 100s' of meters and several thousand tonnes for the same capacity. Getting large amounts of electricity from a small device significantly reduces CAPEX. The compact lightweight devices are also less costly to transport, install and service, bringing down OPEX.

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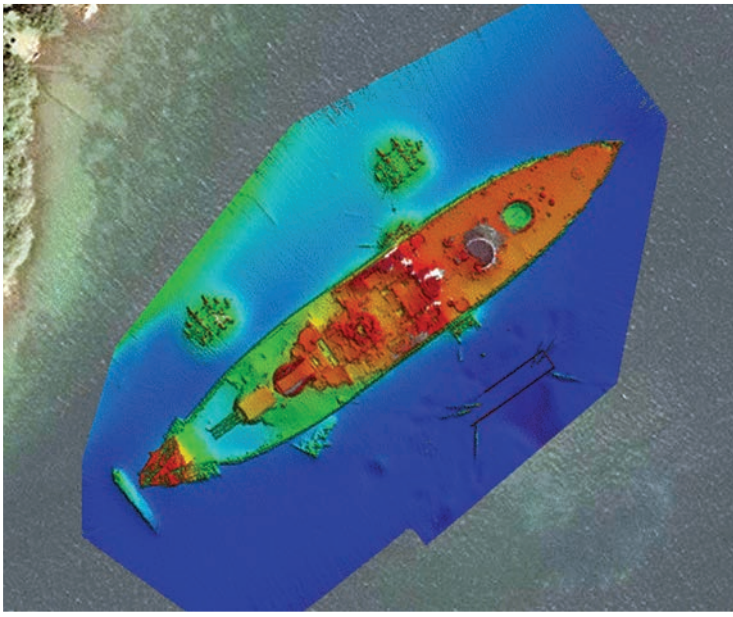
All photos: U.S. Navy

RDML John Okon

Commander, Naval Meteorology and Oceanography Command

Recently the United States Navy and NOAA signed an agreement to jointly expand the development and operations of unmanned maritime systems in the nation's coastal and world's ocean waters. RDML John Okon, Commander, Naval Meteorology and Oceanography Command, shares his insights on the direction and pace of the use of unmanned maritime systems for the Navy's future.

By Greg Trauthwein



How and when you realized that yours would be a career dedicated to Oceanography?

Interesting, I never started out to have a career in Oceanography, but rather in Broadcast Meteorology. At NY Maritime College, I studied both Meteorology and Oceanography and became equally passionate about Oceanography. Thanks to the US Navy, we have a career field in both. As a young Officer I didn't realize Naval Oceanography existed, but one day I had the pleasure to welcome aboard USS TICONDEROGA, AGC Benner and AG1 Skala as a Mobile Environmental Team. From that day forward I found a field and group of Sailors and Civilians that were passionate and dedicated to the sciences and protection of our Constitution. 25 years later ... here I am.

Using the start of your career to today as bookends, put in perspective how the importance/ focus of "Ocean Issues" has changed the most.

The Ocean is critical to National and Global Security. Back in the early 90's the ocean wasn't contested, the US was the most powerful Navy and we had freedom of movement, anytime, anywhere. Now, while we are still the most powerful Navy in the world, near peer competitors are racing to close that gap. The ocean and undersea domain is center stage. With 70 percent of the world populations living near the ocean, 90 percent of global trade occurring on the Maritime Commons, and over 90% of intercontinental communication traveling on undersea cables. The Ocean matters more now than ever before.

Using that same time frame, put in perspective the evolution of unmanned maritime systems as you see it.

Over the past two decades, the Navy's employment of unmanned systems (UxS) has experienced tremendous growth and Naval Oceanography remains at the forefront in development and operations of the vehicles. Naval Oceanography helped lay the groundwork for programs such as the MK18 family of systems. In fact, Naval Ocean-

Photo: U.S. Navy

Photo: U.S. Navy

ography, in cooperation with institutions such as WHOI, SCRIPPS, the University of Washington, and the Office of Naval Research, developed many of the unmanned systems currently in use throughout the Fleet. Additionally, Naval Oceanography fielded SLOCUM gliders in 2010, and by 2019 was the first organization to successfully deploy and operate over 100 unmanned systems simultaneously from one location, the Naval Oceanographic Office's Glider Operations Center.

Please discuss in overview the size and shape of unmanned maritime systems currently in the 'fleet' or at the disposal or USN, and discuss how you see this expanding and evolving in the future.

In the past 10 years, unmanned systems capabilities have continued to expand with the limits of operational potential remaining beyond the visible horizon. We have in inventory approximately 200 unmanned systems, ranging from man portable littoral expeditionary units to the larger 6000M deep ocean systems. These systems are force multipliers for us to provide critical environmental knowledge across the globe to the meet the operational needs of the Fleet. Operating unmanned systems are part of everyday life across a number of Naval Oceanography commands to include a fleet of buoyancy gliders, unmanned surface vehicles, and unmanned underwater vehicles that effectively enable mine warfare, special warfare, and safety of navigation. The

Photo: U.S. Navy

expanded roles of unmanned systems in environmental intelligence operations means their place in the warfighting tool kit is well entrenched. As endurance and complex autonomy improves, you can expect the mission set to grow.

The impetus for this interview was the recent agreement between NOAA and the U.S. Navy "to jointly expand the development and operations of unmanned maritime systems in the nation's coastal and world's ocean waters." Why is this agreement significant, and perhaps more importantly, why wasn't this type of agreement already in place?

For decades, NOAA and Navy have a long history of cooperation and previously developed a framework to broaden coordination to leverage expertise in the development and operational transition of Unmanned Maritime Systems (UMS) under the Commercial Engagement Through Ocean Technology Act (CENOTE). The significance of CENOTE is to further operational use of unmanned systems, as well strengthening the partnership through joint acquisition strategies, and autonomy development.

While NOAA and Naval Oceanography use unmanned systems similarly to collect similar data sets, we do it for very different reasons with very different mission sets. A great example is acoustics. NOAA uses acoustic sensors (like hydrophones) primarily in their fisheries and climate groups. They are monitoring marine mammals, detecting seismic activity, and using it for law enforcement for public consumption. Naval Oceanography collects acoustic information to understand how ambient noise impacts sound pathways through the ocean to enable undersea warfare. CENOTE better postures Navy and NOAA to reduce costs and minimize duplication of effort in development and operations of unmanned systems.

How does USN use unmanned maritime systems today, and perhaps more importantly, how do you see the use of UMS expanding in the near- and long-term (ie. what types of things would you like them to do that they're not already doing?)

Utilization of unmanned systems will continue to expand throughout Navy operations. Early successes with the

MK18 family of unmanned underwater systems demonstrated that unmanned systems can extend the Fleet's reach, direct our talented members to other tough problems, and improve warfighter safety. The Navy has continued to invest in developing the systems that enhance our warfighting posture, keep our Sailors and Marines safe, and keep our adversaries at distance. As AI, autonomy, and endurance mature and improve our ability to sense the environment and grow the tactical advantage. Coupled with efficiency in data handling, dissemination and onboard processing Naval Oceanography will maintain our advantage in the information age.

When you look at the unmanned marine systems today, as a whole, what do you see as the number one technical challenge/ hurdle to make these systems as prevalent as we've seen unmanned systems become on land and in the air?

People often tout power management as the greatest limitation, but we have been making steady advances in endurance. In reality, true autonomy and extended communications remain the barriers to broad ocean unmanned operations. Marine surface and submerged systems operate in very hostile environments and are challenged daily by that environment. The communications to

Photo: U.S. Navy

these systems is never an assured success. UMS systems need to be able to maneuver in that ocean environment, make adjustments according to the challenges that ocean environment presents and most importantly complete the objective or task with very little or often no communications. Energy demand remains a challenge.

Looking at the full scope of responsibility under your command, can you distill what you count as the top three or four advantages/enablers that come with a larger, more capable and connected unmanned maritime system fleet?

Fortunately, Naval Oceanography has fought through the COVID-19 crisis by keeping all six of our oceanographic survey ships conducting critical missions for the U.S. Navy.

Unmanned systems served as a pivotal part of our capability and enable us to collect critical oceanographic and bathymetric information to enable fleet operations. Their top three capabilities include:

1. A greater understanding of the ocean environment based on in situ environmental measurements.

2. The enhanced ability to have an unmanned asset in areas of the world where a manned surface ship is not permissible. Imagine surveying in the Arctic or Antarctic regions that are challenging to reach by other methods. A networked connected fleet of autonomous sensor packages could meet that challenge.

3. The force multiplication effect of having a network of UxS systems (air, surface and subsurface) in theater, providing relevant operationally important environmental data in advance of manned platforms allowing for a clear picture for the warfighter.

In your career, what do you count as the number one technology evolution that has helped oceanographers to do their jobs more safely, more efficiently.

Technology is important and it seems like many folks are chasing the next best thing.

In my opinion, it is the commitment from every aspect of our country, from government, to academia to industry, to work together to solve hard problems in the ocean for our economic prosperity and defense of our country. The ocean has no borders, we must work together to develop a culture of connectedness ... in the end our greatest advantage is people and partnerships.

Photo: U.S. Navy

Meet Rear Admiral John Okon

RDML John Okon is a native of Syracuse, NY, and holds degrees in Meteorology and Oceanography from State University of New York Maritime College and Naval Post Graduate School and National Security and Strategic Studies from the US Naval War College. He commanded Naval Oceanography Antisubmarine Warfare Center in Yokosuka, Japan and Fleet Numerical Meteorology and Oceanography Center in Monterey, California. Admiral Okon is currently the 11th Commander of Naval Meteorology and Oceanography Command and 23rd Oceanographer of the Navy. He is married to Valerie Gessner Okon and they reside in Pass Christian, Mississippi.

Who do you count as the key mentor(s) in your career, explaining what you gained from them.

VADM John "Sarge" Alexander. Sarge taught me honest self-assessment, stewardship matters, and reconfirmed a lesson from my Father, hardwork is a talent equalizer. Sarge was my Executive Officer while I was stationed on USS DWIGHT D EISENHOWER.

If you had best advice for young people thinking of pursuing a career in oceanography, what would it be?

Reach out to your Navy. Naval Oceanography is hiring! Oceanography is an exciting broad and diverse field. Find your passion, be committed, and accept the lifestyle that comes with it.

If you had to recommend one good book, what would it be and why?

I'll give you two. First is *Everyone Communicates Few Connect* by John Maxwell. Leadership is innately personal. If you want to lead and influence, you must learn to connect. It is the number one attribute that stands between you and success. Second, *Two Souls Indivisible* by James Hirsch. This book is a chilling story of two good men that did not let race or background stand between them, their call to duty, and their commitment to each other. Fred Cherry and Porter Halyburton showed how good men can achieve greatness during the worst conditions. I had the pleasure to study at the Naval War College and heard first hand their story and saw their unrelenting bond.

Outside of the job, what do you enjoy doing in your spare time?

Running long distance, woodworking and playing golf with my wife. Outside of that, our three Labrador Retrievers keep us busy throwing the ball and long walks!

Photo: Sperry

Emily Penn's eXXpedition

By Celia Konowe

Emily Penn is an ocean advocate and co-founder of eXXpedition. As an artist, skipper and marine explorer, she is leading the world's newest crew of superheroes: those dedicated to saving our planet. Born and raised in England, Penn grew up sailing and was trained as an architect at the University of Cambridge—a career that would pan out very differently than she imagined. Today, with 12 years of action and outreach under her belt, Penn takes an approach to solving our ocean crises that emphasizes collaboration, community and commitment, all bolstered by her passion, hope and energy towards creating a better future.

As a sailor, Penn's connection to the maritime community has been lifelong. Sticking to character, when she was offered her first job after university in Australia, Penn looked for ways to hitchhike from England on a boat. She managed to join an expedition that was crossing the world's oceans on biofuels and was shocked throughout the trip by the amount of plastic waste they encountered. From floating masses in the middle of the ocean to cluttered coastlines on small islands, the plastic issue was clear and real to Penn. While this experience spurred the start of her work with plastics, it still took several years of expeditions and cleanups for Penn to recognize her new career path.

Never fear, though—Penn's architect days haven't been forgotten. As a constant homage, Penn has adopted art as an important hobby, which provides her with a sense of calm and a closer

"It's about getting eyes on these very remote parts of our planet that so few people ever get to go to, and bringing these stories back to land, which is where we need the change to happen."

look at the surrounding world. "It's like doing science and seeing things that you wouldn't have if you weren't looking as closely. For me, art is a bit the same," she explained. "When you're drawing something, you have to look very closely to do a good drawing. And looking at my life—my transition from an architect and all the travelling I did in my 20s—it's a really nice way for me to observe the world." Beyond her personal affiliation with art, Penn sees such industries as impactful when tackling the plastic crisis. "I think art can play a really keen role in this whole movement. As important as science is, for a lot of people, facts don't mean that much if they don't pull on your heart strings and provoke an emotional response in terms of behavior change." Penn's ability to identify all the necessary and influential characters in the plot of today's climate horror film has made her a key and dynamic leader who isn't afraid to tap into different skillsets for help.

Co-founded by Penn in 2014, eXXpedition does just that. Originating as a one-off trip across the Atlantic Ocean to look at plastic and toxic pollution, eXXpedition gained enough traction as an all-female research team to continue its voyages. In 2019, the organization announced Round the World, a two-year (now three, thanks to the pandemic) expedition to examine plastic pollution in the oceans' gyres, with 300 women brought along (10 on each leg of the tour). eXXpedition's work follows three clear aims, Penn explained. The first is scientific research, which is accomplished by collecting samples from the surface water, the water column, sediment and the air to examine microplastics and identify polymer type. "All of these indicators that try and help us establish, are these microfibers from our clothes? Are they tire dust from our cars? Are they from packaging?" The second goal focuses on communication and storytelling: "It's about getting eyes on these very remote parts of our planet that so few people ever get to go to, and bringing these stories back to land, which is where we need the change to happen," Penn said. Lastly, the organization aims to build an army of women who have seen the problem first hand and are dedicated to creating positive change. Penn believes that there are hundreds of solutions to the plastic problem; we just need people working from every angle. With that in mind,

Photo: Eleanor Church Larkrise Pictures

eXXpedition crew members come from more than 50 nationalities and diverse backgrounds, each with a unique perspective and talent.

Penn sees this dynamism in problem solving as key to improving ocean health. "It's all about people and inspiring and empowering others, whoever they are and wherever they live in the world, to find their superpower—their opportunity, the thing that they can do that's going to make a real difference, and then to set about making that difference." With a united goal of helping the oceans, Penn's various projects (including eXXpedition) are people-oriented, looking beyond the expected professions of being a sailor or a scientist and instead dealing with the public. "Everyone has a unique opportunity. It's all about looking at the people in the room and asking, 'What unique opportunities do you have to make a difference—today, tomorrow, next week, next year?' and then starting to map out that path. And that's my passion," she said.

Emily Penn speaking at Our Ocean Malta.

Photo: Our Ocean

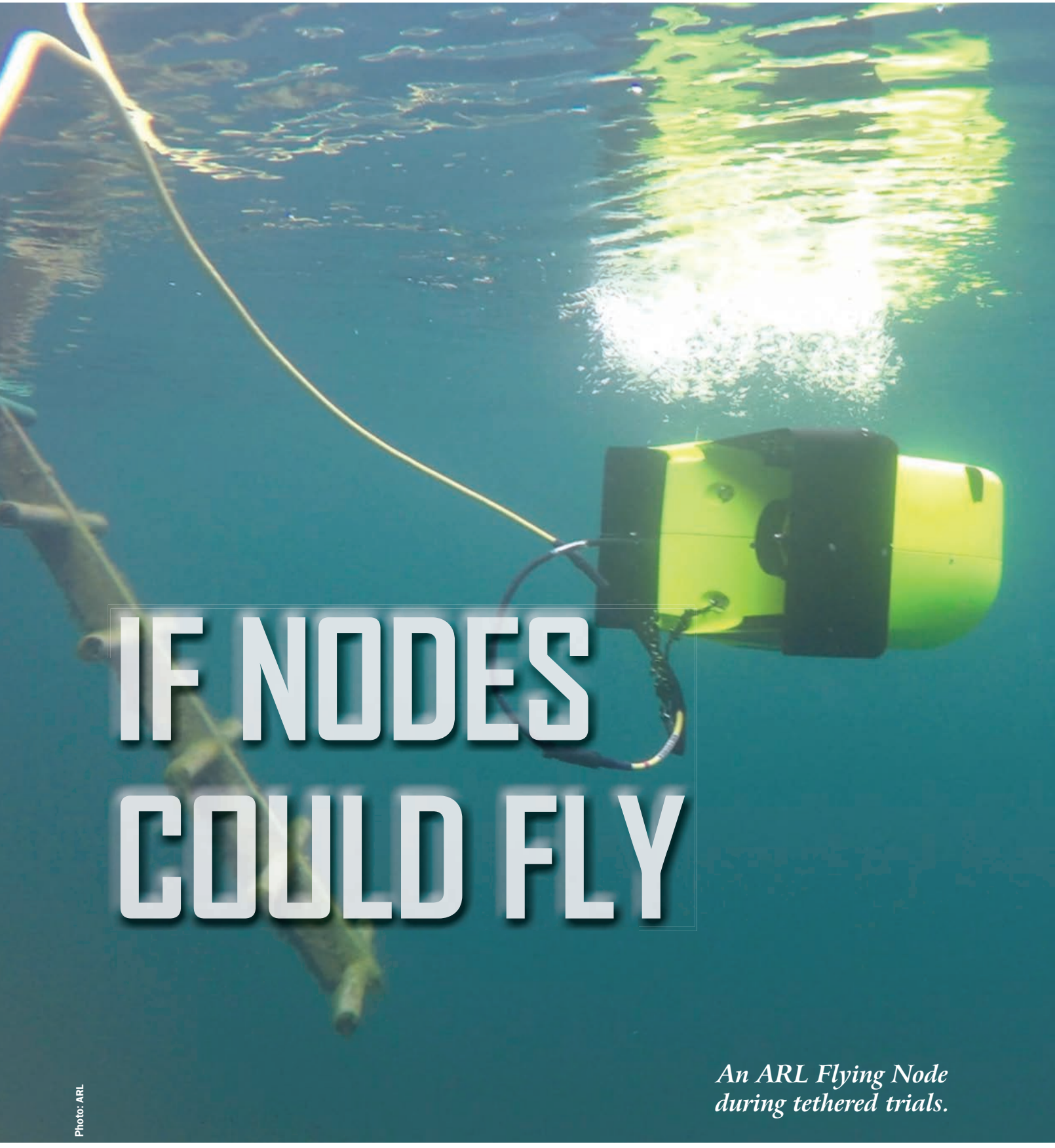
While eXXpedition does a great job of taking hundreds of women on its unique and life-changing voyages, this experience isn't an easy opportunity for everyone—although the ability to help is still as prevalent as ever. With the hope of getting back to sea next April, the team has been processing scientific samples and promoting their most recent plastic pollution resource. Launched on World Oceans Day (June 8, 2020) the SHiFT Platform employs technology to help users identify their role in reducing plastic pollution despite there being so many ways to do so. A partner project between Penn, eXXpedition and SAP, SHiFT. how helps navigate where to begin and provides specific solutions. "One of the limitations of eXXpedition, I think, is that we can only take 10 women at a time on the boat. So, the beauty of SHiFT.how is that it takes it much further," Penn explained.

The SHiFT platform exemplifies the role technology plays in science activism and outreach, especially during a pandemic. With most expeditions cancelled for safety reasons, scientific research has a large obstacle to overcome. However, Penn believes that despite the uncertainty in the last six months, planning how to live with the virus is key, since the climate crisis isn't going away: "The ocean needs it. We're still polluting—there's been a small pause in emissions, but everything else has been very much the same. So, I think we need to get back out there, to continue science and to be able to get closer to solutions." Even after the pandemic subsides, technology will be key to marine science and exploration, thanks to its ability to increase accessibility. "Certainly, projects like ours and others out there are taking exploration that was only available to professionals to now something that is a lot more accessible to everyday people. I think that's really important because we realize more and more that it's not just scientists that need to be exploring—we need storytellers and designers and solutionists to be out there as well," said Penn. On top of that, data collection, as Penn explains while referencing her work with University of Georgia's Marine Debris Tracker app, has become easier, more robust and has a lower

chance of error. In addition to technological advancement, Penn hopes for a larger emphasis on solutions-based science. "I think more and more we need to be asking the question of 'What do we need to find out to solve the problem?' And that's really important—what's the outcome of the science? How's it going to change the world?"

With a lifelong connection to the ocean and a unique view on the plastic pollution problem, Penn has opened new doors in scientific advocacy and activism throughout her career. Equipped with passion, curiosity and resourcefulness, her work demonstrates that no problem is too big for a dedicated crew of heroes. All you need to do is find your superpower.

Photo: Nomad Nmeumonics



IF NODES COULD FLY

An ARL Flying Node during tethered trials.

Photo: ARL

Much has been done in recent years to increase efficiency in the offshore seismic sector, from increasing survey speed, by allowing remotely operated vehicles (ROVs) to carry more nodes, reducing trips to the surface, as well as through automated so-called node on a rope deployment. Making flying nodes is the focus of ARL, reports **Elaine Maslin**.

Autonomous Robotics Ltd. (ARL), a subsidiary of Thalassa Holdings, has been working on what it calls Flying Nodes. These would remove the need for a deployment platform to lay the nodes on the seabed, i.e. the ROV and its ancillary support or rope deployment systems. Flying Nodes will speed up deployment while retaining high positioning accuracy using Ultra-Short BaseLine (USBL) systems and enable more flexible survey geometries compared with cable-based deployment. To put the challenge in context, a single marine seismic survey can involve thousands of nodes being placed on the seabed, complete with hydrophone and geophones to pick up the signals echoed out of the ground from the seismic source vessels.

ARL has been working on its Flying Nodes since 2013, when it bought tech firm GoScience. Today, its design comprises of 600mm-long, 580mm-wide and 300mm-high, winged nodes, like a small autonomous underwater vehicle (AUVs), each housing three geophones and a hydrophone. The idea is that the system can be containerised for deployment from vessels of opportunity. Groups of nodes would be deployed in large numbers via cages that are lowered from the vessel to about 30m deep - in up to sea state 5 and 3 knot surface current. They swim out of the cage and, using variable buoyancy and mass distribution, supported by three thrusters (forward/aft and vertical) and a USBL positioning system, travel to pre-programmed positions on the seabed.

It's not all seismic

ARL currently has two system configuration concepts; a compact system of up to 500 nodes and a full system of up to 3,000 nodes.

The full system, for reservoir and exploration OBS application, would comprise of dual 72-node deployment and recovery (D&R) systems, similar to ROV garages, but containing dual carousel storage slots to sort and house the nodes, and allowing for the use of standard ROV launch and recovery systems. For the full system, two USBL systems would be used, one from the primary node deployment vessel the other on an unmanned surface vehicle (USV) to aid positioning.

Up to 1,200 nodes a day could be deployed using this system compared to 50-80 using an ROV, and at half the cost of an ROV deployed ocean bottom seismic survey, the firm's chairman Dave Grant told the Seismic 2020 conference. Multiple rows of nodes would be deployed simultaneously with positioning accuracy equivalent to ROV deployed nodes and better than cable deployed systems, he says, aiding data quality and enabling repeat or 4D surveys over the same site.

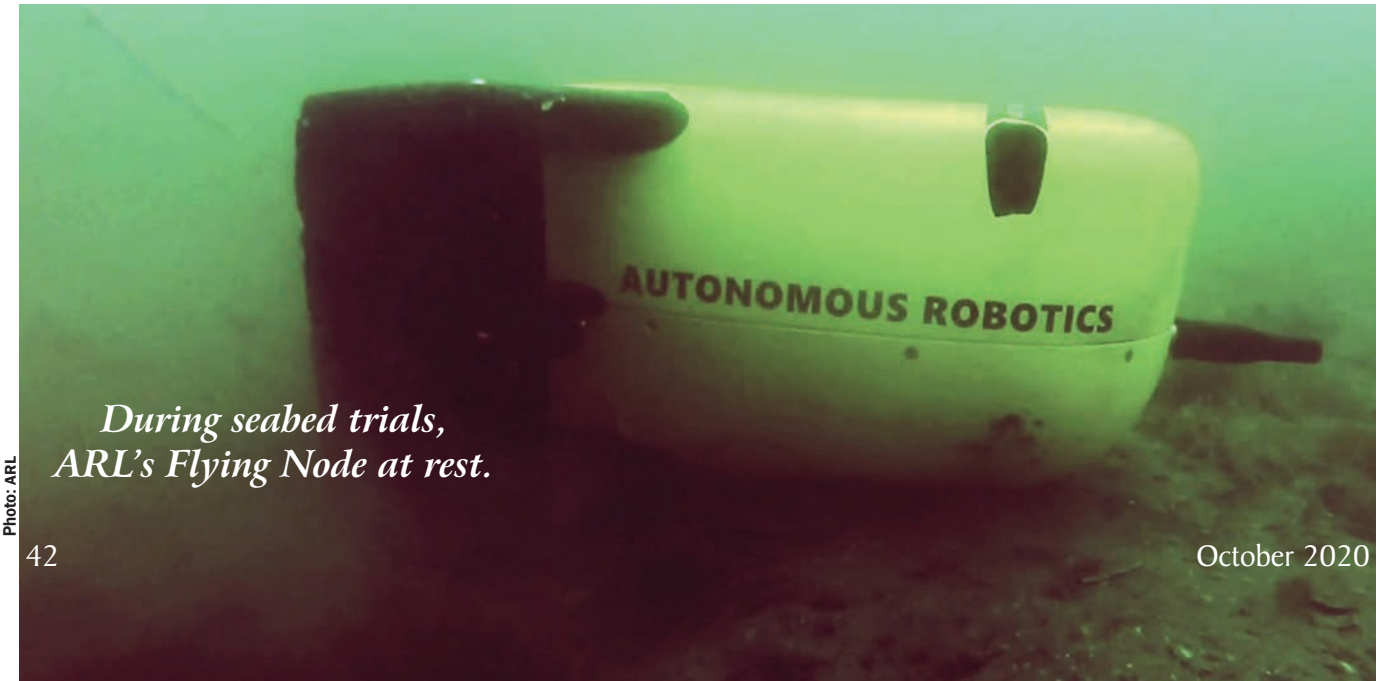
The compact system would operate using a single USBL system onboard the combined node deployment and source system vessel and could be used for towed streamer infill, injector monitoring, water quality measurements and geohazard monitoring. For this, ARL has developed a concept design for a 12 node D&R cage, which is based on passive sled towed bodies used in oceanography.

The nodes are to be equipped with batteries to allow for 60-day deployments, at 3000m depth with longer deployment possible in shallower applications, to record data when seismic source (shot) vessels sail over. Once the shoot is complete, they'd be instructed via the USBL system, to leave the sea bottom and acoustically home in on their cages, before being recovered using automated (also containerised) systems on deck, for recharging and data download.

In 2018, ARL started working with RGU on swarm localisation systems, including moving from an initial seabed position to another.

Sea trials to prove seismic acquisition

The company performed sea trials around Plymouth Sound (UK) in 2018. These were the first autonomous sea trials of the Flying Node and successfully demonstrated autonomous flight. During the trial the ability for the node to take-off and land on the seabed was also shown. "We were pleased with the results of the trial, which demonstrated that the node was controllable, performed the functions required of it and met its performance requirements for example speed and endurance," says Grant



During seabed trials, ARL's Flying Node at rest.

Photo: ARL

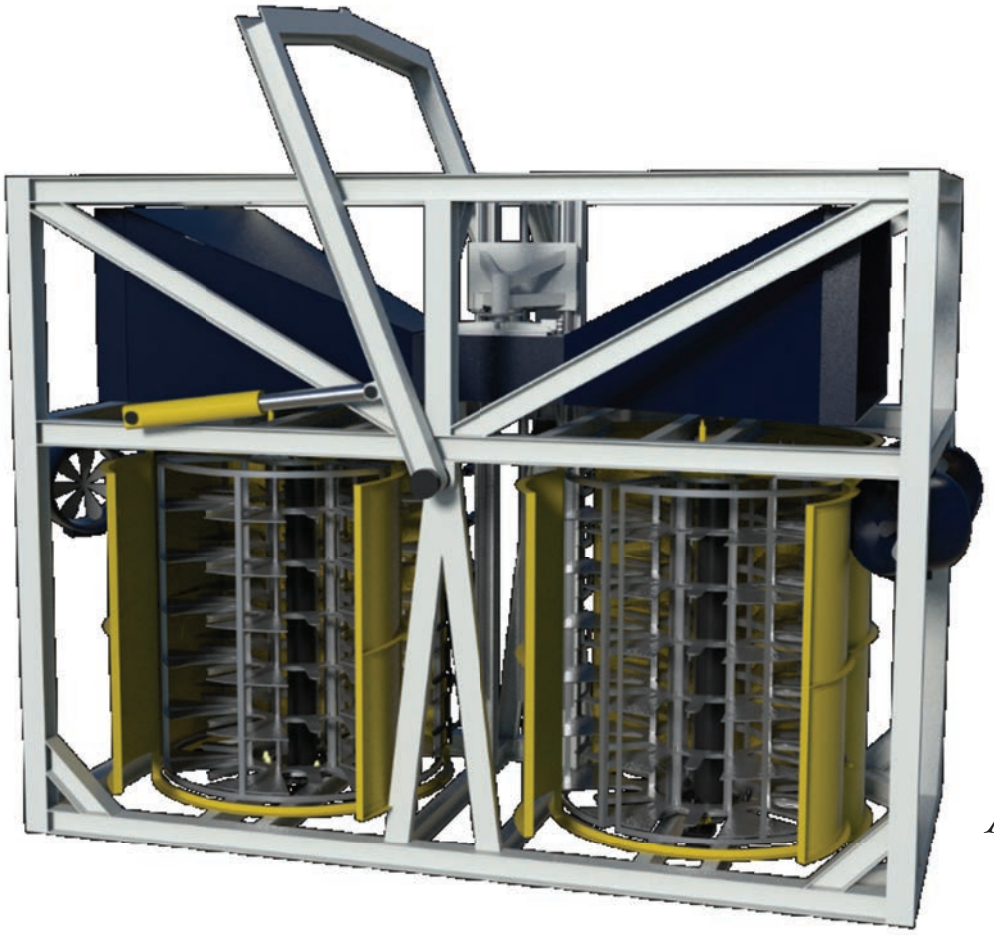


Photo: ARL

A Flying Node twin deployment cage.

In 2019, a seismic field trial successfully demonstrated the node's ability to acquire high quality OBN seismic data, says Grant. The trial took place in Portland harbour (UK), a small 60cu airgun was used to fire over 5000 shots. The data captured by the Flying Node was then compared to an industry standard OBN. Following those trials, ARL is now working on its pre-production prototype Flying Node development and is in discussion with potential strategic partners to bring the system to market in several target market areas.

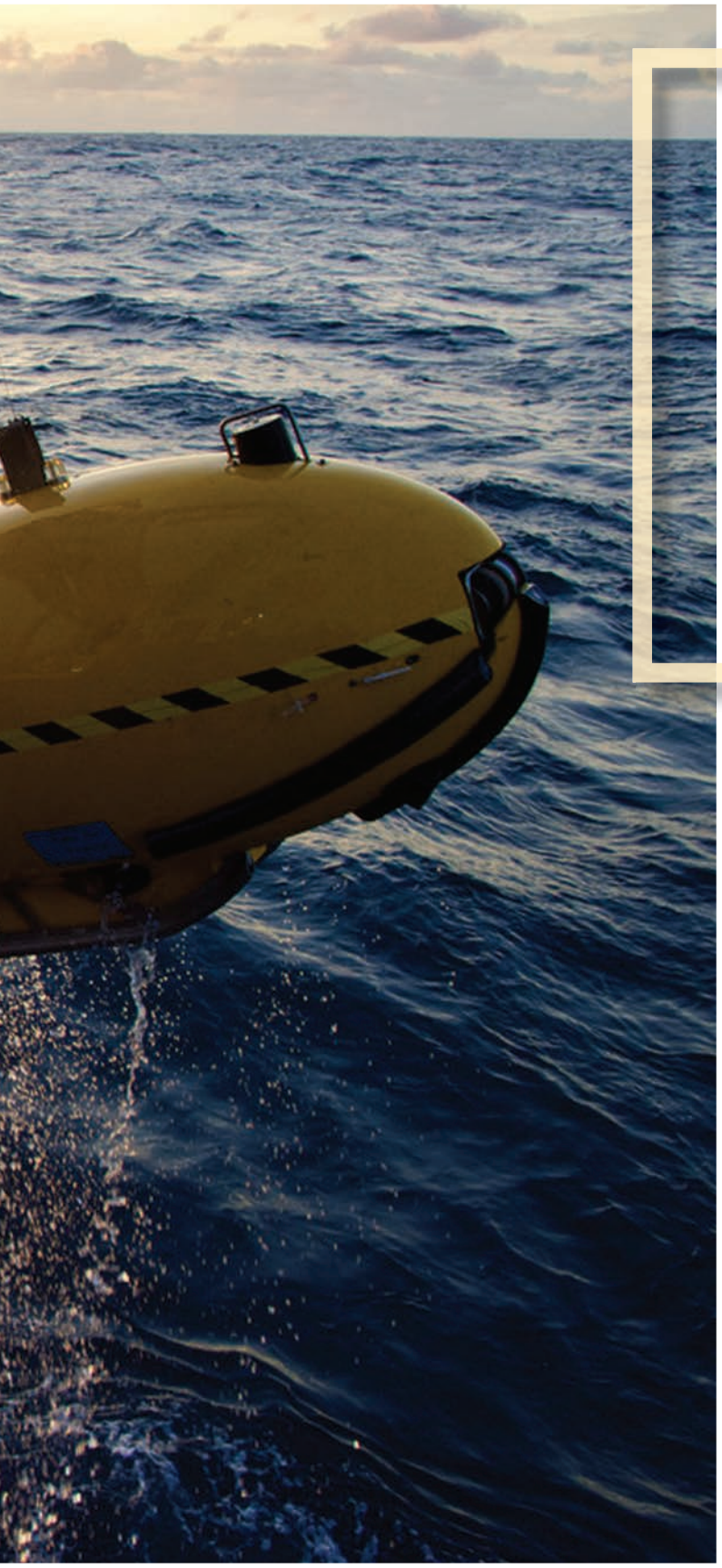
Additional markets

ARL has extended its development efforts to defence applications, "which can make use of the node's ability to carry a sensor payload to the seabed where it can remain covertly acquiring information. An example application for Flying Nodes could be the protection of critical national infrastructure, for example subsea telecommunication cables and oil and gas subsea infrastructure," says Grant.

There is also interest in using the Flying Nodes in offshore renewable energy, where seismic data is required for installation or management of systems and monitoring of storage sites for carbon capture and storage, says Grant. Other environmental applications could include seabed data monitoring and detection of vessels entering sub-sea exclusion areas.

SEABED IMAGING *re-imagined*

Photo: Sonardyne



A project to address the twin challenge of covering large areas of seabed at high resolution, while also processing the gathered data within expedition time-scales, has been delivering promising results.

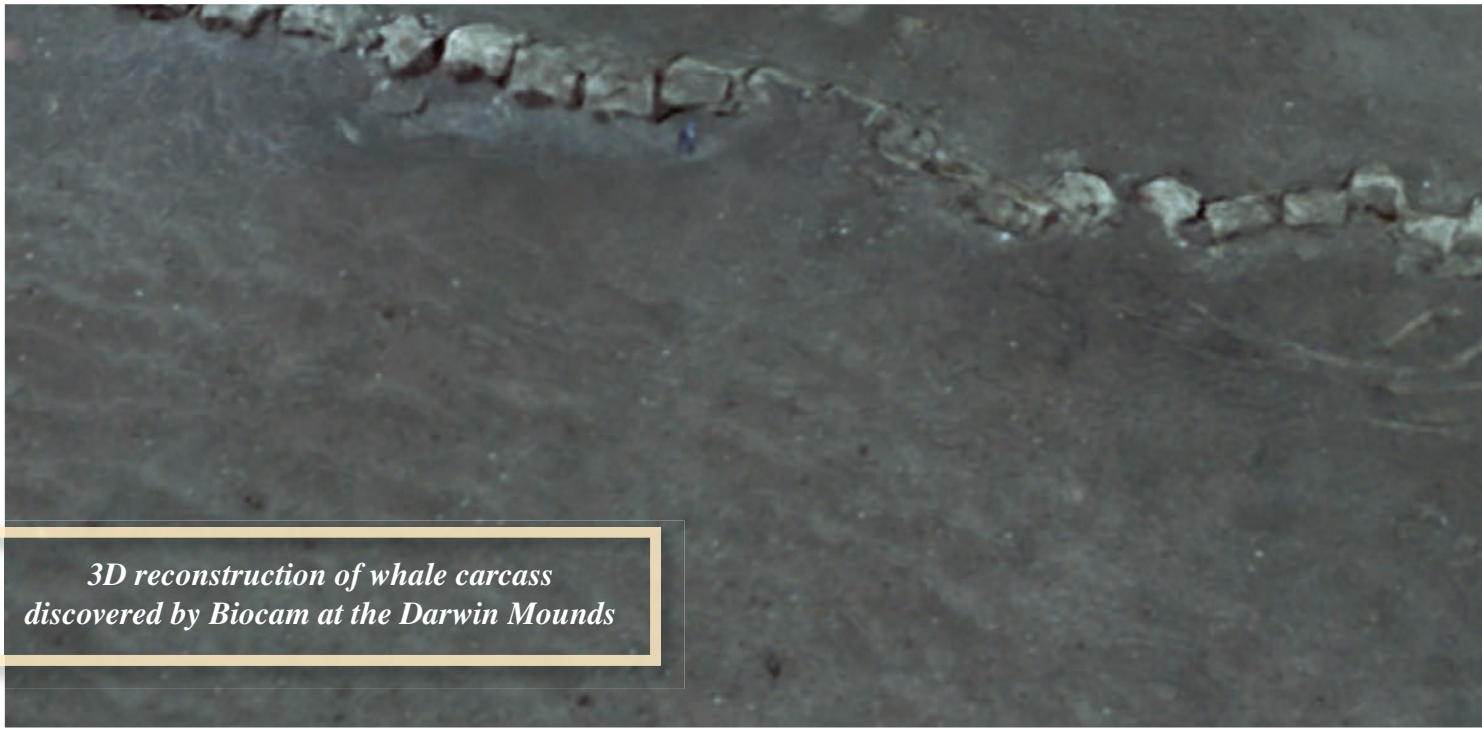
BioCam project participants Geraint West, Adrian Bodenmann, Darryl Newborough, and Blair Thornton explain

It's often said that we know more about the surface of the moon than our own ocean floor – despite half the moon being permanently hidden from our gaze. The challenges involved in imaging these two environments are uniquely different. Imaging the seafloor, in a detailed and repeatable way to allow for meaningful monitoring, poses a dual challenge: being able to cover large, often remote and deep areas quickly, at high resolution.

Existing systems tend to offer either millimetric resolution over small areas or low resolution coverage over wide areas. High resolution imaging also tends to require imaging systems to be within 1-2 m of objects of interest, inviting accidents. The end result for either method is usually extensive, lengthy post-processing on the vast amounts of gathered data.

A new, 3D deep-sea imaging system, developed by the University of Southampton, with support from Sonardyne, under the Natural Environment Research Council's OCEANIDS Marine Sensor Capital "BioCam" program, has gone a long way to resolving these challenges.

During its first 24-hour deployment, a BioCam fitted to an Autosub6000 autonomous underwater vehicle (AUV), from the UK's National Oceanography Centre (NOC), mapped more than 50 times the area of a football pitch at photographic resolution – a rate 40 times that of conventional high resolution imaging systems. By the end of this dive, it had already created the largest continuous visual map of the seafloor ever obtained in UK waters, and went on to map more during the rest of the expedition. The project has also developed a data



3D reconstruction of whale carcass discovered by Biocam at the Darwin Mounds

processing pipeline which provides expedition time-scale information that helps scientists know exactly where they should go back to get better data, during the same expedition – instead of such information emerging from the data months or even years later, when it's too late to do anything about it.

A main driver for this capability has been to help gather the information needed to efficiently monitor seabed biology and ecosystems, such as the cold-water coral found at the Darwin Mounds, a deep water Marine Protected Area (MPA) in the North Atlantic's Northern Rockall Trough, 160 km north west of the Scottish mainland. The area features ~100 m diameter and 5 m high coral covered mounds in 710-1,029 m water depth. It was first discovered by NOC scientists in 1998 and has been protected from bottom contact fishing since 2003.

Cold-water coral reefs are biological hotspots, providing rich habitats for diverse marine life. They are slow growing

BioCam system installation on NOC Autosub6000

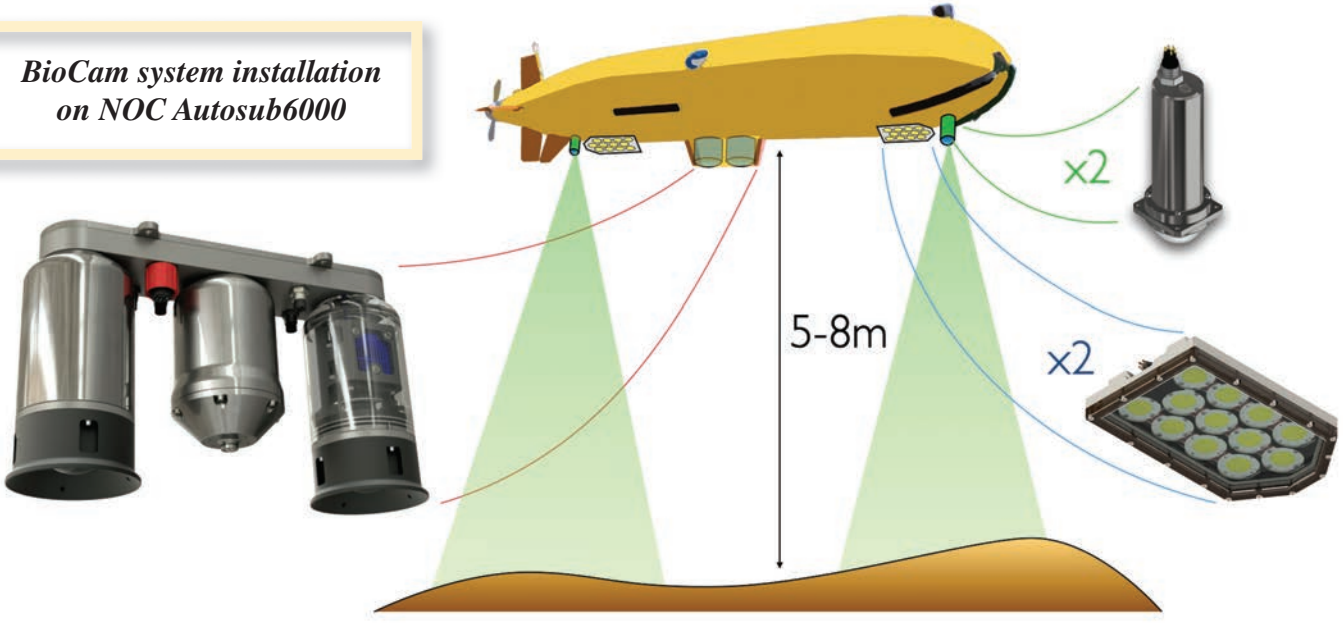


Photo: Sonardyne

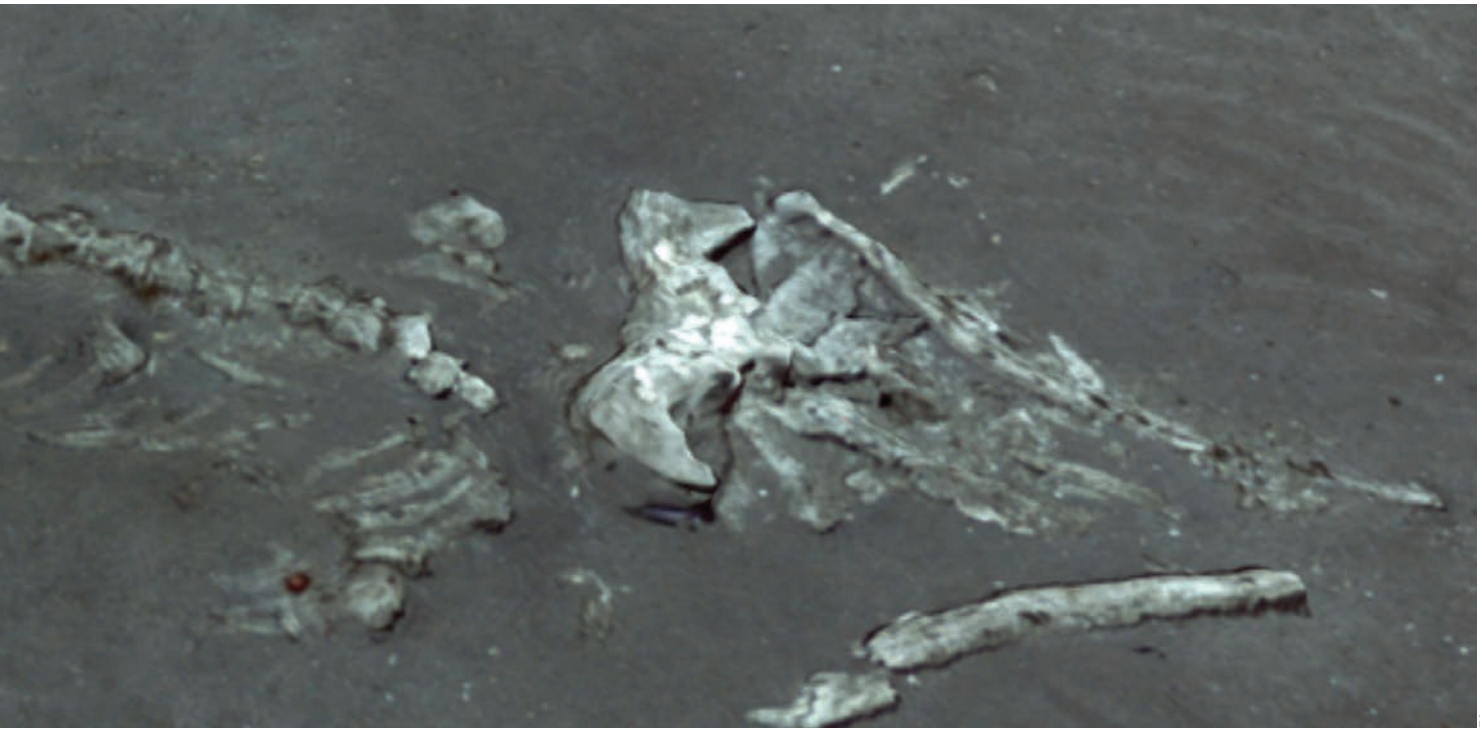


Photo: Sonardyne

(mm or cm/year), fragile and extremely sensitive to environmental changes and human activities such as trawling. Any damage can be irreversible, making monitoring critical. Since healthy coral can only be distinguished from dead frameworks by their colour, imaging – at a subcentimetre-level and in colour – is critical, which means underwater cameras are a must. But because these reefs are sparsely distributed over city-sized areas, monitoring can be time-consuming and costly.

BioCam hopes to address this type of challenge. The project, launched in 2017, builds on the earlier SeaXerocks system and leverages advances in lighting and higher resolution detector technology to enable 3D imaging capable of mapping the seafloor at millimetric-scale, from up to 10 m altitudes. This enables increased area coverage and safer altitude operation from significantly faster-moving AUVs, potentially enabling data gathering at significantly faster rates than existing technologies. The BioCam design has been underpinned by electro-mechanical design, testing and manufacturing support from Sonardyne, with a key focus on ensuring the system was smaller, lighter and less power hungry so that it could be used on long-endurance AUVs.

At its core is a pair of high-dynamic range scientific CMOS (complementary metal–oxide–semiconductor) cameras, each with 2,560 x 2,160 pixel resolution – double that of SeaXerocks. These are mounted in a 4000 m-rated titanium housing, optimised for AUV mounting, that also includes low-power electronics to control the lasers, strobe illumination, communication, data acquisition and processing.

Like SeaXerocks, BioCam uses laser lines, but has two lasers, which are pulsed in synchronisation with the camera.

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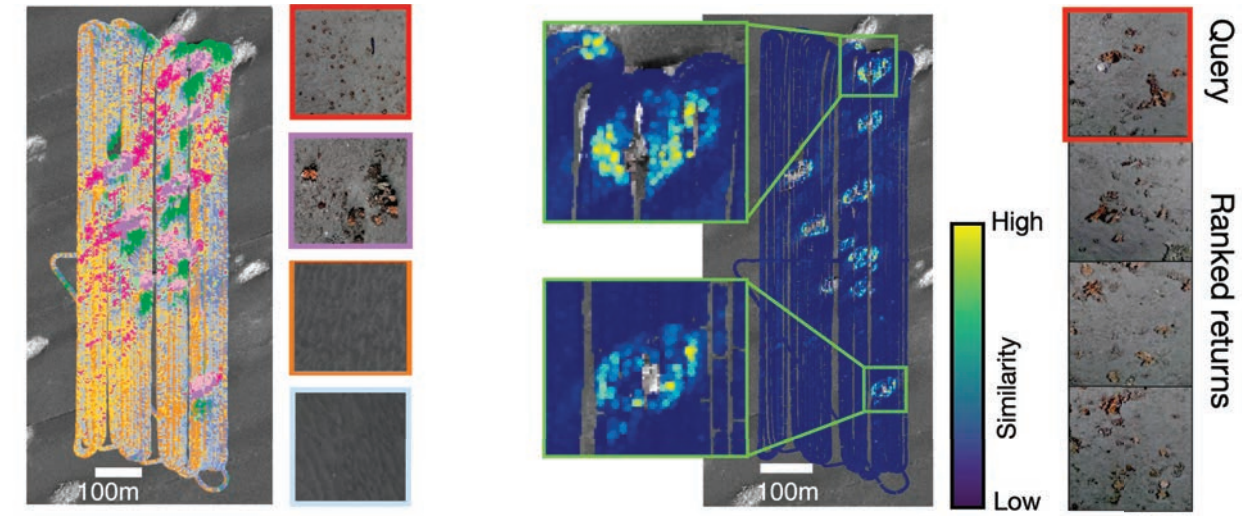


These were installed on the NOC's Autosub6000 to provide an ~8 m swath able to cover several hectares per hour at ~3 mm resolution, enabling large, high resolution 3D texture maps to be created by combining strobe illuminated images and laser line measurements.

BUILDING EXPLORABLE 3D RECONSTRUCTIONS

If anything, this results in even more data being generated. So, a further focus of the project has been automating the creation of large explorable 3D reconstructions and data processing – within a comparable timeframe to the data acquisition.

The process to mesh the strobed and laser images with vehicle navigation data has been largely automated, using the relative position between the camera poses and the bathymetry, to generate depth maps corresponding to each strobe illuminated image frame (having already calibrated the stereo camera after assembly, before an expedition). The images are then colour corrected, using the depth maps and images, and then reprojected on to the bathymetry mesh, creating explorable 3D visual reconstructions.

To rapidly summarise what has been observed, the data processing pipeline uses self-calibrating machine learning algorithms that automatically group similar looking patches of the seafloor, and generates maps showing the patterns they form. To make this easy to understand, the images that are most representative of each group are tagged to the maps, and a user can use any image as a query, to generate maps of seafloor regions that look similar to the query image. Furthermore, the global community of experts are able to participate in this process through online labelling platforms and use of standard formats.

BioCam was put to the test onboard the NOC's Autosub6000 during a cruise over the Darwin Mounds. Tens of thousands of stereo pair images were taken with an average coverage rate of ~16,000 m2/h (not including the overlaps needed to build a continuous mosaiced map of the seafloor) – an order of magnitude higher than conventional millimetre resolution imaging surveys. During one of the dives a whale carcass was found in 956 m water depth. The 3D reconstruction enabled it to be measured, at 7.51-m long and 1.03 m wide at its skull.

Unsupervised clustering of images from one of the dives automatically organised seabed features by colour: pink and purple representing coral; blue, light blue, orange, green and beige representing rippled sand; and lime green and red representing xenophyophores (a large, single cell organism). This data could then be queried. For example, a selected image of coral could be used to identify similar images. The results of such a query showed that the corals were most densely distributed in rings around the base of the mounds; a crown rather than a cap. A separate query of an image showing xenophyophores – a recognised Vulnerable Marine Ecosystem indicator species – showed strong correlation in the tails of the mounds.

One of the goals for the BioCam project was to enable the data it gathers to be easily disseminated to the broader scientific community during an ongoing expedition. A web-based open-access annotation platform Squidle+ was used, with the data still available under campaign dy108-109_nerc_oceanids_class.

OUTLOOK

The Darwin Mounds survey showed the ability to survey a large area quickly, but also to quantify the distribution of species over that area – in an equivalent timescale. Potential uses for this capability are already emerging, such as surveying seafloor ecology around decommissioned sites in the North Sea or surveying areas for natural gas or CO2 leaks. What's more, this could be done without the need for a crewed research vessel on hand, with shore based launch and recovery. The next steps for BioCam include the possibility of real-time, in situ image processing and remote awareness of this processed information.

The Journey to Helping AUVs Think:

How marine roboticists are turning AUV sight into perception

In 2018, marine robotics scientist Arjuna Balasuriya was at the Advanced Naval Technology Exercise (ANTX) in Newport, Rhode Island, testing new software for an autonomous underwater vehicle (AUV). In the past, his AUV research had meant long ocean cruises in rough choppy waters, but for the moment, he was analyzing his algorithms from a comfortable dry seat on land.

Balasuriya and his team from Charles River Analytics were developing an app for Teledyne Gavia AUVs, which could navigate on their own in the oceans to take sonar surveys of the seafloor. But to be truly autonomous, they needed to automatically detect and recognize objects of interest—anything from mines to airplane black boxes to pipelines—so they could do things like decide to reroute for a closer inspection.

Balasuriya recognized that this was a sub-problem from the classic domain of machine learning and computer vision, where Charles River Analytics possessed deep expertise from work on numerous U.S. military and government contracts. When Teledyne expressed interest in finding solutions to this problem back in 2015, Balasuriya thought to himself: why not us?

Now, Charles River is releasing a commercial software product, AutoTRap Onboard, that integrates into Teledyne's Gavia line of AUVs to enable real-time detection and recognition of objects of interest to marine engineers and scientists. The Charles River team first tested and qualified the AutoTRap Onboard system on a Teledyne Gavia in the North Sea off Belgium in 2018.

"The sea state can be really choppy," Balasuriya said, recalling his cruises on the North Sea. "You have to tie your laptop down onto a pole or some structure, and you have to tie yourself down or you will be rolled and thrown out."

Gavia AUVs look like yellow submarines a few meters in length and 50 to 130 kilograms in weight. They can perform ocean surveys with advanced equipment like long-range side scan sonar, useful for commercial, defense and scientific purposes.

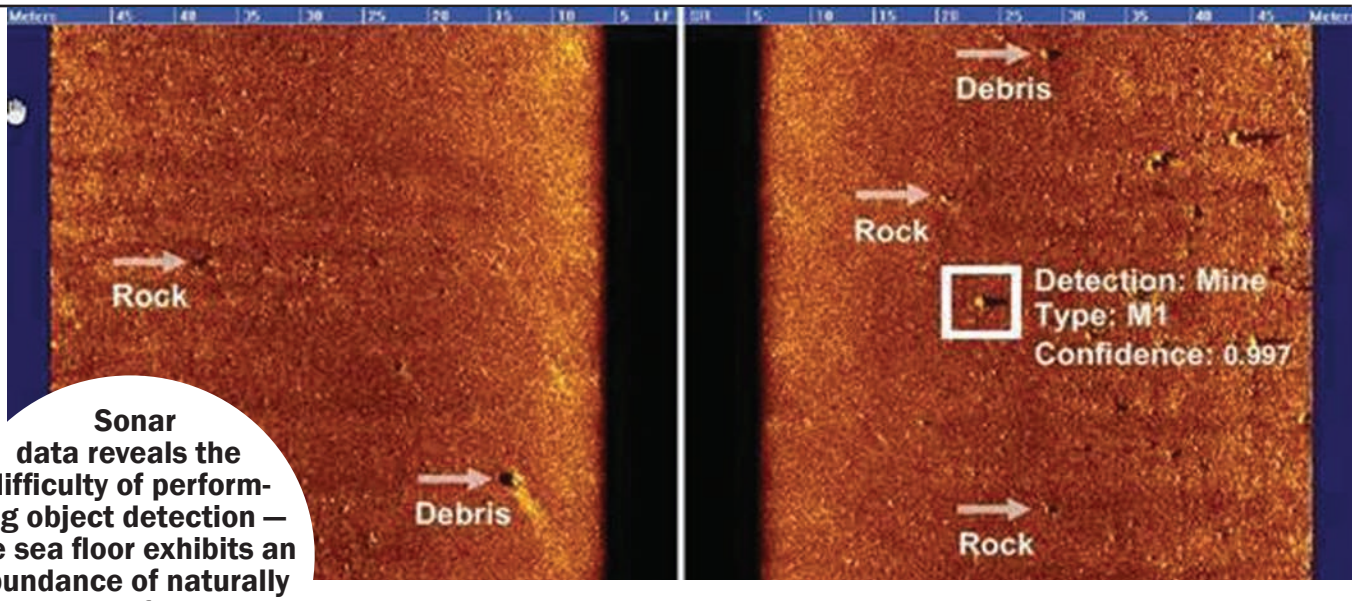
When mounted to the belly of a Gavia vehicle, the sonar creates an image roughly 100 meters wide of the seafloor below. Images from different passes by the vehicle can be stitched together to provide a comprehensive picture or survey of the seafloor.

Before the advent of software like AutoTRap Onboard, human analysts had to painstakingly inspect survey data to find objects of interest. Now, object detection and recognition can be done automatically.

However, due to computational demands, many object detection solutions are designed to be run only after an AUV has returned to the surface and hand-delivered its data back to its operators. The AUV can effectively only play fetch. For an AUV to act on its survey data, such as by returning to an object of interest for closer inspection, its operators must perform costly and

A Teledyne Gavia prepared for testing with AutoTRap Onboard at Ashumet Pond in North Falmouth, Massachusetts.

Teledyne Gavia



Teledyne Gavia

Sonar data reveals the difficulty of performing object detection — the sea floor exhibits an abundance of naturally occurring features that look similar to man-made objects

physically demanding re-deployments.

"Launching and recovering an AUV is not a fun thing to do," Balasuriya said. "It's rocking, and you're trying to get this huge thing into the boat. It's risky."

To address this problem, AutoTRap delivers real-time performance on the embedded hardware of the Gavia. As soon as it finds an object, AutoTRap sends a message to other onboard AUV software so it can (for example) reroute for a closer pass. On an AUV equipped with an acoustic broadband transmitter, AutoTRap can help pass object detections in real-time to a mission planner on the surface.

Because of the wide range of objects of interest (mines, pipelines, shipping containers) Balasuriya and his team needed AutoTRap's object recognition capability to be versatile. To meet this need, they designed an object detection model that implements recent advances in deep learning object detection and representation. This model can be custom trained by CRA engineers to recognize an individual customer's targets of interest. Camille Monnier is the computer vision specialist who leads the development of AutoTRap's sonar data processing model.

"Sonar images are interesting and very noisy, very annoying to deal with," he said. "If you're not familiar with them, they have some interesting aspects which make them very challenging to train a classifier/detector on." Part of the difficulty of performing object detection on sonar images is the limited amount of data available to train a deep learning solution. Well-known deep learning algorithms such as the YOLO convolutional neural network require training on enormous amounts of target object data (such as cats or human faces) to be able to accurately recognize those objects in images. Optical cat images for network training are available in abundance; acoustic sonar images of target objects are not. With its unique object detection algorithms—known as automatic target recognition (ATR) algorithms in the mine hunting community—AutoTRap Onboard has demonstrated excellent detection rates and false positive rates on test targets in the North Sea and in other marine environments, like the North Atlantic off Iceland, where it has identified truncated conical objects on a rocky volcanic seafloor at depths of 10-30 meters with a 90% probability.

That is a significant landmark for Balasuriya and his team, who are leading a journey to help AUVs think and recognize what they see.

AutoTarget Recognition Option for Gavia Vehicles

Teledyne Gavia introduced Charles River Analytics' AutoTRap Onboard AI-based object detection software as a new option onboard its Gavia marine vehicles.

"AutoTRap Onboard automatically detects and identifies target objects in real time," said Dr. Arjuna Balasuriya, Senior Scientist at Charles River Analytics. "This product saves time and money— operators don't have to bring the vehicle to the surface, download its data, and then send it back down for further investigation (if necessary)."

Bob Melvin, Vice President of Engineering at Teledyne Marine Systems, said, "Our customers have been asking us for a reliable way to carry out seafloor surveys, such as mine hunting. AutoTRap Onboard makes finding these targets of interest much easier and builds higher levels of confidence in AI systems." AutoTRap Onboard includes:

- **Target Detector and Target Classifier** – Novel machine learning algorithms that process sonar images to detect, classify, and localize targets of interest.
- **Target Library** – Collection of trained targets. The Target Detector searches for these targets in the sonar image.

What's Up with the Agressive Killer Whales?

Orcas batter sailboats off Spain, Portugal, behavior baffles experts

There are many mysteries in the maritime environment. For Sailors along Spain and Portugal's Atlantic coastline, there has been a recent series of puzzling incidents involving apparently aggressive orcas.

While orcas are not known to attack humans, they can cause damage to boats. In a series of incidents along the Spanish and Portuguese coasts between Gibraltar and Galicia, groups of orcas have been recorded swimming near sailboats and other vessels, and in some cases acting together in such a way as the people on those boats thought themselves to be in grave danger.

The Spanish Maritime Search and Rescue Agency, Salvamento Maritimo, has reported multiple sailing vessels yachts have been damaged by encounters with orcas.

According to the New York Times, the Spanish Ministry of Ecology recorded 13 orca encounters since mid-August off the coast of Galicia alone.

Several sailing vessels, including Urki 1, Amadeus, and the Spanish Navy's racing boat Mirfak, had to be towed into port by Salvamento Maritime rescue vessels because of significant damage to their steering gear. On July 29, a vessel off Cape Trafalgar reported that it was surrounded by nine orcas that rammed the hull for over an hour, turning the boat around, damaging the propulsion system and disabling the rudder. The boat radioed authorities to report it was "under attack" by killer whales. On Sept. 11, a yacht was being transported from Spain to the UK and was rammed more than a dozen times by Orcas, lost steering and had to be towed into port to make repairs.

Some witness reported that the killer whales communicated with one another with extremely loud and high-pitched noises as they were battering the vessels.

In a report published by the Guardian newspaper, Victoria Morris, a biology graduate student and crewmember aboard one of the boats, said she felt like the attack was coordinated. "The noise was really scary. They were ramming the keel, there was this horrible echo, I thought they could capsize the boat. And this deafening noise as they communicated, whistling to each other. It was so loud that we had to shout."

Her four-person crew radioed the coastguard with a distress call about an "Orca Attack." The authorities were astonished. "You're saying you're under attack from orca?" the coastguard replied. When they were towed into port, they found their keel was covered in bite marks and two-thirds of the rudder was torn away. Orcas are the largest members of the dolphin family, and can grow to be 30 feet long and weight 6 tons. Like dolphins, they are intelligent and social, and can

Orcas swim behind a sailboat as it's being towed to safety after what crewmembers describe as a killer whale attack.

follow boats. Over-fishing has affected the orcas' food stocks, resulting in a decline in the population of orcas, and increased maritime traffic in the vicinity of the busy Increased sea lanes near Straits of Gibraltar have negatively impacted their habitat.

Marine biologists think this activity is confined to a single pod of killer whales, because it is highly unlikely that such unusual behavior would occur simultaneously with different pods. Scientists don't know if the orcas are angry, confused, or just being "playful." Their presence in these waters during the summer months is normal as they follow their favorite food, bluefin tuna. Humans can accidently or intentionally harass marine mammals-- it is illegal to purposefully harass marine mammals. However, experts say this apparently aggressive behavior by this group of orcas is extremely rare.

There are no known cases of humans being attacked and killed by orcas in the wild. But Spanish maritime authorities are not taking any chances. They have warned mariners to "keep a distance" from any orcas.

By Edward Lundquist

Submitted by Victoria Morris

Ocean Startup Winners Named

The first Ocean Startup Challenge awarded 14 companies with $25,000 each to help them advance their technologies. They will also receive industry support, including coaching from an Executive in Residence. The companies were among 31 shortlisted to attend online bootcamps, receive one-on-one coaching and pitch to the Ocean Startup Challenge final judging panel last week. The Ocean Startup Challenge winners include:

- **3F Waste Recovery** (Main Brook, NL) is a life sciences manufacturer focused on value adding local fisheries and natural resource waste streams into natural food, cosmetic and pharmaceutical ingredients.
- **Blue Lion Labs** (Waterloo, ON) is providing fish farmers with an early warning sign of a sea lice event by using an underwater camera system powered by artificial intelligence.
- **Glas Ocean Electric** (Halifax, NS) is building electric boat kits to convert existing and new boats to electric propulsion.
- **Grand River Robotics** (Waterloo, ON) focuses on developing highly optimized robotic inspection platforms with connected web-based data back ends. Their AUV is an underwater robotic autonomous IOT solution that will minimize loss of fish through frequent and complete imaging of fish nets to ensure the rapid repair of holes.
- **In Nature Robotics** (Hanwell, NB) designs and manufactures lightweight, low-cost, solar-powered, autonomous airboats for inland and coastal water monitoring and surveying applications.
- **Kavacha.ca** (Canoe Cove, PE) uses fish waste to provide active protection to marine industries through direct-to-metal coatings in harsh environments. Their solution saves users more than 30% on material and labor.
- **Marecomms Inc.** (Halifax, NS) designs and builds broadband wireless communication solutions for maritime environments. RObust Acoustic Modem (ROAM), has been put to numerous tests in the North Atlantic and shown to offer nearly 200 times faster connection speeds.
- **qualiTEAS** (St. John's, NL) is a corrosion inspection service company developing an AI-integrated image analysis software for near-real-time detection of corrosion and cracks on subsea assets.
- **SeaChange Biochemistry Inc.** (Clark's Harbour, NS) creates chemicals for industry from sustainably harvested seaweed through an innovative biorefinery process.
- **SeaHawk Robotics** (Vancouver, BC) develops and operates multi-domain UAV-based ocean obs systems that disrupt current paradigms by improving access, increasing safety, and reducing costs of data collection.
- **Subait Inc.** (Dartmouth, NS) takes a scientific approach to develop a superior sustainable lobster bait substitute based on seafood co-products, replacing environmentally challenging commercial bait fish species.
- **Tracker Inventory Systems** (Sydney, NS) provides aquaculture and seafood processing facilities automated inventory systems to reduce operating costs and provide production visibility.
- **Virgil Group LLC** (Washington, D.C.) is developing legal fisheries analysis software that goes beyond traceability.
- **WeavAir** (Toronto, ON) provides an end-to-end hardware and software solution for vessel emission monitoring by using predictive algorithms that promote regulation compliance and operation costs savings for ship owners, ship managers and port operation teams.

OFFSHORE WIND POWER

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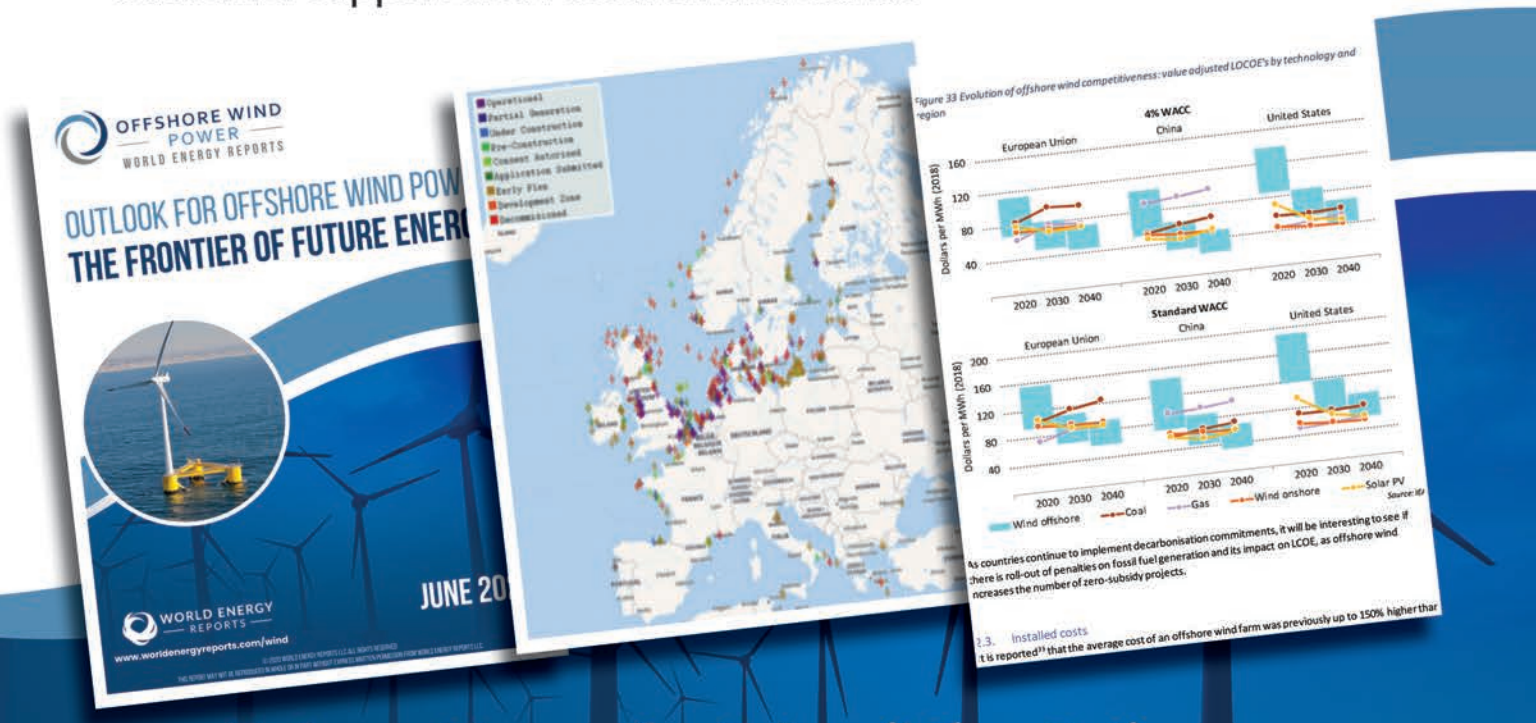

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Clean-Up Quest: 25 tons down, 513 tons to go

Following a five-week clean-up on Aldabra Atoll, one of Seychelles' UNESCO World Heritage Site, where 25 tons of marine plastic litter was removed, researchers at Oxford University have estimated that the cost to clean up the entire island is approximately $4.68 million, requiring 18,000 person-hours of labour.

This is the largest accumulation of plastic waste reported for any single island in the world.

Their projected costs and recommendations were published in *Nature Scientific Reports* and it is reportedly the first time that the financial cost for removing the waste has been calculated.

Small island developing states receive unprecedented amounts of the world's plastic waste. In March 2019, a team from the University of Oxford and Seychelles Islands Foundation, a public trust which manages Aldabra, removed 5% of litter washed up on Aldabra's shores in a five-week mission. The researchers now estimate that 513 tons remain on the island, dominated by waste from regional fishing - buoys, ropes, nets — and 360,000 individual flipflops. Removing the plastic waste equates to $10,000 per day of clean-up operations or $8,900 per tonne of litter — well beyond the capacity of non-profit organizations like the Seychelles Islands Foundation.

Lead author, DPhil student at the Department of Plant Sciences and The Queen's College, April Burt, said: "This eyewatering price-tag makes the economic burden of the unsanctioned import of plastic litter on small island states abundantly clear. The project has highlighted how even remote highly-protected island ecosystems are now being impacted by global pollution and how difficult and costly it is to remedy.

We highlight that the main sources of the pollution arriving on Aldabra are related to the fishing industry in Seychelles, which provides tuna to EU countries and other high-income markets around the world. There should be some recompense for the damage being caused."

Aldabra is an iconic site, described by Sir David Attenborough as one of the world's last remaining natural treasures. It has remained relatively pristine and is home to an array of incredible wildlife.

"The biggest surprise was that the composition by weight was dominated by waste from the fishing industry: 83% of the estimated 500 tonnes of litter remaining on Aldabra is fishing-industry related. This is extremely alarming because it shows that waste generated by the local fishing industry is polluting island ecosystems and having indirect negative impacts on the fish communities it needs to sustain," said Burt.

Largely in response to this clean-up and other similar efforts by local conservation organisations, the Seychelles Government decided to accede to the remaining MARPOL annexes in 2019; most importantly it acceded to Annex V- Prevention of Pollution by Garbage from Ships.

For the full story: bit.ly/30FV49S

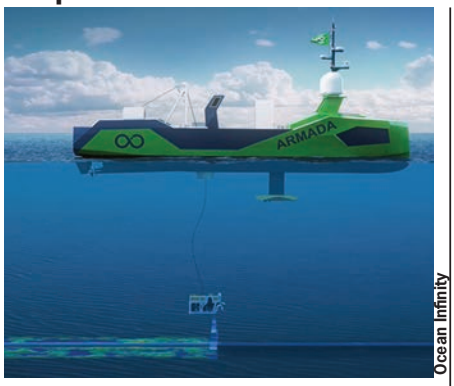
513 tons of waste are estimaged to remain on the island, dominated by regional fishing - buoys, ropes, nets - and 360,000 individual flipflops.

University of Oxford and Seychelles Islands Foundation

People & Companies

News of Note from Around the Industry

Leopards



Ocean Infinity

"CHASMAI"

NSRI

HII Breaks Ground

HII Photo

Leopards Integrated in Ocean Infinity Fleet

Ocean Infinity selected the Saab Seaeye Leopard to complement its 'Armada' fleet of unmanned surface robot vessels. The Leopard work-class underwater vehicles will be deployed from Ocean Infinity's initial 13 environmentally sustainable unmanned vessels for a variety of offshore and coastal services. "The 3000 m Seaeye Leopard was chosen not only because it is well suited to USV applications but more specifically because of its comparable capabilities to a conventional hydraulic work class vehicle, but with considerably less input power, meaning materially reduced carbon emissions," said Dan Hook, Ocean Infinity.

Ocean Infinity's Armada Fleet will be operated and monitored from onshore control centres based in Southampton UK, Austin Texas USA and a location soon to be finalised in Asia. Construction of the fleet is underway and is expected to be operational early next year.

"CHASMAI" aims to Accelerate Tech Commercialization

Strathclyde University has endorsed a methodology developed by NSRI (National Subsea Research Institute) to accelerate the commercializaton of technology in support of the green recovery. NSRI developed a way of measuring commercial viability of a technical innovation to help fast-track getting it to market. Dubbed CHASMAI, the tool is designed to provide a clear indication of the potential commercial viability of early stage technology in the subsea industry that enables both innovators and investors.

By measuring the viability of a technical concept through analysis of various factors including market conditions and funding requirements, it take a systematic approach and helps identify exactly where pioneering companies should be focusing their efforts.

NSRI believes it will be particularly attractive to investors.

HII Breaks Ground on Unmanned Systems Center

"With U.S. Navy's increasing demand for UUVs and USVs, we are committed to investing in and expanding our unmanned systems capabilities," said Andy Green, Huntington Ingalls Industries' EVP and president of Technical Solutions. "Our new Unmanned Systems Center of Excellence will ensure we can continue to provide our customers with the most advanced autonomous systems across all class sizes." With that, HII broke ground on a new Unmanned Systems Center of Excellence in Hampton, which will include two buildings totaling more than 150,000 sq. ft., constructed on the 20-acre campus and purpose-built for unmanned systems prototyping, production and testing.

The center is designed to be a state-of-the-art facility with a high-tech digital manufacturing infrastructure, an agile space, reconfigurable for different production and systems integration projects and have precision machining capabilities, a surface finishing area and a dedicated welding space.

Pictured (L to R): Robert Brown, president of Robert Brown & Associates; Hampton Mayor Donnie Tuck; Governor Ralph Northam; Andy Green, president of HII's Technical Solutions; and Commerce and Trade Secretary Brian Ball.

HII partnered with the Virginia Economic Development Partnership, the city of Hampton and the Hampton Roads Alliance to secure the project for Virginia. More than 250 jobs will be created and will enable collaboration with HII's Newport News Shipbuilding division, which has advanced undersea system engineering capabilities.

"The new campus complements our current facilities in Massachusetts, Florida and Washington that have been delivering marine robotics to the Navy for nearly 20 years," said Duane Fotheringham, president, Technical Solutions' Unmanned Systems business group. "In order to manufacture and support large and extra-large UUVs, the size of the manufacturing operation needs to increase significantly. This new facility will give us the space and infrastructure we need to scale our operations to meet the needs of our

Picolander

Scripps Institution of Oceanography

customers now and into the future."

The first 22,000-square-foot building will be completed by the end of this year. The main 135,000 square-foot-facility is planned to be completed in the fourth quarter of 2021.

Small Picolander Does Big Things for Science

"Picolanders are human size!" said Scripps Institution of Oceanography graduate student Ashley Nicoll. The small autonomous Picolander offers a robust and cost-effective way to study nearshore submarine canyons that play an important role in connecting nearshore and deep-sea ecosystems. Ashley's Picolander, built by Global Ocean Design, rated for depths of up to 1km, includes a self-recording camera, LED lights, batteries, dual countdown timer burnwire release, and a GPS tracking beacon. Picolanders are available for depths to 2 km. Read Ashley's Deep Sea Biology Society poster at **https://www.globaloceandesign.com/current-articles-and-papers.html**.

Eager Wins 2020 AZFP Contest

ASL Environmental Sciences announced Dannielle Eager as the winner of the fifth annual Acoustic Zooplankton Fish Profiler (AZFP) early career scientist award contest. Dannielle is presently studying at the University of Plymouth at Devon, UK at a postgraduate level in the school of Biological

Eager

ASL

and Marine Science. Eager's research will focus on the influence of dynamic seamount oceanography on pelagic biota in the tropical Indian Ocean, with support from the Garfield Weston Foundation, Bertarelli Foundation and the University of the Highlands and Islands. In contrast to surrounding waters, seamounts support high biodiversity and high predator–prey interactions which are driven by oceanographic processes. These energetic processes, which have recently been identified as turbulent internal waves, aggregate zooplankton over seamount summits, sustaining an abundant schooling fish community which is preyed on by sharks. While oceanographic measurements enable the identification of the prevailing oceanographic regime, the AZFP will provide the critical "missing link" whereby we could relate the incidence of internal waves to the schooling of fish and their predation through single target detections.

The awarded AZFP (38/125/200/455 kHz) will be incorporated into an intensive fine scale multi-disciplinary survey being carried out over a four-week period in March 2021 at a seamount where large aggregations of biota have previously been identified. A full complement of moored and vessel-mounted instruments such as ADCPs, thermistor strings and fisheries echosounders will be used to define the fine-scale energetic oceanographic and biological processes with coincident in situ plankton sampling and towed cameras for fish and shark validation. The ultimate aim of the project is to link the oceanographic processes to the aggregation of zooplankton, fish schooling and predatory behavior of sharks with the AZFP as it measures the high spatial and temporal resolution of acoustic backscatter throughout the water column.

Vallourec, FORSSEA Robotics and iXblue Join Forces

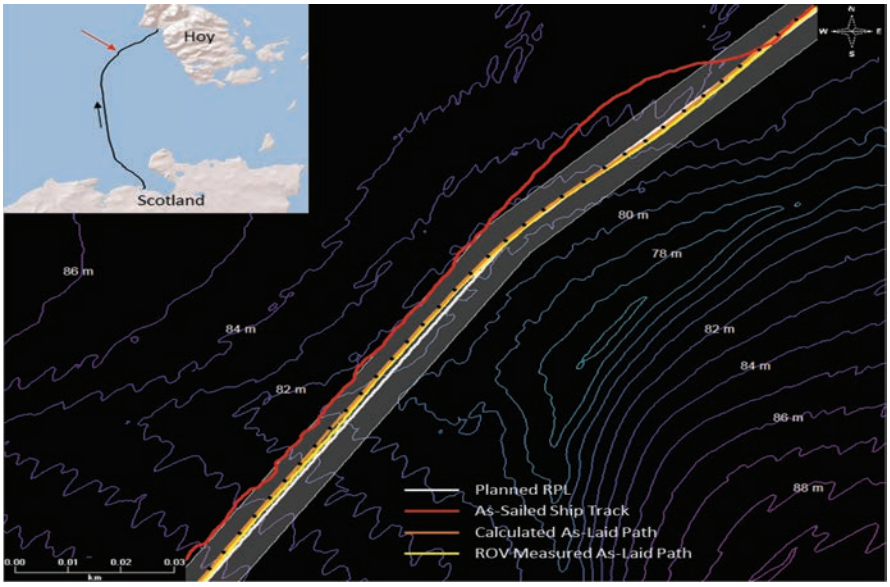
Vallourec, a leader in tubular solutions, is working with FORSSEA Robotics, a startup specializing in smart robotics and visual positioning, and iXblue, a company recognized for its expertise in inertial navigation, subsea positioning and autonomous technologies – to develop a pipeline inspection solution combining subsea drones and the use of visual markers, removing the need for surface vessels. In order to reduce pipeline inspection operational costs, Vallourec, iXblue and FORSSEA decided to develop a solution using visual markers directly integrated on subsea pipelines that enables vessel-free subsea navigation. The project relies on barcodes placed on installed pipes, resulting in many passive positioning references logged with their own coordinates during the laying operation which will remain accessible throughout the life of the field. These markers would be used as navigation aids for subsea drones equipped with FORSEEA cameras and iXblue's inertial navigation systems that easily relay the pipelines' locations to the operators thus removing the need for acoustic positioning systems and costly mother vessels. To remain visible to divers and subsea drones throughout the project's lifespan, these markers are long-term resistant to marine growth and erosion.

New Products

Innovative new products, technologies and concepts

MakaiLay Power

Used on Pentland Firth East Installation



MakaiLay Power

Cable deployment control software MakaiLay, was commissioned on the Cable Laying Vessel (CLV) Normand Clipper in July 2020 by Global Offshore. Global Marine Group is a leading provider of subsea cable installation, maintenance and burial services world-wide for both telecom and power cables through its brands Global Marine and Global Offshore.

As part of Scottish and Southern Electricity Networks' (SSEN) Pentland Firth East project, a 37 km subsea power cable was installed between the Scottish mainland and the island of Hoy, in Orkney. Global Offshore completed the installation using the Normand Clipper with support from Makai and their industry-leading subsea cable deployment software, MakaiLay. The cable was installed to a maximum depth of 90 m, with the majority of the route between 70 and 80 m water depth. The strong tidal currents in the region of the lay, were particularly challenging during this installation, with surface currents periodically exceeding 3 kts, and currents at depth exceeding 1 kt. The Pentland Firth is known to have one of the most powerful tidal currents in the world.

While Global Marine already utilizes MakaiLay software for telecom cable installations, the Pentland East installation marked their first use of the MakaiLay Power Module. The MakaiLay Power Module contains an additional suite of tools designed to address specific issues faced during power cable installations.

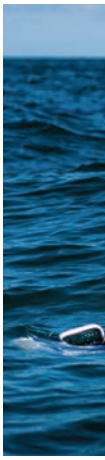
"We were impressed with the accuracy of the MakaiLay Power Module, and believe the MakaiLay software will be a key component in proactively managing the cable installation and reducing dependence on ROV monitoring" said Ian Griffiths, Subsea and Cable Operations Survey Manager at Global Marine Group.

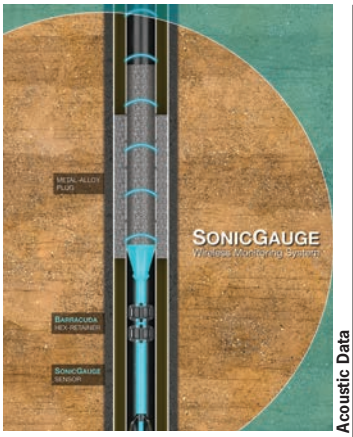
Data from a post-lay survey showed that the average deviation of the MakaiLay calculated as-laid cable path, from the post-lay ROV measured path was 0.73 m over the entire 34 km route.

MIND Tech

MIND Tech, Klein Complete ANTX

MIND Technology and its Klein Marine Systems subsidiary successfully completed a live Advanced Naval Technology Exercise (ANTX) in a collaborative effort with the Naval Surface Warfare Center Panama City Division; Commander, Naval Meteorology and Oceanography Command and in coordination with the Naval Oceanographic Office's Fleet Survey Team (FST), at NSWC PCD. Klein and a group from NSWC Panama City partnered to integrate the Klein UUV 600 and µMAX technologies into their Iver3 vehicle. In addition, Klein partnered with Seafloor Systems, Inc. to integrate the Klein MAX View 600 gap-filling side scan sonar system with their large-format, wave adaptive HydroCat-180 USV.





Acoustic Data

Retainer

Acoustic Data, eveloped a new slickline deployed high expansion retainer for cement and metal alloy plug and abandonment (P&A) applications. In the case of new-generation metal alloy plugs, the HEX-Retainer can be integrated with the company's SonicGauge Plug Verification System (PVS) for real-time long-term barrier integrity monitoring purposes.

The SonicGauge PVS uses wireless communication in the form of acoustic telemetry to transmit downhole pressure measured below the barrier to surface, or alternatively, in deep-set applications.

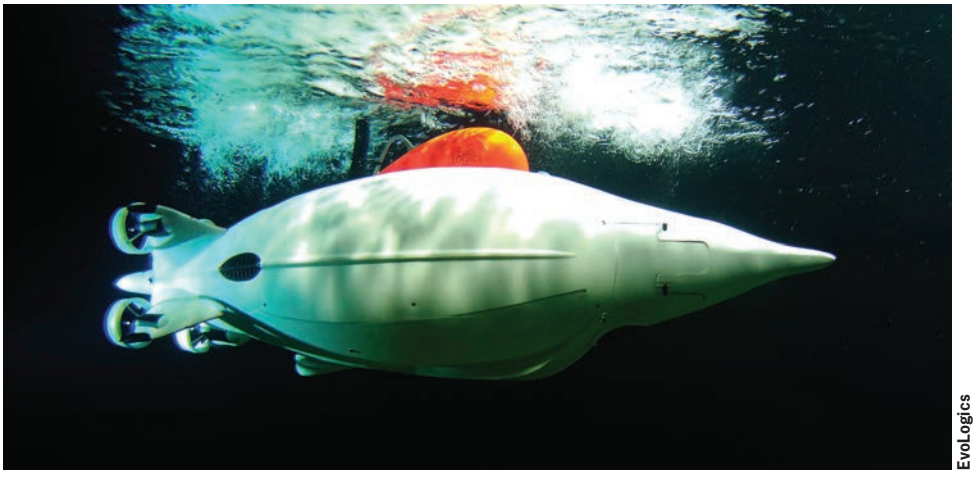
EvoLogics Debuts PingGuin AUV

EvoLogics GmbH celebrated the company's 20th anniversary with the release of the PingGuin, an AUV with low-drag bionic design. The vehicle was developed as part of the MUM collaborative R&D project. Outstanding hydrodynamic properties of a penguin's body became the starting point for the AUV design within the NaviMUM subproject, assigned to EvoLogics.

One of the EvoLogics co-founders, Dr. Rudolph Bannasch studied Adélie penguins and the effectiveness of their locomotion since the 80s, undertaking several field trips to the Antarctic and performing numerous wind tunnel and water tank experiments in Berlin. This research demonstrated that spindle-shaped flow bodies, modeled after penguins, achieve ultra-low drag coefficients in the water.

Hence, the design choices for the vehicle's components were directed at maintaining the shape and contour of an idealized penguin-like spindle to maximize the drag efficiency, so the AUV has very few protruding parts that affect its hydrodynamic performance.

The NaviMUM PingGuin is intended for use as a multifunctional communication node. It would operate in a self-coordinated AUV swarm that enables adaptable positioning and communication scenarios for the MUM system. Each vehicle carries a built-in streamlined EvoLogics USBL modem for underwater data transfers and position estimations, the modem features an integrated atomic clock for precise synchronization of the acoustic network.



EvoLogics

BAE Systems

Meet the Riptide UUV-12

BAE Systems unveiled the newest addition to its unmanned undersea vehicle (UUV) portfolio, the Riptide UUV-12. The 12-in. diameter vehicle is the company's entry into the medium UUV market – joining three small UUV variants – and marks the first new vehicle since last year's acquisition of Riptide Autonomous Solutions. "The Riptide UUV-12 system significantly extends the Riptide family of UUVs by taking us into the medium UUV market," said Jeff Smith, chief scientist at BAE Systems' FAST Labs research and development organization. "With this medium-size platform, we are strategically aligning our modular, open architecture-based UUV platform to meet rapidly expanding applications and requirements."

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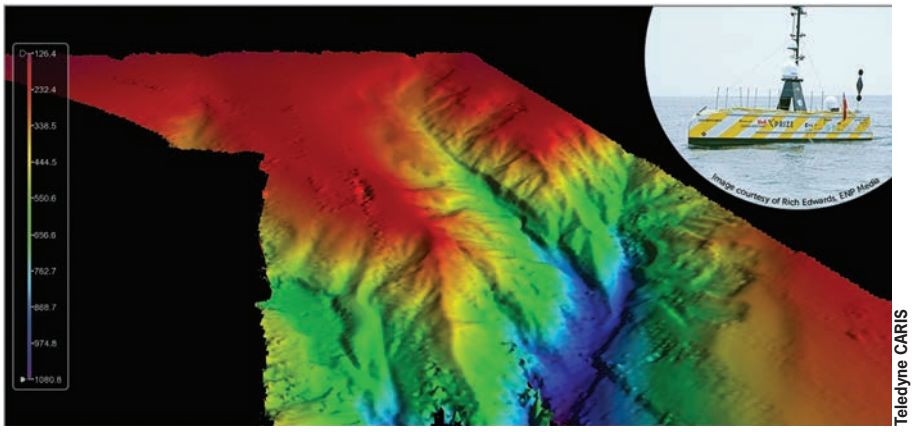
Teledyne CARIS AI Software

Teledyne CARIS, a Teledyne Technologies company, was an integral part of the team involved in the groundbreaking uncrewed offshore survey mission in the Atlantic Ocean. Teledyne CARIS' Mira AI and CARIS Onboard software were present on the vessel to enable autonomous survey and real-time processing operations. The mission's Uncrewed Surface Vehicle (USV) built by SEA-KIT mapped more than 1000 sq kms of the ocean floor in 22 days, while being continuously monitored via satellite communications at its Remote Operations Center in Essex, UK. A specialized team comprised of the GEBCO-Nippon Foundation Alumni Team operated the survey equipment and provided quality control of the data from various 'work-from-home locations' around the world.

The SEA-KIT USV surveyed a predominately unsurveyed area at the southwestern edge of the UK Continental shelf. The image displays the initial results following a fully automated processing workflow. Final processing is currently being completed using CARIS HIPS software to produce the final deliverable for the survey.

The success of the Teledyne CARIS tools in the UTAS project demonstrates its software capabilities to support uncrewed surveys in the future and the crucial role it will play in The Nippon Foundation-GEBCO Seabed 2030 project, an ambitious effort between GEBCO and The Nippon Foundation to complete the global mapping of the ocean floors in the next 10 years.



Teledyne CARIS

SRO Solutions

SRO Solutions is working on a project to replace British Antarctic Survey's (BAS) current asset management system, and help improve the processing and sharing of data between the organization's UK headquarters and polar research stations. The Manchester UK-based technology firm was tasked with migrating all of BAS' existing data from its current AMOS asset management system to IBM's Maximo platform. In addition, SRO has created a number of bespoke applications to handle data covering cargo and freight movements, internal documents, and crew and course planning.

BAS delivers and enables interdisciplinary scientific research in Antarctica, and each season sends around 300-plus research and support staff to the continent. It operates three research stations in the Antarctic and two on Subantarctic South Georgia, and one in the Arctic on behalf of NERC. Other assets include the RRS James Clark Ross, a fleet of aircraft and specialist vehicles, plus the eagerly awaited new polar ship for Great Britain, RRS Sir David Attenborough.

Valeport Launches Next-Gen Sensors

Valeport launched two new sensors for ROVs/AUVs and subsea survey.

The new miniIPS2 (pictured) and new uvSVX, which both offer operationally specific interchangeable pressure transducers that deliver enhanced accuracy for specific depth ranges.

The smart miniIPS2 underwater pressure sensor with accuracy to 0.01%. The miniIPS2 is compatible with Valeport's MIDAS BathyPack and BathyLog software, allowing the depth data to be continually updated for Density variations in the water column.

The compact uvSVX features Valeport's Time of Flight technology and delivers salinity, conductivity and density data, along with SVP as standard. High accuracy data is assured with the addition of Valeport's unique interchangeable pressure module that allows users to maximise operational specific depth requirements. This advanced pressure module, with integral calibration, is quickly and easily changed whilst in the field, with no tools required and without opening the instrument. Delivering 0.01% accuracy, the interchangeable pressure transducer is available in 10, 20,30, 50, 100, 200, 300, 400 and 600bar variants.

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