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## THE FUTURE OF OCEAN TECHNOLOGY

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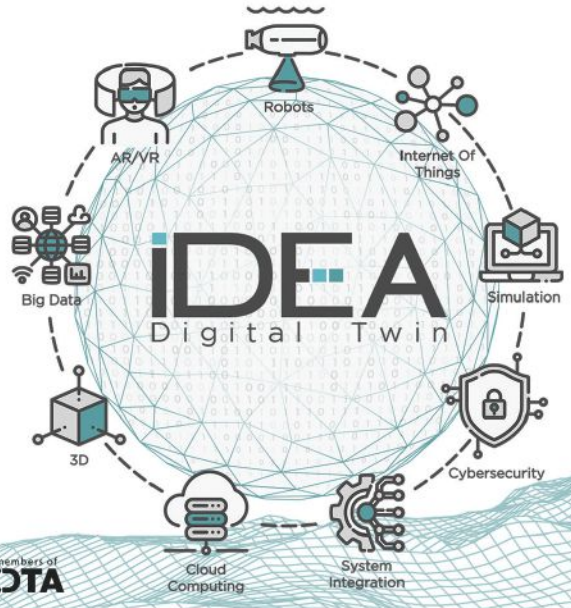


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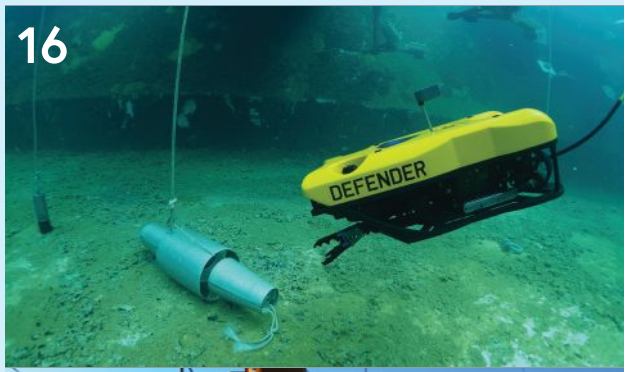


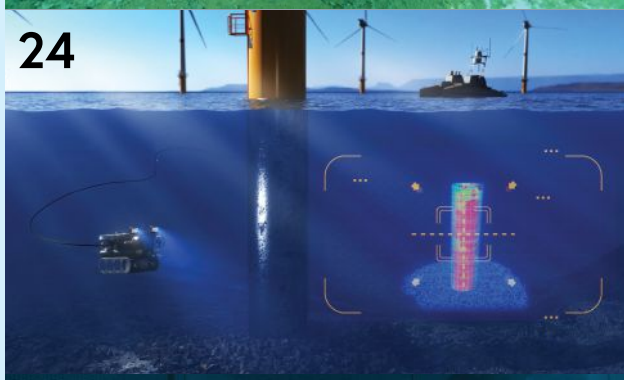




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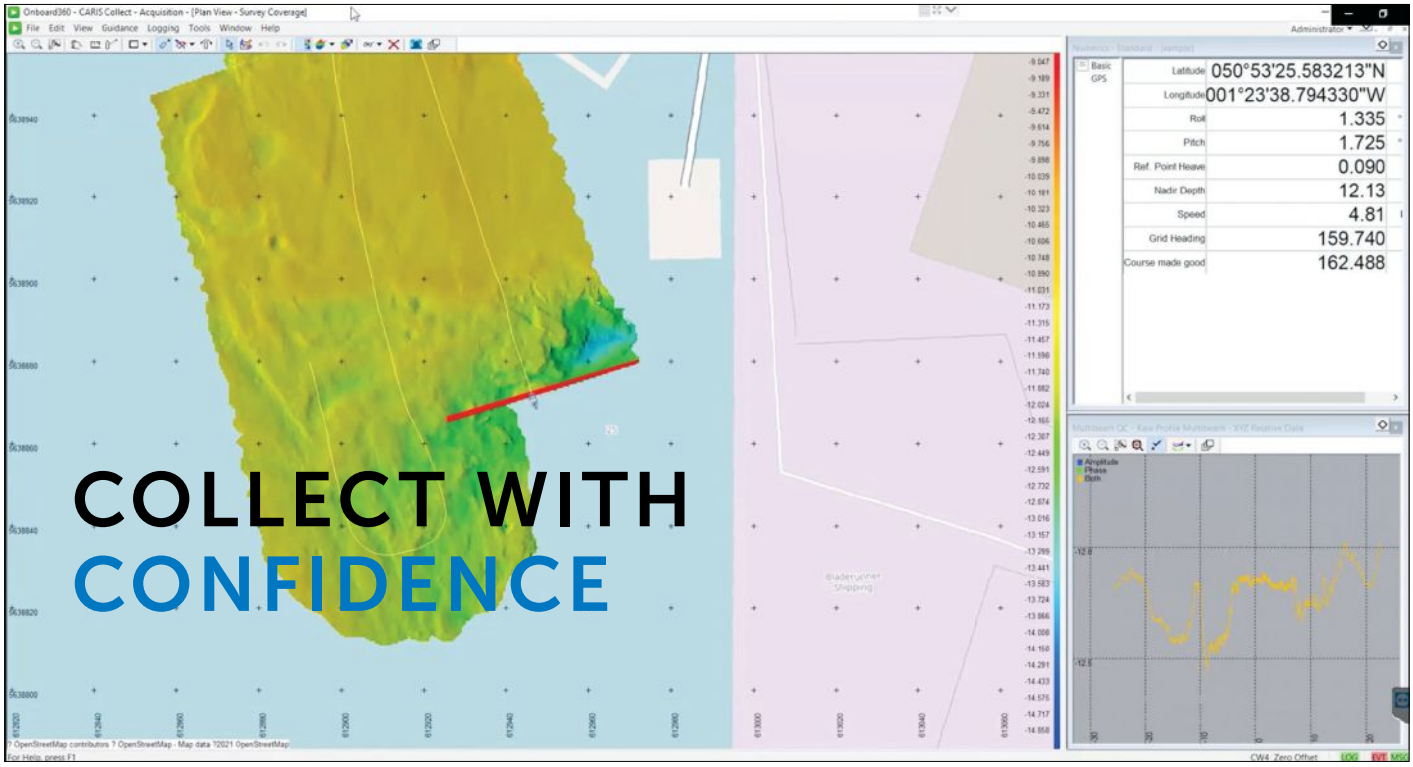


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# THE FUTURE OF **OCEAN TECH: CLIMATE CHANGE CONTENDER**

**By Ed Freeman**,
*Managing Editor, ON&T*

2050 is a landmark year for assessing the overall health of the planet, by when many nations have already pledged to have successfully eliminated their known contributions to climate change.

Notwithstanding the various discrepancies that frame such ambitions—net zero vs. climate-neutral vs. net-zero emissions, etc.—the international consensus, and general fallout from November's COP27, is that failure to immediately strengthen current climate mitigation plans will significantly jeopardize any realistic long-term targets.

The role and impact of the world's oceans in this bleak outlook is, unsurprisingly, of headline concern. They play an indispensable role in sustaining life on earth, both as a producer of oxygen (over 50% of our collective quota) and protein (as a source of seafood and beyond) and as a critical regulator of stabilizing atmospheric patterns. Any human footprint that puts these precious ecosystem benefits at risk, therefore, warrants thorough scrutiny.

However, ocean technology offers a reason to resist the tide of pessimism.

## OPPORTUNITY FOR OPTIMISM

As history attests, in the face of uncertainty, opportunity knocks—especially for the ocean technologist. Here and now, as we contemplate the 27-year countdown to our 2050 reckoning, it is reassuring to reflect on how innovation and enterprise have accelerated our collective understanding and the responsible exploration of the "blue planet" over the last three decades.

Consider, for example, the tech-led diversification of the offshore energy sector and the rapid scaling of offshore wind in Europe (the first offshore wind turbine dating back to 1991, just 32 years ago, in Denmark). As a result, we now see unprecedented investment in offshore renewables around the globe, which includes the integration of alternative sources, such as wave, solar and tidal power.

Or perhaps the advances made in modern marine survey techniques, both in shallow and deeper waters, supported by a growing array of specialized data acquisition and processing technologies, with multi-beam sonar systems and other underwater visualization tools shining a light on underwater environments like never before.

Then there's the present-day acceptance and adoption of AI-fused systems for remote operations, from uncrewed vehicles, above and below the waterline, to digital twins; the operational synergy of smarter hardware and software signals the start of a major paradigm shift for at-sea operating procedures, effectively rewriting the offshore playbook in the interests of improved HSSE standards and carbon-free efficiencies.

## BUILDING A GLOBAL BLUE ECONOMY

With past as prologue, ocean technology's capacity to transform ways of working should abate alarm. But there is still much we cannot yet know. With just 25% of the seabed mapped to date—and sector-wide ambitions to bring that coverage to 100% by 2030—we must continue to "fill the gaps." In doing so, we must also apply data-backed findings to introduce novel and increasingly "climate conscious" ways to study the oceans and, at the same time, cultivate, and sustain the global blue economy.

With the likely—and much needed—expansion of subsea infrastructure (cables, pipelines, seabed construction) and the realization of emerging industries like marine mining and other socioeconomic opportunities within aquaculture and bioprospecting, continued investment in ocean technology will be instrumental, but only if underlined by commercial collaboration and transparent regulation.

This demands cooperation on a new level; the legacy of a prosperous 2050 blue economy will not only be founded on the right technical tools for the job at hand but on stakeholders' readiness to adapt to unfolding circumstances. The most stable currency in times of change is validated data, and as we acquire and process ever larger ocean data sets, this enables ocean industry leaders to establish thought leadership and meaningful change within the confines of a ratified agenda.

In these pages, you will sample such thought leadership. **Happy reading!** *editor@oceannews.com*


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# THE FUTURE OF **HIGH-RESOLUTION** SEABED AND SUB-SEABED IMAGING

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# THE FUTURE OF **SMART ROBOTICS & DATA NETWORKS FOR ADVANCING THE OCEAN INDUSTRIES**

**By Maria Pleskach**,
*Lead Technical Writer, EvoLogics*

**and Peter W. Urbansky**,
*Technical Assistant, EvoLogics*

The speed of innovation is faster than ever, and marine industries are no exception to the global trends. In fact, they may even be among the fastest-evolving tech sectors on the planet. New digital technology drives new quality and quantity for data collection and analytics, the internet of things, machine learning and artificial intelligence, and advanced autonomous robotics. In order to stay competitive, companies in the ocean industry heavily invest in research and development in order to bring new solutions to the market.

At EvoLogics, collaborating with national and international R&D projects has been an integral part of the company's DNA since its very beginning over 20 years ago. Some technologies matured to reach the market, while other developments became a foundation for the work that is still ongoing.

With product ranges covering technology for underwater communication, positioning and networking, and smart robots for surveying and monitoring, we develop the frontier of application scenarios with customers and partners from industry and science.

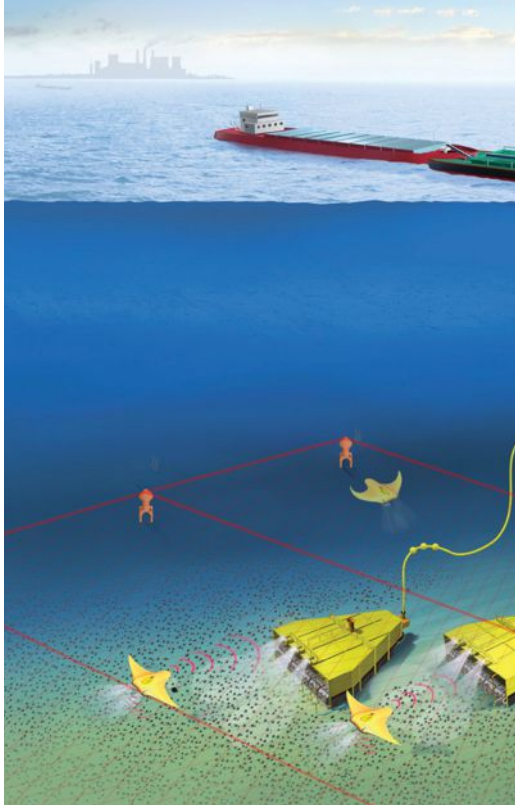
Where do we observe a growing demand? Definitely in environmental monitoring, where tools for observation and data analysis help understand the impact of industrial activity. They go hand in hand with climate research to investigate global processes and climate change. Other rising demands are offshore wind power and other alternative energy sources, offshore oil and gas production, as well as a resurgence of interest in deep-sea mining. There is also a growing need for security solutions that monitor, detect, and alert about surface and underwater traffic at harbors and critical maritime infrastructure.

Building around—and driven by—an ongoing expansion of functionality and overall effectiveness of subsea equipment, we observe a range of general industry trends.

## SCALING TECHNOLOGIES

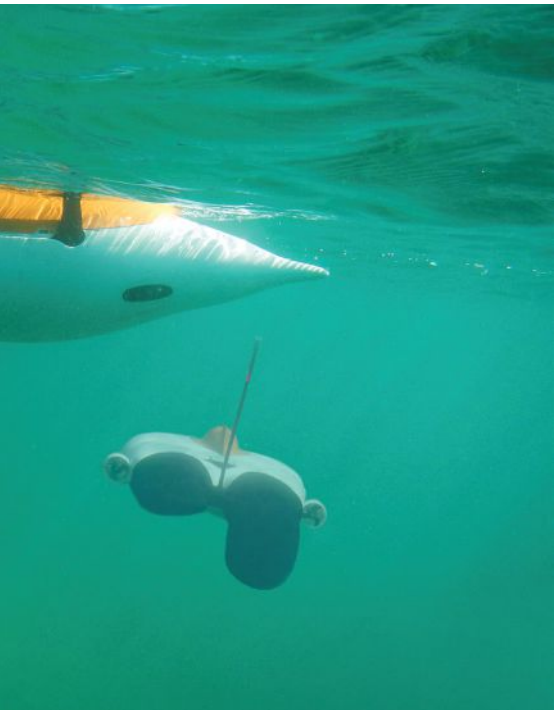
First is a need for more quantity of technology. As more and more tasks must be accomplished underwater, the mission complexity grows, but so does the sheer scale of operations. Advancing the functionality comes along with an increased number of devices that comprise the hardware architecture of today's underwater missions.

The growing complexity of the missions entails the higher data volumes that need to be collected, processed, and analyzed in a fast and effective manner. Scaling up the vessels, crews and logistic



» *Quadroin and Poggy uncrewed underwater vehicles with bionic design. (Photo credit: EvoLogics)*


» *The DeepSea Protection: a render of a deep-sea mining operation. (Image credit: MHWirth)*



» *EvoLogics underwater network node. (Photo credit: EvoLogics)*

efforts would drive up both time and cost. The future needs more compact and smart solutions - this is another trend that persists over the years. The time, cost, logistics, and safety efforts for maritime missions can be significantly reduced with smaller vessels and fewer personnel.

**SUPPORTING AUTOMATION**

*Complex missions also require faster data processing, interconnectivity, and decision-making capabilities to automate most tasks. Robotics should decrease the number of operators, and the operator's efforts, with synergy and self-controlled coordination.*

Throughout our work with customers and R&D partners, the communication and positioning networks of EvoLogics underwater acoustic modems are in high demand. Current tasks involve coordinating data networks of multiple nodes, with some projects requiring over 200+ underwater devices to communicate with each other—comprising a network of Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs), and stationary nodes.

Underwater positioning needs to support autonomously operating vehicles and allow for flexible functionality. Modern needs call for accurate positioning and coordinated, complex swarm behavior of UUVs that execute their missions autonomously.

The communication and positioning methods evolve with ongoing R&D efforts. We see the future in hybrid network-aided positioning methods that combine the accuracy of long-baseline solutions with the low system complexity of USBL.

Multi-modal communication is another rising trend. EU-funded MarTERA UNDINA project is an example: here, EvoLogics and project partners are working on underwater modems that operate over acoustics, optics, and magnetic induction to ensure connectivity over a wide range of distances and subsea conditions. Such wireless networks can exhibit better scalability, maintainability, and environmental impact.

**FUTURE ROBOTIC SYSTEMS**

The future of marine robotics brings missions with multiple moving parts, more accurate and specific data, larger data volumes, more interoperability, and, last but not least, more security. Intelligent robotics should reduce the logistics cost and effort, reduce the number of operators, and mitigate operator fatigue. Here, self-coordinated UUV swarms are set to be the key with innovations in artificial intelligence, object recognition, collision detection, and advanced swarm behavior.

Onboard data processing has become a must for reducing the overwhelming data volumes that need to be transferred, processed, and analyzed.

Growing demand for more data favors multi-sensor payload configurations. Here, integrated data processing avoids overloaded data streams through distributed computing. Advanced methods for data fusion merge values from multiple sensor inputs into a homogeneous structure.

**DEEPSEA PROTECTION**

One of EvoLogics' ongoing R&D efforts is DeepSea Protection, a national project of eight partners funded by the German Federal Ministry for Economic Affairs and Climate Action. It provides a great example of a complex future mission with a highly demanding infrastructure: a deep-sea mining operation.

Safe industrial mining of natural resources on the seabed comes with enormous volumes of data collected at 3+ km depths: surveys of geology and topography, operations support, and environmental monitoring. For such an operation, the new technologies enable a multi-sensor network to simultaneously control remote deep-sea operations and monitor a wide range of environmental parameters to make sure the production activities remain ecologically safe.

By these means, smart new solutions come hand in hand with sophisticated systems for environmental monitoring. Novel autonomous technologies enable informed decisions for efficient operations that are safe for both humans and nature.

For more information, visit: *www.evologics.de*.

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# THE FUTURE OF **LONG-TERM SEISMIC MONITORING CAPABILITIES**

**By Andrew Moores, P. Geo**
*VP of Commercial Development, RBR*

In 2021, RBR and Ocean Networks Canada (ONC) collaboratively designed and deployed a suite of instruments tailored to long-term and remote seismic research. This system is serviceable by remotely operated vehicle (ROV) while deployed, addresses instrument drift internally, can be deployed individually or integrated into a cabled array, and is entirely monitored by a portable data controller and power hub.

Deployed in the Cascadia subduction zone off western Vancouver Island, B.C., Canada, it is adjacent to but disconnected from ONC's North-East Pacific Time-series Undersea Network Experiments (NEPTUNE) cabled observatory. The project is led by the RBR research and development team together with ONC's Dr. Martin Heeseman, a marine geophysicist interested in seismology, tectonics, tsunamis, and scientific seafloor drilling.

## SCIENTIFIC OVERVIEW

Accurate long-term measurements are essential to oceanographic research, particularly in geodetic, seismic, and geodynamic studies. An uninterrupted monitoring system can save lives, tracking important changes in seismic activity and helping researchers quantify coastal hazards.

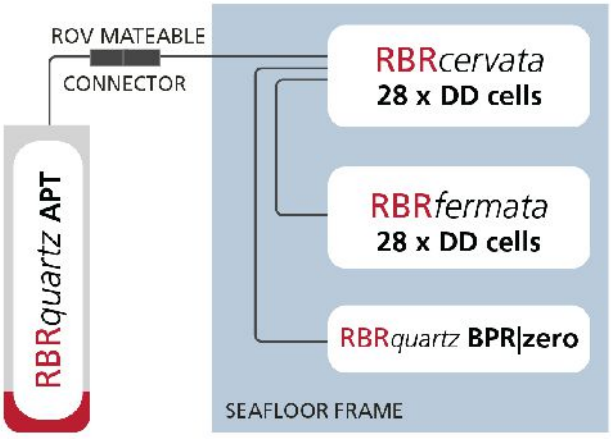
Extended deployments allow researchers to understand overarching trends in oceanographic parameters that cannot be resolved in shorter observation periods. They show long-term variabilities, for example seasonal variability, and are more likely to capture abnormal or unexpected events. Long-term deployments are also considered more cost-effective than a series of short-term deployments, as they reduce ship time and deployment cost.

In general, long-term oceanographic observations are limited by the instrumentation's power consumption and storage capabilities, and this was the biggest challenge the teams aimed to address. Instrument packages are typically deployed in one location for months to years and need to be entirely self-sufficient. In addition, as opposed to short-term deployments, which communicate with researchers in real-time or at regular intervals, long-term deployment platforms are usually isolated until the planned recovery date.

One notable exception is with cabled instrument arrays, such as ONC's NEPTUNE observatory. Instruments connected to the reinforced fiber-optic cable infrastructure have a direct communication link to computers onshore. Some networks also supply power to the instruments. Unfortunately, these networks are incredibly cost-intensive to build and maintain and are feasible in only few areas. The challenge the teams faced was how to get the same amount of data from a region where the infrastructure doesn't exist.

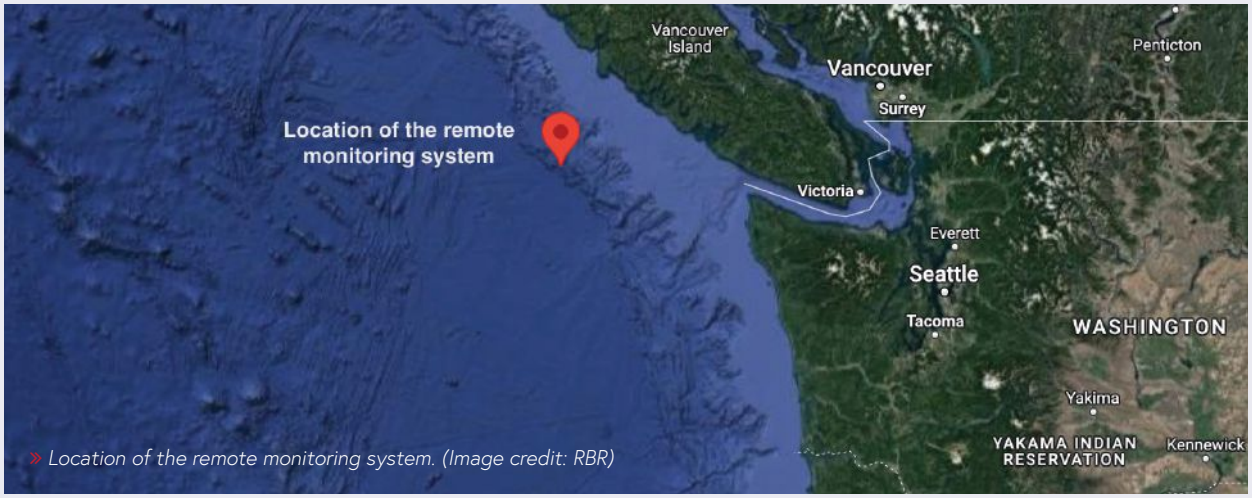
## TECHNOLOGY & COLLABORATION

Breaking the traditional division between "product developer" and "product user," both RBR and ONC took an active role in all stages of




» *The RBRquartz³ APT is buried at a distance from the seafloor frame. (Image credit: RBR)*


» *The RBR instrument suite. (Image credit: RBR)*




» *Location of the remote monitoring system. (Image credit: RBR)*

the project, drawing on each other's strengths to put these observation platforms in place.

"We wanted to design a product that is broadly useful, but that is also tailored to ONC's specific application," says Greg Johnson, RBR president. "We have the technology, we have the resources available, and we have the support we can offer when needed. It really became a question of how we can use all the tools we have together to make a highly successful project."

Working so closely with ONC has allowed RBR to address challenges from different knowledge bases, not only in product development but also with data processing and troubleshooting. For example, when Heeseman discovered an abnormality in his data, he was able to work directly with the developers at RBR to quickly investigate the underlying cause. The teams found that less than 0.03% of the data were affected (less than 24 hours of data per year of deployment) and were able to collaboratively design and implement a solution to address the issue.

The RBR-ONC instrument suite has three components: an RBR*quartz*$^3$ BPR|zero (bottom pressure recorder), an RBR*quartz*$^3$ APT combined BPR and accelerometer, and an RBR*cervata* brain-and-power hub. The system also includes an additional RBR*fermata* battery pack. It is entirely serviceable by ROV, which is one of the requirements of the project.

All instruments will tend to drift over time. The RBR*quartz*$^3$ BPR|zero is a unique version of the RBR*quartz*$^3$ BPR that actively measures its drift based on multiple measurements and recalibrates itself as needed. Designed specifically for deep long-term deployments, it can detect 0.01mm changes in surface water level from 1,000 m below the surface. It uses an integrated Paroscientific Digiquartz® pressure sensor to achieve a pressure resolution of 10ppb, and also has a high-accuracy temperature sensor. The RBR*quartz*$^3$ BPR|zero is currently integrated into both the remote system and the NEPTUNE observatory.

The RBR*quartz*$^3$ APT is a single-tool solution for deep-sea early earthquake warning and tsunami monitoring. This instrument includes a research-grade triaxial accelerometer, a high-accuracy temperature sensor, and an integrated Paroscientific Digiquartz® pressure sensor. Since recalibrating the accelerometer's orientation is quite involved, the teams added some customizations such as modifying the instrument connectors to be ROV-mateable, eliminating the need to retrieve the APT when swapping out the other instruments.

The teams were also able to adapt the RBR*cervata* data controller and power hub to Heeseman's application, for example by designing a simple way to resynchronize its onboard clocks just before deployment and just after recovery to correct for drift. The RBR*cervata* is a combination of the RBR*cervello* data controller ("cervello" being the Italian word for brain) and the RBR*fermata* battery canister. It has a battery life of roughly two years on lithium batteries, which the teams were able to extend to four years with an additional RBR*fermata*. It continuously downloads the internal storage of the RBR*quartz*$^3$ BPR|zero and RBR*quartz*$^3$ APT to its own 128GB SDXC memory card, creating a central data location. Both the physical design and its internal software allow the RBR*cervata* to be easily swapped out by ROV without disrupting the other instruments, ensuring truly continuous monitoring. In addition, the teams can process the data from the recovered data controller while the newly deployed hub continues the observations.


» *The instruments deployed underwater. Photo capture by the ROV. (Image credit: ONC)*

**KEY TAKEAWAYS**

Researchers are increasingly looking for innovative technology to address tougher and tougher problems in oceanography.

*This monitoring project shows how tight collaboration between industry and researchers enables long-term deployments in otherwise inaccessible areas.*

Working together along all stages of the project creates a unique blend of expertise with tangible benefits for both parties.

"RBR was selected for this project because of its proven performance and track record of responsive customer service," writes Heesemann. Working together to solve technical and logistical issues in cutting-edge applications and instrumentation is a mindset that the ONC researchers share with the team at RBR.

For more information, visit: *www.rbr-global.com*.

RBR

# THE FUTURE OF **THE US UNDERSEA TECH ECOSYSTEM RELIES ON COLLABORATION**

**By Molly Donohue Magee**,
*Executive Director,*
*Undersea Technology Innovation Consortium*

> As work continues to replace our aging ship and submarine fleets, it is imperative to prioritize aggressive investments across maritime and undersea tech research and development.

From undersea and maritime innovation to recruiting and retaining top notch talent, the global competition for discovering the next big tech breakthroughs and for building the best teams remains fierce. Strengthening our competitive edge when it comes to defense innovation is critically important, especially as global powers, including China, become more established.

Given our nation's military and economic reliance on the power of our oceans, we must act with urgency to deliver innovative undersea and maritime technology solutions that provide a competitive advantage to combat the effects of climate change, strengthen our international trade routes and global supply chains, and protect the international flow of data running via undersea cables.

Given the depth of this challenge, how do we achieve results?

## CREATING CAREERS

As work continues to replace our aging ship and submarine fleets, it is imperative to prioritize aggressive investments across maritime and undersea tech research and development. These efforts must also champion the importance of working together to accelerate our progress. Collaboration is key to rapidly delivering the strongest solutions to support our national security efforts.

The spillover effects of these collaborative efforts will have tremendous economic benefits. Investing in undersea technology innovation has the potential to create thousands of high skill, high tech, high wage jobs. For instance, the demand to build the Columbia and Virginia Class submarines is growing and represents a once-in-a-generation opportunity for skilled trade workers and engineers and technologists.

## SEIZING OPPORTUNITIES

Looking across these national security priorities, the Undersea Technology Innovation Consortium (UTIC) is playing its part in three ways by:

- Strengthening public and private partnerships—including academia—to form a national network of resources, expertise, products, and services to accelerate growth in undersea and maritime technology and facilitate related research.

- Providing the environment to collaborate, facilitate rapid development testing, and commercialize innovative technology through the Navy's Other Transaction Agreement (OTA) for Undersea and Maritime Innovative Technology. To date, more than 100 prototype technology needs have been identified. Prototype projects with a value of more than $400 million have been awarded to UTIC member companies to support these naval undersea technology requirements.

- Highlighting STEM and trade career exploration efforts from K-12 through degree programs to excite the next generation about undersea and maritime tech opportunities. Today we are facing a shortage of engineers, designers, technologists, and skilled trade workers to execute the research and development we need to remain competitive.

UTIC supports the Defense Department mandate to stimulate overall innovation strategies. Without dedicated resources and direction our undersea and maritime tech innovations may be delayed and that will inhibit us from maintaining our technology superiority.

It is only when we fully integrate the breadth of organizations contributing to technologies and applications in the undersea and maritime domain that we will see real results. UTIC is committed to growing the industry-academic voice working to put the essential pieces together.

The more cross-sector organizations and institutions that are part of our consortium, the faster and more efficiently we can deliver results to advance our national maritime defense priorities.

For more information about membership, visit: *www.underseatech.org.*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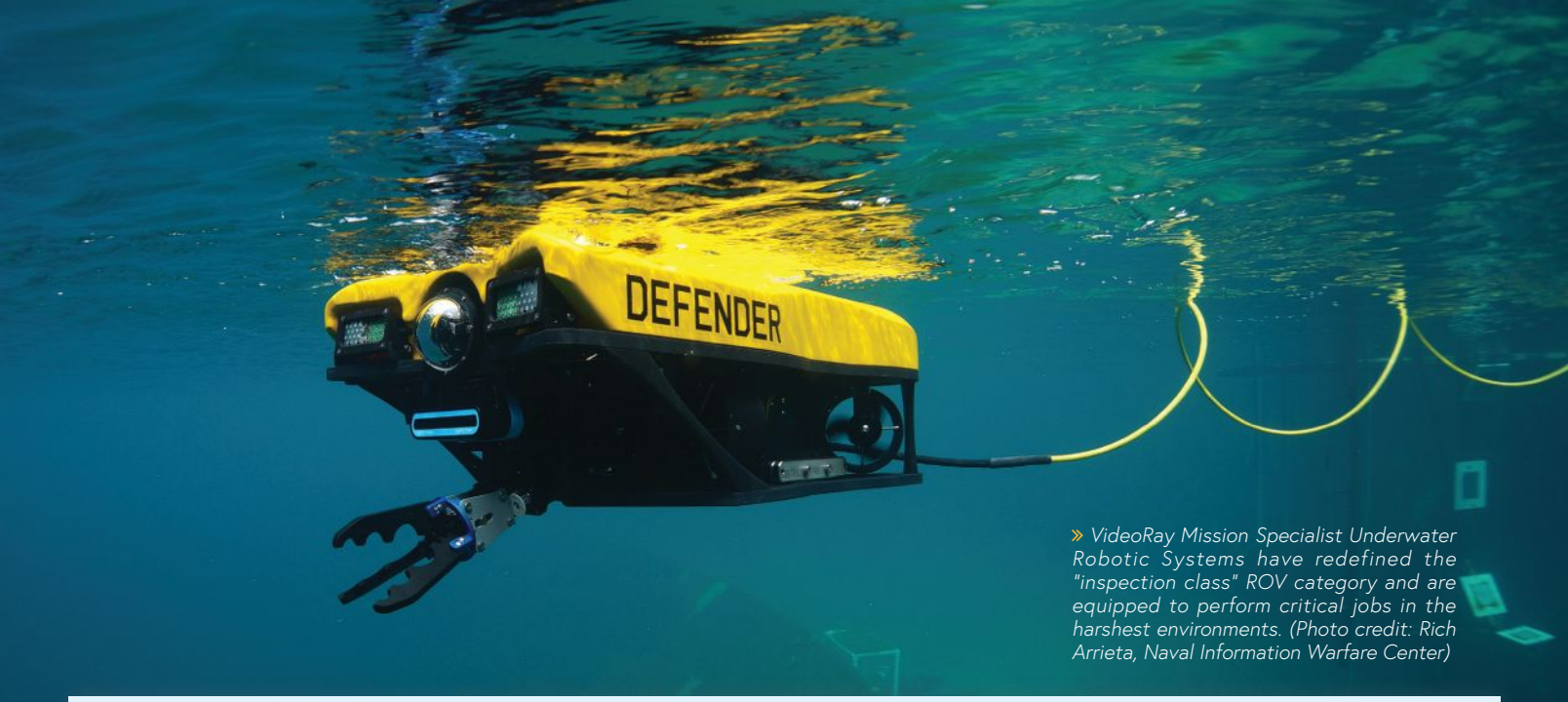



» *VideoRay Mission Specialist Underwater Robotic Systems have redefined the "inspection class" ROV category and are equipped to perform critical jobs in the harshest environments. (Photo credit: Rich Arrieta, Naval Information Warfare Center)*

| FEATURE |

# THE FUTURE OF **UNDERWATER ROBOTIC SYSTEMS TECHNOLOGY**

**By Chris Gibson**,
*Vice President Sales & Marketing, VideoRay*

VideoRay is the world's leading manufacturer of underwater, portable, inspection-class underwater robotic systems also known as ROVs. VideoRay's Mission Specialist underwater robotic systems are used around the world to support national security, first responders, object search and recovery, infrastructure examination and science and research.

The Mission Specialist Defender system is VideoRay's largest and most powerful configuration, optimized for precise control, heavier payloads, lifting and specialized operations. The Defender system has seven thrusters for exceptional maneuverability. It can move in any direction and maintain active pitch to move the vehicle in an upward or downward orientation.

The Mission Specialist Pro 5 system is designed for speed, efficiency and portability and handles missions with size, space, weight, and deployment speed constraints.

## AUTONOMOUS OPERATION

Engineers at VideoRay are rapidly developing technological advances and leveraging artificial intelligence (AI) to enable our underwater robotic systems to autonomously perform increasingly complex and hazardous jobs in the most challenging conditions. Autonomous control is applied to piloting and navigation tasks and intervention jobs like manipulator control for capturing images, cleaning, grabbing and measuring. Autonomous systems also simplify data collection, analysis, and reporting.

Semi-autonomous control reduces the required level of human operator engagement because the vehicle uses sensor data to understand and react to its environment and perform tasks. Fully autonomous systems will leverage artificial intelligence and machine learning to function entirely without the control of a human operator.

Underwater robotic technologies that VideoRay will begin rolling out commercially through new Mission Specialist modules include:

• Object perception and recognition systems informed by AI to achieve fully autonomous underwater robot operation. These capabilities can provide a better picture of the underwater environment, enabling the system to locate and identify objects before humans can. This technology saves time and money and helps keep divers out of dangerous situations.

• Point cloud modeling uses the system's sensors, cameras and lasers to collect data points from an underwater object and generate a 3D model of the subsea environment. AI detects, locates and classifies objects

and enables mapping technologies to autonomously control the thrusters. Equipped with point cloud modeling technology, the system will be able to process data about its surroundings to navigate within that space, classify the environment in relation to its task, perform inspections and manipulative tasks, then report on its mission.

• Distance deployment to send an underwater robot for a long-range mission is challenging because the system uses a tether to transmit communications back and forth from the underwater robot to the control panel on shore or on a ship. That means personnel can deploy the vehicle only as far as the tether allows. However, an underwater robotic system with an autonomy engine module powered by a subsea Edge computer processor will support system control at the vehicle. With Edge technology, communications will be possible no matter the distance through the water via a wireless acoustic modem using communication networks such as radio frequency, wi-fi or satellite.

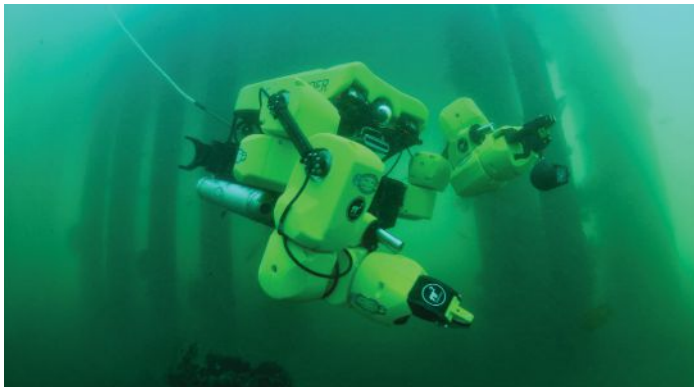
• Underwater resident systems to house a fleet of robots for large recurring jobs will eliminate the need for operators to be present on-site because charging and maintenance can be performed remotely. Resident systems technology will enable a network of robotic systems to monitor and maintain subsea assets by flying scheduled automated patterns and sending personnel the data wherever they are located.

**COMMERCIAL APPLICATIONS**

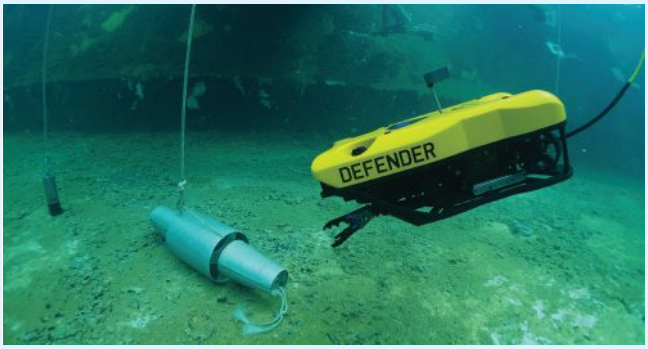
Autonomous and perceptive technologies have many commercial applications, and VideoRay is excited to bring these advances to its customers. The autonomy engine module is a subsea Edge processor which enables system control at the vehicle. Subsea vehicle batteries provide power at the vehicle instead of at the surface through the umbilical. This will enable the system to operate and "return home" if the umbilical is severed. This battery technology also will facilitate tether-less robot operations.

Because VideoRay customers can be up and running quickly—completing successful missions within just a few weeks of purchase—they enjoy a rapid return on their investment.

In addition, they also protect their investment. Every system from VideoRay can be upgraded to integrate these technologies at any time—without having to buy a new system. Customers who purchased a Mission Specialist system years ago can upgrade the vehicle and extend its capabilities by simply adding an updated tool or sensor module. That includes the AI and perceptive technologies as we roll them out commercially.



» *The durable modular platform is built to handle heavy payloads and a wide array of sensors and tooling. (Photo credit: Rich Arrieta, Naval Information Warfare Center)*




» *VideoRay is working with the U.S. Navy to develop innovative underwater robotic systems to perform remote explosive ordnance disposal (EOD) missions. (Photo credit: Rich Arrieta, Naval Information Warfare Center)*

» *VideoRay systems deliver industry leading power and maneuverability, enabling operations in currents up to four knots. (Photo credit: Rich Arrieta, Naval Information Warfare Center)*

**COLLABORATION WITH THE U.S. NAVY**

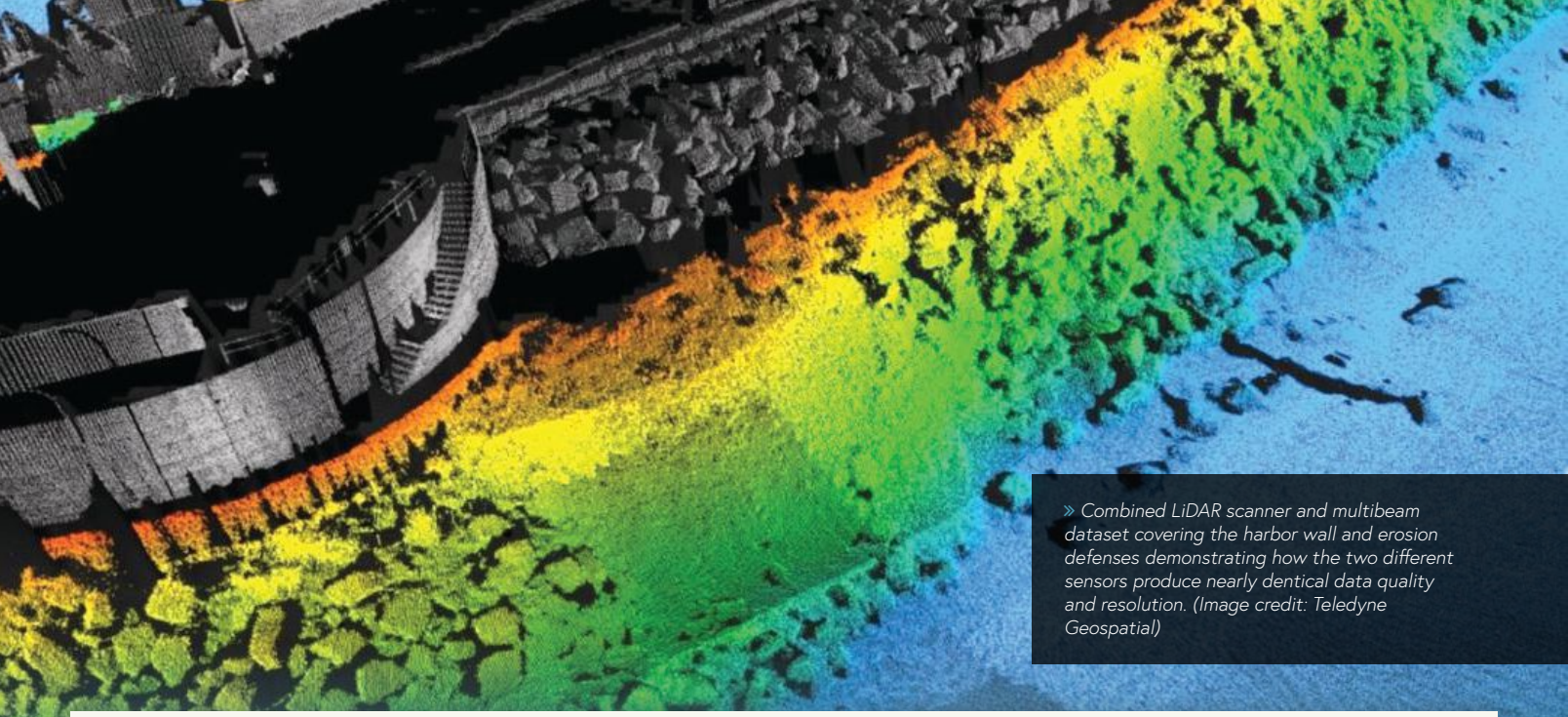
VideoRay is working with the U.S. Navy and several integration partners to develop innovative perception and autonomous technology for underwater robotic systems to help keep vessels and personnel safe during explosive ordnance disposal (EOD) missions.

VideoRay is currently fulfilling a large and diverse order by the U.S. Navy for its Mission Specialist Defender systems. The Navy is standardizing on VideoRay Defender Mission Specialist systems due to their superior capabilities, flexibility and upgradability of the large number of systems deployed since 2019. VideoRay's customer support for the Navy includes training facilities and personnel in Pottstown, Pennsylvania, and in San Diego, California.

In addition to the U.S. Navy, VideoRay has delivered or has firm orders from 20 other navies and coast guards from allied nations. As a result of these orders and commercial orders, VideoRay expects revenue in 2022 to be roughly double that of 2021 and is in the process of building up its manufacturing capacity to meet growing demand.

As these autonomous control innovations come to market, VideoRay experts are on hand to help customers select the latest tool and sensor modules to accomplish missions safely and efficiently.

For more information, visit *www.videoray.com* or call +1 610-458-3000.



» *Combined LiDAR scanner and multibeam dataset covering the harbor wall and erosion defenses demonstrating how the two different sensors produce nearly dentical data quality and resolution. (Image credit: Teledyne Geospatial)*

| FEATURE |

# THE FUTURE OF **LIDAR-ASSISTED COASTAL SURVEY & INSPECTION**

**By Travis Hamilton**,
*Product Manager,*
*Teledyne Geospatial*

The scale by which twenty-first-century advances in ocean technology have transformed the programmatic study of our planet's oceans can often be difficult to contextualize.

Today's expanding toolkit of marine technologies, replete with uncrewed vehicles, multibeam sonars, and a host of other smart sensors and instrumentation engineered to enable remote sensing, quality data collection, and precise sampling campaigns, would likely leave the early pioneers of coastal survey "all at sea."

Modern sonar technology, initially developed to counter the growing threat of submarine warfare in World War I & II, was the technical breakthrough that triggered a more ambitious approach to oceanography, and to this day remains the chief protagonist of subsea geospatial exploration missions. However, in recent years, LiDAR (Light Detection And Ranging) systems have played an important supporting role in high-profile campaigns to map the seafloor, measure water depths, and inspect seabed features, including man-made structures and lost shipwrecks.

## LiDAR IN THE PACK

LiDAR employs lasers—infrared for topographic scanning or a water-penetrating green for bathymetric measurements—and collects swaths of distance and angle measurements with hundreds of thousands of points per second to produce 3D point cloud surveys. Although LiDAR is a long-established technology, new photonics and optics are stretching its practical uses, from small "pucks' for the automotive industry, to terrestrial tripod-based systems, to small aerial systems for drones and larger units for fixed-wing aircraft.

*As interest in coastal zone mapping increases, LiDAR looks set to play a pivotal role in delivering measurable efficiency gains and better-quality data for a range of stakeholders, including coastal survey and inspection.* In particular, small autonomous platforms are making it much easier and cost-effective to deploy LiDAR technology on coastal mapping projects. Rather than needing to deploy an expensive fixed-wing aircraft or research vessel, a compact LiDAR system can be mounted onto

a drone to perform an aerial survey, or a mobile LiDAR system can be just as easily incorporated into the payload of a rapidly deployable Uncrewed Surface Vehicle (USV) to gather coastal topographic and bathymetric data in small channels and near critical infrastructure, like bridges and dams.

## COASTAL MAPPING

The comprehensive mapping of any target coastal zone demands that operators collect data from above and below the waterline. To ensure this happens seamlessly, LiDAR offers the perfect operational synergy with multibeam echosounders, allowing the full extent of the coastal zone to be efficiently mapped and detailed to similar resolution and accuracy.

This sector-wide need to optimize the field procedures associated with coastal mapping, submerged structure inspections, ports and harbor management, and general asset modeling for offshore planning has been further bolstered by the utility of "digital twins" (virtual model of a physical object) and using remote sensing technologies to perform previously labor-intensive manual tasks like inspection.

Aside from the field-proven efficiency LiDAR can afford operators, there is also a large safety factor at play. The coastal zone is a notoriously hazardous environment and attempting to mobilize crewed vessels in such waters can lead to unacceptable levels of risk. LiDAR introduces an alternate approach that allows the coastal zone to be mapped from either a surface vessel in safer waters or a fully airborne craft.

At Teledyne Geospatial, we have found that for studies aiming to tie together both terrestrial and offshore datasets, the deployment of an airborne bathymetric LiDAR (green laser) can often represent the most efficient tool for mapping large areas of shallow water—up to 70 m deep in ideal conditions.

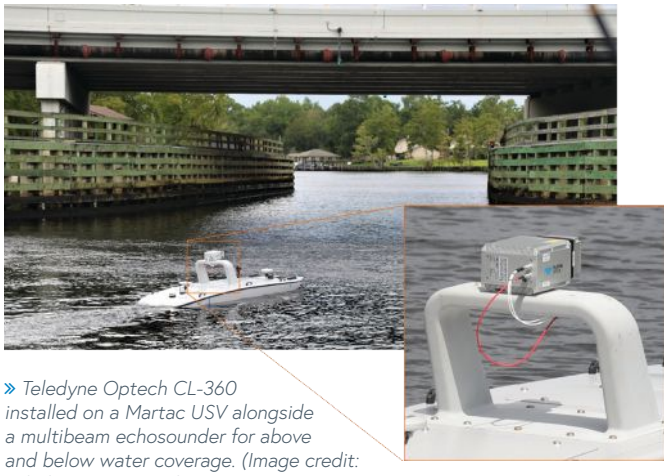
For mapping coastal waters with more variance, Teledyne Geospatial's terrestrial scanners, the Optech Polaris and Optech TLS-M3, can be easily installed on a survey boat then quickly transitioned to performing static scans on land, providing the flexibility to capture the above water part of a full dataset in a way that a marine-only system cannot.

We have also developed a lightweight system well-suited to be deployed as a commercial alternative on small USVs. The Optech CL-360 has survey grade range, resolution, and accuracy in a small form factor that allows the performance of larger topographic LiDAR systems to be deployed on small uncrewed platforms, which are most often used in ports, small waterways, and hard-to-access waters.

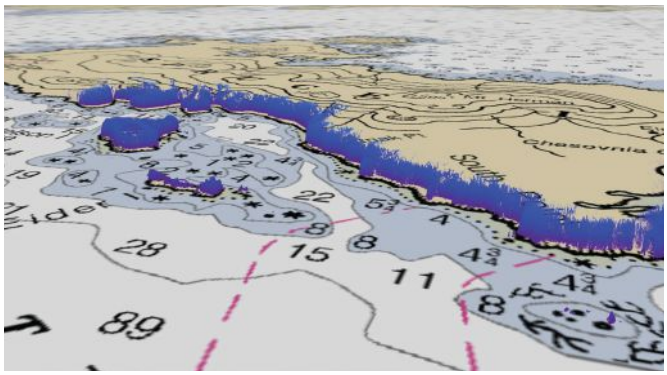
## WORKFLOW EFFICIENCY

This operational choreography between complementary technologies, whereby the chosen LiDAR system maps features above the waterline whilst an echosounder maps below, signals a new era of operational efficiency and accuracy for hydrographic survey. This allows the industry to capture shoreline verification data, map the location of above-surface hazards, outline clearance heights under bridges and powerlines, and much more. Coastal management professionals, using cooperative platforms, can map coastal zones for ongoing or event-related erosion and provide infrastructure inspections. In the end, through the merging of the above and below waterline data sets, digital twins of infrastructure like dams, breakwaters, wharfs, and bridges can be generated.

Creating seamless workflows is also an important point for allowing



» *Teledyne Optech CL-360 installed on a Martac USV alongside a multibeam echosounder for above and below water coverage. (Image credit: Teledyne Geospatial)*



» *Example of LiDAR data collected from a terrestrial scanner mounted on a marine survey vessel along offshore Alaska. (Image credit: NOAA)*

LiDAR technology to be easily accepted and integrated into marine survey operations. Teledyne Geospatial brings together high-performance Optech LiDAR systems with highly regarded and trusted CARIS marine software solutions. This ultimately ensures that the LiDAR and echosounder data are collected and processed together in a trusted marine software workflow.

## FUTURE APPLICATIONS

As the benefits of survey efficiency and increased resolution of information are becoming better understood and accepted, we expect to see growing interest, trial, and adoption for the use of LiDAR systems in the marine environment. Ongoing technical enhancements will continue to coalesce the disciplines of topographic and bathymetric survey, and ultimately drive the demand for complete and cohesive solutions for simultaneous mapping above and below—a robust subsea-to-sky 3D geospatial capture and visualization solution.

The continued integration of uncrewed platforms—above, on, and below the water—will only further drive the technological development of LiDAR systems and broaden their applicability in the marine industry.

We can expect this to result in market demands pushing for improved workflows for managing the increased volume of data being collected, focusing on aspects of data management, and automated workflows for extracting features out of the datasets, making it easy to produce and disseminate the valuable information from the collected data.

For more information, visit: *www.teledynegeospatial.com*.

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**Teledyne Geospatial**
Imaging Solutions for Land and Sea

# THE FUTURE OF **21ST CENTURY OCEAN EXPLORATION TECHNOLOGY**

**By Mashkoor Malik, PH.D.**,
*Science & Technology Division Chief, NOAA Ocean Exploration*

**By Philip L. Hoffman**,
*Science & Technology Division Technology Lead, NOAA Ocean Exploration*

> Like many ocean-going organizations, NOAA Ocean Exploration believes that our future success will depend on increasing our use of autonomous technologies.

For over 20 years, NOAA Ocean Exploration has brought the mysteries of the deep ocean to the light of day for the ocean science community and the American people. Our remarkable record of deep-sea discovery has been enabled through the adoption of a variety of technologies: A dual-bodied Remotely Operated Vehicle (ROV) system that can go to the deepest parts of the ocean; multibeam echosounders that reveal the contours of seabeds never seen by human eyes; sampling tools that reveal the secrets of the seafloor to scientific examination; and telepresence technologies that enable the sharing of data, including high-resolution video, from the seafloor to labs, classrooms, and desktops around the world in real time.

As we look ahead to the next two decades, we see numerous new and expanding technologies taking the stage, as well as technologies being repurposed from other industry segments, and even other science disciplines to meet the challenges that the US Congress and the ocean science community have set before us.

## AUTONOMOUS TECHNOLOGIES

Like many ocean-going organizations, NOAA Ocean Exploration believes that our future success will depend on increasing our use of autonomous technologies. In the short and medium terms, this means using machine learning (ML) to process our data faster and uncrewed systems to significantly expand our sampling and data acquisition capabilities.

With nearly 10,000 hours of video data in the archives at the NOAA National Centers for Environmental Information, we are working with several public/academic/private partner teams to implement ML to annotate our video, detecting and identifying organisms and geological forms observed during ROV dives. This commentary will make our video data more useful for a variety of audiences and purposes. It will also further our goal of making ocean exploration data more easily accessible by reducing the burden of excessive data analysis by end users.

## EXPANDING EXPLORATION

NOAA Ocean Exploration is also funding and hosting academic and private-sector efforts to develop and demonstrate a variety of new at-sea autonomous platforms. By supporting the use of towed sonar to search for maritime heritage resources, facilitating the testing of Autonomous Underwater Vehicles (AUVs) and landers for hadal depths (+10,000 meters), working with partners at the NOAA Ocean Exploration Cooperative Institute on multi-vehicle operations, and more, we are demonstrating the great value we see in using sensor-equipped uncrewed vehicles to acquire more data, in more places.

Thanks to expanded telepresence opportunities from the growing low-Earth orbiting satellite constellations, we expect to leverage our successful telepresence program to reach more shore-based scientists, community members, and students. Their input, fed into our ML models for video and sample annotation, will speed up the rate of discovery. Combining this inclusive technology with our increasing capabilities in ML and uncrewed vehicles will be our technology sweet spot for many years to come.

NOAA OCEAN EXPLORATION

# A NEW HIGH-TECH CHAMPION IS BORN

ECA Group and iXblue join forces and become Exail. The group specializes in cutting-edge robotics, maritime, navigation, aerospace and photonics technologies. With a strong entrepreneurial culture, we deliver unrivaled performance, reliability and safety to our customers operating in severe environments. From the deep sea to outer space, Exail expands your capabilities with a full range of robust in-house manufactured components, products and systems.

exail

expanding your capabilities

# THE FUTURE OF LEANER, GREENER, AND SAFER OFFSHORE WIND MARINE SURVEY

**By Shayan Haque**,
*Business Development Manager, Exail*

» *DriX's hydrodynamic monohull and drop keel guarantee exceptional stability and balance in high waters (sea states 5) and in cross current situations. (Photo credit: Exail)*

The US offshore wind (OSW) industry is poised for massive growth in 2023 and beyond.

However, the operating costs and practicalities associated with wind farm planning is a major hurdle for developers. Geotechnical and geophysical surveys are traditionally conducted using large survey vessels and work class ROVs, a bottleneck of activity that puts additional strain on ports, harbors, and coastal communities. Furthermore, the environmental preservation of the marine ecosystems found in and around the target sites for development is of mounting concern, and so proposals are often subject to stringent and lengthy permitting processes, which can significantly jeopardize project deadlines.

*To meet these challenges, however, operators can now rely on new—and proven—uncrewed technologies like Uncrewed Surface Vessels (USVs) for a leaner, greener, and safer alternative to executing the data-rich marine survey campaigns needed for thorough OSW planning and construction.*

## UNCREWED SOLUTION

Exail's (formerly iXblue) DriX is a highly reliable, multi-faceted ultra-low-carbon-footprint USV that enables operators to remove humans from risky offshore operations. With its unrivaled speed, intelligent obstacle avoidance system (OAS), stability and reduced noise radiations, DriX offers significantly more efficiency, endurance, and safety across many different survey operations—including nearshore activities in shallow, high-traffic waters—than traditional survey methods.

As a fully certified USV (by Bureau Veritas (BV) and Lloyd's Register), DriX has a key role to play in both the OSW planning (and build out) phase by executing multibeam (MBES) surveys for site investigations, pre-construction surveys for monopiles and cable routes, and during trenching operations and as-laid surveys, and the post-construction operation and maintenance (O&M) phase, running scheduled inspection maintenance and repair (IMR) procedures, including fisheries and biomass assessment.

## EXTENSIVE DATA CAPTURE

OSW development relies on precise seabed mapping and analysis. Data acquired from both nearshore shallower depths and deeper offshore sites is thus critical. Operators must however ensure that their data acquisition operations cause minimal disruption to the surrounding ecosystem—including the native sea life—or other potential hazards, such as UXOs..

USVs can be instrumental in this process. DriX is capable of operating in less than a meter of water—impossible for ROVs and AUVs or other long-established survey methods—but is also equipped with a wide range of sensors for deep-water survey, including an MBES capable of data capture to depths of 3,600-m, ideal coverage for pre and post cable lay routes. DriX can also be equipped with Exail's Gaps USBL (Ultra Short Base Line) system, an excellent solution for accurately (and autonomously) tracking subsea assets, such as trenchers and ROVs, where traditional acoustic methods can be challenging, especially when operating in a noisy environment with long lay backs.

DriX's hydrodynamic monohull and drop keel guarantee exceptional stability and balance in high waters (sea state 5) and in cross current situations, further validating the integrity of the data. The tumblehome bow cuts through the incoming waves, adding to minimize the wave induced motions on the vehicle, and allows for high operational speeds of up to 14 knots.

In terms of operational endurance, DriX can sail for 6 days at 7 knots. It can maintain continuous operations for 24 hours at a top speed of 14 knots, with a 10-day mission operating at 4 knots. Further efficiency gains are possible by force multiplication—the synchronized deployment of multiple units to carry out the same mission plan.

## SITUATIONAL AWARENESS

DriX can operate autonomously under the supervision of a DriX supervisor or be directly

piloted using a remote control. The supervised autonomous operation can be performed either in Line of Sight (LOS) or Over the Horizon (OTH), relying on a proprietary software framework developed by Exail.

Vehicle safety is governed by an intelligent obstacle avoidance system (OAS) that triggers real-time alerts and, when in autonomous mode, can course correct the USV to avoid any object to be avoided, while keeping the operator in the loop at all times.

DriX's 360° situational awareness is optimized by a sensor suite that includes radar (long range detection; 3D LiDAR; 360-degree optical (camera) coverage; an Inertial Navigation System (position/attitude); GPS (position); an Automated Identification System (AIS); and a forward-looking Infrared Camera (IR). A 3D volumetric sonar such as Exail SeapiX, capable of providing real-time full 3D biomass assessment and bathymetry in shallow and deep waters, can also be integrated. This multi-sensor payload facilitates full situation awareness in variable weather and affords a 24-hour operational envelope.

## KEEPING DATA SAFE

Thanks to its composite hydrodynamic monohull with Kevlar reinforcement, the 8-m DriX is both surprisingly lightweight and robust. Sensors are fully integrated within a retractable "universal gondola" located 2 meters below the surface, with space to accommodate a variety of interchangeable sensor combinations, including MBES, Inertial Navigation System (INS), Ultra Short Baseline (USBL), Sub-Bottom Profiler (SBP), Sound Velocity Profiler (SVP), Magnetometers, in a bubble-free environment. An embedded high grade IMU (Exail Phins Compact C7 INS) avoids any bias or mechanical decoupling between the acoustic antennas and the measurement of the motions.

## FUTURE OUTLOOK

To establish true operational efficiencies throughout the full life cycle of offshore windfarms, USVs like DriX will prove instrumental over the coming years. Intuitive uncrewed systems that minimize a project's CO2 footprint, while at the same establishing unprecedented HSSE standards, present offshore energy developers with a leaner, greener way of working in typically challenging marine environments.

When it comes to long duration wind measurements in greenfields for future wind farm development, DriX is also an attractive mobile alternative to the standard use of static buoys and has also proved well suited to perform other autonomous survey operations in and around wind farms, such as scour detection.

Prioritizing the ongoing development of smart ocean technologies, like DriX, that seamlessly integrate the latest in intelligent marine instrumentation and leverage the advances in speed, endurance, agility, and non-intrusive data gathering platforms is key to driving responsible, carbon conscious efficiencies throughout each phase of wind farm development.

For more information, visit. *www.exail.com*.


» *DriX being deployed from NOAA's Thomas Jefferson survey vessel. (Photo credit: Exail)*


» *DriX conducting an MBES survey offshore Conwy, UK. (Photo credit: Exail)*

exail

# THE FUTURE OF **OCEAN TECH BEGINS WITH CANADIAN SMEs**

**By Kendra MacDonald**
*CEO,*
*Canada's Ocean Supercluster*

Food security, resilient supply chains, energy transition, and the climate crisis—these are a few of the challenges we hear about every day in the news, at work and at home. They are also challenges that present opportunities with a magnitude so great it is unlikely to find an industry, business, government, or community with an interest in ocean that is not also thinking about them.

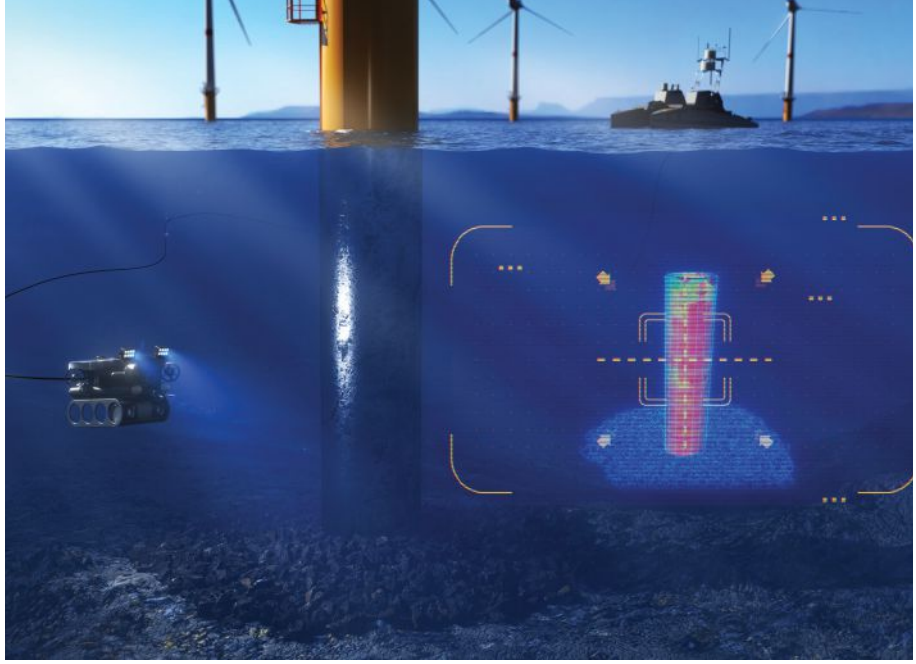
In helping solve these global challenges, Canadian small and medium sized enterprises (SMEs) are becoming increasingly competitive and winning with their ocean technology.

## PROJECT PORTFOLIO

Canada's Ocean Supercluster (OSC) projects are collaborative in nature and designed to accelerate the development and commercialization of ocean solutions. More than 120 new ocean products, processes, and services are being made available globally as a direct result of the cluster's current project portfolio alone. With 86 active projects, teams are comprised of largescale business, research, not for profits, government, and at least one SME partner per project. Instrumental in the problem-solving and innovation of these projects, Canadian SMEs are delivering ocean technologies to improve ocean processes, collect better data, reduce emissions, and increase safety of ocean workers. In the current OSC portfolio, SMEs lead 96 percent of projects gaining access to investment, partners, and markets that might not have otherwise been possible, as well as accelerating company growth, global reach, and competitiveness.

In the first five years of Canada's Ocean Supercluster, there has been significant focus on enabling: increased capability in

» *Seaspan Ferries, testing energy storage systems for larger vessels.*



» *Voyis, developing uncrewed surface vessels for inspection of offshore windfarms.*

remote operations, environmental monitoring and management, and the collection of data; detecting, monitoring and protecting species with technologies that help understand species movement and health including sensors, tracking, and environmental DNA; marine shipping focused on decarbonization including transitionary fuels to renewable diesel to carbon neutral options such as increased battery storage for vessels; as well as working in collaboration with Indigenous Peoples and ocean community partners, and helping grow a diverse workforce and more new ocean companies.

**NEW FRONTIERS**

This year, the world's largest technology conference showcased ocean technology expert content for the first time; a telecommunications giant has announced its business interests in aquaculture technology development; and countries around the world continue to come together around our collective ocean opportunity through the High-Level Panel for a Sustainable Ocean Economy. With the rise of the new blue economy, technology companies are looking at applications in ocean sectors, first use cases, and significant market growth potential. With four of the top 35 best ocean startup ecosystems in the world ranked in Startup Genome's first Blue Economy report, Canada is well positioned to support those opportunities for companies at all stages.

Newfoundland and Labrador-based CoLab Software partnered with ocean companies Kraken Robotics and Genoa Design through their cluster involvement and ventured into ocean for the first time with an OSC project that was originally on their technology development roadmap several years down the road. This work contributed to their rapid growth during the height of the global pandemic.

Leading an OSC project focused on offshore inspection in challenging ocean environments, Waterloo, Ontario's Voyis has expanded into new markets and developed new applications for their technology. For this project Voyis developed the Perception Remotely Operated Vehicle (ROV), where their ROV Skid has already been demonstrated to the U.S. Navy for mine countermeasure and subsea construction applications, with follow-on demonstrations scheduled for 2023.

Katal Energy, based in landlocked Calgary, Alberta, developed a transitionary fuel to reduce diesel consumption and harmful emissions but didn't initially consider the immediate impact potential for marine shipping. Through Canada's Ocean Supercluster and building new partnerships across the country, they are now testing their products on Miawpukek Horizon Maritime Service's icebreaker, the Polar Prince, with exciting early results.

**DEMONSTRATED OUTCOMES**

With significant momentum building across the entire Canada's Ocean Supercluster network, project teams and their SME partners are delivering incredible outcomes.

In their OSC project, British Columbia's Corvus Energy introduced the Blue Whale battery-based energy storage system to help make electrification for larger vessels a reality. In June, Havila Kystruten's passenger ship *Havila Castor* out of Norway proved it could sail with zero-emissions using the Blue Whale installed onboard their commercial vessel.

Ontario's BMT Canada Ltd reached a major milestone with full-scale testing of its Smart Microgrid technology from their OSC project. They have demonstrated continuous power management that minimizes interruptions and provides a clean energy integration solution for remote communities, with potential future adoption for customers in both commercial and military settings.

Graphene Innovation Technologies, operating out of Nova Scotia, announced a significant deal with Eastern Pacific Shipping out of Singapore to supply their innovative vessel coatings as the company expands and revitalize their global fleet of 200 vessels with a focus on decarbonization.

**AMBITION 2035**

*With the longest coastline in the world, the fourth largest ocean territory, and some of the most innovative people on the planet, Canada's Ocean Supercluster has big ambition for growth of the broader ocean economy in Canada—five times growth by 2035.*

This is expected to be driven by energy, seafood, ocean technology, marine transportation, tourism and recreation, and the public sector. It's Canadian SMEs that will help lead the future of ocean technology in the context of this broader ambition. In demonstrated areas of strength in Canadian ocean innovation, SMEs are expanding to meet the increasing global demand for made-in-Canada ocean products, processes, and services now and in the future.

For more information, visit: *www.oceansupercluster.ca.*

CANADA'S OCEAN SUPERCLUSTER

» *Testing transitionary fuel on board the Polar Prince.*

# THE FUTURE OF **TECH-DRIVEN CORAL REEF RESEARCH**

**BY AMY APPRILL**,
*Microbial Ecologist,*
*Woods Hole Oceanographic Institution*

WOODS HOLE OCEANOGRAPHIC INSTITUTION

> New approaches are needed to provide early indicators of the onset of coral and ecosystem stress before health has declined to a point where symptoms manifest and it is too late to intervene.

The Woods Hole Oceanographic Institution's (WHOI) Reef Solutions Initiative is a group of scientists and engineers focused on developing solutions to the coral reef crisis. Through transformative science and innovative technology, the team is enabling solutions to help save and rebuild coral reefs, helping the coastal communities that reefs protect and support.

Reefs are in decline and face a wide range of challenges. The health of coral reefs is assessed by divers through visual surveys and by satellite imagery. But these approaches only document visual symptoms of stress and provide no information about the underlying mechanisms stressing reefs. New approaches are needed to provide early indicators of the onset of coral and ecosystem stress before health has declined to a point where symptoms manifest and it is too late to intervene.

## AUTONOMOUS OBSERVATION

The Reef Solutions Initiative launched at WHOI in 2021 is taking reef science from labor-intensive, diver-based surveys to autonomous observation networks, and from these data offering key solutions to support and rebuild reefs. Beginning in October, 2021 in the U.S. Virgin Islands, this multiyear venture has supported reef-based engineering, monitoring, and restoration projects in the hopes of creating a blueprint for an international coral reef observation and diagnostics network.

At our research site in the U.S. Virgin Islands, our team of scientist and engineers are working together to develop innovative, scalable monitoring systems and strategies, including "smart" robots with vision—and passive acoustics—guided capabilities to observe and sample coral reefs on greater scales. Yogesh (Yogi) Girdhar is a computer scientist at WHOI introducing a new generation of autonomous underwater vehicles (AUVs). His team's new CUREE robot, is used to autonomously observe reef substrate, listen to the reef sounds, and visually track reef animals using artificial intelligence—a promising milestone. The robot, through its various operation modes, can detect changes in the behavior of keystone species due to ecosystem changes, identify biodiversity hotspots that might justify additional attention, and provide continuous monitoring of coral restoration efforts. These capabilities till now have been hard to scale up with the use of divers, and even other robots.

## INTERDISCIPLINARY COLLABORATION

Improving diagnostic signatures of early-stage reef stress and developing new treatments to enhance reef health and resilience is moving forward through collaborations among interdisciplinary scientists and engineers. One novel, transformative technology focused on coral stress is DISCO, (DIver-operated Submersible Chemiluminescent sensOr), developed at WHOI by WHOI Senior Scientist Colleen Hansel. DISCO measures superoxide, a form of reactive oxygen that may provide a key diagnostic indicator of coral stress. The team is currently re-engineering DISCO for autonomous deployments and detection of a suite of chemical stress signatures.

Corals and other reef life, use a variety of environmental cues to determine the best reef habitat to settle in for their lifetime. WHOI scientist, T. Aran Mooney, a sensory biologist at WHOI, is using underwater sounds to monitor reef coral health. By leveraging advances in underwater recording devices and acoustic data processing, Mooney's team is understanding the relationship between coral reef soundscapes, larval settlement, and biodiversity. Intervention strategies using sound is one promising tool to help corals, fish and other reef life repopulate damaged or degraded reefs. All of these efforts combine into a comprehensive, multidisciplinary approach to understanding and preserving these complex ecosystems so that perhaps we can finally give reefs the chance they deserve in a rapidly changing ocean.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# THE FUTURE OF **SMART DIVE PACKAGES**

**By Richard Heath PhD**,
*CEO,*
*Subsalve USA*

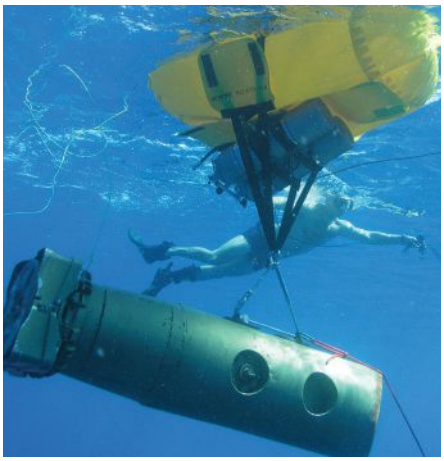
The Blue Economy is poised to continue and accelerate its growth in 2023 and beyond. This will be driven by growth in sustainable production and harvesting of food, expanded investment in offshore wind and related renewable energy approaches, predicted high intensity and frequency of storms, the return of favorable economics for offshore oil/gas investment, and the continued need for preparedness for a changing risk environment related to marine conflicts.

The continued growth of the Blue Economy requires continued advancement in technologies to support and catalyze the growth of these end markets. Some macro technology trends will contribute to the needed technologies and the following are a few examples of relevant technology trends that will be further elaborated with example of solutions that enhance the safety, efficiency, and flexibility of approach to carrying out important tasks in the marine environment.

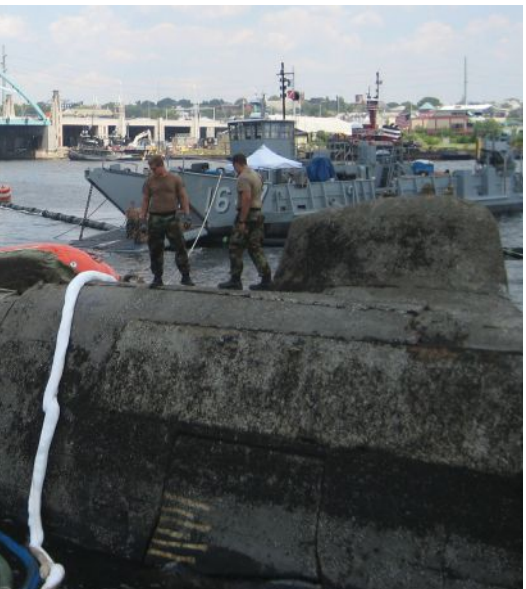
**Smart Devices:** Smart technologies in the area of sensing and control will continue to impact the marine working environment. This will include opportunities for significant improvements in what may have been considered very traditional products.

**New Materials:** New materials are constantly being developed and after an incubation period the news materials enable the development of creative new solutions that were previously difficult to manifest. We are particularly focused on new fabric technologies and the transition of additive manufacturing from a pure prototyping capability to a viable solution for low run parts manufacture.

**Autonomous/unmanned vehicles and support systems:** The past decade has seen a rapid development of unmanned and autonomous solutions on the land and in the air. In addition, Remotely Operated Vehicles (ROVs) have had an important impact on work underwater. The marine environment creates some unique demands particularly with regard to support systems. Full realization of the opportunities for impact of autonomous/



» *Mark V ORCA System training in mine retrieval, in Hawaii. (Photo credit: Subsalve USA)*

unmanned vehicles will be supported by new launch and retrieval systems that can be transported and deployed easily from a greater variety of platform vessels.

## SMART DIVE PACKAGES

Subsalve has long been know as the leading innovator in buoyancy solutions for the myriad of different marine challenges from mine retrieval to salvage operations, and cable and pipeline construction to offshore drilling/platform maintenance.

With a diverse and established product line, most dive teams are very familiar with the conventional use of Subsalve lift bags to carry out a wide variety of tasks safely.

*Motivated by needs expressed by military customers, Subsalve—in collaboration with several key strategic partners—has developed and deployed smart packages to enhance the safety and efficiency of using lift bags in challenging dive operations.*

The Buoyancy Control systems can actuate lift bags in a variety of modes including by acoustic signal. In addition, with advanced sensor and communications technologies the systems can rapidly and actively monitor position of the object in the water column enabling autonomous or manual control of ascent or decent in wired or wireless modes.

## FUSING MATERIALS

Subsalve and their sister company AEF have also been actively involved in delivering innovative products based on high strength and three-dimensional weave fabrics, including industrial grade dropstitch fabric. A single modular work platform kit can provide a configurable 150ft$^2$ work surface with 3,000 pounds of buoyancy that divers can easily carry to and rapidly deploy at the worksite.

» *Top: Neutral buoyancy lab - NASA astronaut training; Middle: Draught reduction in Toronto, Canada - helping to launch a new ice cutter; Bottom: Raising a Russian submarine, now on display as a museum piece in Providence, RI. (Photo credits: Subsalve USA)*

» *Salvage of a luxury yacht off the coast of Sardinia, Italy. (Photo credit: Subsalve USA)*

» *Water load test bags for crane testing. (Photo credit: Subsalve USA)*

Using combinations of new and conventional materials we have delivered a variety of docking solutions and capture systems that facilitate the launch and retrieval of many different objects.

The Blue Economy will be a continuing driver of economic growth, jobs, and innovation. We look forward to continuing to deliver enabling products to support that growth.

For more information, visit:
*www.subsalve.com.*

| FEATURE |

# THE FUTURE OF **NAVIGATION SYSTEMS**

**By Xavier Orr**,
*Co-founder and CEO, Advanced Navigation*

Artificial intelligence (AI) and artificial neural networks (ANN) were conceptualized in the 1940s as automated systems inspired by the neural networks that constitute a biological brain. The system is based on "artificial neurons" that interconnect similarly to a biological system. Each neuron can transmit signals to other neurons, making cross-connections possible and affecting how connected neurons interact.

ANN/AI systems are adaptive and predictive, based on neural interconnections. For example, previous data input, errors, corrections, predictions are recorded, analyzed, and compared with real-world data. The results are incorporated into interactions within the neural network to improve predictions and corrections. Effectively, the system can "learn" and apply this to its own operation.

Non-binary systems that impart "intelligence" have seen parallel development in other scientific areas. In 1960, mathematician and inventor Rudolf Kalman developed an algorithm that estimates unknown variables based on uncertain measurements. This is known as the Kalman Filter, which remains widely used in navigation systems, and uses current sensor readings and past estimations to provide predictions of the future system state.

## CHALLENGES IN NAVIGATION

*Modern navigation systems use multiple sensors to provide estimations of unknown variables.*

For example, GNSS provides location and velocity estimation, which are unknown variables, and the differential between satellite signal send-receive times are the measurements.

A major challenge to navigation is providing valuable estimations of hidden variables amongst uncertainty. For example, GNSS uncertainty depends on external factors, such as atmospheric effects and clock precision. Filtering, estimation, and correction using ANN processing is increasing precision inertial navigation.

## ARTIFICAL NEURAL NETWORK

At its core, an ANN is able to "learn" from input, output, historical, and previously estimated data to calculate higher accuracy outputs over time. That is, storing previous estimates and comparing them to actual measured values, then adjust/respond/recalculate automatically to increase future precision. A typical ANN goes through two distinct phases, which remain in a cycle of continual refinement.

- **Initial:** Processing units within the ANN are "taught" rules that guide its outcome. These teach the system to recognize

patterns in data by comparing actual output produced with the desired output.

• **Secondary:** Corrections that have been learnt (also known as back-propagation) are applied to the actual data to achieve the desired output.

### DEEPER LEARNING THROUGH LONG SHORT-TERM MEMORY

Advanced Navigation solutions are based on the long short-term memory (LSTM) AI principle. This technique is well suited to classifying, processing, and making predictions based on sensor data. LSTM provides a processing layer that contains "memory cells". These memory cells are interconnected in ways that allow fine filtering of data, based on recurrence and multiple other parameters, as the data is processed.

The following are some major advantages to LSTM:

- **Context:** The range of additional motion and time data that is collected over time and interleaved to create cross-connected filtering. The more important the filter is seen to be and the recurrence of it provides greater contextual "weight". This "bigger picture" format provides additional elements into the signal processing that, when filtered correctly, provides greater prediction accuracy and resolution.

- **Storage length:** Memory cell contents are not discarded after a defined period like some other systems. Instead, the data context and recurrence determine retention duration. More frequent context and recurrence, the longer the data is valid.

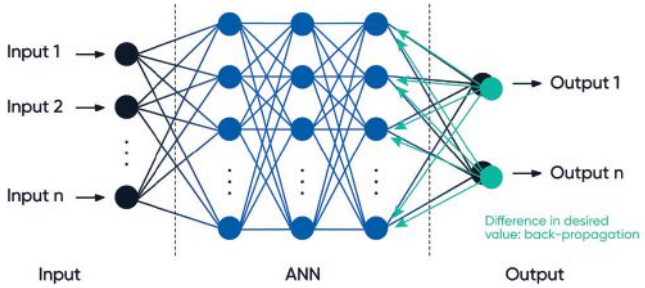
- **Learning and time lag handling:** An LSTM offers better lag handling than standard recurrence based neural networks. Through forward and back-propagation, memory cells can be corrected as the system learns. Through learning and error correction, the LSTM can bridge lags and eliminate limitations of non-LSTM models that experience degradation of accuracy over time.

Advanced Navigation ANN uses three types of memory-based learning:

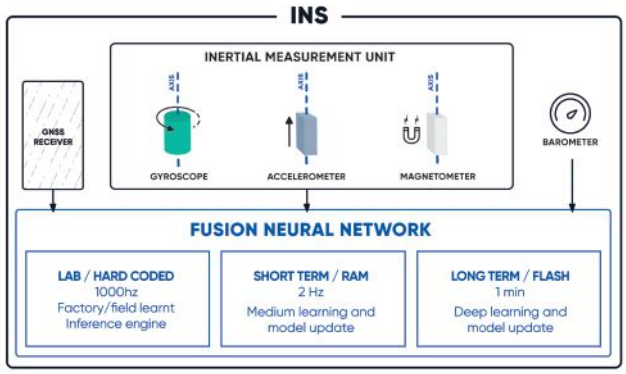
- **Long-term:** Logical and fact-based rules that are derived from laboratory testing are applied to input data at 1000 Hz. Processing is performed by the inference engine, which formulates decisions based on deep learning algorithms.

- **Short-term:** Applies a more constrained "medium" level learning that is used to update the inference engine model at 2 Hz.

- **Deep:** Re-models the system and applies more complex updates to the learned model, based on all sensor data, once per minute.




» *Image showing how back-propagation feeds into the ANN. (Image credit: Advanced Navigation)*




» *Diagram showing ANN integration in an INS. (Image credit: Advanced Navigation)*

### PROBABILITY FILTERING AND ANN

Two common errors are addressed during processing:

- **Deterministic:** Biases, scale-factor and non-orthogonal errors are inherent and known, so can be predicted precisely. Sensor calibration can eliminate deterministic errors and is applicable to both mathematical/statistical probability and ANN filtering.

- **Stochastic:** Instabilities and electrical noise errors are random, but may be analysed statistically, although difficult to predict accurately.

- **Integrity monitoring:** ANN integrity monitoring is superior to traditional filters as it identifies and rejects erroneous measurements and adjusts anticipated accuracy/inconsistency of inputs with a finer granularity. This is an advantage, particularly in conditions that may cause exaggerated variance input data, that can be difficult for traditional filters to handle without introducing errors.

- **Vehicle modelling:** Kalman filter-based systems typically use profiles that apply basic constraints on position, velocity, and acceleration. This results in vehicle modelling by typical motion. Contrastingly, ANN profiling applies more detailed dynamic motion model constraints. This allows for better error tracking and attenuation, more reliable data, and overall higher accuracy.

### THE ADVANCED NAVIGATION ADVANTAGE

Developing a highly constrained ANN model that is tightly coupled to sensory hardware is extremely complex. The Advanced Navigation founders began this process in 2007 as university research to develop a highly constrained, custom neural network specifically for inertial navigation systems. This required extensive R&D and rigorous laboratory and field testing to build a substantial body of empirical data. This data was used to establish the required ANN learning patterns.

### A PROMISING FUTURE

AI based on LSTM ANN architecture brings a new approach to inertial navigation applications and solves deficiencies using mathematical/statistical approaches. Using a software platform to perform multi-layer learning and processing allows for less hardware-intensive systems, higher update frequencies and less power consumption. This leads to a lower SWaP-C at each performance level.

For more information, visit: *www.advancednavigation.com*.

ADVANCED NAVIGATION

# THE FUTURE OF **TECH-LED OFFSHORE ENERGY SOLUTIONS TO BRING NEW OPPORTUNITIES**

**By Erik Milito**,
*President,*
*National Ocean Industries Association*

> There is a potential for a Gulf of Mexico wind lease sale in early 2023, along with Central Atlantic offshore wind lease sales later in 2023.

The American offshore sector could be poised for a very busy 2023. From offshore oil and gas to carbon capture to wind, there should be a high level of momentum in every sector. With economic uncertainty and rising energy prices, Americans needs the offshore more than ever.

After an unprecedented gap in offshore oil and gas lease sales, the *Inflation Reduction Act* (IRA) provided a shot in the arm for the U.S. offshore oil and gas industry. The IRA reinstate the previously vacated Gulf of Mexico Lease Sale 257 and mandates three previously cancelled offshore oil and gas lease sales.

There is greater near-term certainty for companies to procure critical acreage and continue to invest in American energy projects, which will support high-paying jobs and energy supplies for years to come. New leasing opportunities underpin the foundational long-term health of the offshore oil and gas sector. Economic activity today can be tied back to previous supportive government policy decisions.

## CARBON CAPTURE & STORAGE

Offshore carbon sequestration is entering an exciting era. Carbon capture and storage (CCS) offers a way to trap GHG emissions right at the source and then transport and inject the emissions underground based upon technological expertise rooted in oil and gas. CCS technology can help flatten GHG emissions as lower-carbon energy alternatives mature in the market.

Technological innovation and federal support are helping to make it feasible for industrial plants to install CCS systems. The Gulf Coast region is a region known for producing so much of the energy and feedstocks essential for the building blocks for the products we use in our everyday lives. Through offshore CCS, high intensity manufacturing hubs along the Gulf Coast are well positioned to emerge as global leaders decarbonization innovation.

The first federal regulations overseeing offshore CCS are on the horizon and could be finalized next year. A clear and stable regulatory framework will provide the certainty needed to build an emerging sector, spur American leadership, and ensure the effective deployment of a critical tool to address climate change.

## OFFSHORE WIND ADVANCES

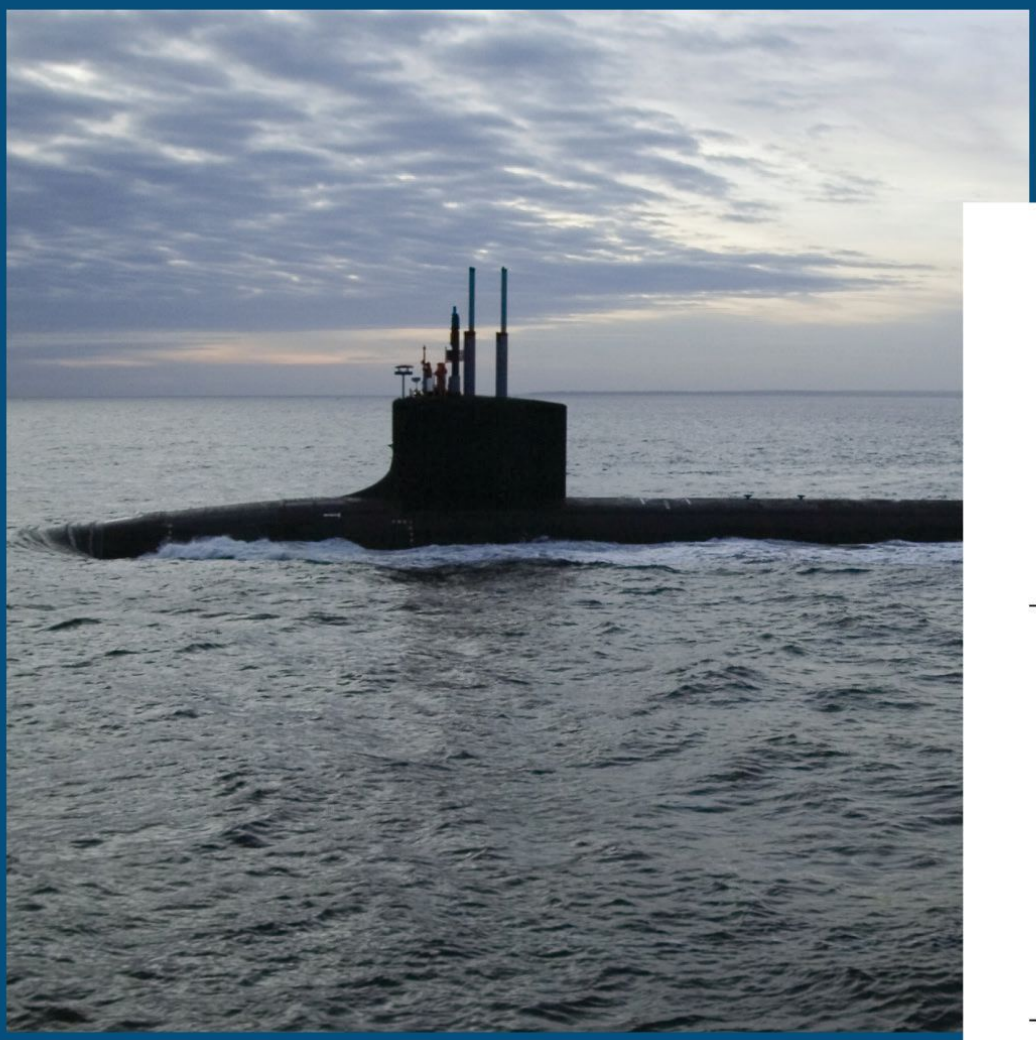
A generation of Cajun and Texan marine and service companies are already helping build the new American offshore wind industry. Now, American offshore wind is moving beyond the Northeast.

The "vents de carême," or "strong spring winds," in the Gulf of Mexico are poised to become part of the new wind economy. There is a potential for a Gulf of Mexico wind lease sale in early 2023, along with Central Atlantic offshore wind lease sales later in 2023.

With the December 2022 wind lease sale offshore California and an upcoming lease sale offshore Oregon, the U.S. can become a floating wind leader. Pacific Coast projects require floating wind farms to tap their wind resources due to deep water depths.

Floating wind technology is still young, despite the expectation that most future offshore wind resources will be located in deepwater. Two-thirds of America's offshore wind energy potential, including along the Pacific Coast and in the Gulf of Maine, are in deepwater areas. Federal initiatives aim to funding accelerated breakthroughs across engineering, manufacturing, and other innovation areas. By being in the floating wind game sooner rather than later, the American offshore wind sector is in a strong position to be a global leader.

From high-paying jobs and economic growth to low emissions and greater energy security, the offshore energy sector offers a path forward with benefits for all of society. While a new year always some degree of uncertainty, there is one thing you can bet on: American offshore energy will continue to be a source of solutions for society's most pressing energy needs.



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# THE FUTURE OF **MARINE ROBOTICS AND DIGITAL TWINS**

**By Mitch Winter**,
*Technical Sales & Training Representative, GRi Simulations*

Despite having spent years in the Ocean Energy sector, we at GRi Simulations owe our soft hands and dry socks to having been in the ancillary world of ROV simulation, and this experience is what informs our perspective on this topic.

Over that time, we have had dozens of projects creating digital twins of marine robotics—mainly simulations of ROV operations; but in recent years we have had more and more projects working with AUVs (Autonomous Underwater Vehicles), USVs (Unmanned Surface Vehicles) and developed digital twins of subsea project assets, mainly for the oil and gas sector. Combining these digital twins with more relevant, timely, accurate and accessible data has created huge opportunities for enhanced operational and engineering design efficiencies.

GRi Simulation's Virtual Remotely Operated Vehicle (VROV) simulator software was first released in 1999, designed to facilitate ROV pilot training by creating efficiencies of high-fidelity training without requiring vessel time.

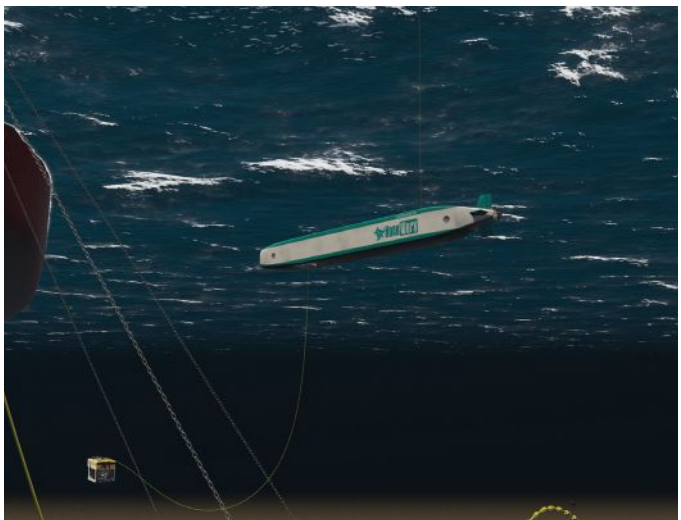
As time went on, new and interesting simulation challenges continuously arose in the areas of hazard identification, ROV accessibility, equipment design and procedure verification. Sometimes GRi would be tasked to simulate complex scenarios such as a riser pull-in or pipeline repair operation, or be asked to simulate a small operation or the functionality of a tool to address a specific problem. It seemed there was always something that could be learned from the simulation element that could reduce risk and increase efficiency, and sometimes it would identify an issue that would not otherwise have been found until the ROV was on-site. But it seemed to be always about risk reduction, for both for personnel and the environment, and saving time and money.

More recently, we have observed that these concerns remain, but the environmental risk now includes net zero emissions as a necessary goal; and net zero approaches, digitization and digital twinning are critical means to these ends.

## DIGITAL TWINS

A digital twin is a virtual representation of a real-life asset or system, containing as much pertinent information as possible, allowing it to be used for visualization, simulation, evaluation, and predictive planning among other use cases. GRi's first foray into virtual models of real-world assets were simulations supporting field design and construction projects in the Gulf of Mexico, the North Sea, West Africa, and the South China Sea.

Currently, GRi's iDEA-DT (*Interactive Design, Engineering & Analysis—Digital Twin*) software is our most recent software application, designed for interactive data connectivity and visualization along with operational simulation capabilities and subsea architecture design tools for offshore assets. iDEA-DT development is being greatly facilitated by membership in IDTA (Industrial Digital Twin Association) as GRi develops solutions to support Industry 4.0 initiatives and promote utilization of the standardized digital twin data model, the Asset Administration Shell (AAS), which is the digital basis for autonomous systems and AI. Simulations and such digital twin-enhanced virtual environments with integrated historical, current, and real-time data will play a larger role in ROV or AUV development and operations as autonomy and artificial intelligence designed to respond to critical events with optimal human intervention.



» *The HonuWorx Loggerhead simulation an ROV deployment in VROV. (Image credit: GRi)*


» *ARV-i inspecting an aquaculture farm in VROV. (Image credit: GRi)*

**AUTONOMOUS VEHICLES & NET ZERO**

Over the years, the industry has progressed from divers to human pilots for ROV operations, supported by functions such as auto-heading and auto-depth, to station keeping and way-point navigation.

*Interest in and development of autonomous vehicle systems has expanded globally and visionaries in offshore energy have identified remotely operated or autonomous oil and gas platforms, which minimize vessel activity through reduced crew and transport requirements.* With this approach combined with Asset Integrity Management systems, Inspection Maintenance and Repair campaigns are expected progress from ROV support vessel campaigns to unmanned systems supported by seabed resident docking platforms or deployment from an AUV – such as the HonuWorx Loggerhead.

**HONUWORX LOGGERHEAD**

The HonuWorx Loggerhead system is composed of an all-electric UUV that acts as a mothership, transporting and deploying intervention capable ROV's, which are controlled from shore through distributed control software with variable levels of autonomy. The Loggerhead system is an all-weather subsea intervention solution as it isn't affected by weather systems above the ocean's surface, it requires no offshore staff, and produces zero CO2 emissions.

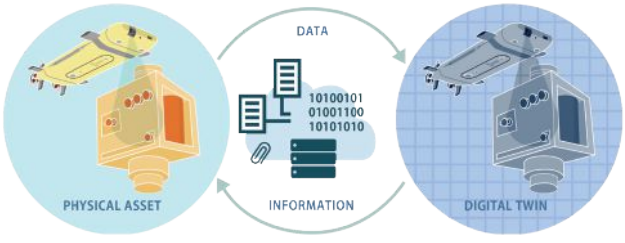
During phase 1 simulator development of Loggerhead, HonuWorx commissioned GRi Simulations to develop a 3D interactive model of their prototypes for testing in virtual environments. This project involved modeling the Loggerhead UUV, including several interactive components such as: operable hatch doors, latches for the communication buoy and ROV, dynamic tethers and a variable ballast system that could be altered during the simulation in increments of 1 kg. Upcoming simulator phases will help establish and test the autonomous control system for the platform.

**TRANSMARK SUBSEA ARV-i**

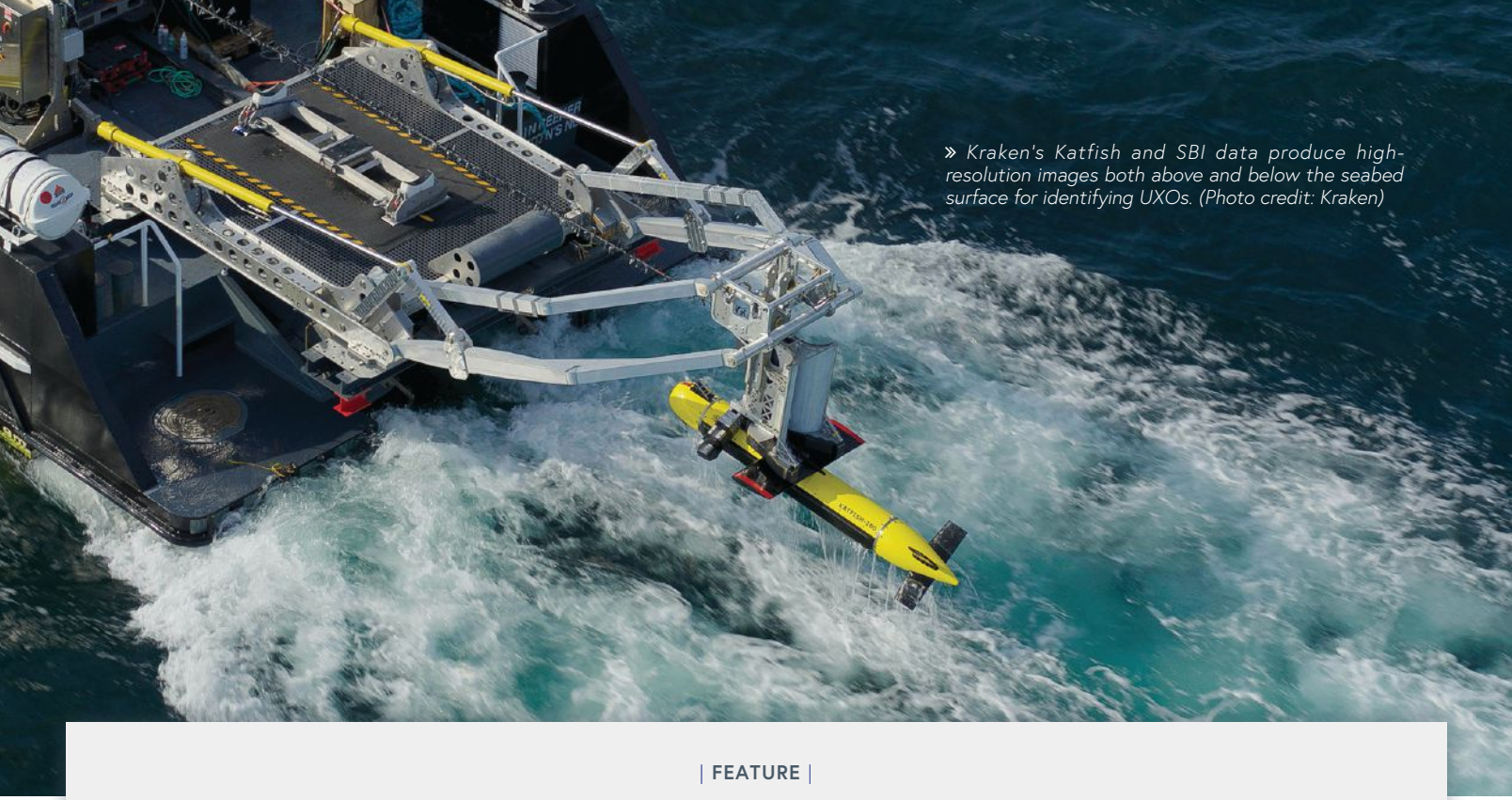
Earlier this year, GRi began work with Boxfish Research and Transmark Subsea to simulate the ARV-i (arv-i.com), an autonomous underwater vehicle, designed to continuously monitor assets for oil & gas, wind farms and aquaculture. This tether-less vehicle can operate fully autonomously or be piloted with manual controls and operates without a tether utilizing its own resident docking platform. GRi provided ARV-i scenarios in a virtual aquaculture facility featuring dynamic salmon models, in addition to a virtual windfarm and oil and gas environments.

Keeping a close eye on and assisting in the development of new technologies has been one of the most interesting and satisfying elements of GRi's time in ocean technology; and we are looking forward to seeing more and more collaborations come to fruition as the future of marine robotics research and development is realized.

For more information, visit: *www.grisim.com*.




» *Digital Twins visualize real-world data in an interactive 3D interface. (Image credit: GRi)*



» *Kraken's Katfish and SBI data produce high-resolution images both above and below the seabed surface for identifying UXOs. (Photo credit: Kraken)*

| FEATURE |

# THE FUTURE OF **SUBSEA UXO DETECTION**

**By Vincenzo Molitierno**,
*Business Development Lead, Kraken Robotics*

With new, ambitious targets set for renewable energy output, the world is turning to its oceans to act as a reliable source, whether wind, waves, or tides. Meticulous planning, construction, and operation of safe infrastructure wholly rely on contextual understanding both on and below the seabed.

One of the more pertinent threats to offshore wind development comes from the remnants of bygone conflicts—bombs and munitions or Unexploded Ordnance (UXO) left behind during successive wars. With an estimated 1.3 million tons of explosives in the marine environment, UXOs pose a serious risk to offshore renewable energy production.

## UXO RISK ASSESSMENT

To reduce construction and operational risks, marine developments must begin with a comprehensive UXO risk assessment, eventually leading to an "as low as reasonably practicable" (ALARP) sign-off, confirming the UXO risk is reasonably mitigated. Risk assessments typically begin with detailed desktop studies provided by industry experts, eventually leading to seabed surveys using multibeam echosounder, side-scan sonar, and magnetometry. While cost-effective, broad-sweeping, and reasonably swift to acquire, the result of these surveys is often a listing of hundreds, even thousands, of targets requiring further investigation by a Remotely Operated Vehicle (ROV) or divers before possible removal and disposal.

The drawback with perceived cost-effective solutions is that the resolutions achieved (0.3 m at best) from side scan sonar data coupled with the magnetic information can often lead to significant false positives. Indeed, approximately 95% of potential UXO targets identified during initial surveys turn out to be false positives—either marine debris or simply magnetic content within the seabed sediment. Given the dynamic nature of seabeds in the marine environment, there is always the likely possibility that potential targets have long since been buried and cannot be ruled out by seabed mapping methodologies alone.

The necessity to reduce the risk of encountering UXOs during the construction phase and to achieve ALARP sign-off for each target can lead to heavy disruptions to a development schedule, resulting in time and cost overrun. Considering up to 95% of this overrun is due to false positives, the offshore industry requires more sophisticated survey techniques to help reduce these delays as much as possible.

## SYNTHETIC APERTURE SONAR (SAS)

Kraken Robotics, and its subsidiary PanGeo Subsea, offer specialized survey solutions to

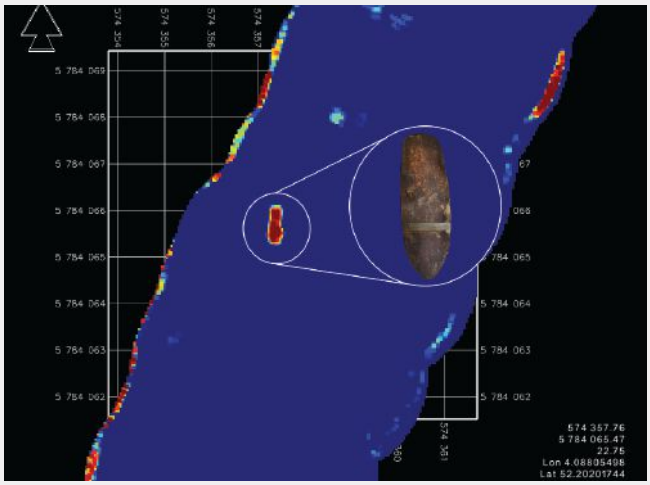
help bring the risk of encountering UXOs in the marine environment. Kraken's KATFISH system is a high-speed, actively stabilized vehicle utilizing Synthetic Aperture Sonar (SAS) to acquire seabed data with 2 cm constant resolution across a 400 m swath. Acquired alongside IHO-certified multibeam data from the same tow-vehicle, SAS is then draped to produce super-high resolution 3D imaging in post-processing. KATFISH operates up to 10kts survey speeds and can be deployed up to sea state 5, thanks to its intelligent winch and autonomous launch and recovery system. Coupling super-high data resolution and robust operational capabilities mean KATFISH offers an unparalleled seabed mapping solution to image potential UXO on the seabed.

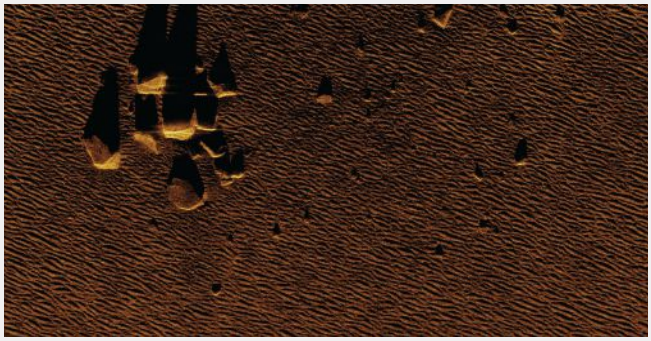
Offering high-resolution 3D imagery below the seabed with its Sub-Bottom Imager™ (SBI) system, PanGeo has proven to provide solutions to offshore wind developers by reducing potential UXO investigation targets. Using SAS and proprietary beamforming technology, the SBI offers real-time 10 cm resolution data, penetrating up to 8 m below the seabed. Using a multichannel array of acoustic sensors, the SBI uses the acoustic data that scatters off the sides of targets to provide a high-resolution image of an object's exterior. Geoscientists can then interpret this data to provide reports to the developer's UXO consultant in real-time offshore. Being able to visualize the shape of an acoustic target and understanding its dimensions gives UXO experts far more confidence to assess its potential as a threat. With this, a developer's target list is regularly reduced by 70%.

While the SBI excels as a complementary tool to existing survey methodologies, building on broadly acquired magnetometer and seabed mapping data, acoustics is essential when considering that not all bombs and munitions are made of highly-ferrous material. Frequently, magnetometry surveys leave non-ferrous mines undetected, and while they are far less common, this characteristic makes them even more threatening. The beauty of acoustics lies in its fundamentals, imaging density changes, meaning the only requirement to image intact buried munitions is for the density of



» *Coupling Kraken's Katfish data with PanGeo's Sub Bottom Imager data renders the ultimate picture for identifying UXO threats. (Image credit: Kraken)*





» *The ability to visualize the shape and dimension of targets easily identifies targets as potential threats. (Image credit: Kraken)*

the seabed surrounding the object to be different from the object itself. With this in mind, the SBI is the premier tool for identifying non-ferrous buried UXO in the marine environment and has helped developers globally in this capacity.

**HIGH-SPEED DATA INTEGRITY**

Coupling Kraken's SAS and PanGeo's SBI data—which can be acquired from the same mobilized vessel—paints the ultimate picture for clients when considering UXO. Unrivalled seabed data offers the ultimate confidence when considering a UXO threat, coupled with market-beating imaging of the sub-seabed; never before have developers had such a clear image of what's going on beyond the surficial layer of their site.

The correct questions are being asked; how can detection surveys be carried out faster; how can the systems be more readily available; how can large data volumes be processed more efficiently? Kraken Robotics is investing heavily in R&D to answer those questions. Answers which will lead to a common goal of bringing renewable energy online faster. Smaller towed platforms, compatible with more industry-standard equipment, are being designed, allowing the company to react to client requirements more readily and with greater availability.

Investments in high-speed data links bring the data to shore much faster, and machine learning is being used to increase data processing efficiencies on a massive scale.

Kraken Robotics and PanGeo Subsea plan to continue their positive disruption of the offshore survey industry by offering market-leading acquisition speeds coupled with unbeaten data resolution. Swift operations and speedier delivery of results allow developers to plan their construction phases with a better understanding of their site conditions, ultimately reducing delays and costs.

To learn more, visit: *www.krakenrobotics.com*.

# THE FUTURE OF THE GLOBAL OIL AND GAS MARKET

**By G. Allen Brooks**,
*Author,*
*Energy-Musings.com*

> Oil demand's collapse in early 2020 marked the bottom of the petroleum industry's last cycle and the beginning of the next.

Seven years ago, the outlook for global oil and gas markets changed. Saudi Arabia's oil price cut on 2014's Thanksgiving Day ushered in an oil era described by BP's CEO Bob Dudley as "lower for longer" when outlining his company's planning scenario in January 2015. That December, 195 countries agreed in Paris to an international treaty to limit greenhouse gas emissions to keep the global temperature increase to 1.5° C by 2100. That meant implementing plans to cut emissions by roughly 50% by 2030. The target of the cut was fossil fuel emissions, especially oil and gas.

The $100-a-barrel oil boom that peaked in mid-2014 was quickly labeled as the industry's last boom. Renewable fuels would soon replace oil and gas energy. Cars would be electric, homes would be heated with electricity, and manufacturing processes would be powered by electricity. What would generate the electricity? Wind and solar—centuries-old technologies—were embraced as the next global power system.

## TRANSITION TURBULENCE

When the oil boom became a bust, hundreds of energy and service companies went bankrupt, sapping the industry of its finances and talents. Policymakers ignored this development since it fit with their notion of petroleum as a "sunset industry." Who needed more petroleum in a net zero emissions world?

The transition to a carbon-free energy world was interrupted by the COVID-19 pandemic, and two years later by Russia's invasion of Ukraine. Energy security quickly trumped clean energy. The weakness of intermittent power became evident when the wind failed to blow, and clouds obscured the sun for weeks. Decades-long energy strategies were questioned and often jettisoned. More oil and gas, along with coal and nuclear energy was needed.

Oil demand's collapse in early 2020 marked the bottom of the petroleum industry's last cycle and the beginning of the next. Half a decade of underinvestment in new oil and gas resources assured a tightening supply situation just as world economies recovered from pandemic lockdowns. Government anti-oil policies, combined with political attacks on the morality of oil and gas restricted capital flowing to the industry, limiting supply growth. Accelerating oil demand met intractable supply and sent prices soaring. Economic and societal dependence on oil and gas became clear. More, not less, oil and gas were needed, but long industry lead times signaled that only sustained higher commodity prices will entice more investment and curb unnecessary consumption.

## SUPER-CYCLE

The next oil and gas super-cycle is underway. The strong stock market performance of energy and other commodity stocks this year reflected the start of this new cycle. Referred to as "The Revenge of the Old Economy," we are looking at a multi-year span of higher-than-normal oil and gas prices, producing outsized earnings and cash flows for energy companies that will fund production growth and increased returns for investors. Based on history: the 1970s cycle extended from 1968 to 1980, while the 2000s cycle went from 2002 to 2014. This cycle may last until after 2030.

Super-cycle dynamics will not prevent brief periods of oil and gas price weakness or significant strength, as near-term economic conditions unbalance energy markets. Predicting the demise of the industry was premature. Oil and gas are so vital to society's prosperity and survival that petroleum will be in demand for decades to come.

# REDEFINING ACOUSTIC NAVIGATION

## SUBSONUS
USBL/INS

- 0.1 ° Roll & Pitch
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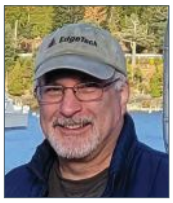
Subsonus is a miniature USBL & INS that provides accurate position, velocity, and heading at ranges of up to 1000 metres. Its acoustic heading transfer technology allows GNSS heading to be transferred from the surface to a unit underwater. As a result, Subsonus can achieve high accuracy heading underwater without a gyrocompass and with no susceptibility to magnetic interference.

ADVANCED NAVIGATION

# THE FUTURE OF **GHOST GEAR LOOKS LESS HAUNTING WITH SIDE SCAN SONAR INTERVENTION**

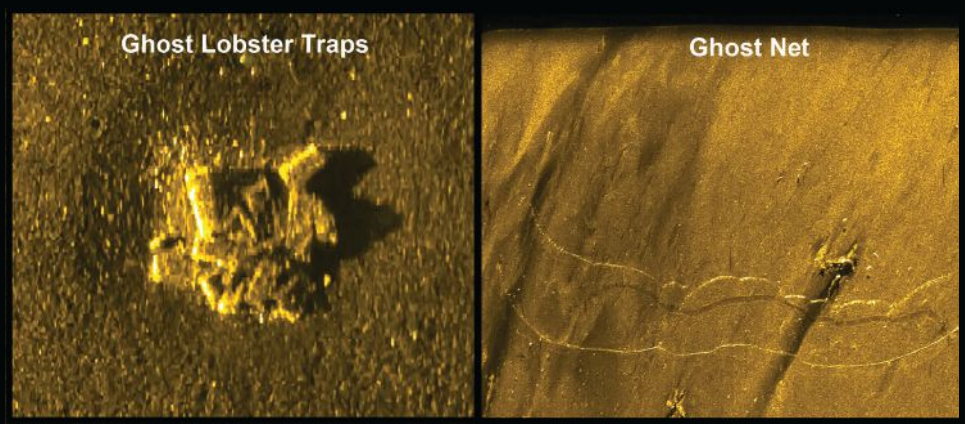
**By Garry Kozak**,
*President,*
*GK Consulting*



**and Rob Morris**,
*Product Line Sales Engineer,*
*EdgeTech*

Ghost gear is lost or discarded fishing equipment—nets, ropes, and abandoned traps or pots—that continues to fish long after being lost or discarded, sometimes for years. The unfortunate result is the quiet killing of fish, turtles, lobster, crabs, and entangling mammals such as seals, whales, and dolphins. The United Nations Environment Program Report of 2009 estimates that over 640,000 tons of fishing gear is lost or discarded every year into the oceans. It is suggested that this results in the death of 150,000 whales around the globe every year.

Ocean nations have become very aware of the issue and various agencies and non-profit groups are acting to now fund projects to locate and recover these deadly marine-animal-booby-traps. It turns out that side scan sonar, designed to map the seafloor, is a very effective tool to help locate and map ghost gear.




» *Ghost lobster traps and net. (Image credit: EdgeTech)*

## SONAR SURVEILLANCE

*Ultra-high resolution side scan sonar systems, like the EdgeTech 4125i 600/1600 kHz, are presently in use by various organizations around the world to locate piles of ghost traps, including lost nets.* Once located, recovery operations using grapples, divers, or ROVs are used for the removal and disposal. Being lightweight and portable, the intuitive side scan sonar systems can be operated out of any vessel of opportunity and require very little training for organizations to become operational.

The sonar systems, besides being used for ghost gear location, are also in use by marine fisheries law enforcement. Agencies such as NOAA's Marine Fisheries Law Enforcement branch use side scan sonar to monitor illegal fishing activities as well as observing in-situ commercial fishing deployments of traps and nets on the seafloor. The sonar imagery allows the verification of the location and number of traps in a string as well as showing any floating net ropes etc. that may entangle whales, or other marine life. It has become a valuable tool in the day-to-day enforcement of fishing regulations.

## IDENTIFYING THE THREAT

The oceans have become the world's dumping ground for lost or discarded old fishing gear, and the impact on the ocean environment is undeniable. A greater investment in expanding programs for ghost gear recovery needs to be done as well as educating the commercial fishing community that using the ocean as a dumping ground for old fishing gear is doing major damage to the marine ecosystems that they rely on for their living. The old saying "out of sight, out of mind" mentality has no place when it comes to the world's oceans.

Whales are not only impacted by ghost gear (floating derelict nets etc.), but existing commercial trap fishing, and the nets used, creates a second hazard from the age-old practice of having surface floats and down lines to the trap strings or bottom nets. The vertical lines are a major hazard to whale movement and migrations. EdgeTech has designed a

new Ropeless Fishing System that removes vertical lines from the water column.

**ROPELESS FISHING SYSTEM**

The best way to reduce ghost gear is to prevent fishing gear from becoming lost in the first place.

EdgeTech has developed the 5112 Ropeless (End line on Demand) Fishing System (RFS) to eliminate the need for persistent vertical lines in the water column that connect fishing gear to a surface buoy. The intent is to alleviate possible whale and other marine-life entanglement, help prevent Ghost gear, relocate lost gear, and reduce gear conflicts.

The RFS consists of a release cage with the appropriate length of line stored in the cage, detachable floatation cover with an integrated EdgeTech 5112 rugged acoustic release transponder, deck unit with transducer and the EdgeTech Trap Tracker application running on an IOS or Android device.

The RFS release cage is set out like any other rope-and-buoy trap, it can be attached to a single trap or at the beginning and or end of a trawl line and then recovered like a standard trap and buoy. Commands from the Trap Tracker application are sent to the BLEAT deck unit that then sends the commands to the 5112-release mounted in the release cage. The RFS receives the command then acts and replies with information to the Trap Tracker application such as, RFS ID, deployed position, recovered position date and time which is then uploaded to the Trap Tracker database and is shared with other Trap Tracker users within a certain distance to protect the fishers' privacy.

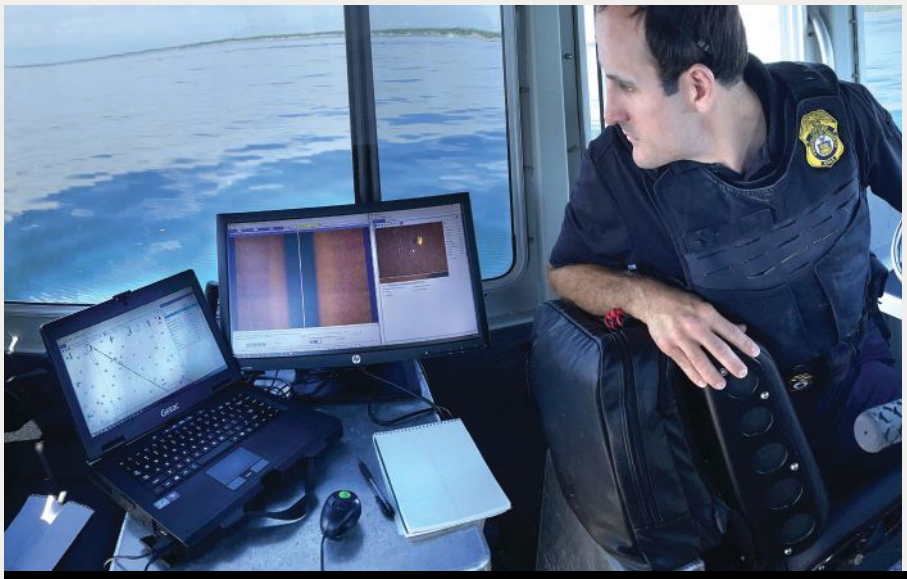
This visibility helps fishers to know where the EdgeTech RFS equipped gear is set even in fog or at night or from distances up to 5 nm away to help mobile fishers maneuver around long trap trawls preventing unintentional gear conflicts which is one of the main causes of ghost gear.

If gear has moved from where it was set for whatever reason, the RFS system can geo-locate underwater units using Ranging and Trilateration.

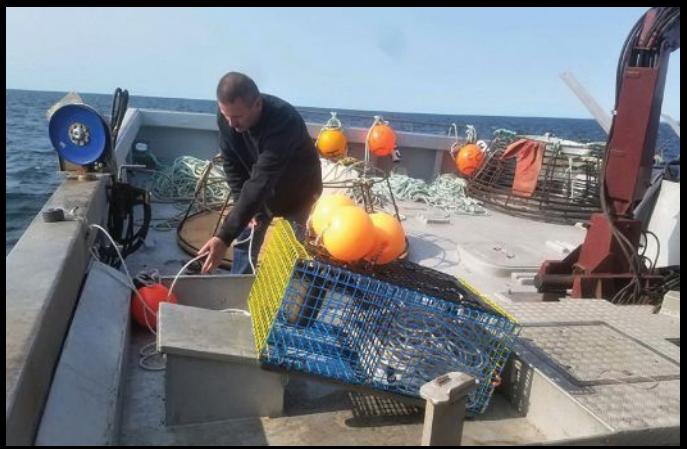
This geolocation feature allows Fishers to pinpoint the location of lost underwater units up to 2,000 meters (1 nautical mile~) away that may have moved from mobile fishing conflicts or some other means. By searching using a grid pattern, large areas can be covered quickly allowing for the relocation and recovery of lost gear.

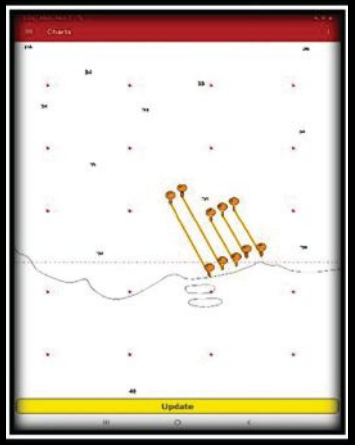
There was a real-world incident that occurred in 2020 where a mobile fisher in a restricted area dragged off several 40 pot trawls. By using the ranging geolocation function, the Trap Fisher was able to locate and recover the trawls that were equipped with the EdgeTech RFS almost five miles from where they were originally set. Not only did this prevent 80 traps from becoming ghost gear but it saved the fisher over $15,000 to replace the lost gear.

For more information, visit: *www.edgetech.com*.



» *Side scan sonar has become a valuable tool in the day-to-day law enforcement of fishing regulations. (Photo credit: EdgeTech)*





» *The RFS consists of a release cage with an integrated EdgeTech 5112 Trap Tracker application. (Image credits: EdgeTech)*

# THE FUTURE OF **REAL-TIME DATA FROM SEABED TO SPACE AT COVE**

**By Melanie Nadeau**,
*CEO,*
*COVE*

The number of Ocean Enterprise companies operating in Canada continues to grow at a pace outperforming our global counterparts. At the heart of this expanding Canadian sector on the shores of the Halifax Harbour is COVE, home to a community of over 60 ocean tech companies that are creating the world's next practical, commercial, and revolutionary ocean tech advances.

Successful growth at COVE has been driven by the ability to connect and innovate. Every day, COVE brings people, ideas, resources, and assets together to propel Canada's, and the world's, marine technology sector.

## STELLA MARIS

In May of 2021, these principles of connection and innovation culminated in the launch of the Stella Maris, a multi-sensor seabed platform capable of holding a wide variety of sensors that collect different oceanographic parameters, developed by a team of top engineers at COVE.

The platform, which sits 10 meters below the surface and 100 meters from COVE's wharf, functions as an accessible and affordable marine instrumentation testbed for ocean technology companies to conduct product development, verification, and commercialization to get their products to market faster. Users can remotely monitor, control and configure equipment on the platform from the operations center located on the edge of COVE's wharf. Since first touching down on the ocean floor, the platform has been a source of collaboration, with many tenants at COVE relying on data from other sensors to help support their own.

The opportunities for collaboration also extend beyond COVE's physical location. Stella Maris has the capability to allow companies to put sensors on the platform and receive real-time data from wherever they are in the world, something that has grown international interest.

Although COVE is proud to look back at the early success of Stella Maris, the focus is now on looking to the future.

Through the development of Stella Maris, COVE is able to collaborate various data sets and parameters into an interface that displays them. While today this is on a smaller scale with a single platform, COVE is thinking bigger.

*Knowledge of the ocean, its health, and its activities are crucial to the successful operation of naval, commercial, and research vessels, and in turn, to international security and economic stability.*

The trifecta of environmental, safety and economic concerns are exacerbated in ports, where a high concentration of marine activities mandates sound decision-making while minimizing uncertainty. Connecting port users of all backgrounds with good information in a timely fashion is of primary importance.

## DATA DEMOCRATIZATION

COVE's Digital Harbour: Seabed to Space is a collaborative initiative that will digitally monitor Halifax Harbour with an integrated system incorporating real-time data sources from stationary and mobile infrastructure located in the water, on land, in the air, and via satellite.

» *COVE, located in Halifax Harbour, is home to a community of over 60 ocean tech companies. (Photo credit: COVE)*


» *Stella Maris is a multi-sensor seabed platform able to support a wide range of oceanographic sensors. (Photo credit: COVE)*

Digital Harbour's objective is to collect large longitudinal and spatial datasets of key metrics to create solutions for a multitude of users in both the public and private sectors.

It can improve port safety and the efficiency of vessel travel, saving both costs and lives in the process. Additionally, it allows for new technologies to reach the market faster as their impacts will be more closely understood, driving business and economic growth.

Finally, close monitoring of environmental factors and port health allows for both public and private actors to make the most advantageous actions for port and ocean longevity for generations to come.

COVE's Digital Harbour will collect a variety of oceanographic parameters that are important for understanding the marine environment. Some examples are eDNA to determine biological species that are present in the water column, acoustic data using hydrophones to better understand vessel noise and movements, and CTD data, which is crucial for understanding the physical and chemical properties of the marine environment.

The data collected from these diverse sources will be hosted on a centralized platform and will allow companies to develop visualization and interpretation tools that will benefit naval, industry, and research-focused end-users by providing all-domain situational awareness, commercial opportunities, and improved predictive modelling techniques.

Throughout this process, previously used data will be given new relevance in helping classify trends and changes over time. In all, Digital Harbour creates the foundation for the ocean data ecosystem to notably enrich data collaboration, access to information, data processing tools, and technology development in the industry.

**CENTER FOR INNOVATION**

The ability to grow the ocean economy requires a concerted effort to radically progress how we harvest food, generate energy, transport goods, provide services, and transform

» *Halifax Harbour has become a hub for collaborative ocean innovation, exemplified by the launch of COVE's Digital Harbour initiative. (Photo credit: COVE)*

legacy industries to a more digitized mode of operation. The Digital Harbour is responding to this challenge and creating a scalable, global solution to digitize the ocean for commercial value in an environmentally sustainable way.

Undoubtedly, this is a major undertaking. There are only a handful of regions in the world with a dense enough cluster of aerospace and ocean companies to create a similar type of platform and data infrastructure; that is if they were able to coordinate and justify such a project.

Halifax Harbour is a prototypical mid-size port with naval, commercial, research and recreational activities in a constrained physical harbor space. Located in a province that is home to 31% of Canada's ocean enterprise companies, it is an ideal location to demonstrate an all-domain situational awareness network.

The ability to cost-effectively monitor marine areas and deliver commercially relevant data-based solutions is desirable to several regions around the world. With a successful deployment in the Halifax Harbour, led by global ocean tech leaders at COVE, Digital Harbour will revolutionize industry-centered global ocean sensing and ocean data applications.

For more information, visit: *www.coveocean.com*.

COVE

# THE FUTURE OF **OCEANOLOGY INTERNATIONAL AMERICAS**

**By David Ince**,
*Event Director,*
*Oi Portfolio, Reed Exhibitions*

> The event will deliver three days of face-to-face business on the show floor allied to extensive conference and technical sessions...

Oceanology International Americas (OiA), opening its doors in February 2023 will play host to some 2,500 ocean professionals looking to improve strategies for exploring, protecting, and sustainably operating in the world's oceans and waterways.

Helle Auken Lygum, Imaging Marcomms Manager at OiA exhibitor Teledyne Marine summed up the expectation building around the industry: "Teledyne Marine looks forward to reconnecting in person with all our global customers and partners at OI Americas 2023. We will showcase all our latest underwater technologies including our newest multibeam sonars for manned and autonomous surface vessels from Teledyne RESON as well as the new Benthos Ultra Compact Modem and Pathfinder DVL from Teledyne RDI."

Stephanie Herndon, Director of Marketing & Communications at Arctic Rays LLC is also ramping up activities ahead of the February 2023 event: "Ready for launch at OiA, Arctic Rays' new, 1,000 m rated, subsea surveillance system comprises topside hardware with video management software and subsea hardware for networking of lights, cameras, and pan-and-tilt units. We're also particularly proud of Yellowfin, the company's new machine vision system, and our own pressure relief valve, Barnacle. Almost ready for launch is a new battery-powered camera option for Mako, our existing camera that films in 4K/UHD, FHD and HD. This new option opens many new possibilities for filming in situations where power availability is limited. Plus, there are a couple of other new products in early-stage development that we can't yet reveal publicly that will likely break cover at the show too!"

## COMPELLING AGENDA

The event will deliver three days of face-to-face business on the show floor allied to extensive conference and technical sessions covering a huge range of subject areas from naval meteorology and remote monitoring, to delivering net zero and uncrewed vessel operations.

Developed in partnership with the Marine Technology Society, and the Society of Underwater Technology, the conference plenary sessions and technical tracks have been designed to ensure attendees get the best possible insights and most up to date knowledge from representatives of government, academia, and industry.

## THOUGHT LEADERS UNITE

The conference program is already shaping up to be a Who's Who of industry thought leaders including such luminaries Under Secretary of Commerce for Oceans and Atmosphere & NOAA Administrator Rick Spinrad, Brad Ack of Ocean Visions, Kendra MacDonald of Canada's Ocean SuperCluster, and Dawn Wright of ESRI.

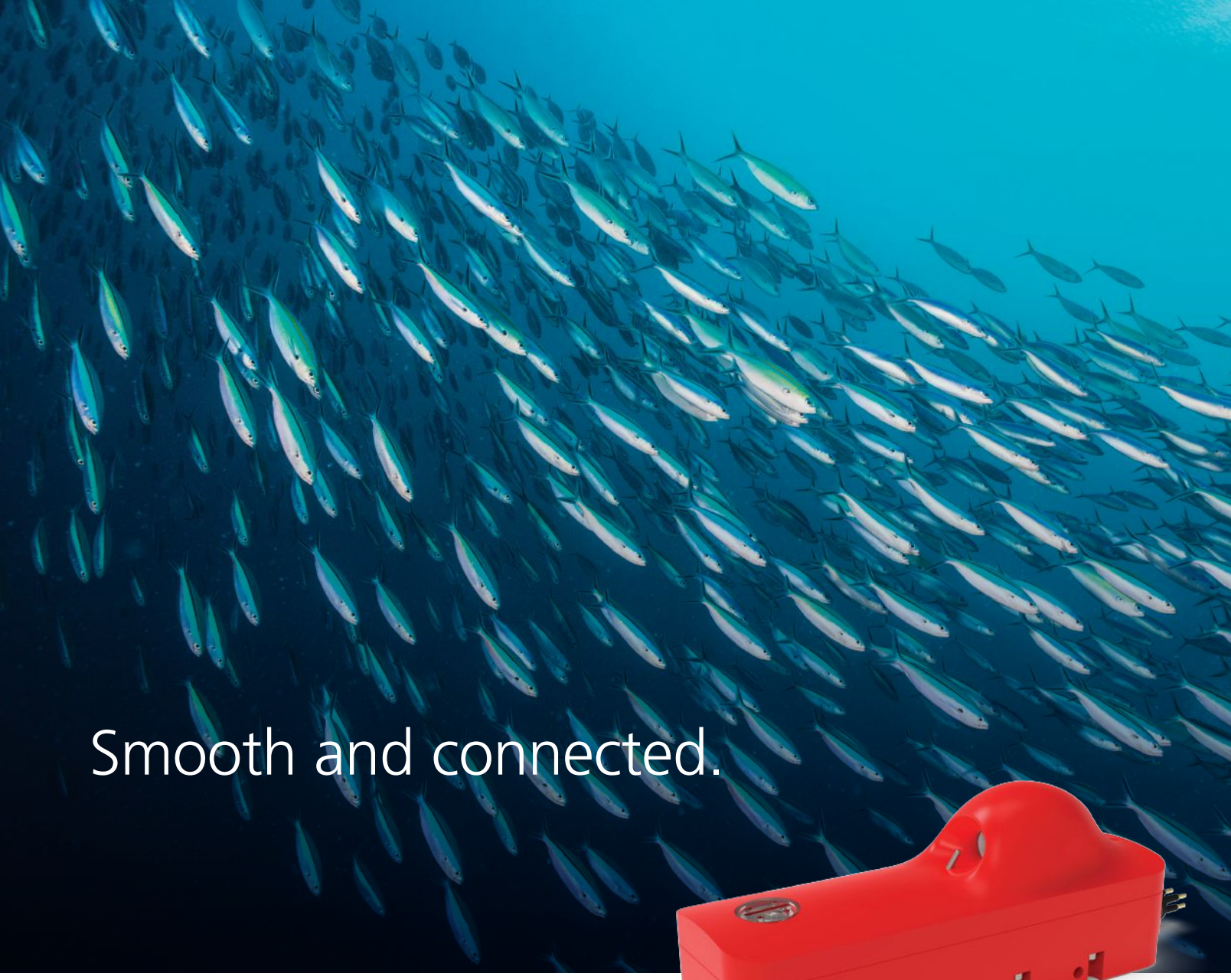
On the show floor exhibitors will deliver inspiring content on Sensors & Instruments, Vessels, Vehicles & Platforms, Data Communications, Data Analysis and more. Meanwhile, Town Hall programs in development will provide exhibitors, US Government and the Navy with more opportunity to interact, drive partnerships, and boost innovation and collaboration, while the US Government Ocean Hub has been developed in partnership with NOAA to provide greater connection between Industry and US Government technical, research and strategic personnel. The Hub will facilitate partnerships between federal agencies, industry, and academia to support climate change adaptation, ocean research, education and economic growth.

## EXCLUSIVE ON&T OFFER

We've negotiated a fantastic deal on OiA Conference Badges for ON&T subscribers.

Single day conference badges are usually $300, and 3-day badges are usually $650, however as a subscriber to ON&T you pay just $255 for a single day, and $552.50 for a 3-day Conference Badge when you use this code ON&TOIA2023 when prompted at registration.

There are even greater savings to be had if you buy multiple badges on the same transaction. It's easy to get your discounted badge, use this link *https://www.oceanologyinternationalamericas.com/en-gb/enquire.html* and fill in the registration form and when you come to payment details, simply pop the code in the promo box.




## Extend glider and AUV missions with the RBR*legato*³ C.T.D

Salinity, density, speed of sound, and more - the RBR*legato*³ C.T.D extends the measurement capabilities of gliders and AUVs. The CFD-optimized, pump-free design uses 90% less power than traditional CTDs and is unaffected by surface contaminants or freezing conditions. This enables longer deployments or high-resolution sampling in a wider range of environments. The RBR*legato*³ C.T.D can also control additional sensors to simplify integration, configuration, and data management.

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# THE FUTURE OF **DEEP-SEA MINING HINGES ON TECHNICAL TRANSPARENCY & FAILSAFE SYSTEMS**

**By Don Brockett**,
*Chief Operating Officer,*
*Okeanus Science & Technology*

In November, The Metals Company (TMC) announced the successful retrieval of 3,000 tonnes of potato-size polymetallic nodules from seafloor depths of over 4,000 meters in the Pacific Ocean's Clarion Clipperton Zone (CCZ). In total, over 4,500 tonnes were harvested by a custom Allseas-designed collector vehicle, of which 1,500 tonnes were purposely left on the seafloor, with the remainder being transported to the deck of the recently outfitted *Hidden Gem* via a 4.3-km riser pipe system.

For many, even the most seasoned of ocean professionals, deep-sea mining remains a cloudy prospect. Opinion and conjecture tend to dominate the headlines. Robust scientific analysis and technical transparency less so. However, for a certain breed of Deepwater technician—like those who comprise the expert subsea engineering and fabrication team at Okeanus—the successful completion of TMC's full scale-system demonstration in the CCZ—the first since the late 1970s—is more than just an historic milestone.

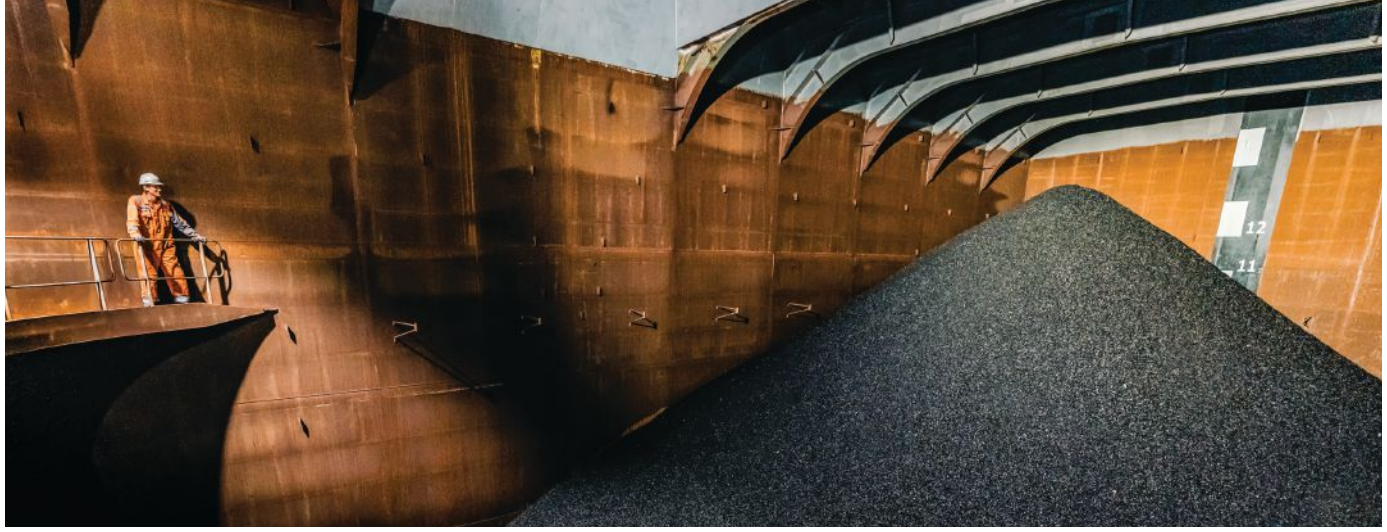
This profound accomplishment crowns decades of technical speculation and debate surrounding the most effective and responsible way to mine the staggering volumes of these naturally occurring rock concretions, rich in increasingly scarce metals such as cobalt, copper, and nickel, among other rare earth ores. (Accumulations vary but even conservative estimates suggest a potential of 15 – 20 kilograms of nodules per square meter.)

The goal for developers as they field these sophisticated collector systems is to establish and validate a safe, secure, and ecologically sound means of gathering and processing a yield of nodules sufficient enough to create not only a new and sustainable mining industry, but one able to supply today's society with a steady and reliable source of the much-needed metals required to build out and fulfil the infrastructural needs of tomorrow—a future reliant on mass electrification supported by next-generation battery manufacturing and towering renewable energy infrastructure—today. Stakeholders maintain that offshore mining activities will also help expand our collective understanding of deep-sea environments through a program of ongoing environmental monitoring.

## DEEP-SEA MINING TECHNOLOGY

Whether the seabed mining industry transitions from the current exploration phase to full commercial exploitation is now more a question of public policy and regulation—the purview of the International Seabed Authority (ISA) and its member states—as opposed to technical capacity. After all, much of the equipment used during TMC's pilot test isn't all that dissimilar to what was used by the mining consortiums in the late 1970s, one of which, Ocean Management Inc. (OMI), had now retired SOSI/Okeanus founder Ted Brockett leading the seafloor collection team, culminating in the first ever successful deepsea mining demonstration. Modified most certainly, but most of the critical assets—such as vessels and riser pipes—are borrowed straight out of the long-established offshore oil and gas E&P toolkit.

But not the collector vehicles; they truly represent the pinnacle of present-day subsea engineering. While current proposals do vary—for example, TMC and Allseas advocate the efficacy of a trencher-like vehicle, while others, including Impossible Metals (previously Impossible Mining), proffer a more exacting approach to nodule selection by deploying AUV swarms—designing equipment to operate reliably and efficiently at depths of up to 6,000 meters poses unique challenges. Notwithstanding the many technical innovations that our twenty-first



» *TMC's haul of 3,000 tonnes of polymetallic nodules aboard Allseas Hidden Gem. (Photo credit: TMC)*

century ingenuity has brought to underwater exploration, working at these depths isn't easy.

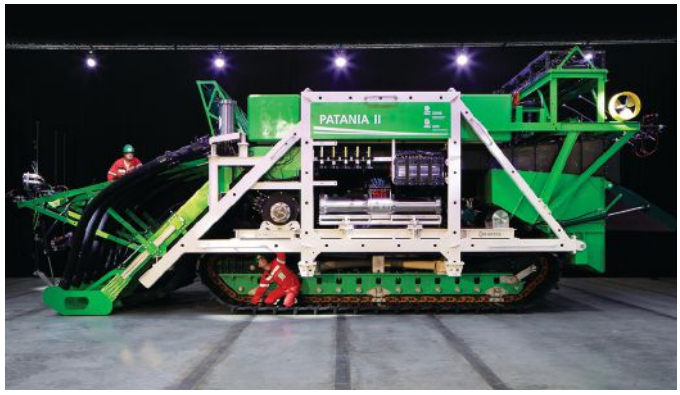
As an example, despite a very professional and transparent approach involving independent environmental monitoring and state-of-the-art technology, Global Sea Mineral Resources NV (GSR) ran into issues during their prototype seafloor nodule collector technology trial involving the connection between the umbilical and the collector. Before the incident happened, the trial had been progressing well, with the collector successfully traversing the seafloor and collecting nodules.

Importantly, GSR had prepared for multiple scenarios and the vehicle was successfully recovered within a few days and soon after was working again on the seafloor at 4200 m water depth. At the time, Kris van Nijen, Managing Director of GSR said: "We are taking a cautious, step-by-step approach to project development. We conduct these trials to better understand the challenges involved so we can continuously refine our technology. The prototype has functioned well, and learnings will be taken into the next phase of development." For GSR, attention now turns to developing a full-scale system with riser pipe.

## FAILSAFE ENGINEERING

These recent demonstrations—both by TMC and GSR—represent a culmination of many hours of research and development work on dry land, stretching back years. Okeanus was involved very early on in the development of a collector concept for OceanfLORE, a joint venture between IHC and DEME Group. DEME group later founded GSR.

This work, almost a decade ago, had its roots tracing back to some early SOSI and '70s collector designs. The final design has evolved since those concept stage CAD drawings, but the hallmarks of the initial engineering principles applied remain, and with good reason.




» *Patania II, GSR's deep-sea mining collector vehicle. (Photo credit: GSR)*

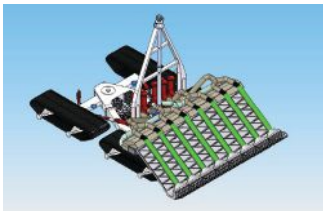
At Okeanus, we believe that the goal when designing technology to reliably operate in harsh and often unpredictable waters is to, as per the fabled U.S. Navy "KISS" principle (Keep It Simple Stupid) decrees, avoid "overengineering" a solution. Understanding what you can and cannot control at depths found in the CCZ is paramount, and unnecessarily complicating a mining system in the interests of stretching yield is an obvious trap.

*The most expediate and considered route to commercialization for deep-sea mining is one that promotes a greater transparency of in-situ testing, to both help abate environmental concerns and streamline monitoring and regulation.*

Some mining companies have, traditionally at least, been somewhat guarded about their proprietary technologies, but this will only anchor progress today. Clarity of information and cooperation are the key ingredients to meaningful collaboration now.

## HANDLING THE FUTURE

Operating in the deep ocean is challenging. The key, for an operator, is to manage any incidents that may occur and mitigate against a possible reoccurrence. Therefore, having the right launch and recovery assets and deck handling equipment to deploy these ultradeep-water systems—or indeed the ancillary assets such as an ROV to monitor its progress—is imperative.



» *Okeanus's original concept drawings for GSR/DEME's collector. (Image credit: Okeanus/DEME)*

Okeanus specializes in the design, development, and manufacturing of a wide variety of specialty multi-purpose winches, A-Frames, and Launch And Recovery Systems (LARS) for commercial Deepwater exploration. But we also recognize that, as is the case with pioneering deep-sea mining campaigns, for many applications a standard commercial-off-the-shelf product is simply not suitable or readily available. For such projects we partner with clients to engineer from scratch or manipulate existing proprietary designs to generate a purpose-built design ready for fabrication.

To find out more about Okeanus' expanding portfolio of full-service fulfillment and turnkey design and fabrication services, visit: *www.okeanus.com*.

# THE FUTURE OF **MARITIME IoT**

By metOcean telematics

MetOcean Telematics (MetOcean), a global leader in ocean tech, has built a business working in some of the most remote environments on the planet. When it comes to a future in which those environments are increasingly connected to the rest of the world by way of the Internet of Things (IoT), it's only fitting that the company has brought forward innovations meant to bridge the gap.

Headquartered beside the Atlantic Ocean in Dartmouth, Nova Scotia—a region with a longstanding connection to the fishing industry and the Navy, as well as a burgeoning ocean tech industry—MetOcean, which will soon celebrate 40 years in business, got its own start in ocean technology, focusing on real-time solutions for environmental monitoring. Over time, the company expanded through a partnership with JouBeh Technologies, a leading global Iridium® Satellite Reseller, and the fruits of that partnership, MetOcean Telematics, is now a pioneer in the field of satellite communications.

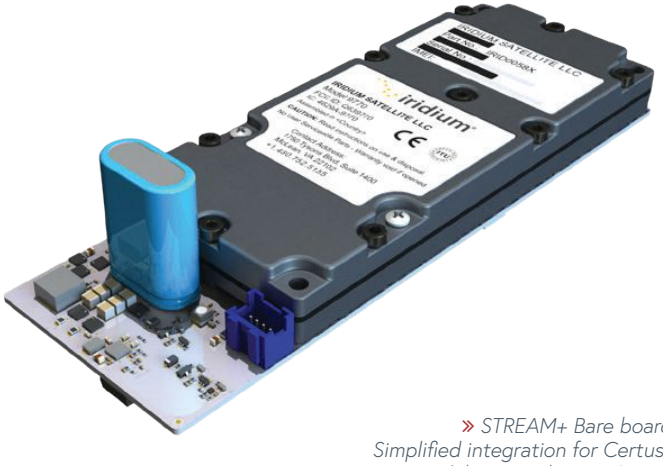
## MACHINE TO MACHINE COMMUNICATION

These two spheres come together in STREAM+, the company's latest product. Using the Iridium Satellite Constellation, STREAM+ allows users to send and receive data from anywhere in the world—including its most remote places. "We have no cell towers in the middle of the ocean," says MetOcean Technical Product Manager, Rami Nassif. "So, we have to rely on satellite technology to enable us to get critical communications."

While other products exist to provide satellite connectivity for the commercial market, Nassif says STREAM+ is filling a gap in the IoT space, offering machine to machine communication—for instance, with vessel monitoring systems, where a device needs to regularly transmit GPS data, or in systems meant to monitor for oil spills, where it's critical that information is relayed swiftly and securely.

Nassif says a key feature of STREAM+ is that it's designed to be accessible to users who haven't yet had the opportunity to work with satellite communications. "Where we position ourselves is we try to decrease that learning curve," says Nassif. This means an easy-to-use serial interface that allows someone to physically connect their device, as well as industry standard protocols such as PPP and FTP that are familiar to those with basic web developer skills; as a result, someone whose expertise is not primarily in satellite can still use the device. The device itself keeps a low profile, and is optimized to be both compact and lightweight while maintaining a competitive price point.


» *STREAM+ Enclosed unit: Data anywhere on the planet. (Photo credit: MetOcean)*




» *STREAM+ Bare board: Simplified integration for Certus®. (Photo credit: MetOcean)*

## PARTNERING WITH IRIDIUM

Nassif says the SatCom/IoT space is the direction the company has been looking to move in for years, but it's only recently that advances in technology and infrastructure have made this possible—including by partners at Iridium. In 2018, the Iridium Network achieved a breakthrough, with the launch of Iridium NEXT Constellation. The Iridium Network is the only truly global satellite network, and the 66-satellite constellation offers pole-to-pole coverage and built-in redundancy, as well as the advantage of using Low Earth Orbiting (LEO) satellites, which offer faster data transmission from ground to satellite and back. As part of this breakthrough, Iridium has deployed Certus®, a satellite broadband service allowing for IP-based connection over satellite, enabling products like STREAM+. Data access and transmission through STREAM+ are further simplified by the Iridium's integration with Amazon Web Services (AWS), allowing user information to be relayed directly to an AWS file management service rather than having to travel through the Network.

As part of MetOcean's growth in the satellite broadband space—and as an Iridium Value Added Reseller—MetOcean's offerings go beyond STREAM+ to cover the full range of maritime communication. These include the VesseLINK 200 and VesseLINK 700 from partner Thales, which use the Iridium Network to offer reliable essential voice, text, and web communications for captains and crew on vessels or fleets of any size, in applications ranging from safety services to operational reporting. With a simple interface, the VesseLINK can be easily integrated with existing equipment, offering an L-band connection with download and upload speeds of 176 kbps, for the VesseLINK 200, and for the 700, download and upload speeds of 700 kbps and 352 kbps, respectively. To support users, MetOcean also offers airtime plans for the Iridium Satellite Network, as well as 24/7 technical support for Iridium products.

## SUPPORTING USV OPERATIONS

*Going forward, cost-effective, reliable satellite connectivity stands to become even more important, as Unmanned Surface Vehicles (USVs)—remotely operated machines that travel on water surfaces—carry out a greater role in at-sea monitoring and data collection, a shift that has been accelerated by the pandemic.*

"Because of COVID-19 and the way things are progressing within the industry, users are looking for more of a reliable source to get their data," says MetOcean Director of Sales - SatCom, Emily MacPherson. "Due to operational logistics, costs, and overall safety for personnel at sea, government agencies and companies are limiting the number of personnel they send into the field to conduct studies and deployments. They are looking to more remote command and control options, like Iridium." This has already translated to significant growth in the global USV industry; from a valuation of approximately US$520 million in 2020, the industry is expected to grow at a CAGR of 10.5% through 2027, reaching US$1.1 billion by that year.

As the benefits of USVs from a cost and safety standpoint—as well as the scale of the issues they can help monitor, like water contamination—become ever more evident, USVs are setting a new paradigm for data collection. The STREAM+—which offers a bi-directional, real-time command and control option for remote applications—helps the USV industry realize this potential, offering reliability in the field while maintaining operational ease and decreasing costs for the end-user. In USV applications where the sizes of datasets being transmitted are larger than the STREAM+ (which offers 100 kbps of data throughput) can accommodate, the VesseLINK offers throughput of 700 kbps, augmenting the satellite coverage for USVs that MetOcean offers.


» *VesseLink on US Coast Guard Cutter Healy - operating ~600 nautical miles north of Prudhoe Bay, Alaska. (Photo credit: Thales)*


» *Thales VesseLink: Dependable maritime communications, from pole-to-pole. (Photo credit: Thales)*

» *VesseLINK outfitted on Unique Group Subsea Australia's Uni-pact USV. (Photo credit: Unique Group)*

The growing potential of satellite communication has changed users' expectations; people no longer want to be limited in how and when they can transmit the data they're collecting, says MetOcean CEO, Tony Chedrawy. In the years ahead, MetOcean is well positioned to capitalize on that increasingly limitless horizon. "This is the space we're [already] in," he says. "I see us continuing down this path for many years to come."

For more information, visit: *www.metocean.com*.

# THE FUTURE OF **DEEP SEABED MINING CALLS FOR MULTILATERALISM**

**By Michael W. Lodge**,
*Secretary-General, ISA*

> After more than 30 years of exploration, and considering new advances in marine technology, there is a clear role for marine minerals in decarbonizing our economies and supporting an inclusive blue economy.

The world must rapidly and drastically cut emission of carbon dioxide and other greenhouse gases. The question is how to do this without compromising social and economic growth? Part of the answer may lie in the seabed and its resources.

Clean energy technologies require a wide range of minerals and metals. Increasing the supply of these resources will be indispensable to the success of the green energy transition. The International Energy Agency has estimated that, under a sustainable development scenario, demand for minerals will quadruple by 2040.

The question is, where will these minerals come from? One option is to drastically increase the footprint of terrestrial mining, with all its attendant environmental, social and governance problems. Another option is to look at potential new sources, including marine minerals, which exist in abundance both on the continental shelves of States and in the deep seabed beyond national jurisdiction.

## ESTABLISHING A REGULATORY FRAMEWORK

This latter area, which covers more than 50 percent of the world's ocean floor, is subject to a unique global governance regime under the United Nations Convention on the Law of the Sea (UNCLOS) of 1982. It is managed collectively through an international organization—the International Seabed Authority (ISA)—created specially to ensure that the mineral resources of the deep seabed are developed in a way that guarantees equal access to all States and in a way that does not harm the marine environment.

UNCLOS establishes that it is the right of all States, rich or poor, developed or developing, coastal or landlocked, to conduct exploration and, eventually, to exploit deep-seabed minerals. The only conditionality around the exercise of this fundamental right is that all activities must be carried out in accordance with the rules, regulations, and procedures of ISA to ensure the protection of the marine environment.

## DATA-RICH ANALYSIS

Under this global legal framework, exploration has been taking place steadily and consistently over the past 30 years, ensuring that vast amounts of geological and environmental data are available to help ISA manage this global commons, using the best available scientific data and the precautionary approach. Several exploration contractors, including contractors sponsored by India, Japan, Germany, Belgium, and Nauru, have started to test mining components, including polymetallic nodule collectors, riser systems needed to lift minerals from 5,000 meters, and environmental monitoring and remote sensing technology. The results of these tests are giving us extraordinary insights into the environmental impacts of deep-sea mining and how they can be mitigated and avoided.

The results of these technological developments also feed into the regulatory processes currently ongoing at ISA. The ISA Council is currently developing the regulations to allow deep-sea mining to begin, including deciding on the proper environmental safeguards. These regulations must be adopted by consensus, thus ensuring that the regime is robust and has buy-in from all interests. The Council will continue the negotiations on the text in 2023. Completing this work is the best guarantee the world has that deep-sea mining will be carried out under a single global regime in a way that prevents damage to the marine environment and benefits all humanity.

## TRADE-OFF

After more than 30 years of exploration, and considering new advances in marine technology, there is a clear role for marine minerals in decarbonizing our economies and supporting an inclusive blue economy. Indeed, a critical trade-off may exist between deep seabed mining—which would be highly regulated and scrutinized through ISA—and reliance on growth in sometimes weakly regulated sub-sectors and terrestrial mining sites.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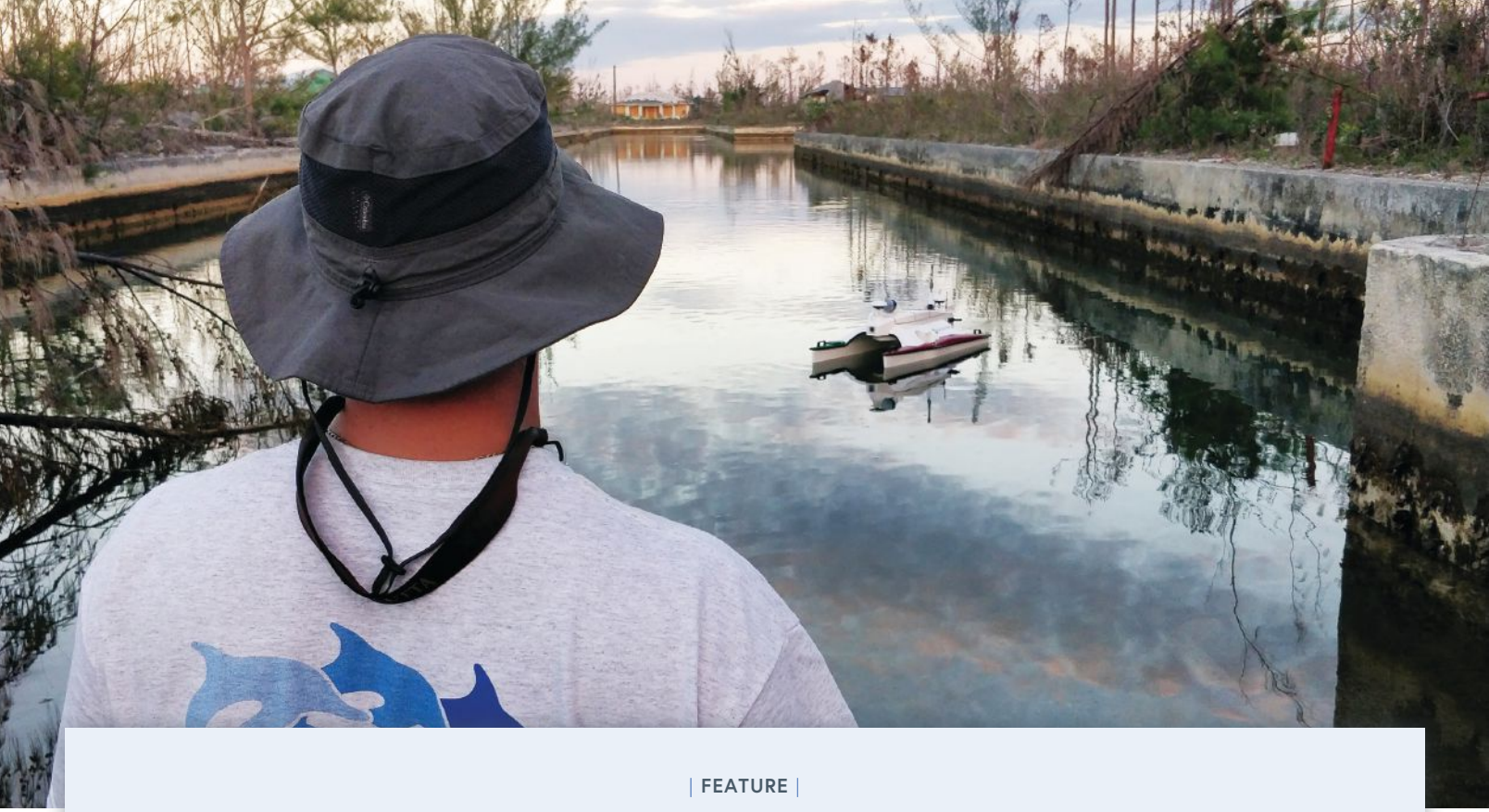


| FEATURE |

# THE FUTURE OF **TECH-INSPIRED COASTAL SURVEY FOR HURRICANE RESILIENCE**

**By Rob Collaro**,
*Director,*
*Morgan & Eklund*

Despite the rather bleak outlook published by the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC) in April, until late September, the 2022 Atlantic Hurricane season had proven, by historical standards at least, relatively benign.

Then, on September 26, Tropical Storm Ian, only the ninth named storm of the season, became the fourth hurricane—and second major hurricane—of 2022. Having impacted Cuba as a high-end CAT 3 system, it made landfall on Florida's east coast, near Punta Gorda, as a strong CAT 4, bringing sustained winds of 150 mph and a deadly storm surge. (Hurricane Ian has been confirmed as the deadliest to strike Florida since the 1935 Labor Day hurricane, claiming 157 lives in total, 146 in Florida.) Ian went on to cause widespread damage throughout the state before reentering Atlantic waters, and after this intensified again and made its second landfall in the US, this time South Carolina, as a CAT 1 hurricane. The financial toll for this year's villain is estimated to be over $50 billion.

Whether this season's final reckoning of 14 storms, 8 hurricanes (3 of which uncharacteristically formed in November), and 2 major hurricanes qualifies as "above-normal" activity is perhaps debatable. Still, the general uptick in extreme weather events over the last decade is less questionable. 2020 ranks as the most active Atlantic Hurricane season (June through November) on record (30 named storms), while 2021 (21 named storms) grabs third spot, denied only by 2005's infamous record of 15 hurricanes—7 major—and the well-documented devastation caused by Hurricane Katrina.

## COASTAL PRESERVATION MEASURES

Any variance in season forecasting, despite the extensive data and modeling capabilities, clearly creates challenges for the authorities charged with planning the necessary interventions designed to preserve coastal environments. Naturally, beaches and coastal communities bear the brunt of landfall interactions, and their concession to storm surge tends to swamp the media spotlight. But we can only fully assess the physical damage to shorelines once the storm passes and the waters recede, with beach erosion and sediment displacement of paramount concern.

The pressures placed on beach nourishment projects around the US coastlines, especially in Florida, highlights the extent of the problem. According to the National Beach Nourishment Database, which has been compiled over the last two decades and is updated annually by members of the American Shore and Beach Preservation Association (ASBPA), across 81 communities in Florida, there have been as many as 753 registered beach nourishment events, dating back to 1935.

Cumulatively, these projects amount to nearly 350,000,000 cubic yards of sand being strategically placed on 288.1 miles of beachfront at the compounded cost of over $1.9 billion. This constant investment in shifting sands represents an ongoing battle with nature to make coastal regions—and the communities that call them home—hurricane resilient.

| YEAR | NAMED STORMS | HURRICANES | MAJOR HURRICANES | ACCUMULATED CYCLONE ENERGY |
|---|---|---|---|---|
| 2012 | 19 | 10 | 2 | 132.6 |
| 2013 | 14 | 2 | 0 | 36.1 |
| 2014 | 8 | 6 | 2 | 66.7 |
| 2015 | 11 | 4 | 2 | 62.7 |
| 2016 | 15 | 7 | 4 | 141.3 |
| 2017 | 17 | 10 | 6 | 224.9 |
| 2018 | 15 | 8 | 2 | 132.6 |
| 2019 | 18 | 6 | 3 | 132.2 |
| 2020 | 30 | 13 | 6 | 179.8 |
| 2021 | 21 | 7 | 4 | 145.7 |

» *The ten years prior to 2022's Atlantic Hurricane season show a pronounced uptick in cyclonic activity. (Source: Colorado State University)*

» *The Atlantic Hurricane season has a profound consequence on Florida's coastlines and drives the need for ongoing beach restoration and nourishment projects.*

## RAPID RESPONSE SURVEY SERVICES

The measured execution of coastal restoration and beach nourishment projects relies heavily on surveyors to monitor the shifts in hydrographic and topographic variables on a particular stretch of the coast. This is an important part of what we do at M&E. We have been working with public and private sector clients for nearly 40 years to identify the cumulative impacts of extreme weather events through wading profiles with hardbottom mapping, onshore/offshore beach profiling pre- and post-event, multibeam surveys of artificial reef structures, and the inspection of dune conditions. Our goal is to assist authorities with the precise data required to trigger and monitor the most appropriate restorative action.

With greater frequency—and intensity—of storm events, time is of the essence. A major landfall, especially if it hits during an exceptionally

» *Coastal restoration and beach nourishment projects relies heavily on surveyors to monitor the shifts in hydrographic and topographic variables.*

high tide, will leave a stretch of coastline perilously exposed to repeat events. Our customers rely on our ability to rapidly mobilize and acquire and process the data they depend on.

To further streamline this process, our field teams deploy some of the most recent innovations in marine survey technology. For accurate analysis of shifting sediment, in the surf zone, intracoastal waters, or up and down the many manmade inlets around which so many communities dwell, surveyors rely on mapping above and below the waterline to render a 360-degree view of all data points.

*In recent years, we have capitalized on the advances in compact LiDAR systems and integrated them into some of the uncrewed assets we deploy to gather multibeam data.*

The synergy between this new generation of "pucks" and the latest multibeam sonars translates into immediate operational efficiency for all stakeholders.

## UNCREWED SYSTEMS

The ability to incorporate these and other relevant sensors into the payloads of Autonomous Surface Vehicles (ASVs) also affords us access to potentially hazardous waters. Geodata not only allows dredgers to plan interventions but also identify the quantity, size, and distribution of any storm-related debris, which in some cases can pose a significant threat to navigation.

We are currently mobilizing a team to the city of Naples, Florida, to survey the damage caused by Hurricane Ian. In addition to our standard survey toolkit, we will also be deploying one of our ASVs—a SR-Surveyor M1.8 (SeaRobotics)—both as a means of force multiplication and to access some of the more hard-to-navigate inlets, which are likely littered with debris. The portability and modular versatility of ASVs allow us to run quick spot surveys of manmade structures found in some of the inlets, such as vertical sheet pile walls and bulkheads, as well as hard-bottom mapping and beach profiling.

The growing acceptance of uncrewed vehicle technology for the survey of hurricane-prone coasts essentially equates to better data (advances in sensor accuracy marginalize human error), quicker (rapidly deployable force multipliers allow surveyors to focus on real-time data processing, not the handling of instrumentation), and for cheaper (fewer in-field overheads and topside support needed).

For more information, visit: *www.morganeklund.com*.

# THE FUTURE OF **MARINE ROBOTICS IN THE FIGHT AGAINST INVASIVE AQUATIC SPECIES AND HULL BIOFOULING**

**By Don Darling**,
*President,*
*SeaRobotics*

SEA ROBOTICS
AN ADVANCED OCEAN SYSTEMS COMPANY

How to mitigate against the spread of Invasive Aquatic Species (IAS) remains one of the most complex and pressing challenges in the marine domain. So much so, in fact, that the United Nations Environmental Programme considers the growing prevalence of these so called "marine invasions" as one of the four greatest threats to marine and coastal ecosystems.

Although planned actions to stifle these opportunistic micro-organisms, plants, and animals are often reported as local interventions, meaningful and long-term containment strategies require a comprehensive and concerted response from unified stakeholders in the ocean industries.

Reliable data are instrumental, not only to identify and monitor the migration of individual Invasive Aquatic Species but also to analyze the various *pathways* that enable them to prosper. While certain climatic variables, such as shifts in wind, ocean currents, and extreme weather, act as direct *pathways*, there are several human-mediated *pathways*, including common practices associated with the shipping industry, that offer IAS a "free ride," so to speak.

## BALLAST WATER

The standard operating procedures of the shipping industry are a source of ongoing review for the International Maritime Organization (IMO), the UN agency responsible for the safety and security of the shipping industry and the prevention of marine and atmospheric pollution associated with vessel operation. One area of ongoing concern is the treatment of ballast water. As much as 10 billion tons of ballast water is transported around the world each year by the global shipping industry's 55,000-strong merchant fleet, with large ships able to transfer over 50,000 tons of ballast water across the oceans in less than ten days. This constant displacement of seawater gives passage to around 7,000 species of aquatic plants, microbes, and animals every hour of every day as ships transit from port to port.

» *As much as 10 billion tons of ballast water is transported around the world each year by the global shipping industry.*

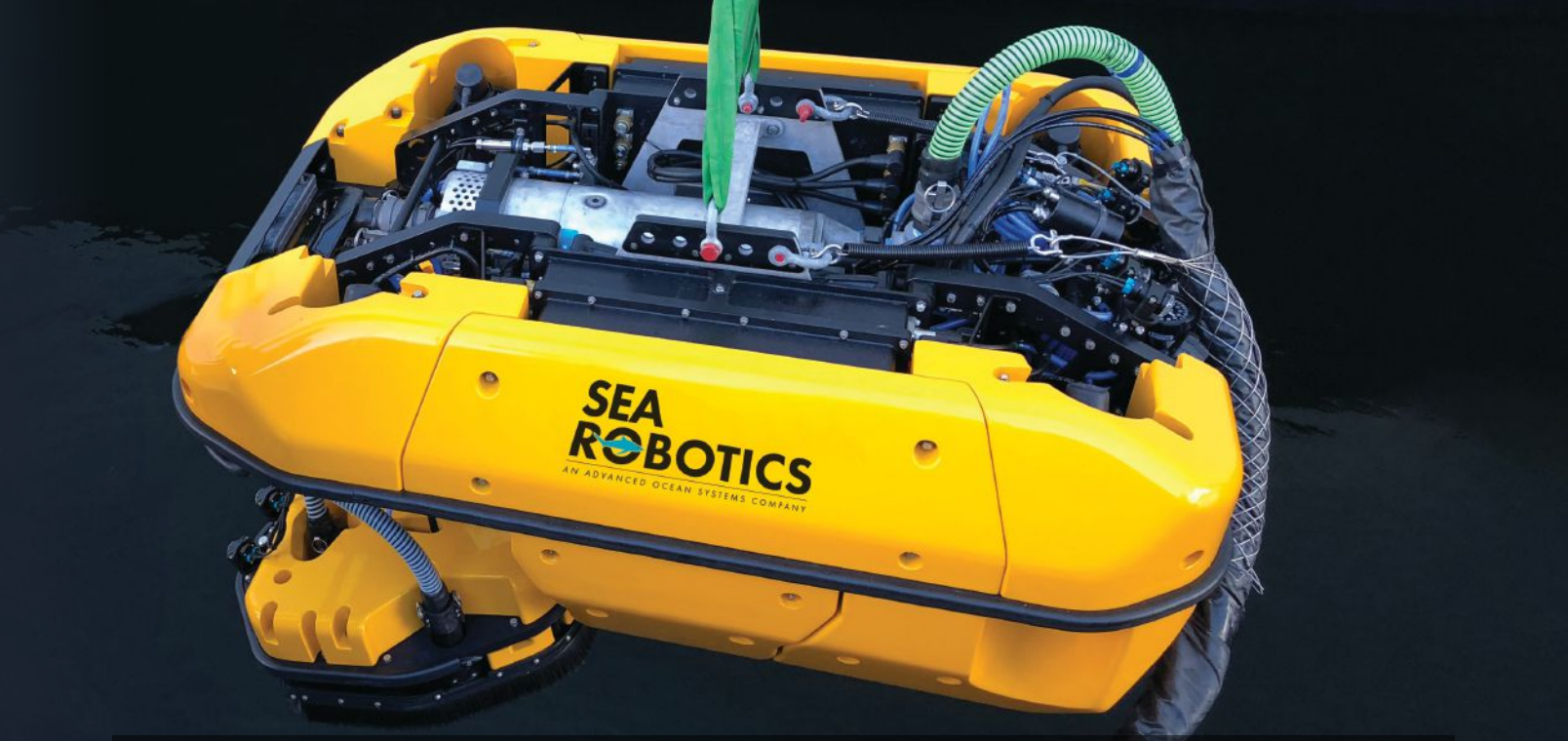
As a result, and in accordance with the IMO's Ballast Water Management Convention, there has been significant emphasis on the development and integration of ballast water treatment systems—which typically employ a number of cooperative technologies—to remove aquatic organisms and pathogens (or at a minimum render them harmless) before ballast water is released into a new location.

## BIOFOULING

Interventions for the second recognized *pathway*, hull biofouling—the undesirable accumulation of plants, algae, and microorganisms on a ship's hull—pose other, very distinct challenges for operators. The benefits of a clean hull extend beyond the containment of invasive species: colonized hulls cause exponential friction which, according to the Office of Naval Research, account for up to 60 percent more hydrodynamic drag; the more drag, the higher the fuel consumption and, therefore, the corresponding CO2 emissions. In short, dirty hulls benefit no one other than adept IAS.

*Recent advances in ocean technology, in particular subsea sensors and AI-led control systems, have accelerated the development of intelligent marine robotics designed to execute planned interventions to combat the spread of IAS by establishing a more tech-assisted approach to hull husbandry.*

Removing vessel fouling at the biofilm level—to proactively "groom" a ship's hull—safely and efficiently relies on the application




» *SeaRobotics' SR-HullBUG also uses a unique effluent capture and filtration system to remove fouling to the micron level. (Photo credit: SeaRobotics)*

of several complementary technologies but centers around the emerging capacity of subsea robots.

**MARINE ROBOTICS**

Over the years, there have been a number of prototypes fielded. Still, to date only a few vehicles have proven commercially scalable, such as Jotun's *HullSkater* ROV (Remotely Operated Vehicle), in partnership with Kongsberg, and Armach Robotics' Hull Service Vehicle (HSV), the headline act in the company's subscription-based robotic hull cleaning offering.

In terms of engineering architecture, the blueprints for the ROVs for hull grooming share much in common. But there are subtle differences, some of which are significantly dependent on whether the end-goal is to simply clean the hull or offer extended benefits, like removing the biofouling—and any associated invasive species—from the surrounding waters. For example, another field proven ROV, *Hullwiper* is notable for its capacity to filter the resulting effluent from grooming prior to releasing it back to the harbor, a task not achieved by either Jotun or Armach's ROVs. Thorough hull grooming may deliver performance benefits to a vessel, but it does little to safeguard the local subaquatic ecosystem if the offending effluents are simply pumped back into the sea.

Another distinction, *HullWiper's* in-port grooming services use adjustable high-pressure seawater jets to avoid, so the company says, the use of abrasive scrubbing or harsh chemicals. Whether this is a more effective approach than a brushing mechanism—as is the case with Jotun and Armach—demands further investigation. Like *Hullwiper*, SeaRobotics' *SR-HullBUG* also uses a unique effluent capture and filtration system to remove fouling to the micron level, allowing us to ensure that particulate and heavy metals are safely removed from the effluent before returning it to the surrounding waters. However, like the HullSkater and Armach's HSV, the *SR-HullBUG* favors brushes—nine in total—for its grooming tool.

**COLLABORATION NEEDED**

Advanced subsea technology will no doubt prove a facilitator in the fight against both IAS and hull biofouling. However, intelligent robotic systems will only get stakeholders in the maritime sector so far unless they are supported by stricter regulatory governance and an unwavering commitment by vessel owners to transparently "self-police" and document their hull management measures—which includes ballast water treatment. With the clarity that quality data provides, inaction is not an option. Only once this issue is treated as a communal challenge will a sustainable use of ocean resources be achievable.

» *SR-HullBUG uses a 9-brush tool to proactively groom a ship's hull. (Photo credit: SeaRobotics)*

Fortunately, there are several industry bodies that advocate a more comprehensive approach to mitigation, such as the Global Industry Alliance (GIA) for Marine Biodiversity, an initiative managed by GloFouling Partnerships, charged with improving biofouling management and tackling these two related environmental issues: the surging threat presented by the proliferation of Invasive Aquatic Species (IAS) and Greenhouse Gas (GHG) emissions from all offshore industries.

As nations recalculate a path to net zero and a more holistic and sustainable use of ocean resources, our ability to learn, adapt, and respond to scientifically robust data and unfolding macroeconomic scenarios will be critical. Today, thanks to more comprehensive subsea data, ratified regulations, and the precise integration of cutting-edge ocean technologies, we are better equipped to target and combat some of our most ardent adversaries, like IAS.

For more information, visit: *www.searobotics.com*.

# THE FUTURE OF **OFFSHORE WIND IS IN OUR SIGHTS**

**By Liz Burdock**,
*Founder and CEO,*
*Business Network for Offshore Wind*

> States across the US are scaling up for what they know will be a significant decade for American offshore wind. Now we must roll up our sleeves and work together.

US offshore wind has cemented itself as a cornerstone of the nation's energy transition. 2022 is the last transition year this industry will experience as our first commercial project puts steel in the water, and our dreams of an industry move from paper to reality. Pushing the market forward is unrelenting demand from states on three coasts, long-term favorable tax policies, and the support of the federal government.

The Inflation Reduction Act (IRA) was a major shot to the arm, itself largest clean energy bill ever passed, that will propel forward all renewable energies in the US. With the long-term development and manufacturing tax policies in place, consistent state demand, and new lease areas, we can clearly see just how robust and impressive the US market will be, and soon.

However, we knew standing up a new industry overnight would never be easy.

## COORDINATED COLLABORATION

As we move forward to installation on a large-scale, our reality becomes shared hurdles obstacles. None of this is unexpected—the US is attempting to establish a market in less than a third of the time it took Europe, so growing pains are inevitable. But the industry is facing major challenges, and without collaboration and coordinated action, project installations—that will lead to job creation, climate change mitigation, and economic growth—will be unacceptably delayed.

The Business Network for Offshore Wind has emphasized in meetings with federal and state government officials that the US must keep up the intensity and focus our efforts on building a strong, dedicated domestic manufacturing supply chain while addressing common bottlenecks.

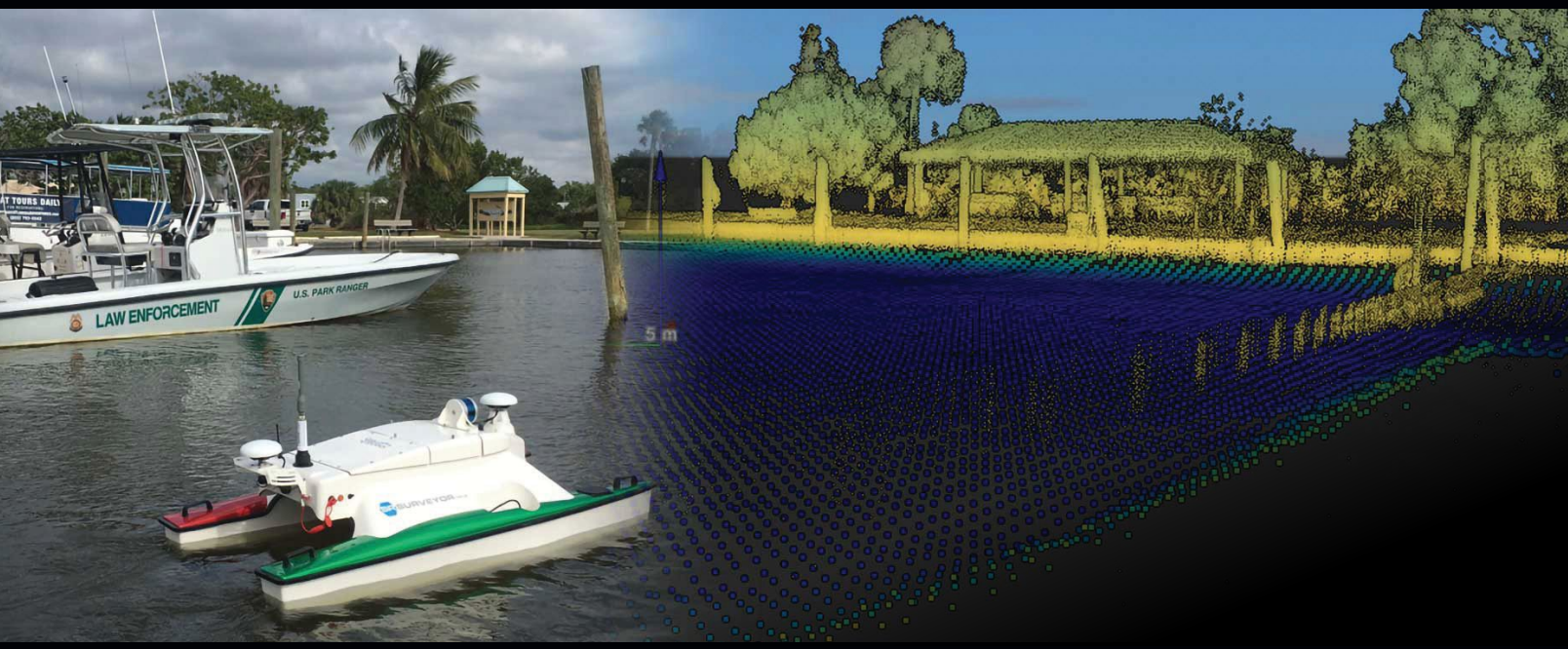
BOEM is doing tremendous work pushing the industry forward in a responsible manner, yet our permitting system still lags demand and projects have not yet consistently made their way through to final approval. To date, BOEM has completed three of seven wind energy lease sales and two of sixteen construction and operation plans (COPs) it planned to complete by 2025. The agency needs more support, our laws need to be updated, and the industry must find ways to collectively cut down on timelines with greater data sharing.

## INVESTING IN INFRASTRUCTURE

Our transmission system is still unprepared to foster aggressive development—a problem that is common to all renewable energies—and demands greater federal leadership to overcome regional collaboration issues. Our ports are receiving a steady stream of state and federal investment, but it may not be enough, and we have not yet solved our vessel and supply chain shortage. A recent federal report noted we needed five Wind Turbine Instillation Vessels (WTIVs) operating simultaneously installing hundreds of monopiles a year in US waters, but only two have been identified and our monopile facilities are still under construction.

If these problems seem large, the impacts of a global recession have finally caught up to the US market. Higher commodity costs, higher interest rates, and tight supply chains (in the face of equally growing global demand) threaten individual projects and wider market development. To meet the moment, we need build our industry holistically, which requires state and federal policies that foster robust domestic supply chain growth, workforce development, and higher wages.

The future of offshore wind is clear. Demand for offshore wind in the US continues to grow unabated. Current state long-term goals grew 60 percent in Q3 of 2022 alone and targets exceed 70 GW. States across the US are scaling up for what they know will be a significant decade for American offshore wind. Now we must roll up our sleeves and work together.

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# THE FUTURE OF ON&T

**By Your ON&T Team**

> Optimizing the next generation of tools designed to advance our understanding and exploration of marine environments—some of the harshest and most unpredictable on the planet—will rely on the ardent determination of its makers to apply breakthrough concepts to bring about meaningful change in the field.

This is the third volume of ON&T's ***The Future of Ocean Technology***. The intention of our inaugural year-end Special Edition, back in 2020, was to reunite industry thought leaders at a time when the in-person exchange of ideas, due to the disruption caused by the COVID-19 pandemic, proved almost impossible. We wanted to create a unique, article-only (no news) showcase for fresh thinking and shine a much-needed spotlight on some of the tech-led projects seeking to reshape operational best practices and debunk outdated conventions.

We were, to put it mildly, overwhelmed at the response. ***The Future of Ocean Technology*** has since established itself as one of our most popular editions on the calendar. Whereas with our regular editions—in which our editorial team carefully curates the news, views, and insights based on a carefully planned calendar of monthly themes—our December edition invites our readership and advertising partners to set the editorial agenda.

## UNCREWED SYSTEMS

Spoiler alert: one of the more dominant themes in the coming years, a view amplified in these pages, will be the advent and growing acceptance of uncrewed systems for a wide range of marine applications. The planned orchestration of increasingly autonomous assets above, on, and below the waterline—a cooperative ecosystem of Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs), Uncrewed Surface Vehicles (USVs), and Uncrewed Aerial Vehicles—continues to push operators towards a paradigm shift: remote operations.

ON&T will, therefore, extend its coverage of uncrewed systems, especially the uncrewed vehicle industry, in 2023. Not only will we publish the ninth version of our ***Uncrewed Vehicle Buyers' Guide (UVBG)*** in July, but we will also be complementing this "***Who's Who***" of advanced marine engineering with the Q1 2023 release of our latest ***USV Market Summary & Forecast***, a concise market study that presents exclusive insights into this fast-evolving market.

Dedicated subscribers of ON&T will no doubt notice a few other exciting editorial tweaks in 2023 as we continue to bring focus to what's next.

## COVERING WHAT'S NEXT

ON&T's new-look editorial calendar is now ready for download and sets out a broad range of trending topics. As always, if you have an editorial idea in mind, be sure to reach out—we want to hear from our readers.

Press releases, as ever, should be sent to *pr@oceannews.com* and content ideas are welcome via our website: *https://oceannews.com/your-content-matters*.

Covering what's next also means reporting on key industry happenings in person, so we are pleased to report that ON&T will be extending our coverage of key industry conferences. As a long-term media partner of the industry's premier events, both our editorial staff and our magazines will be onsite at many of the big meets—see our editorial calendar for planned distribution.

## A DEDICATION

As these tech-packed pages amply demonstrate, the future prospects for ocean technology are exhilarating. But for all the lure of smart technology, it would amount to little without its masters. Optimizing the next generation of tools designed to advance our understanding and exploration of marine environments—some of the harshest and most unpredictable on the planet—will rely on the ardent determination of its makers to apply breakthrough concepts to bring about meaningful change in the field.

And so, this Special Edition is dedicated to all the ocean professionals out there that make this future possible. *Thank you*.

# WE COVER WHAT'S NEXT

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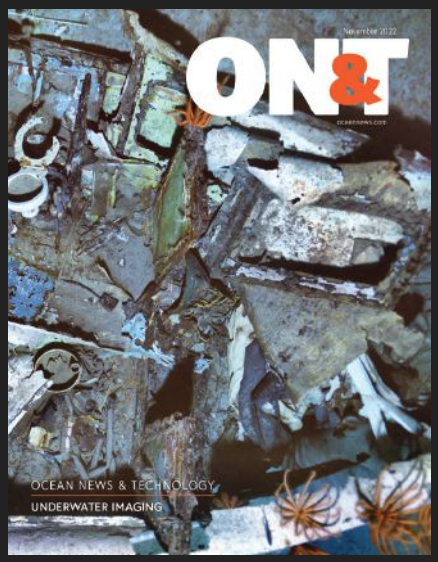







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| **MARCH**<br>**Editorial:** Feb. 20<br>**Ad:** Mar. 10 | » **UNCREWED VEHICLES**<br>Ocean Business / April 18-20 | **Editorial Topics:** Remote Marine Survey, Seafloor Mapping, Harbor Security, Long-Range Ocean Research, Coastal Monitoring<br>**Product Focus:** USVs, AUVs, LARS, UAVs, Sonars, Propulsion and Positioning Systems |
| **APRIL**<br>**Editorial:** Mar. 20<br>**Ad:** Apr. 7 | » **MARITIME DEFENSE & SECURITY**<br>UDT / May 9-11 | **Editorial Topics:** Coastal Surveillance, Mine Countermeasures (MCM), Anti-Submarine Warfare (ASW), Search & Rescue, Submarine Cable Infrastructure & Protection<br>**Product Focus:** USVs, XLUUVs, AUVs, ROVs, Amphibious Vehicles, MCM, ASW |
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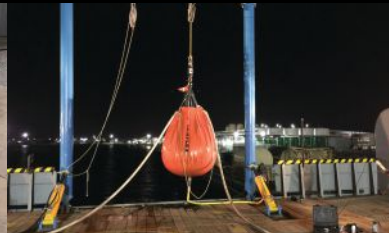

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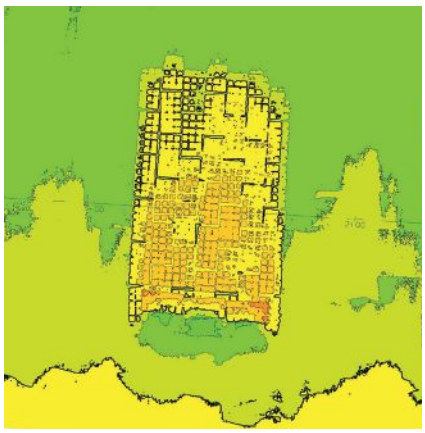

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