MARINE TECHNOLOGY REPORTER

January/February 2026
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UNDERWATER VEHICLE ANNUAL

TRENDS IN 2026

Subsea Defense
Threats, Modularity, and Agility

Atomic Clocks
Navigation in an Era of GNSS Spoofing

Oceanology International 2026
Bringing COAST to the Stage

Cable-Laying ROV
Quantum EV Takes Next Step Towards CLV Integration

Volume 69 Number 1

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On the Cover

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Editorial

Scan the QR code to access the **Marine Technology TV** YouTube page:

Belated happy new year and welcome back to another year with *Marine Technology Reporter*. We kick off our year the only way we know best—with the annual underwater vehicle issue. Starting on page 38, we look at seven companies to better understand what customers are looking for and how the underwater vehicle industry is keeping up with those demands.

On page 8, we further explore 2026 trends with David Strachan's column on subsea defense. This theme prevails throughout the issue, understandably mirroring the world outside. On page 14, Seequent explores solutions to advance unexploded ordnance (UXO) detection and later, on page 34, Wendy Laursen explores how increased global navigation satellite system (GNSS) spoofing has accelerated the development of atomic clock technology. Sonardyne continues the topic of navigation on page 24, monitoring seafloor movement with GNSS-A, which combines satellite positioning with underwater acoustics.

Amir Garanovic, managing editor of our Offshore Engineer title, takes a dive into SMD's electric remotely operated vehicle (ROV), Quantum EV, which will soon assume its role alongside Jan De Nul's Fleeming Jenkin cable-laying vessel (CLV). Later, on page 28, we celebrate the life and service of R/V Endeavor, the University of Rhode Island's recently retired research vessel, as the institution looks ahead to new horizons.

And last, but certainly not least, we're anticipating a lot of news flow during this year's Oceanology International (Oi26) at Excel London, March 10-12. This year's show features a new conference track, COAST, focusing on all things coastal for visitors and exhibitors. A deep dive on what COAST will look like in person can be found on page 42.

We'll be making new connections, reconnecting with old friends, and highlighting the best of the marine industry at Oi26. Ahead of the show, we encourage you to reach out and set up a time to chat. We look forward to seeing you across the pond.

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MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 69 *No. 1*
ISSN 1553-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

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

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

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Image courtesy of SIDUS Solutions, LLC

Upgrade Path for Existing Systems

Operators already using SIDUS SS250-series positioners can access absolute encoder performance without full replacement. SIDUS offers a backward-compatible absolute encoder upgrade that enhances reliability and accuracy while eliminating homing requirements. This approach allows fleets to extend system life and gain next-generation capability while protecting existing investments.

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For technical specifications, integration guidance, or upgrade options, contact SIDUS Solutions or visit: ***www.SIDUS-Solutions.com.***

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Britten

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Kevin Hardy is President of Global Ocean Design, creating components and subsystems for unmanned vehicles, following a career at Scripps Institution of Oceanography/UCSD. He holds patents in the field of ocean landers. He is on the academic advisory board of Instituto Milenio de Oceanografía at the Universidad de Concepción, Chile. Hardy received an honorary Doctor of Science degree from Shanghai Ocean University in 2018. He proposed making thick wall glass spheres to Nautilus Marine Service/Vitrovex (Germany) that opened the hadal depths to routine exploration. He writes for the *Journal of Diving History* and the *MTR*.

NEW YEAR, NEW GEAR:
Threats, Modularity, and Agility to Drive Subsea Defense in 2026

Official U.S. Navy photo

A U.S. Navy Global Autonomous Reconnaissance Craft (GARC) maneuvers in the Atlantic Ocean during UNITAS 2025, the 66th iteration of the world's longest-running multinational maritime exercise.

By David Strachan, Strikepod Systems

The year 2025 will be remembered as one of accelerating technological evolution and mounting geopolitical strain in the maritime domain. As the curtain rises on 2026, the stage is set for further disruption driven by advanced technologies, evolving undersea threats, and contested maritime spaces. From the North Atlantic to the Persian Gulf, from seabed imaging to surface surveillance, marine technology is increasingly central to securing access, protecting infrastructure, and managing escalation at sea. While the precise trajectory of these developments remains uncertain, six areas are likely to shape subsea defense in the year ahead.

Port and Harbor Security

On December 15, 2025, Russia's Novorossiysk Naval Base was rocked by a powerful underwater explosion. The Ukrainian Security Service (SBU) subsequently claimed to have struck a Russian Kilo-class submarine berthed inside the harbor using a previously unrevealed UUV, "Sub Sea Baby." If accurate, the incident marked the first known use of a UUV to conduct an attack inside a defended naval port. Beyond its impact on Russia's Black Sea Fleet, the strike exposed the vulnerability of well-protected, high-value harbors to uncrewed systems, and highlighted the ongoing convergence of mines, torpedoes, and UUVs. As a result, 2026 may see heightened interest in port and harbor security, including underwater barriers, intrusion detection systems, and non-kinetic counter-UUV systems, such as the Stingray net system from Annapolis-based Oceanetics.

The Finnish Navy vessel Hila with the Porkkala Coastal Battalion carries U.S. Marines with 2d Reconnaissance Battalion, 2d Marine Division During Operation Baltic Sentry in Southern Finland, Feb. 25, 2025.

U.S. Marine Corps photo by Lance Cpl. Brian Bolin Jr.

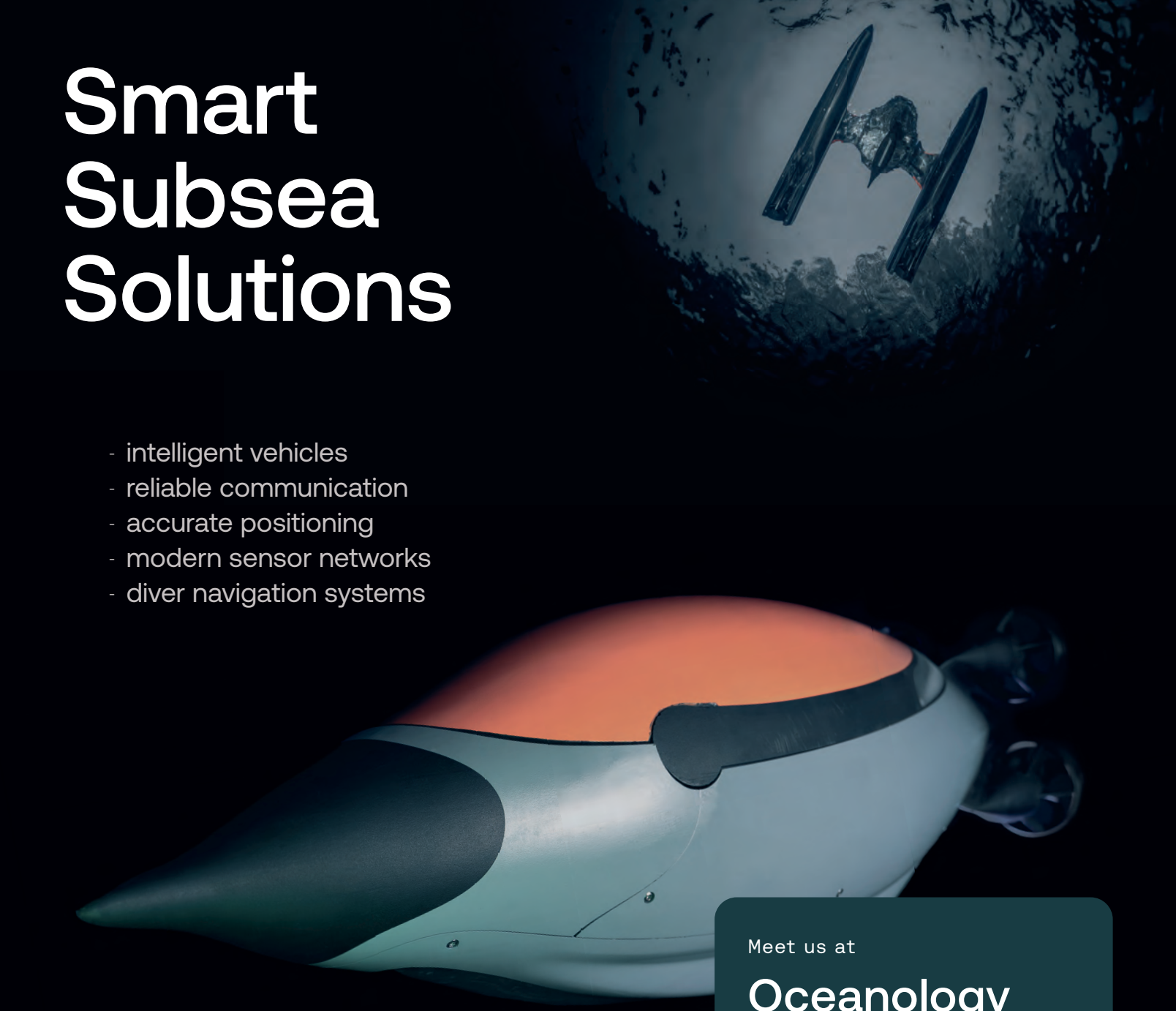
Critical Underwater Infrastructure Defense

Recent subsea incidents continue to underscore the vulnerability of critical underwater infrastructure (CUI) and the growing need for systematic protection. Repeated disruptions to submarine cables and pipelines in the Baltic Sea, South China Sea, and Red Sea have exposed how contested the seabed has become. In response, NATO announced Operation Baltic Sentry in January, 2025 to enhance vigilance and deterrence in the Baltic Sea. Similarly, in December 2025 the United Kingdom launched Atlantic Bastion, a broad initiative aimed at strengthening undersea threat monitoring and response across the North Atlantic, including protection of CUI. Atlantic Bastion seeks to integrate autonomous surface and underwater vehicles, crewed ships, aircraft, and advanced sensors into AI-enabled networks capable of detecting, tracking, and responding to undersea threats. While Atlantic Bastion extends beyond seabed infrastructure protection alone, it illustrates how undersea security is increasingly being approached as a systems problem rather than a platform-specific challenge. In 2026, further advances in seabed mapping, persistent sensing, autonomous inspection, and AI-enabled data fusion will continue shifting protection of CUI toward continuous, networked awareness and response rather than episodic patrols.

XL-AUV Deployment

With Anduril's Ghost Shark now a Royal Australian Navy

Smart Subsea Solutions



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- reliable communication
- accurate positioning
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Credit: Anduril

U.S. Navy Graphic/Released

Graphic illustration of the Orca, an extra-large class Unmanned Undersea Vehicle, Naval Undersea Warfare Center Division Keyport was assigned as the In-Service Engineering Agent.

Freedom AUV and Liberty Resident System Mobile Docking.

Credit: Oceaneering International

(RAN) program of record, 2026 may mark the first year an extra-large autonomous underwater vehicle (XL-AUV) formally assumes an operational role. Early employment is likely to emphasize integration into fleet exercises rather than routine tasking, but this would represent a meaningful transition from demonstration to adoption. The RAN could emerge as an early reference model for how large autonomous undersea platforms can be incorporated into fleet operations at scale.

By contrast, the future of the U.S. Navy's XL-UUV effort, Orca, remains uncertain. The Government Accountability Office (GAO) has questioned whether it will transition to a program of record, and in late 2025, reporting emerged that a draft Navy plan associated with the new Portfolio Acquisition Executive for Robotic and Autonomous Systems (PAE RAS) proposed canceling or redirecting funding for Orca as well as BlackSea Technologies' Global Autonomous Reconnaissance Craft (GARC). Since Orca was conceived, Navy acquisition culture has increasingly emphasized expendability, commercial solutions, and rapid prototyping. While Orca is capable and carefully engineered, its size, cost, and complexity make it difficult to scale and somewhat ill-suited to this environment. Even if restructured rather than canceled outright, Orca may primarily function as a testbed, with its autonomy, endurance, and integration lessons informing future extra-large vehicle efforts. Although no direct replacement has been announced, the Defense Innovation Unit (DIU)'s call for a Combat Autonomous Maritime Platform (CAMP), a commercially available, demonstration-ready system for long-range, high-capacity payload delivery, appears at minimum to be a hedge against Orca's uncertain trajectory.

DIU Accelerated Procurement

High-velocity procurement pathways, particularly through DIU, are likely to remain a defining feature of defense acquisition into 2026. This approach was evident in 2025 across multiple domains, including the undersea environment, with DIU's calls for CAMP as well as low-cost undersea effectors. Earlier, in 2024, uncertainty surrounding the Snakehead program's transition to a program of record led the Navy to pursue a COTS solution, selecting Oceaneering International to provide a large displacement unmanned undersea vehicle (LDUUV). This pattern of prioritizing fieldable capability over prolonged development cycles appears set to continue. Momentum is already carrying into 2026 with DIU's call for an Autonomous Vehicle Orchestrator, a vehicle-agnostic, plain-language system designed to task, coordinate, and manage autonomous platforms at the fleet level. Structured as a $100 million challenge to be executed through a series of iterative vendor sprints, the effort reflects DIU's intent to compress timelines, broaden vendor participation, and arrive at operationally relevant prototypes more quickly. These initiatives signal a continued shift away from monolithic programs toward an acquisition model aimed at delivering autonomy-enabled capabilities at speed and scale.

Integrated Mine Countermeasures (MCM)

Last year marked several key milestones in the mine countermeasures (MCM) space. The U.S. Navy deployed its first operational Littoral Combat Ship (LCS) MCM mission packages, just as the last remaining Avenger-class MCM ship, USS Devastator, was formally decommissioned in September. In Europe, the Dutch Navy's future mine countermeasures vessel HNLMS Vlissingen entered sea trials in early 2025, representing a new generation of robotic MCM platforms emerging from the joint Belgian–Dutch program to replace the Tripartite- and Alkmaar-class minehunters. At the payload level, NATO placed

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Universities, research centers, underwater archaeology teams

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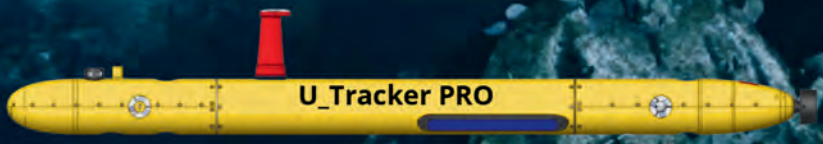

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Use cases:
Commercial diving companies, port authorities, industrial inspection teams

Advantages:
Industrial-grade mapping, real-time diver support, precise bathymetry, endurance, FOG INS, GNSS-denied operations, precise imaging, precise georeferencing, man-portable system

U_TRACKER L

Use cases:
Offshore and subsea inspection, critical infrastructure monitoring, maritime surveys, autonomous navigation in complex environments, long-range missions, oceanographic monitoring

Advantages:
Mission-grade precision, high-resolution sonar and cameras, long endurance, FOG-based INS, GNSS-denied operations, edge computing, user-friendly interface, post-mission analysis, man-portable system

FOR MORE INFO

EdgeLab S.p.A. edgelab@edgelab.eu www.edgelab.eu

The merchant vessel Seaway Hawk sails in the Arabian Gulf while transporting decommissioned U.S. Navy Avenger-class Mine Countermeasures Ships, USS Devastator, USS Dextrous, USS Gladiator and USS Sentry.

U.S. Navy photo by Mass Communication Specialist 2nd Class Iain Page

a multi-nation order for several hundred Exail K-Ster mine neutralization vehicles, reinforcing a shift toward standardized, unmanned MCM capabilities across allied navies.

As geopolitical instability persists in key maritime regions, MCM is likely to remain a high-level procurement and operational priority in 2026. Two potential flashpoints could see MCM forces operating in live environments this year: a post-conflict mine clearance effort in the Black Sea should a ceasefire in Ukraine prompt NATO involvement, or renewed MCM activity in the Persian Gulf if U.S. pressure on Iran intensifies following recent crackdowns. In both cases, assured access and freedom of navigation would hinge on the rapid deployment of effective MCM forces.

In 2026, we will likely see increasing emphasis on interoperability at both the platform and payload levels to enable seamless coalition operations, driven in part by improvements in data fusion. MCM may also converge with broader undersea domain awareness and CUI protection missions, as the same sensors, platforms, tactics, and analytics used to counter mines are increasingly applied to monitoring seabed cables, pipelines, and port approaches.

Containerization

As navies contend with aging fleets, constrained budgets, and rapidly evolving undersea threats, containerized payloads are emerging as a core naval architectural principle. Modular, mass-producible, platform-agnostic, and comparatively low-cost containerized systems offer a practical way to configure force packages with minimal impact on hull design or crew training. In 2025, the U.S. Navy reinforced this approach by soliciting industry proposals to rapidly prototype containerized payload unmanned surface vessels (USVs) capable of being fielded quickly and at scale. Under the Modular Attack Surface Craft (MASC) initiative, which consolidated the Navy's Large and Medium USV programs, USVs are envisioned as standardized carriers for containerized payloads, including sensors, communications systems, electronic warfare equipment, and weapons. In 2026, containerization is likely to further solidify its role as a risk-reduction mechanism for naval procurement and force structure, with interest expanding into modular ASW, minelaying, MCM, and CUI defense systems. Industry players such as SH Defence, with its proprietary Cube plug-and-play mission modules, illustrate how containerization is enabling navies to field adaptable capabilities without committing to fixed platform architectures.

Harder, Better, Faster, Stronger

Trends emerging from 2025 point toward a maritime security environment defined by ruggedized, distributed, adaptable payloads, persistent awareness, and operational agility. As autonomy, modularity, and data-driven subsea operations continue to mature, 2026 will likely see navies prioritize flexibility, interoperability, and speed of integration over exquisite, single-purpose solutions. Whether addressing mine threats, protecting CUI, or countering uncrewed systems, success will increasingly hinge on the ability to sense, decide, and respond decisively across domains.

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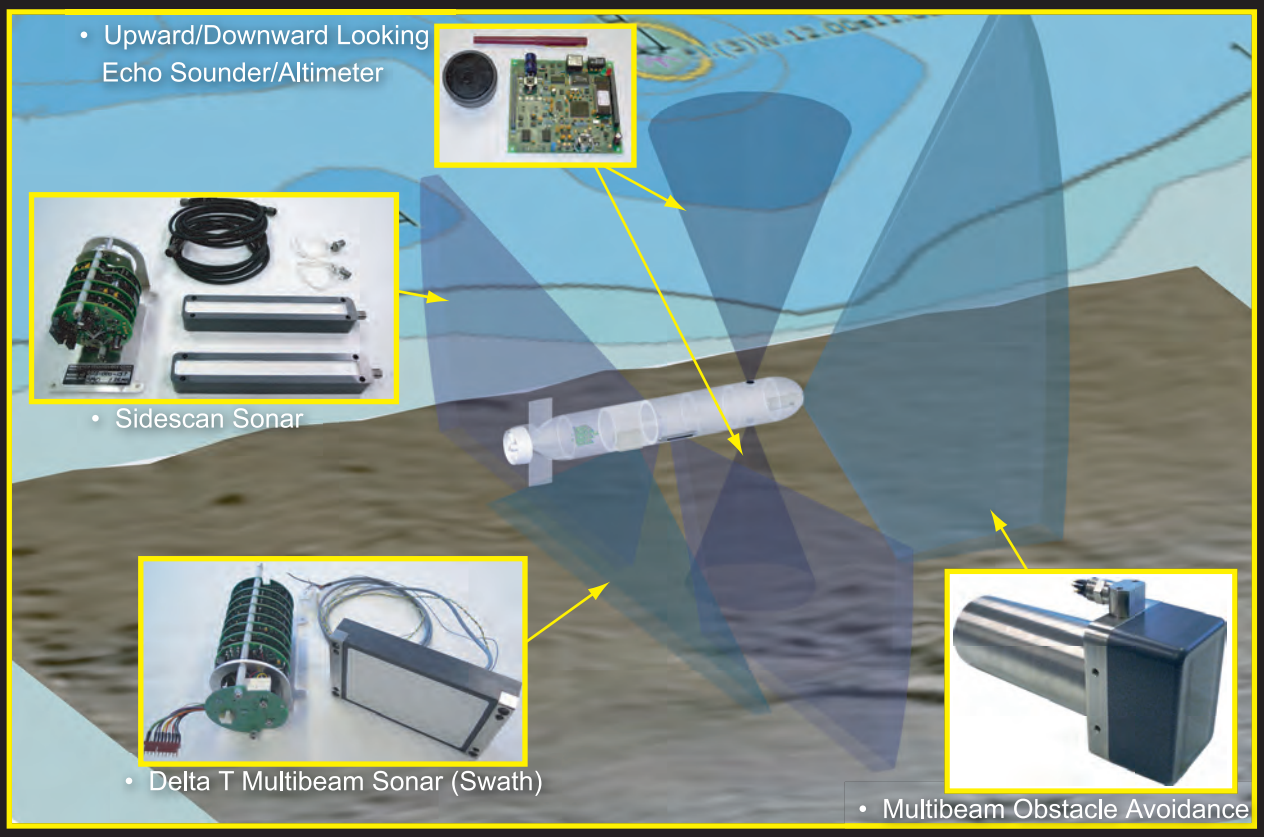

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MODERNIZING UXO DETECTION:
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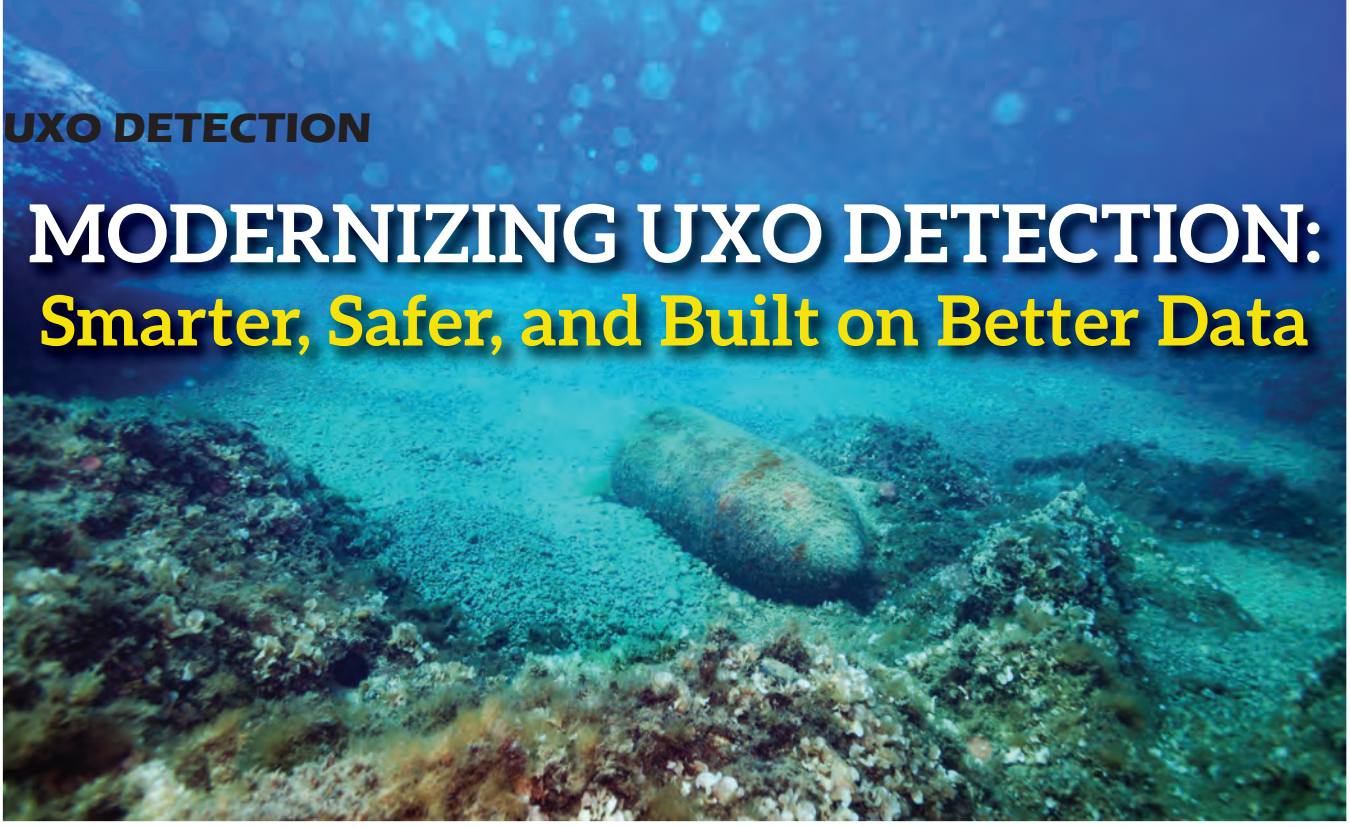

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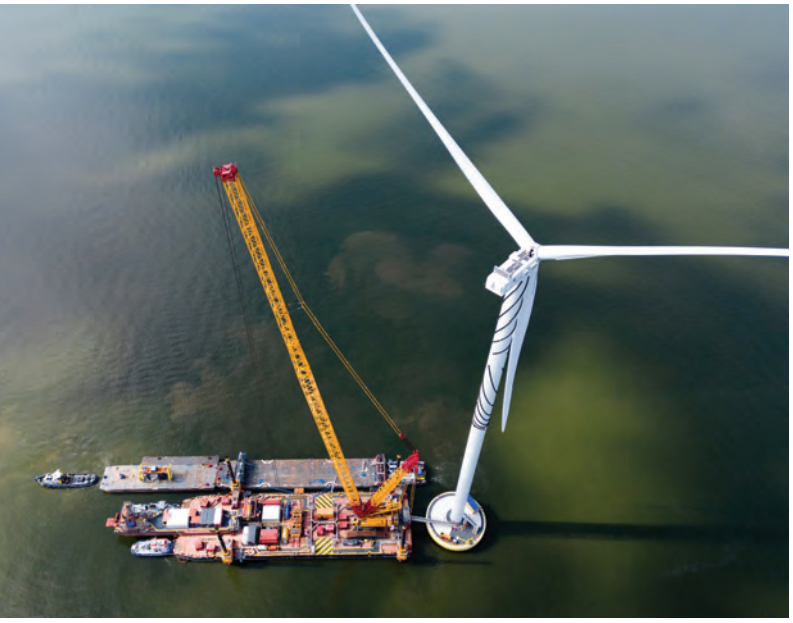
Unexploded ordnance (UXO) remains one of the most pressing challenges for marine infrastructure projects worldwide. With more than 80 countries affected, 110 million landmines still hidden, and 20,000 deaths annually, the need for effective UXO detection has never been more urgent—or more complex.

Before offshore wind farms or subsea cables can be installed, UXO campaigns must clear the seabed of dangerous items. These operations are essential for safety but come at a high price: vessels costing upwards of £50,000 per day, investigating just ten targets daily. Yet, recent analysis shows that only 4% of investigated targets are actual UXO—highlighting enormous potential for optimisation.



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Smarter Target Reduction and Advanced Algorithms

Industry innovators are responding. Seequent, a global leader in subsurface software, is helping transform UXO detection through advanced geophysical tools like Oasis montaj and its UXO extensions. These solutions unify disparate datasets, streamline workflows, and enable consultants to extract maximum insight from magnetic data—reducing time, cost, and risk.

One of the most exciting developments comes from Jack Brighouse, founder of ALM Geophysics, who has spent over three years developing the ALM Classifier. This sophisticated optimisation algorithm compares new magnetic responses against thousands of historical UXO signatures, providing unprecedented confidence in target classification. With over 3,000 targets already in the system—including 230 confirmed UXO—the classifier is proving its potential to cut unnecessary investigations and save millions.

"When you're paying £50,000 a day for a vessel, even a 10% reduction in targets represents huge savings," says Brighouse. "But it's not just about cost—it's about making smarter decisions and demystifying UXO detection."

The Foundation: Good Data Matters

While new workflows and algorithms are transforming UXO detection, one principle remains unchanged: "Garbage In, Garbage Out." Even the most advanced tools cannot deliver accurate results without clean, reliable data. A solid foundation of quality data is the most important piece of the puzzle.

An accurate interpretation depends on careful data cleaning and correction—steps that are often treated as optional but are critical for success. Corrections for issues like sensor lag, navigation errors, heading, background noise, sensor levels, and altitude must be applied consistently to ensure confidence in the final dataset.

© koiguo/Getty Images - Image courtesy Seequent

Beyond these basics, strategic processing decisions matter. Knowing when inversion should or shouldn't be applied, how to use signal-to-noise separation effectively, and realistically assessing confidence in depth models can dramatically improve outcomes. By taking the time to ensure your starting data is the best it can be, you enhance the accuracy of your interpretation and maximise the effectiveness of every tool you use.

The Future of UXO Detection

The future lies in combining quality data, smart algorithms, and modern technology—from AI and drones to advanced geophysics. These innovations are not only improving efficiency—they're making infrastructure projects safer for everyone.

Meet Us at Oceanology International 2026

Join Seequent and leading experts at Oceanology International 2026 to explore how modern technology is reshaping UXO detection. Visit us at Stand R301 for demonstrations of Oasis montaj UXO workflows, and discover how you can make your next marine project safer, faster, and more cost-effective. Secure your Free Oceanology ticket here.

Download our free eBook, "Modernising UXO Clean-up," to explore these breakthroughs in detail and hear from experts driving change across the sector.

Seequent, The Bentley Subsurface Company, helps organisations to understand the underground, giving them the confidence to make better decisions faster. Seequent builds world-leading technology that is at the forefront of Earth sciences, transforming the way our customers work. Every day we help them develop critical mineral resources more sustainably, design and build better infrastructure, source renewable energy, and reduce their impact on the environment. Seequent operates in 145+ countries while proudly maintaining headquarters in New Zealand.

Celebrating the completion of Site Acceptance Testing of the first commercial Quantum EV for client Jan De Nul.

Credit: SMD

FROM TRIALS TO CABLE LAY:
SMD Quantum ROV Set for Fleeming Jenkin Integration

By Amir Garanovic

Subsea technology and services company SMD has completed Site Acceptance Testing (SAT) on the first of its pioneering electric subsea remotely operated vehicles (ROVs), the SMD Quantum EV, marking a milestone as the system moves toward offshore deployment. The SAT operations were carried out at DEEP Campus near Bristol.

The first Quantum EV, purchased by Luxembourg-based marine contractor Jan De Nul, is expected to be integrated into Jan De Nul's Fleeming Jenkin cable-laying vessel (CLV) ahead of commercial deployment in 2026, linking the arrival of a new electric work-class ROV platform with a new-generation CLV designed for large-scale offshore renewables work.

SMD Quantum EV: Electric ROV Design and Performance

The Quantum EV forms part of SMD's modular electric vehicle (EV) range, designed to support work-class subsea intervention while reducing the inefficiencies associated with conventional hydraulic ROV systems. According to SMD's product documentation, electric propulsion allows a higher proportion of input power to be converted into usable thrust reaching 63%, compared with hydraulic systems capable of 34% conversion, while also reducing topside power and equipment requirements.

The launch of Fleeming Jenkin CLV.

Credit: Jan De Nul

The EV platform is designed to operate in multiple configurations, including umbilical-powered, battery-powered roadmap, or hybrid modes combining both. SMD also highlights the possibility of deploying the vehicle using a lighter, data-only umbilical in battery mode, reducing drag and simplifying launch and recovery. For umbilical-powered operations, the system uses a high-efficiency, high-voltage DC power transmission approach intended to reduce umbilical size and handling loads.

In its standard configuration, the Quantum EV has a depth rating of 3,000 meters, with optional configurations rated to 4,000 meters and 6,000 meters. The vehicle has a payload capacity of up to 400 kg and a total vehicle power of 200 kW or 268 hp. Thruster configuration consists of four horizontal and four vertical Curvetech electric thrusters, supporting high levels of maneuverability and station-keeping accuracy.

Performance figures provided by SMD include impressive bollard pull and surface speeds, enabling the system to continue operations in high currents. Auto-functions include heading, depth, altitude and ROV dynamic positioning.

The vehicle is also designed to support a range of tooling options, including hydraulic tooling supplied by onboard power units, enabling it to perform intervention, inspection and construction support tasks in demanding subsea environments.

Fleeming Jenkin CLV as Operational Platform for SMD Quantum EV

Fleeming Jenkin, Jan De Nul's newest CLV, was launched in October 2025 at the CMHI Haimen shipyard in China by flooding the dry dock and is scheduled for delivery in the second half of 2026, after completion of final construction and sea trials.

Designed for the installation of subsea cables for renewable energy transmission, the vessel has a cable carrying capacity of 28,000 tons, making it the largest cable-laying vessel in the world.

Fleeming Jenkin is equipped with three cable carousels—two 11,000-ton turntables above deck and one 7,500-ton turntable below deck—along with two fiber optic tanks, enabling the vessel to bundle and lay up to five cables simultaneously, with combined carousel capacity described by Jan De Nul as double that of any other cable-laying vessel currently on the market.

On the aft deck, the vessel features a cable laying chute for shallow-water operations and a cable laying wheel to improve efficiency at greater depths, supported by three 50-ton tensioners capable of handling and controlling cable tensions of up to 150 tons.

The vessel is designed to install cables in water depths of up to 4,000 meters and will be equipped with two work-class ROVs housed in a dedicated ROV hall, each with a 4,000-meter depth rating.

From an environmental perspective, Fleeming Jenkin is classified as an Ultra-Low Emission vessel (ULEv), featuring a dual exhaust filter system that removes up to 99% of nanoparticles from emissions using a diesel particulate filter and nitrogen oxides (NOx) reduction system, while its engines can operate on biofuel and green methanol.

The vessel also incorporates an electric hybrid power plant combining generators with a 2.5 MWh battery, designed for peak shaving, load smoothing, spinning reserve and optimized engine loading.

Once operational, Fleeming Jenkin will immediately begin work on TenneT's 2 GW Program, installing export cables on four offshore grid connections, bundling and laying four cables per connection, resulting in the installation of more than 2,800 kilometers of cable over a distance exceeding 700 kilometers.

Why the Pairing Matters for Next-Gen Subsea Ops

Taken together, the SAT milestone for SMD's Quantum EV and the build-out of Fleeming Jenkin CLV underline a broader trend visible in the project details provided by both companies—scaling up offshore wind transmission infrastructure, while tightening operational efficiency and emissions performance across the vessel-and-tooling chain.

SMD's vehicles put emphasis on endurance, precision, and reduced downtime for subsea tasks, while Jan De Nul's vessel is described as purpose-built for larger, heavier cable campaigns at greater water depths—supported by an emissions-control package and hybrid power architecture.

With installation on Fleeming Jenkin expected soon and commercial deployment referenced for 2026, the first Quantum EV system is now moving from test completion toward field readiness anchored to one of the industry's newest high-capacity cable layers.

Underwater acoustic monitoring:
safeguarding marine life in harbour expansion projects

The world's ports are expanding at an unprecedented rate. Driven by the rapid growth of offshore wind energy, increasing global trade, and the need to accommodate ever-larger vessels, harbour extension projects have become a cornerstone of modern maritime infrastructure development. However, beneath the surface of these engineering achievements lies a significant environmental challenge: **underwater noise pollution**. Construction activities such as pile driving, dredging, and rock placement generate intense sound levels that can severely disrupt marine ecosystems. To address this issue, underwater acoustic monitoring has emerged as an essential tool, enabling port authorities and construction firms to mitigate the impact of noise on marine life while ensuring regulatory compliance.

This article explores the critical role of underwater acoustic monitoring in harbour expansion projects, examining its technological foundations, regulatory frameworks, and real-world applications through case studies in Europe and the Caribbean.

The environmental impact of underwater noise in port construction

Marine construction activities produce three primary types of underwater noise, each with distinct characteristics and ecological consequences. The first is **impulsive noise**, generated by activities such as pile driving and rock placement. These sounds are characterised by their high intensity and short duration, with levels reaching up to 260 decibels relative to 1 µpascal at 1 metre. For marine mammals, which rely on sound for communication, navigation, and hunting, exposure to such noise can result in permanent hearing damage, behavioural disruption, and even physical injury or death.

The second type is **continuous noise**, typically produced by dredging operations and vessel traffic. While less intense than impulsive noise, continuous noise can mask biological sounds, interfere with echolocation, and cause chronic stress in marine species. Studies have shown that prolonged exposure to continuous noise can lead to habitat displacement, reduced reproductive success, and increased vulnerability to predation.

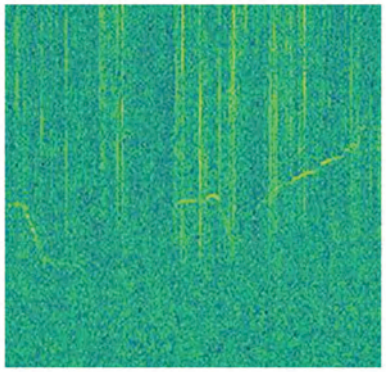
The third category is **chronic noise**, which persists after construction has been completed. This includes the operational noise from increased vessel traffic, which can alter the acoustic environment of entire regions. Chronic noise has been linked to long-term changes in marine animal behaviour, including shifts in migration patterns and feeding grounds.

Regulatory frameworks governing underwater noise

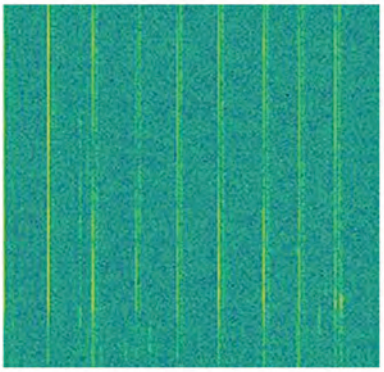
Recognising the threats posed by underwater noise, governments and international organisations have implemented a range of regulations to mitigate its impact. In the European Union, the **Marine Strategy Framework Directive (MSFD)** requires member states to monitor and reduce underwater noise to achieve "Good Environmental Status."

In the United States, the **Marine Mammal Protection Act (MMPA)** and the **Endangered Species Act (ESA)** mandate the use of mitigation measures, such as exclusion zones and real-time monitoring, to protect marine mammals during activities like pile driving and dredging.

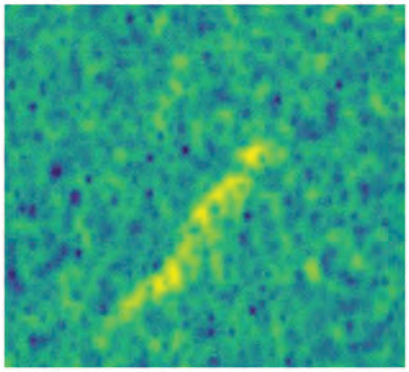
AI-powered detection and classification of marine mammals vocalisations



Dolphin whistle



Dolphin clicks



North Atlantic Right Whale upcalls

Image courtesy of RTsys Underwater Technologies


Real-time noise & mammal monitoring from the quay (4G data transmission)

Images courtesy of Somme France

The role of passive acoustic monitoring

Passive Acoustic Monitoring (PAM) involves the use of hydrophones to detect and analyse underwater sounds. Unlike active sonar, which emits sound waves, PAM systems simply listen to the acoustic environment, making them ideal for monitoring marine life without causing additional disturbance. PAM systems can be deployed in various configurations, autonomous recorders, and real-time monitoring buoys, depending on the specific requirements of a project.

One of the key advantages of PAM is its ability to provide real-time data. **RTsys Underwater Technologies**, a world leader in the design and manufacture of PAM systems is even enhancing the PAM capabilities by providing advanced software that can automatically detect the vocalisations of marine mammals, such as dolphin clicks and whale vocalizations. When these sounds are identified, the system autonomously trigger alerts, allowing construction teams to implement mitigation measures, such as shutting down operations or reducing the power of machinery.

PAM systems can be used for long-term acoustic surveys. By deploying hydrophones before, during, and after construction, researchers and regulators can establish baseline noise levels, assess the impact of construction activities, and evaluate the effectiveness of mitigation measures. This data is invaluable for ensuring compliance with environmental regulations and for informing future projects.

Case studies: PAM in action

Two notable examples are **the port expansion projects** in Pointe-à-Pitre, Guadeloupe, and Joinville, Île d'Yeu, France.

The extension of Quay 12 at the Port of Pointe-à-Pitre in Guadeloupe involved the construction of a 120-metre quay to accommodate larger vessels. The project presented significant environmental challenges, as the surrounding waters are home to protected species such as the Antillean manatee and the Guiana dolphin. To minimise the impact of construction noise, a comprehensive PAM system was deployed, including a buoy-based recorder. The system was used to monitor noise levels in real time, with automated alerts triggering when predefined thresholds were exceeded. This allowed construction teams to adjust their activities to stay within regulatory limits and avoid disturbing marine life.

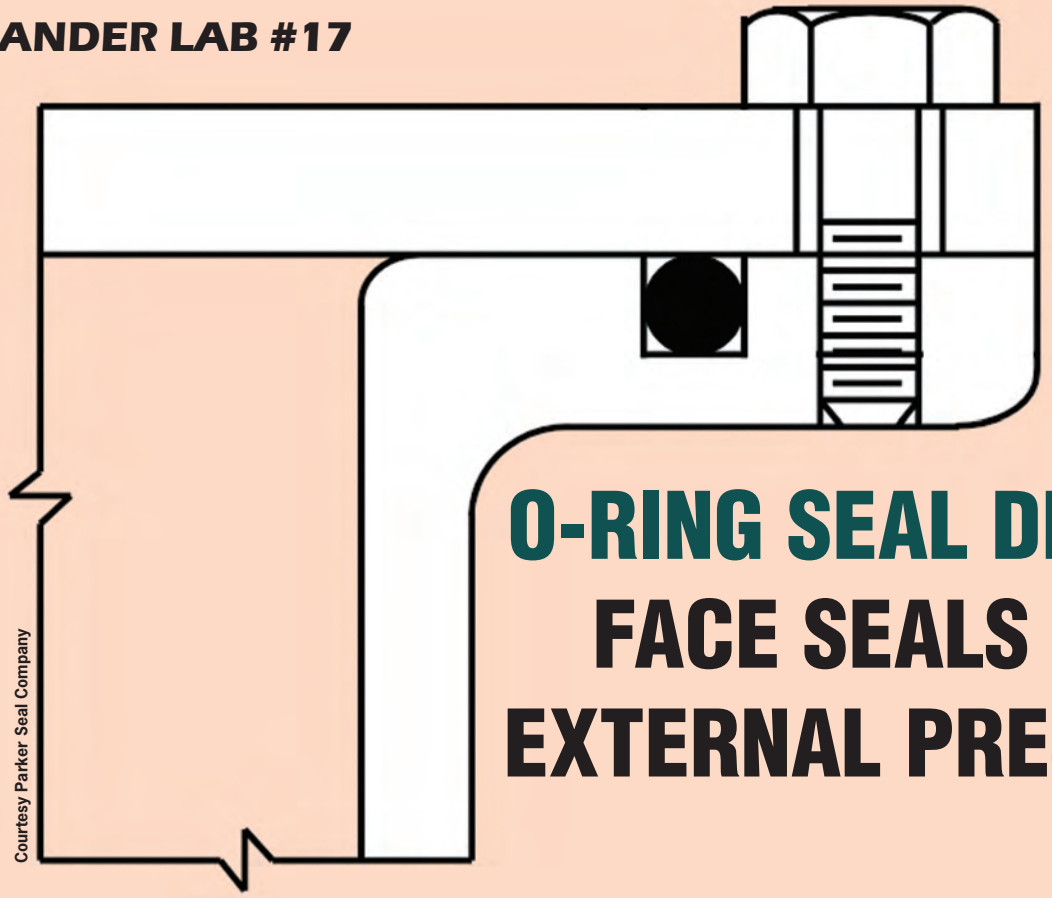
The adaptation of Port Joinville on Île d'Yeu for the maintenance of offshore wind farms presented **a different set of challenges**. The port required extensive dredging and quay reinforcement to accommodate maintenance vessels, activities that posed a risk to local dolphin and porpoise populations. To address this, a five-month PAM monitoring program was implemented combining real-time acoustic observations, both marine mammals and noise monitoring, along with visual surveys. The system, which included RTsys PAM surface system – not buoy- equipped with AI-powered detection software, was able to identify directly from the harbour's quay the presence of dolphins and porpoises **in the construction zone (no need for large logistic management at sea, reducing costs and risks)**.

Technological innovations in underwater acoustic monitoring

The field of underwater acoustic monitoring is evolving rapidly, driven by advances in technology and increasing regulatory pressure. One of the most significant developments is the integration of **Artificial Intelligence (AI) into PAM systems**. AI-powered software, such as **RTsys Rubhy** [AI], can automatically detect and classify the vocalisations of marine mammals. **Spectrograms and audio samples are forwarded to a custom web platform** for expert review.

Conclusion

Underwater noise pollution is a significant environmental challenge associated with harbour expansion projects. However, through the use of Passive Acoustic Monitoring (PAM), port authorities and construction firms can mitigate the impact of noise on marine life while ensuring compliance with regulatory requirements. As the demand for port infrastructure continues to grow, the adoption of PAM and other noise mitigation technologies will be essential for balancing economic development with environmental protection. **https://rtsys.eu**



O-RING SEAL DESIGN: FACE SEALS FOR EXTERNAL PRESSURE

By Kevin Hardy, MTR Columnist, President, Global Ocean Design LLC

It's a mechanical problem first. If the seals don't work, what's inside doesn't matter anymore.

Right off the bat: Parker Seal Company literally wrote the book on o-ring seals. There is no better design reference for o-ring seal design than the Parker O-ring Handbook (ORD-5700). A pdf is available for free at <**www.parker.com**>. It is mandatory reading for ocean engineers, and contains much more detail than possible in this article. Zoom in on the sections relevant to your work, then come back later and explore other seal designs, such as dovetail grooves, SAE Boss seals, crush seals, rotary seals, and others that might be helpful another day on another project. In my early years at Scripps, I found the Handbook a little confusing in parts. Older, experienced engineers and machinists helped me through it. In the long time since, from inside the Arctic Circle to the bottom of ocean trenches, Parker design guidelines never once let me down. Pretty epic win-loss ratio. In the early 1980's, after a perplexing housing leak at sea, I reversed engineered and found underwater connectors from two companies that would predictably fail prematurely, at 1/3 of their catalog value, due to poor o-ring seal design. Presented with the evidence, the companies resisted change, so I presented at MTS conferences and wrote on "End-user Verification of Quality Control." In the end, the companies revised their designs and obsoleted the poor ones.

Some basics:

1. The o-ring seal is a means for creating a barrier to fluid flow. The o-ring seal assembly consists of an o-ring installed in a groove. (Parker calls it a "gland," but I'm an engineer and that makes be blush. So, it's a "groove" and an "endcap.")
2. Important: Assembly lubricants should always be used sparingly. They are just used to decrease friction and allow the o-ring to respond to pressure and move inside the groove.
3. The leading cause of o-ring failure in design is extrusion through a gap.
4. A Face seal is always better than a Radial seal because the gap the o-ring must seal is generally zero. (A radial seal on a plug in a bore requires some radial gap to just get the parts together. That's a story for another day.) There is typi-

Figure 1 (above)

An o-ring in a groove with the endcap secured.

cally metal-to-metal engagement between the end cap and groove with a face seal, so there is no extrusion gap. Parker states, "Instances have been reported of sealing pressure of 200,000 psi with a 70-durometer o-ring." I routinely test hadal depth components with face seals and 70-durometer o-rings to 18,500-psi using the Parker's Design Chart A4-3 for o-ring face seals.

5. Think of o-ring elastomers as high viscosity incompressible fluids.

6. Larger o-ring cross-sections are more tolerant of surface imperfections, have better resistance to compression set, and have larger machining tolerances for the groove.

7. Smaller o-ring cross-sections require less space, and take less force to compress.

8. Soft durometers seal rougher surfaces.

9. Harder durometers resist extrusion better.

10. Selecting the proper o-ring elastomer requires some knowledge of fluid compatibility (ORD-5700, Section 7), operating temperature range, maximum pressure, time under pressure, and allowable compression force for assembly. For mid-latitudes in seawater, a good choice is 70 durometer Nitrile or Buna N (NBR). It's inexpensive, has good shelf life, is fine with silicone grease, and readily available. EPDM is another good choice. Very low temperatures are tolerated by silicone, but you need a different lubricant than silicone grease.

11. There is a force multiplier to consider. Assuming the end cap is strong enough to resist ambient pressure at depth (See reference to "Under Pressure" below), the force acting on the endcap loads the smaller area of the face of the cylindrical pressure case below it. The land area supporting the multiplied force is further reduced by the size and placement of the face seal o-ring groove. Move the o-ring groove as close to the cylinder's outer circumference as possible. If a back-up o-ring is desired, make it a radial seal.

Engineers can follow Parkers' short form for face seals, where general allowances are given (Parker ORD-5700, Design Chart A4-3), or refine the design for a specific application, including stretching an o-ring for a groove slightly larger than spec.

Other design notes:

1. Anodizing aluminum changes dimensions of the finished part. ODs get bigger by 0.002," ID's get smaller by 0.002," groove depths remain the same, while change in some dimensions don't matter. Adjust relevant part dimensions on the print. That's the engineer's job, not the machinist's. Putting a

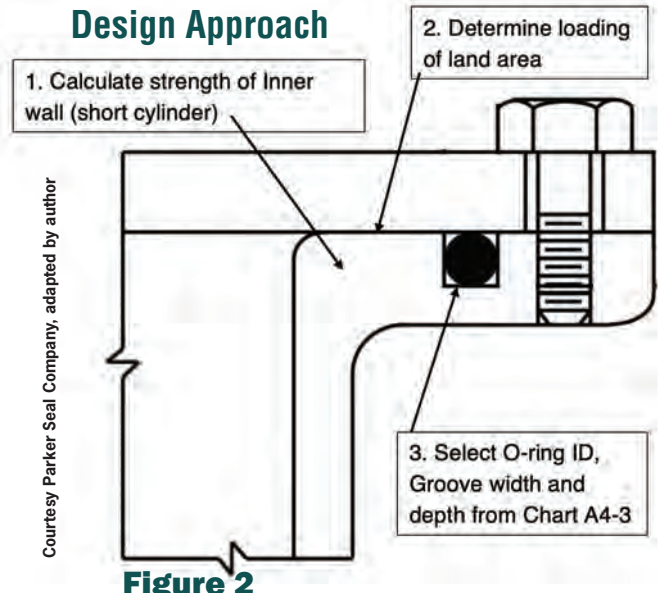


Figure 2

Design sequence in layout is described above. Full design requires consideration of means to secure endcap and load o-ring. A partial vacuum may do the trick instead of a pattern of bolts.

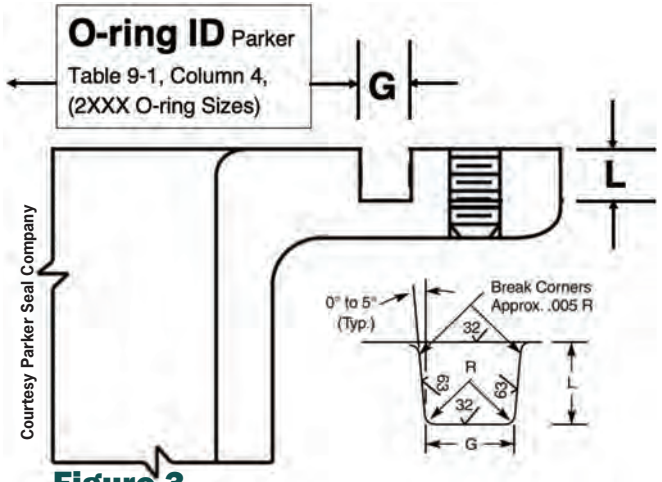


Figure 3

Determine o-ring groove size. Use **O-ring ID** (Parker Table 9-1, Column 4), G (groove width), and L (groove depth) from Parker Design Chart 4-3 (below). Groove detail is in the lower right.

note in 8-pt type in the lower left corner on the blue print that states "Dimensions apply after anodize" is asking for trouble. The machinist wants what you want: a perfect part the first time. Help him out. (A future article on anodizing aluminum is in the works.)

2. If the o-ring size you prefer is inbetween two standard sizes, Parker allows you to stretch the o-ring into a slightly larger groove, but not more than 5%. A stretched o-ring can result in a smaller cross-sectional area, requiring the depth of the groove to be made shallower to maintain recommended squeeze. (See Parker Handbook Sections 3.3 and 3.5).

Remember: You can stretch the o-ring fit a larger groove, but you cannot make the o-ring fit a smaller groove.

3. If needed, use of soft plastic probes or wood toothpicks to remove o-rings from grooves is recommended. Never use steel dental tools, paperclips, or other materials harder than the housing material.

4. Danger: dissimilar materials corrosion: An o-ring in a stainless-steel connector installed in an aluminum endcap could meet every Parker spec. But, two different metals in direct contact and submerged in seawater form a battery. The less noble material absolutely will corrode. Murphy's Law guarantees the pitting corrosion will burrow under the o-ring. A second o-ring will delay the inevitable until the corrosion reaches the second sealing surface. Avoid dissimilar materials in direct contact.

5. Interesting note: An o-ring groove has two critical dimensions: the ID and the groove depth. The specified width of the groove already starts larger than the o-ring (Section 3.7), so the outer wall is not engaged in the sealing process for external pressure. The outer wall could even be eliminated, and the o-ring be exposed directly to the sea, though that also exposes the o-ring to some potential sources of damage. The outer wall acts like a shield to protect the o-ring from random damage.

6. Treat open o-ring seals with the same care as an open wound. Cleanliness and careful handling of the seals and sealing surfaces is crucial.

O-Ring Size Parker No. 2	W Cross Section Nominal	W Cross Section Actual	L Gland Depth	G Groove Width Liquids	G Groove Width Vacuum and Gases	R Groove Radius
004 through 050	1/16	.070 ±.003 (1.78 mm)	.050 to .054	.101 to .107	.084 to .089	.005 to .015
102 through 178	3/32	.103 ±.003 (2.62 mm)	.074 to .080	.136 to .142	.120 to .125	.005 to .015
201 through 284	1/8	.139 ±.004 (3.53 mm	.101 to .107	.177 to .187	.158 to .164	.010 to .025

Courtesy Parker Seal Company

Figure 4

Design Chart 4-3: Design Chart for O-Ring Face Seal Grooves (Glands,) diameters 1/16", 3/32", and 1/8" only. (3/16", 1/4", 3/8", and ½" not shown.)

Additional notes:

1. Parker's Application Engineering Department personnel are available to review your project, including temperatures, pressures, groove (gland) design, bolt torque, surface finish, etc. They will offer alternate design ideas if that's helpful. The Parker O-Ring & Engineered Seals Division is located in Lexington, KY, USA, Phone: 1-(859) 269-2351, Fax: 1-(859) 335-5128, ***www.parker-orings.com***.
2. Use of DeepSea's, "Under Pressure", will assist the engineer in determining optimal pressure case and end cap dimensions. It's very helpful for "what if" variations. The program may be downloaded for free at <***https://www.deepsea.com/under-pressure-design-software/***>.
3. PREVCO Subsea Housings provides guidelines for handling and installation of o-rings. A properly designed o-ring seal can still fail if intent is not made to carefully clean, inspect, and install the o-ring. ***https://prevco.com/wp-content/uploads/2017/11/HANDLING-AND-INSTALLATION-OF-SEALS.pdf***
4. A pdf of the NRL Memorandum Report 4809, "O-Ring Installation for Underwater Components and Applications," C. J. Sandwith, (1982), is available at the Global Ocean Design website ***https://www.globalocean-design.com/other-useful-references.html***

Acknowledgements

The author thanks Ray Haworth, Electric Boat, Frank Snodgrass, Mert Ingraham, Chuck Fleming, Baron Thomas, Scripps Institution, and Luigi Zoni, Parker Seal Company, for the design insights they have shared.

Citations:

Parker ORD-5700, 50th Anniversary Edition, <***https://www.parker.com/content/dam/Parker-com/Literature/O-Ring-Division-Literature/ORD-5700.pdf***>

"Lander Lab" is a hands-on column of Ocean Lander technologies and strategies, a unique class of unmanned undersea vehicles, and the people who make them. It is meant to serve the global ocean lander community in the manner of Make Magazine and other DIY communities.

Comments on this article, or suggestions for stories of interest to other Landereans are welcome. Ocean lander teams are encouraged to write in about their work. Please feel free to contact Kevin Hardy <***khardy@marinelink.com***>.

The USGS Wave Glider on mission equipped with Sonardyne GNSS-A instrumentation.

MONITORING THE RESTLESS EARTH FOR THE NEXT "BIG ONE"

By Michelle Barnett, Ocean Science Business Development Manager at Sonardyne

When the 8.2 magnitude Chignik earthquake hit off the coast of Alaska in 2021, it was a big warning signal. The largest earthquake in the US since 1965 and one of the largest globally in recent years; it was a reminder of the geohazards lurking, out of sight, off our coastlines.

Offshore events like these could trigger a tsunami, putting major coastal cities and regions at risk.

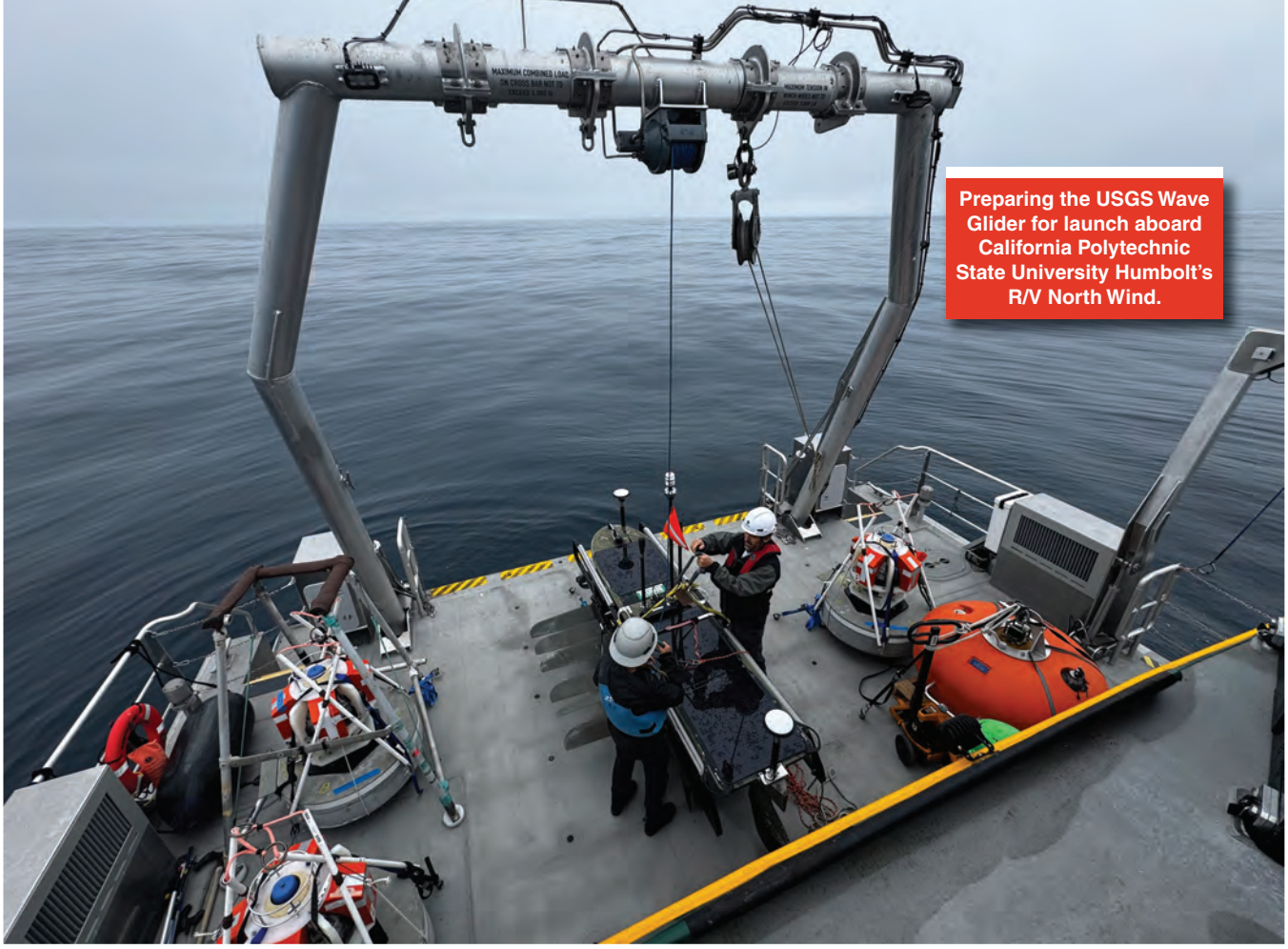
But, until recently, the geological activity that leads to an earthquake like Chignik was a significant blind spot to scientists, lying hidden and inaccessible beneath the waves.

Now, thanks to ongoing collaboration and development between underwater technology company Sonardyne, Scripps Institution of Oceanography and the U.S. Geological Survey (USGS), the ability to remotely monitor our restless earth is not just possible but also becoming standard practice.

Using a technique called GNSS-A, an increasing amount of coastline most vulnerable to earthquake and tsunami hazards, including the US Pacific Coast, is being monitored.

What is GNSS-A?

GNSS-A works by combining satellite positioning with underwater acoustics to track seafloor movement with centimeter-level accuracy. An uncrewed surface vessel (USV) with Sonardyne's GNSS-A payload patrols above an array of So-



Preparing the USGS Wave Glider for launch aboard California Polytechnic State University Humbolt's R/V North Wind.

All images courtesy USGS

nardyne Fetch transponders on the seabed.

Combining its known surface position with acoustic pulses down to each Fetch transponder allows it to calculate the precise position of each transponder – and therefore the position of the seabed it's sitting on.

By repeating these measurements over time, scientists can track the movement of tectonic plates across faults to better understand and estimate earthquake and tsunami hazard.

One of the organizations using this technique to monitor subduction zones, where one plate is sliding under another, is the USGS. They first started exploring its use in 2017, working in collaboration with the University of Hawaii and Scripps, and using a Wave Glider and seabed sensors, in order to measure how friction between two tectonic plates restricts sliding and causes a build-up of stress - essentially measuring "how stuck are the plates."

Since then, they've continued to contribute to the development of GNSS-A using Sonardyne GNSS-A modules and Fetch transponders.

Expanding GNSS-A monitoring along the Cascadia Subduction Zone

A big focus for USGS is the Cascadia Subduction Zone, a 1,000 km long fault off the Pacific Northwest coast that runs from Vancouver Island in Canada to northern California.

Between 2021 and 2025, USGS has installed four monitoring sites on the seabed off the US Pacific coast at the southernmost extent of this zone.

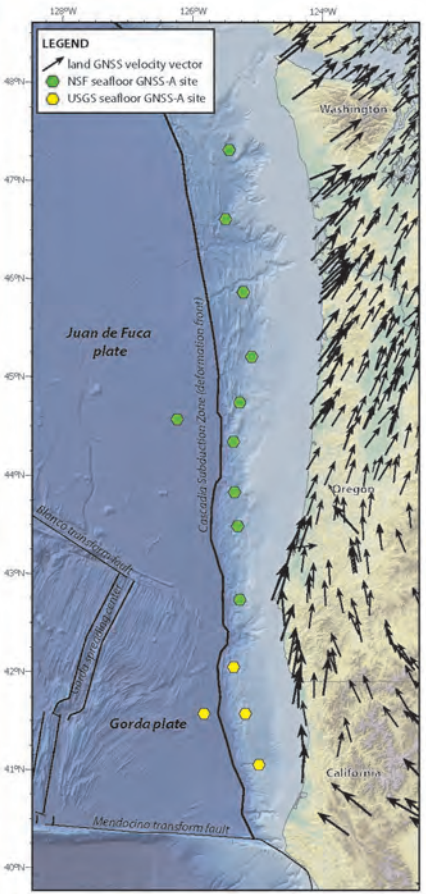
They are part of a wider network along the Cascadia Subduction Zone where subduction involves three plates, the Explorer, Juan de Fuca and the Gorda, sliding beneath the North American Plate, creating the potential for magnitude 9+ earthquakes and large tsunamis.

The USGS GNSS-A sites, each with three Fetch transponders, are on the southernmost Gorda plate where the uncertainty of the Gorda plate motion relative to the North American plate motion has implications on the size and recurrence of earthquakes in the region.

"Before we had this capability, we were only able to use GPS networks on land to estimate, to a sub-millimeter level, the slow movements of the seafloor 50 plus miles offshore," says Todd Ericksen, Geodetic Engineer at the USGS' Earthquake Science Center in California.

"But the seafloor was a blind spot; a major missing piece of the global tectonic jigsaw puzzle which meant the true scale of the hazard beneath the ocean was largely unknown. Our instruments stopped at the shoreline."

"For somewhere like the Cascadia subduction zone, where oceanic plates are being subducted beneath the North American plate, seafloor geodetic sites are filling a major gap, helping us to better understand earthquake and tsunami hazard. If plates 'lock' in this zone, building up stress, that whole coastline, and cities like Vancouver, Victoria and Seattle, face significant tsunami risk."



Above: GNSS-A equipped Wave Glider midships, loaded aboard the R/V North Wind in Eureka, CA, and surrounded by three seafloor geodetic benchmarks to be deployed along the Cascadia Subduction Zone.

Right: Topo-bathymetry map of the Cascadia subduction zone showing geodetic velocities on land and offshore USGS and NSF seafloor geodetic sites.

Critical insights from the Aleutian subduction zone

One of the tectonic sources of large earthquakes that USGS has been monitoring is the Aleutian Subduction Zone. It was here that the Chignik earthquake struck – and USGS was ready for a post-earthquake response mission.

Just a couple of years before, three GNSS-A monitoring sites had been set up on the seafloor off Alaska, in the Aleutian subduction zone, by a team of scientists funded by US National Science Foundation (NSF).

Several Wave Glider surveys had been carried by the USGS and Scripps prior to the M8.2 Chignik earthquake, monitoring the position of the sites in about 1,200 m water depth.

Within weeks of the earthquake, USGS had their Wave Glider back out to measure what movement there had been during and shortly after the earthquake.

Despite challenging weather conditions, the mission collected high-fidelity GNSS and acoustic data with eye-opening results.

"The tsunami was modest, but the seismic event was the largest in the US for nearly six decades," says Ericksen, "so we expected a large movement. But it was incredible to know exactly how much – and that was 1.4 m." This was a critical insight into the co- and post-seismic movement, helping to understand subduction zone dynamics."

The big question was, did the Chignik earthquake increase the state of stress and tsunami potential on the up-dip portion of the fault or not?

"The measurements showed that the fault moved 2 – 3 m horizontally in a shallow part of the fault, less than 20 km below the seabed, helping us to understand how stress builds up along the fault and is released in an earthquake," he says. "These results suggested that the cumulative slip had relieved stress on the shallow portion of the fault and therefore, the Chignik earthquake likely did not increase tsunami potential of the shallow fault.

"It also showed the effectiveness of the GNSS-A technique and the utility of rapid response GNSS-A measurements to better assess tsunami and earthquake hazards in the region."

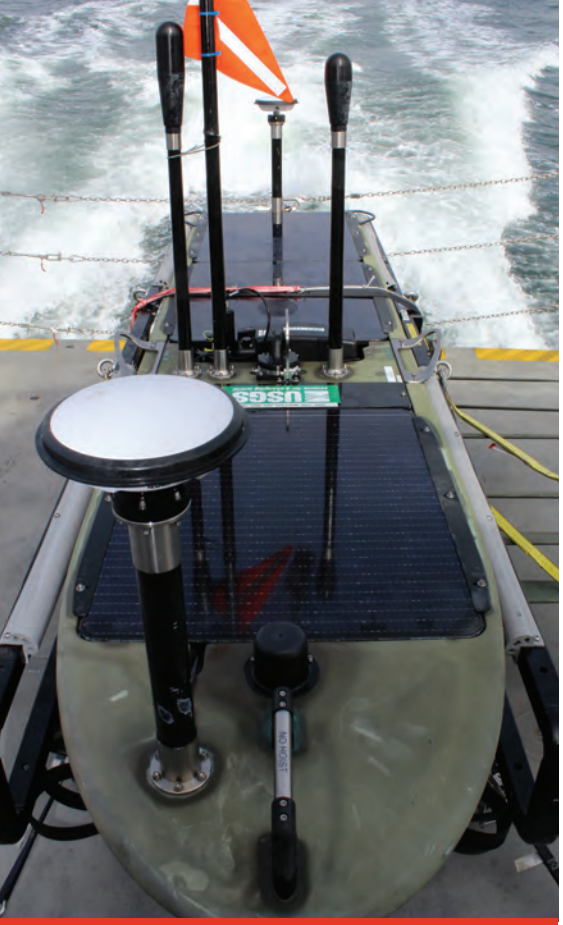
The origins of GNSS-A

The ability to measure the movement of plates on the seabed is not that new. It's based on what was originally called the GNSS-A technique, first developed by Scripps, specifically David Chadwell and Fred Spiess.

"Combining GNSS positioning and acoustic measurements to track seabed movement was a clever idea – and it worked," says Michelle Barnett, Ocean Science Business Development Manager, at Sonardyne.

"But the cost of using crewed ships to do the positioning made it cost prohibitive. It was also technically challenging."

"So, working with Scripps, in the early 2010s, we developed a combination of our Fetch long-life sensors and an off-the-shelf GNSS-A payload for Wave Gliders that can go out and do the survey work at a much lower cost than using a crewed ship."



The USGS Wave Glider recovered aboard the R/V North Wind after a successful survey.

Read more on the Chignik data in ScienceAdvances Vol.9, No.17, Rapid shallow megathrust afterslip from the 2021 M8.2 Chignik Alaska earthquake revealed after seafloor geodesy.

Worth the wait, even when waiting on weather

The technique is not without its challenges, however. After gathering the positions of the Aleutian subduction zone transponders, Ericksen and his team were naturally keen to see the data.

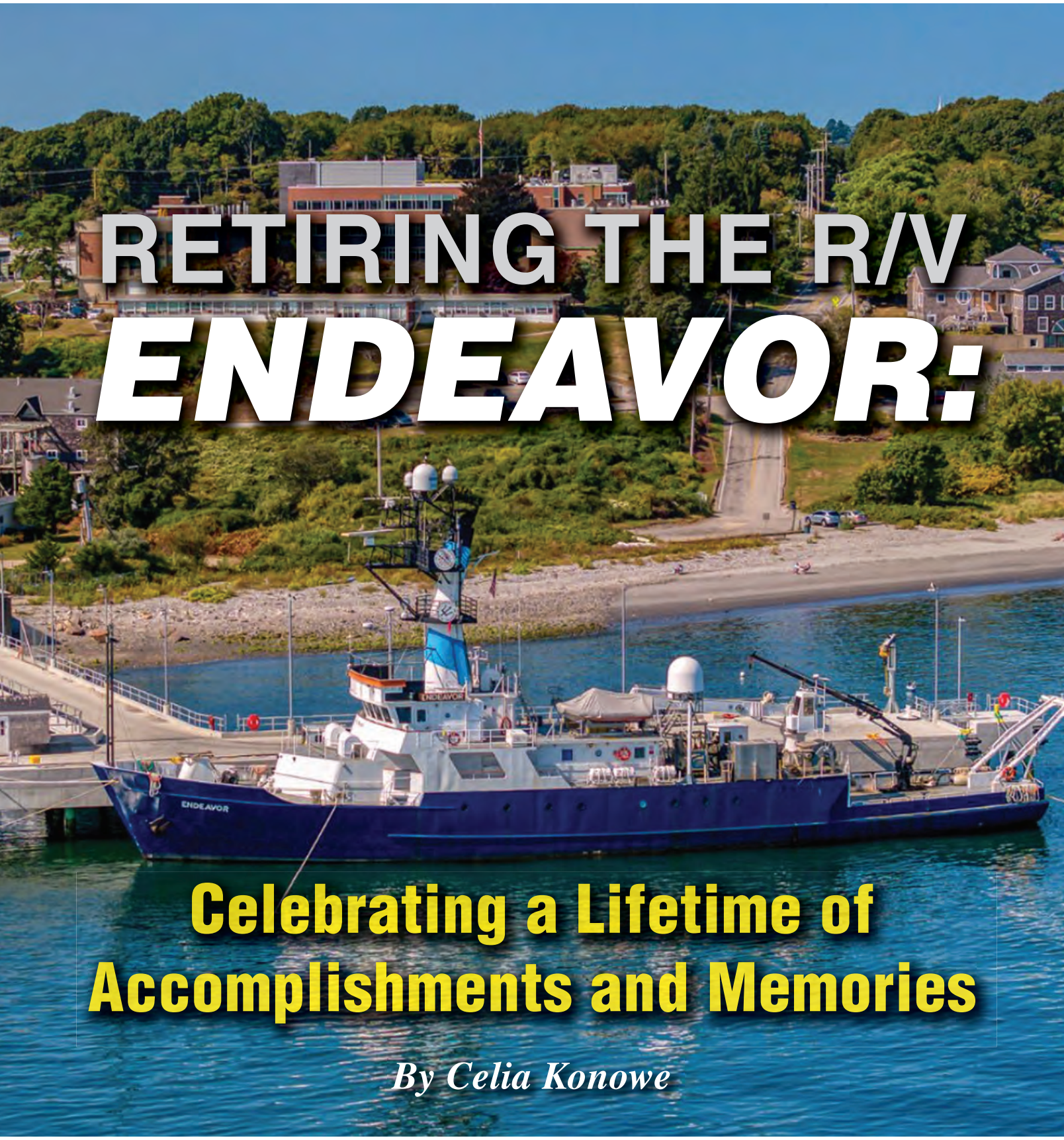
Due to the significant amounts of data involved – we're talking 25-30 GB per site (comprising three Fetch) – only subsamples are sent back to shore from the USV, primarily for quality control.

So, they have to wait until the USV comes back – or is brought back – to shore. Low levels of daylight in the Alaskan winter (when the Chignik survey was carried out) meant limited power availability for the USV.

Combined with bad weather, coordinating its recovery proved challenging, resulting in it taking four-months to recover the Wave Glider and offload the data.

Still, the wait was worthwhile and the results are providing greater insights than we've ever had before.

Credit: URI



RETIRING THE R/V ENDEAVOR:

Celebrating a Lifetime of Accomplishments and Memories

By Celia Konowe

In September 2025, R/V *Endeavor*, the University of Rhode Island's (URI) research vessel, sailed on her 736th and final voyage, bringing 50 years of service to a close. Rhonda Moniz, host of the DEEP DIVE podcast, sat down with Endeavor's Port Captain Brendan Thornton and Scientific Service Manager Erich Gruebel to celebrate the vessel's accomplishments and talk about what's next.

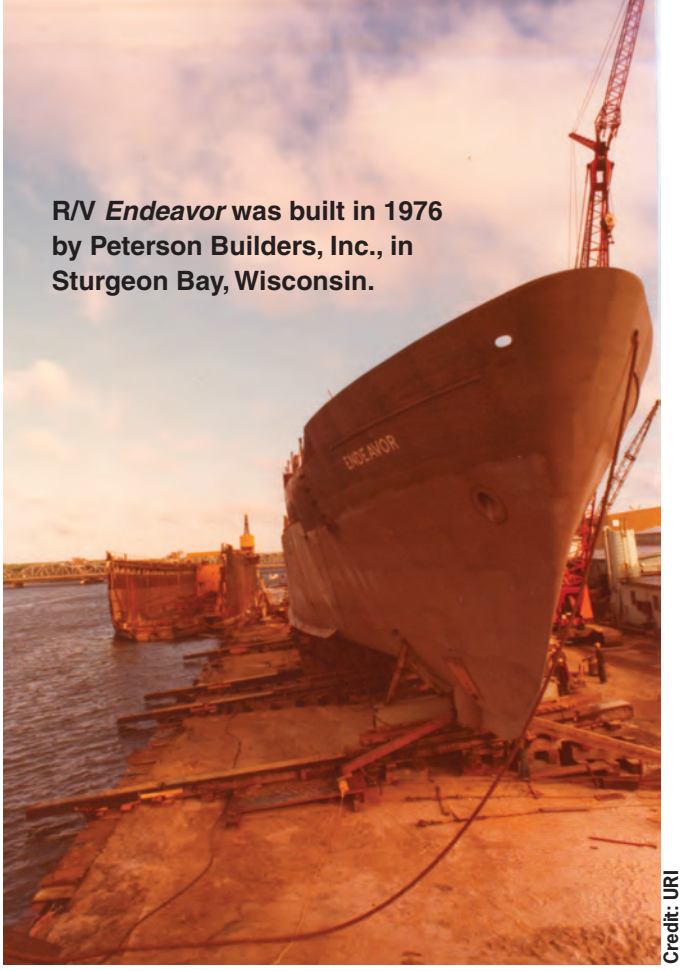
Built and rebuilt to serve

Endeavor joined URI's Graduate School of Oceanography (GSO) in 1976 as one of the first purpose-built research vessels in the University-National Oceanographic Laboratory System (UNOLS) fleet. She succeeded URI's previous research vessel, Trident, which was a converted 1945-era Army freighter. Endeavor served on various environmental studies around the world until 1993, when she was refit in her original shipyard in Sturgeon Bay, Wisconsin, continuing her work until this past fall. Endeavor has been as far west as Hawai'i, as far south as Brazil, up to Norway, and out to the Black Sea.

On her 736 cruises, Endeavor served as a platform for scientists from around the globe and for cutting-edge technologies. "It's been a privilege to take out scientists from different disciplines and to be able to work with many different institutions from all over the world—not just URI—to further environmental research and ensure that the measurements are taken for a better planet," stated Thornton. "It's also been very rewarding to work with a lot of new technology and equipment that is going to further shape the oceanographic community and sampling in the future."

R/V Endeavor's specifications:

- Built in 1976 with a major mid-life refit in 1993
- Length overall: 185'
- Draft: 18'6" aft, 12'6" forward
- Cruising speed: 10 knots
- Max speed: 14 knots
- Range: 8000 nautical miles @ 12 knots
- Endurance: 30 days
- Complement: 12 crew, 17 scientists, 1 Marine technician

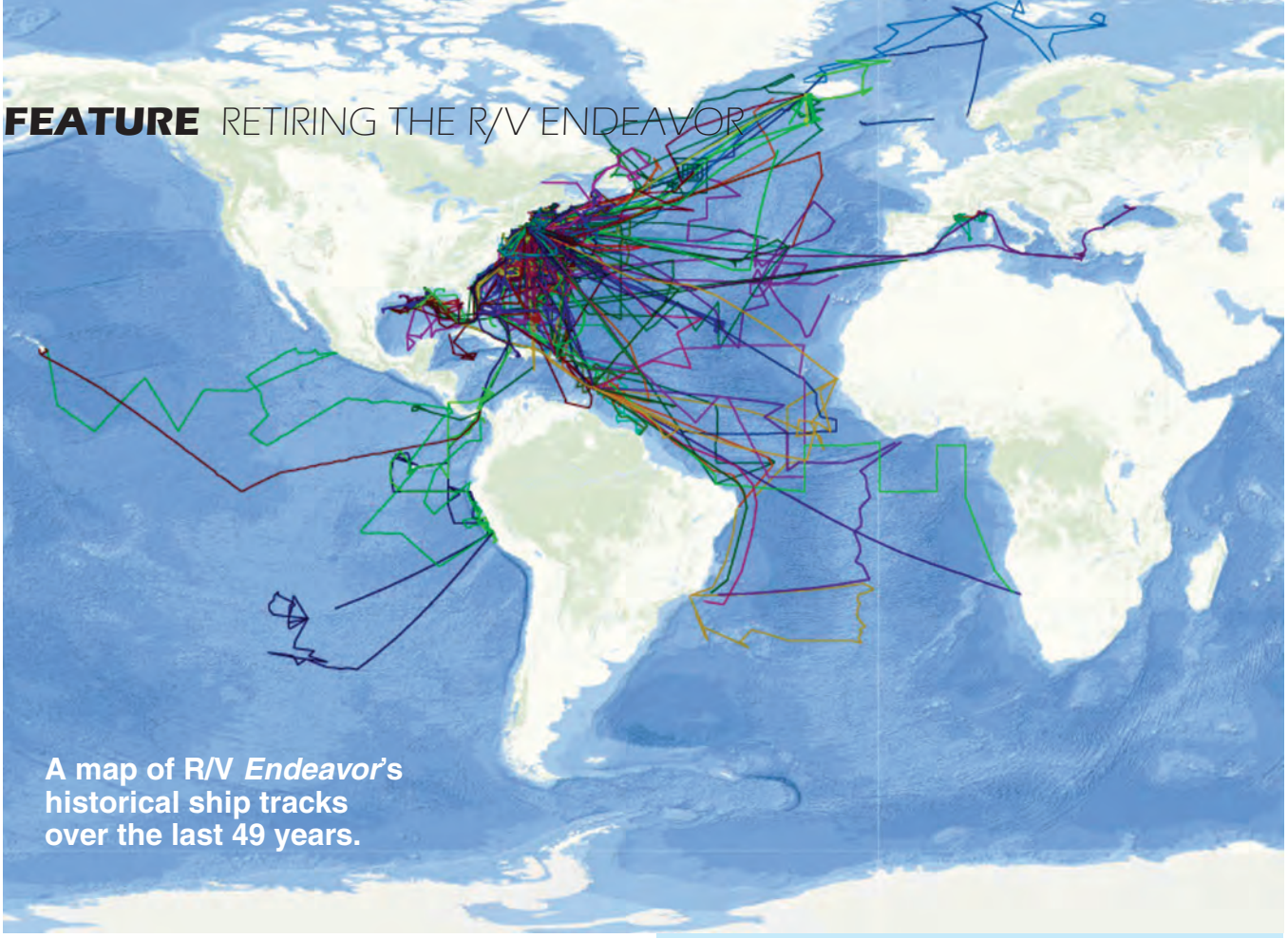


R/V *Endeavor* was built in 1976 by Peterson Builders, Inc., in Sturgeon Bay, Wisconsin.

Credit: URI

The Ram Band at *Endeavor*'s christening on December 11, 1976.

Credit: URI



A map of R/V *Endeavor*'s historical ship tracks over the last 49 years.

Credit: Bonny Clarke

Endeavor also played a significant role in times of need. "Some of the highlights are rapid response to things like the Haiti earthquake and the BP oil spill," said Gruebel. Primarily, however, she delivered as a general research vessel. "Oceanography is a body of research—it's not just individual discoveries. The amount that this single ship has contributed over the years is what makes me proud," he added.

During the half-century Endeavor spent at URI, she saw many technological updates, including through the mid-life refit. "If you look at different pictures, you can see that the lines of the ship have drastically changed. They added another deck in 1993, different systems, winches—to adapt to a lot of the new technologies that have come aboard and other research ships...We like to joke, there's a good mix of museum pieces and new technology on board," Thornton said.

"Technology and scientific capability wise, if you stepped on Endeavor today, after 50 years of service, you would never know that it's a 50-year-old ship. We worked very hard to keep it up to date. We're constantly installing new equipment. In the last five or six years, there's been huge advances in satellite communications and cybersecurity, and we're a leader in that regard," Gruebel added.

New era, new Dawn

As Endeavor heads into retirement, URI is planning for its new vessel, R/V Narragansett Dawn, which at time of writing

On December 15, the tanker Argo Merchant ran aground off Nantucket Island during a storm, carrying more than 7.7 million gallons of fuel oil and thrusting Endeavor into service. The vessel broke apart over the following week, unleashing one of the largest oil spills in U.S. history.

In September 2015, the R/V *Endeavor* served as the base for a five-day mission to explore two World War II shipwrecks off the Rhode Island coast: the German U-853 submarine and the SS Black Point, the last U.S. merchant ship sunk in the Atlantic. Scientists used remotely operated vehicles to survey the wrecks, streaming dives live online and on Rhode Island PBS.

Credit: URI

Learn more about R/V *Endeavor* on the most recent episode of the **Deep Dive** Podcast with Rhonda Moniz.

DEEP DIVE

For R/V *Endeavor*'s final cruise, the ship traveled to Nova Scotia and the northeastern coast of Newfoundland, where the science team assessed the ecological impacts of oil and gas activities using CTDs, manta nets, and a multicorer.

Credit: URI

The ship returned from its final cruise to the Bay Campus on September 20, 2025.

Credit: URI

is under construction in Houma, Louisiana, and will be delivered in March 2026. By design, this latest vessel will feature new capabilities and technologies.

"From the operational side, one of the biggest requests that a lot of the scientists seem to have in the fleet is for dynamic positioning systems," said Thornton. "That allows the vessel to stay put in one place based on coordinates that we can plug into the system. That'll be very useful for ROV and AUV operations—things that require the ship to stay in one spot. Right now, we have one propeller, one rudder and a bow thruster. So, it requires a lot of ship handling and we can get the job done, but the precision is something the scientific community can look forward to."

"One of the primary reasons for replacing the Endeavor, despite the advanced age of the ship, is that there's a lot of modern oceanographic work that the vessel can't do and that requires dynamic positioning and a lot of the advanced sonars," Gruebel added. "Endeavor's hull—the physical shape of the hull—just can't support things like multi-beam and sub-bottom profilers."

Thornton and Gruebel admit that a new vessel and onboard technology will create staffing implications too. "I think one of the biggest challenges we're going to face is, in the last several years, there's been a shortage of both maritime professionals and marine technicians who are able to care for this equipment. It's highly skilled labor and requires a willingness to spend time at sea. And these new ships are just so advanced—they're unlike anything out there. I think that's going to be the biggest challenge we face, is supporting a vessel that has all this modern equipment," Gruebel said.

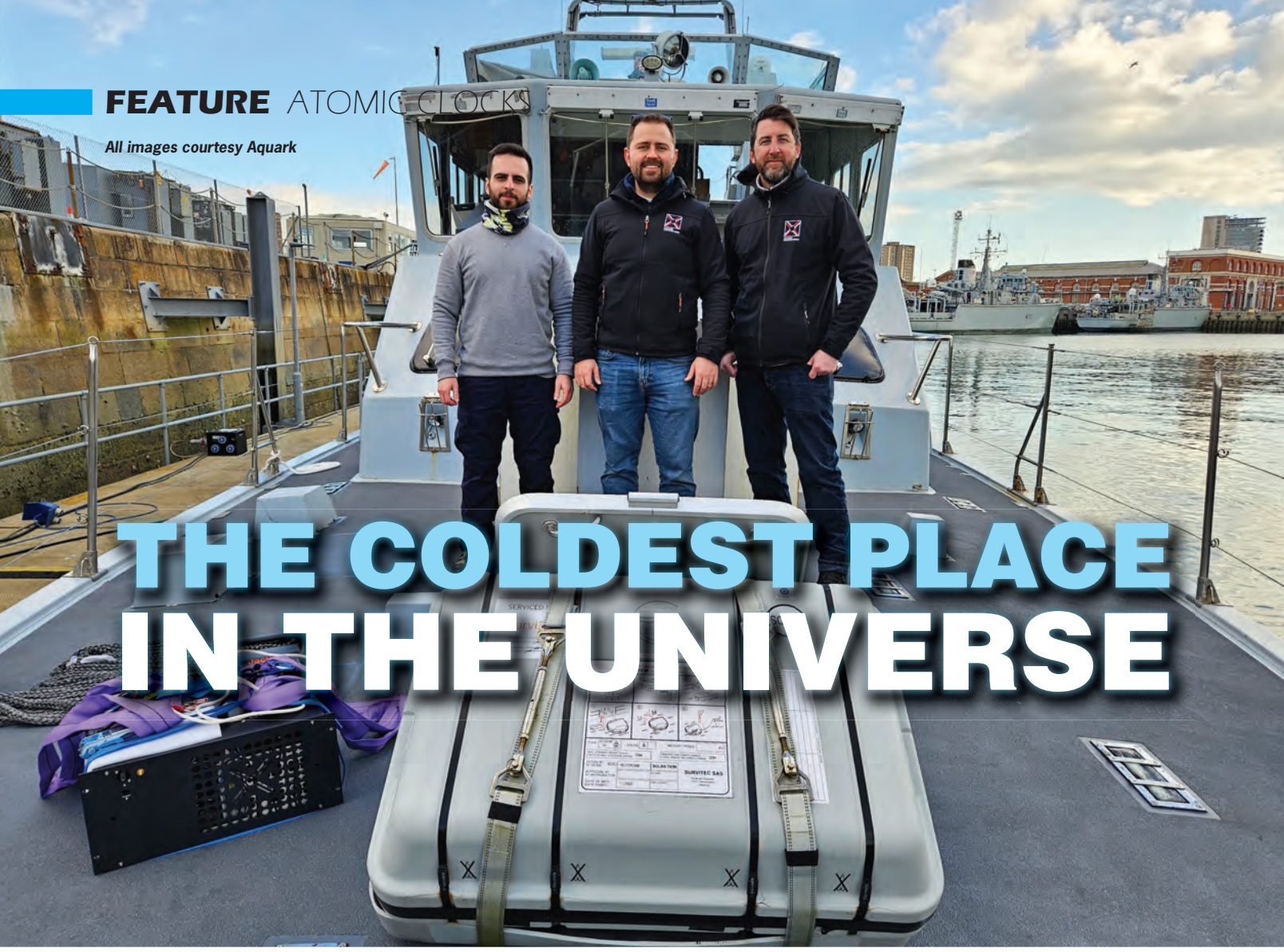
One for the ages

Endeavor's record is one of versatility and perseverance. "It's impressive to have over 730 successful science missions. It's a real testament to the crew, technicians and scientists on board because 50 years of success is almost unheard of. It's the longest running oceanographic vessel in the fleet," Thornton said. "It's a testament to the National Science Foundation (NSF) and the ship's operators for being able to successfully run a vessel that long. There was a lot of care, a lot of thought, a lot of planning and good people that went into making sure she had successful operation for this number of years.

Gruebel also feels that Endeavor's success is a reminder of the importance of research vessels. "I don't think the general public has a very good idea of how important the ocean is to your daily life and getting the message out that the field of oceanography—it's not just whales and dolphins and being able to train scientists, technologists and maritime crew, because you will always need ships to be at sea, despite advances in robotics and automation and satellite imagery. There'll always be a need for research vessels. They're complicated and expensive to operate, but it's just like space exploration. It's part of the pursuit of humanity."

Since Endeavor's retirement, the GSO and NSF have been in talks to determine the vessel's next phase, either continuing to serve in a new role or as a source of parts donated to other institutions. Regardless of the outcome, Endeavor's legacy has been established over a 50-year career across academia, marine research, global emergency response and in the lives of countless scientists, students, professors, technologists and beyond. Her impact at URI and in the greater scientific community will be long-lasting and meaningful, leaving R/V Narragansett Dawn with a legacy to continue

All images courtesy Aquark



THE COLDEST PLACE IN THE UNIVERSE

The increasing need for GNSS-denied navigation due to the risks of spoofing has led to a quantum step-change in the development of atomic clock technology.

By Wendy Laursen

A UK company has reached a temperature of minus 273.149996°C in the quantum technology it uses in its atomic clock, effectively creating the coldest place in the universe. It's a high-tech solution for an age-old problem: accurate navigation at sea without the support of satellite systems.

Alexander Jantzen, Co-founder & Chief Operating Officer at Aquark Technologies, explains: "At the beginning of the 18th century, knowing your latitude when navigating was long understood by observing the position of known distant stars above the horizon, however the longitude was a dangerous mystery. The longitude problem comes from the fact that our planet rotates, and we have no fixed point of reference to compare with when out at sea."

The solution to this problem came in 1735 when John Harrison developed the first practical marine chronometer.

"The solution to navigation accuracy was – and still is – precise timing," says Jantzen. "Harrison solved the longitude problem, showing how accurate positioning was possible with the chronometer (the most reliable timekeeper in its day). He compared the time from a known location – such as where the ship set sail from – with the time of day where the ship was located. Knowing the difference in time of when noon occurred allowed the ship to precisely know its longitudinal position."

By the 1980s, satellite navigation systems in the Global Navigation Satellite System (including GPS) rendered chronometers largely obsolete for practical navigation, because the

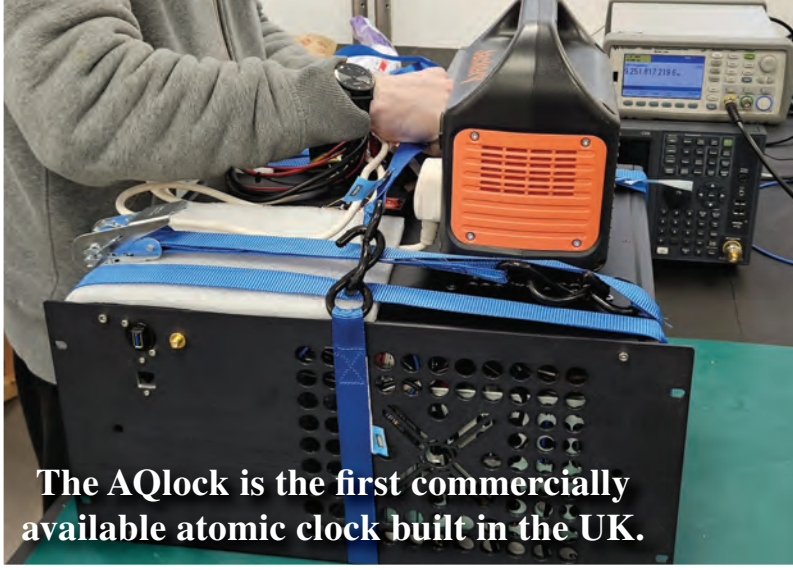
time signals needed for accurate navigation mostly then came from atomic clocks on GNSS satellites.

If GNSS is disrupted, atomic clocks provide reliable holdover, delivering a stable timing signal until GNSS access is restored, because they provide a highly precise, reliable and continuous ticking that cannot be interfered with.

"Out at sea, spoofing detection is only as good as your timing reference. Bridge systems need something 'ticking' with accuracy as a reference source. When all is well, a vessel's bridge position, navigation and timing (PNT) systems will have the same 'ticks' as an atomic clock. But when a GNSS receiver is spoofed, its timing speeds up in relation to the reference 'tick' which can result in unreliable positioning data and dangerous navigation errors if the spoofing is undetected," says Jantzen.

"PNT resilience can be achieved when the system detects a gap between the ticks of the atomic clock and the GNSS. The system can switch to the atomic clock's time signal during spoofing and will revert to GNSS when the timekeeping gap closes."

"The best precision timing systems today measure the natural and stable frequency properties of atoms as defined by quantum mechanics and use them to correct drifts from an expected point, typically a 10 MHz oscillator," says Jantzen. "To generate the highest accuracy, you must access the atom undisturbed for as long as possible to remove noise and average out random variations. At Aquark, we do this by laser cooling the atoms close to absolute zero."



The AQlock is the first commercially available atomic clock built in the UK.

At the extreme temperature achieved by Aquark, the atom's natural quantum "tick" can be measured for longer periods, as the natural movement of the atoms is slowed by a factor of almost 10,000 from 290 m/s to 34 mm/s. The frequency of the clock is continuously checked against the atomic frequency and automatically corrected if needed, reducing its long-term drift without requiring any correction from the timing signal usually provided by GNSS.

Aquark has conducted the first underwater test of its AQuest cold atom trap onboard the National Oceanography Centre Autosub Long Range autonomous underwater vehicle.

"The solution to navigation accuracy was – and still is – precise timing."

– Alexander Jantzen,
Co-founder & Chief Operating Officer at Aquark Technologies

In June 2025, Aquark partnered with the Royal Navy to deploy AQlock aboard HMS Pursuer for a three-day sea trial. The trial was the first of its kind, testing the stability of the AQlock when operated in open sea conditions. During the trials, the cold-atom clock operated continuously, providing precise timing without a correction from GNSS, despite being exposed to continuous pitch and roll of the vessel.

Aquark also conducted the first underwater test of its AQuest cold atom trap, a key component ofAQlock, in dynamic conditions onboard the National Oceanography Centre Autosub Long Range autonomous underwater vehicle. The collected data provided performance metrics about the system's behavior and robustness at different temperatures and pressures.

"What makes the trial remarkable is that laser cooling atoms has historically only been possible when a system is carefully isolated from most external disturbances, which is a big engineering challenge in itself on dry land. So it was an achievement to see our core technology - the Super-Molasses Trap - function underwater to form ultra-cold atom clouds."

Discovered in 2019 at the University of Southampton, the Super-Molasses Trap used by AQlock reduces the tried and tested recipe for making cold atoms to a much simpler setup that only needs the right geometry of laser light and ultra-high vacuum (pressure equal to outer space). What makes it unique is that it does not need a supporting magnetic field.

It is hard to overstate the significance of this in engineering terms as it removes about 50% of system complexities, Jantzen says. It fundamentally changes how the atoms are used and paves the way for an alternative path to that which has led the entire field for almost four decades.

"The Super-Molasses Trap allows us to reduce the size, weight, cost, and power consumption of quantum sensing systems."

That has been the main challenge for atomic clocks to date. The more precise they are, the bigger they become. High performance and conventional cold-atom systems, such as magneto-optical traps, remain bulky, expensive, and impractical outside laboratory environments.

Aquark is now closing in on its goal to reduce global reliance on GNSS for operations, infrastructure, telecommunications, finance, transportation, and many other sectors. "Cold matter technology is at the heart of what we do – and timing is just one application for it. With future demand and innovation, Aquark will be in a good position to develop cold matter devices that can address the full spectrum of potential applications. These might include gravity sensors for advanced navigation, underwater exploration, and environmental monitoring as well as new capabilities in radio frequency and inertial force sensing.

"There are clear demands for resilience today, however we believe that the greatest use of the technology is in the applications yet to be realized."

RISING EXPECTATIONS:

Credit: Boxfish Robotics

A DEEP DIVE ON UNDERWATER VEHICLES

By Celia Konowe

Underwater vehicles have solidified their position, with autonomous and remotely operated platforms becoming core operational tools across offshore, defense, inspection and maintenance, exploration and marine science applications. As the subsea industry rapidly evolves to keep pace with global trends, several defining themes emerge amongst leading vehicle companies—multi-use, usability, visibility, endurance and, unsurprisingly, autonomy.

MULTI-USE

As underwater vehicles assume more responsibility, there is a noticeable shift away from standalone, single-domain vehicles in favor of fleets of autonomous platforms, deployable on the surface, in the air and under the waves.

"The most common theme we see is the ability to operate in multi-vehicle autonomous teams with other platforms," said Terry Sloane, founder, owner and managing director of Planet Ocean and ecoSUB Robotics, an operating division of Plant Ocean. ecoSUB demonstrated a multi-use fleet in their 2021-2023 SoAR (Squads of Adaptive Robots) project, which coordinated a large-scale survey and exploration mission designed, monitored and adapted in real-time by an intelligent "Autonomy Engine." The SoAR fleet consisted of ecoSUB's Autonomous Underwater Vehicles (AUVs), the National Oceanography Centre's Auto-Hover 1 hover-capable platform, and Sonardyne's REAV-60 Unmanned Surface Vehicle (USV) "Decibel."

Duane Fotheringham, president of the Unmanned Systems group in HII's Mission Technologies division noted that the scale of underwater vehicles is growing. "Customers are moving away from buying one or two vehicles for experimentation and toward fleet-level quantities. That shift signals that unmanned undersea systems are transitioning from trials into sustained, operational use with real training, logistics and lifecycle expectations."

Credit: ecoSUB

USABILITY

User experience holds enormous weight for customers shopping for underwater vehicles. Systems need to be efficient, customizable and ultimately useful for the desired work.

"Customers want systems that can handle uncertainty, operate with limited communications, and integrate smoothly into broader maritime forces that include crewed ships, aircraft and other unmanned platforms," said Fotheringham. "They're also looking for reduced operator burden."

"We're also seeing strong demand for smaller, more portable platforms that don't require large vessels or complex logistics

Credit: AeroVironment Inc/VideoRay

to deploy," said Vera Bronza, director of sales and marketing at Boxfish Robotics. Precise data synchronization is also very important, she added, as the company's AUVs can synchronize data from all sensors, navigation and imaging.

"Beyond that, customers care a lot about efficiency and usability: how quickly the system can be set up, how many people are needed to operate it, and how much useful data can be collected in a single deployment. Flexibility is also important, so systems can evolve as project requirements change."

Flexibility is a well-recognized element for VideoRay, which prioritizes modular vehicles. "Customers want everything. They want vehicles to be tiny and portable, but also super powerful and take giant payloads. That's where modular technology is awesome, because we can accommodate that to a larger degree," said Marcus Kolb, chief technology officer at VideoRay, an AV Company. Their newest vessel, Mission Specialist Wraith, builds upon its predecessor, Mission Specialist Ally, promising improved agility and increased thrusters.

VISIBILITY

While underwater vehicles need to be efficient and operator-friendly, they also must be effective at what they do best—seeing what humans cannot. High-quality imaging is always near the top of a customer's list, Bronza stressed. "Reliable navigation and positioning are also critical, especially for surveys that need to be repeated over time."

Higher-quality imaging also indicates a shift towards increased tools and sensors for visibility and data visualization. "We're also seeing an interest in photogrammetry, where customers want to generate high-resolution 3D point clouds and/or 'digital twins' of underwater infrastructure for long-term monitoring," said Joseph Segato, account executive at Deep Trekker. "Finally, in low-visibility environments, a multibeam sonar has become a non-negotiable requirement due to visibility constraints."

Credit: SubCtech

Battery skid deployment for oil & gas customer.

ENDURANCE

The performance and functionality of an underwater vehicle is only as impactful as its endurance, with customers across the board seeking longer deployments. While this isn't exclusively based on battery capacity—energy management and mission configuration are also factors—subsea batteries constitute their own rapidly involving industry, balancing energy density, safety, modularity and regulatory compliance.

Many subsea batteries are lithium-ion (Li-ION), which offer an ideal balance between energy density, weight, volume and lifecycle performance, explained Sören Johannsen, chief operating officer and head of marketing at SubCtech. “For underwater vehicles, high energy density directly translates into longer mission endurance or increased payload capacity. Li-ION batteries also provide high efficiency, stable discharge characteristics and good scalability across different system sizes.” Deep Trekker's REVOLUTION Remotely Operated Vehicle (ROV) and Boxfish's AUVs and ROVs are all powered by Li-ION.

Deep Trekker’s REVOLUTION ROV.

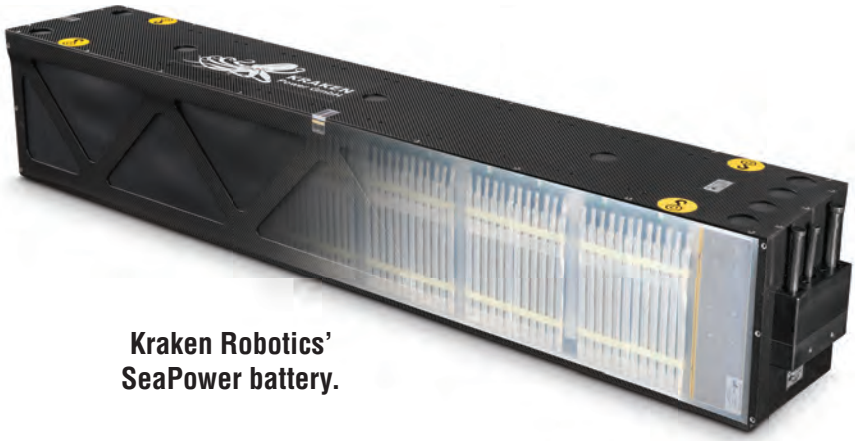
Credit: Deep Trekker

SubCtech's own SmartPowerBlocks are also Li-ION, combining a modular mechanical design with integrated battery management, monitoring and safety functions for subsea applications. “Their modularity allows customers to scale capacity and voltage without redesigning the entire power system,” Johannsen said. SmartPowerBlocks are also customizable, adapting battery geometry, capacity, voltage levels and interfaces to match specific vehicle constraints and mission requirements. “This can include form-factor optimization for tight hull spaces, redundancy concepts for safety-critical applications, tailored discharge profiles or integration with vehicle-specific communication and monitoring systems. We also adapt solutions for different regulatory environments, whether for defense platforms, scientific vehicles, or oil and gas all-electric systems, while maintaining a common, qualified technology base.”

Kraken Robotics’ SeaPower battery platform is also built on Li-ION technology, embedding pouch cells and electronics in a silicone polymer matrix and operating up to 6,000 meters. It boasts a pressure-tolerant, potted architecture that removes the need for rigid pressure housings or oil compensation and is built on a modular design, allowing for voltage, size and energy to be adapted to project needs. “We're seeing a strong increase in demand for SeaPower batteries, particularly for defense applications and extra-large unmanned underwater vehicles (XLUUVs), where endurance, reliability, and safety are mission-critical,” said Patrick Paranhos, Vice President, Battery Systems. “This growth reflects a broader shift toward longer-range, higher-power subsea platforms operating in increasingly complex environments.”

At HII, the REMUS Unmanned Underwater Vehicle (UUV)

Credit: HII



Credit: Kraken Robotics

Kraken Robotics' SeaPower battery.

also offers a modular energy architecture, allowing the vehicle to carry one, two or three battery packs and for endurance to be scaled depending on speed, payload and operating profile. While Li-ION batteries are the most common, alkaline batteries are also an option for certain specialized missions. ecoSUB's AUVs are also standard fit with rechargeable Li-ION batters, but alkaline cells can still be accommodated.

VideoRay took battery needs into their own hands. "We were going back and forth between nickel-metal hydride because they're easy to ship, and Li-ION, which are a real pain to ship. We co-developed our own simply because we couldn't find anybody else that made one," said Kolb. "Our batteries, like all of our modules, have a brain on board. They have a node that can talk to request information. But more than that, they actually output regulated power at 48-volt nominal, and then it goes down to the cutoff voltage on lithium."

AUTONOMY

Autonomy is a growing request, if not requirement, in the subsea industry and beyond to enable work to be completed faster and over a longer period than when operated by a human. Simply put, more data points can be collected, processed and visualized. In offshore, exploration and defense applications, autonomous systems remove a level of risk by reducing dangerous or extreme situations. What's crucial, Fotheringham emphasized, is that underwater vehicles are capable of autonomy beyond sea trials. "Autonomy is expected to function in real-world conditions, not just controlled scenarios."

Underwater vehicles are evolving from specialist tools into routine, networked assets, guided by project needs and customer demands. While multi-use, usability, visibility, endurance and autonomy stand out as common trends for next-generation vehicles, they also serve as indicators for the seemingly boundless possibilities still to come.

OCEANOLOGY INTERNATIONAL 2026 BRINGS ASHORE NEW COAST FOCUS

By Celia Konowe

Oceanology International (Oi), the world's leading forum for ocean science, engineering and technology, is returning for its 57th year, larger than ever and with a new conference track that mirrors the trajectory of the global ocean sector. A new exhibition focus called COAST has been added to address the critical challenges facing coastlines increasingly battered by storms, flooding, erosion and rising sea levels.

Oi26, taking place March 10-12 at Excel London, is shaping up to be the largest in its almost six-decade history. An additional hall has been added to the trade-show floorplan, meaning the exhibition will now cover more than 21,000 square meters of indoor space, said David Ince, event director. The organizers expect around 450 exhibiting companies from over 30 countries and more than 8,000 international attendees across the three show days.

"The hundreds of exhibitors at Oi represent the full breadth of the ocean technology and marine science ecosystem, from developers of sensors, instrumentation and uncrewed systems through to providers of data, software, surveying, engineering and operational services," said Ince. "The show brings together solutions supporting offshore energy, ocean observation, defense, ports and maritime infrastructure, climate & environmental monitoring and emerging blue economy applications, giving attendees a comprehensive view of how the ocean enterprise is evolving."

The show also serves as a premier event for the ocean sector to showcase new innovations and technologies. "We've seen evidence from previous years that exhibitors plan their strategies around Oi and decide it is the best time to unveil their latest developments, partnerships and technological advancements. In 2026, we expect the show floor to host over 100 product and service launches, and a significant number of exclusive announcements," Ince added.

Making Waves

Larger attendance, a bigger floorplan and 100 product launches are just part of the reason Oi26 should be a standout industry event. In response to global coastal challenges, the inaugural COAST conference track will focus on innovation and solutions in topics like coastal zone management, protecting the environment in coastal waters, coastal resilience, ports and terminals, and coastal infrastructure protection.

Additionally, as real-time data and predictive modeling prove increasingly vital for coastal planning and disaster response, Oi will offer opportunities to explore integrated monitoring platforms and early warning systems. The balance between economic activity and environmental protection, another critical intersection, will also be addressed by highlighting solutions that support sustainable tourism, aquaculture and coastal livelihoods.

COAST will manifest on its own stage as a three-day content program, placed as a core feature within the exhibition alongside Ocean Futures, the technical conference and dockside demonstrations.

"We've been working closely with organizations including the UK Environment Agency, The Crown Estate and Cefas (Centre for Environment, Fisheries and Aquaculture Science) to ensure a strong and credible COAST focus that complements the wider Oi content, while also bringing new organizations and audiences into the event," Ince explained. "In addition, more than 60 exhibitors across the exhibition will be highlighting specific coastal and shallow-water solutions, creating plenty of opportunities for attendees to connect with relevant companies and expertise."

COAST will further enhance the traditional Oi program across the exhibition and conference by highlighting developments in coastal protection, erosion control, sediment transport analysis, shoreline stabilization and climate adaptation that support sustainable coastal development and ecosystem protection. Importantly, COAST will be fully integrated into Oi, rather than positioned as a standalone feature, meaning visitors will encounter coastal solutions alongside offshore, deep-water and data-driven technologies, reinforcing the global relevance and transferability of ideas.

COAST also won't be solely British, despite Oi's London locale. "While the UK provides a strong and relevant backdrop for many coastal challenges, COAST has been conceived as a global platform, reflecting the international nature of Oi itself. Coastal and shallow-water issues such as erosion, flooding, infrastructure

resilience, habitat protection and climate adaptation are shared challenges across regions, from Europe and North America to Asia-Pacific, Africa and small island states," said Ince.

He added, "COAST is another example of how Oi continues to reflect where the ocean enterprise is heading. Our role is to ensure that the event mirrors that direction, creating opportunity for exhibitors and visitors alike while bringing new organizations, ideas and solutions into the show. With the increasing convergence of offshore, coastal, climate, data and infrastructure challenges, it makes sense for us to give greater visibility to these interconnected areas. COAST allows us to do that in a structured way, while remaining fully aligned with the broader Oceanology proposition. The exhibitors and content featured within COAST are therefore international in scope, both in terms of the companies involved and the case studies, technologies and expertise being showcased. As with the wider Oceanology program, we're working closely with a broad network of global stakeholders from industry, government and academia to ensure the content reflects different geographies, operating environments and regulatory contexts."

Sea You There

By hosting these conversations amongst 8,000 attendees and 450 exhibiting companies, COAST has the potential to change how coastlines are perceived and protected. Solutions developed for one coastline can be exchanged across borders, then adapted and applied worldwide.

"COAST is a new gateway for leading companies in the field to join the global gathering at Oi and gain access to a highly targeted and engaged audience—to demonstrate their solutions for dynamic nearshore environments and engage with coastal engineers, hydrographic surveyors, geospatial analysts, port and harbor engineers, environmental consultants, marine data specialists and coastal planners," said Ince.

"Simply that if you're involved in any way in monitoring, exploring or operating in the world's oceans, coastal zones or waterways, I believe you'll find real value in the connections, insights and direction gained at Oi—and I hope to see you at Excel London from March 10-12," Ince concluded. The ***MTR*** team concurs and we plan to see you there.

POWERING THE DEEPEST FRONTIERS:

CHOOSING LITHIUM BATTERIES FOR EXTREME SUBSEA VEHICLES

By William Kohnen, *President and CEO, HYDROSPACE Group Inc.*

As human and robotic exploration moves deeper into the ocean than ever before, the performance expectations placed on subsea vehicles continue to rise. At full-ocean depth, every system must operate flawlessly under crushing pressures, near-freezing temperatures, and total isolation. At the center of this challenge lies one of the most mission-critical technologies of all: energy storage.

Lithium batteries have become the undisputed champions of high-energy applications, delivering unmatched energy density in compact, lightweight packages. For subsea vehicles, this translates directly into longer dives, greater payload capacity, and expanded operational reach. But in the deep ocean, not all lithium batteries are created equal. What truly separates a deep-sea-ready power system from a conventional battery is not just how much energy it stores, but how safely, reliably, and powerfully it delivers that energy in the most extreme environment on Earth.

Beyond Energy Density: Power Where It Matters

Deep-sea vehicles are power-hungry machines. High-thrust propulsion, powerful lighting arrays, hydraulic systems, manipulators, sensors, and life-support equipment demand more than endurance alone — they demand sustained high current. Many high-energy lithium batteries are limited to modest discharge rates, requiring complex parallel architectures to meet vehicle power needs.

ICTINEU Submarins S.L. has engineered its lithium battery systems to deliver both high energy and high power. With continuous current capabilities in the 80 to 120 amp range, ICTINEU batteries are purpose-built to support the heavy electrical loads of manned submersibles and large deep-ocean platforms. The result is fewer battery modules, cleaner system integration, and vehicles that can operate with confidence under peak power conditions.

Safety Designed In, Not Added On

In manned submersibles, safety is not a feature, but the foundation. ICTINEU's battery systems are developed specifically for deep-ocean operation, where thermal events, water ingress, or electrical faults are simply unacceptable. Every system incorporates a comprehensive, embedded Battery Management System with individual cell monitoring, redundant temperature sensing, and intelligent fault protection.

Twin set of 6000m DNV certified Submersible Power banks, 50 Kwhr @ 148 VDC 30 Kwhr @ 266V.

All images courtesy Ictineu Submarins SL

Solid-state relays provide rapid, arc-free disconnection in abnormal conditions, including high-voltage configurations. Internal fire-propagation barriers, water-detection systems, controlled exhaust pathways, and pressure-tolerant construction further elevate safety margins. These designs are validated through environmental testing and are certified to DNV rules for Electrical Energy Storage Systems, a critical benchmark for deep-sea and manned operations.

Proven at Full Ocean Depth

Leadership in the deep-sea industry is defined not by specifications, but by performance in the field. ICTINEU batteries have been selected to power some of the most advanced subsea vehicles ever built, including platforms that have reached the deepest point on the planet — the Mariana Trench. They are also deployed across next-generation 6,000-meter-class submersibles and deep-ocean systems where endurance, reliability, and safety are mission-critical.

Founded in 2007 in Barcelona, ICTINEU Submarins developed its battery technologies alongside its own manned submersibles, refining them through five generations of evolution. Each generation has advanced compactness, safety architecture, certification readiness, and manufacturing quality, resulting in a family of scalable, pressure-tolerant lithium battery systems purpose-built for deep-sea exploration.

A Complete Deep-Ocean Power Solution

In North America, Hydrospace Group represents ICTINEU and brings expertise in manned submersible systems and deep-ocean integration. Together, they deliver complete, certified power solutions backed by real-world experience at the deepest depths.

When mission success depends on power, safety, and reliability, choosing a deep-sea battery is not simply a technical decision. It is a strategic one. ICTINEU's lithium battery systems stand at the forefront of subsea energy technology, powering the vehicles that are redefining what is possible beneath the surface of our planet.

ICTINEU Submarins S.L.

Founded in Barcelona in 2007, ICTINEU Submarins S.L. specializes in deep-sea manned submersibles and pressure-tolerant lithium battery systems engineered for the world's most extreme environments and continues to lead in safe, reliable deep-ocean power systems. ICTINEU batteries are DNV-certified and proven in some of the deepest dives ever achieved, including full-ocean-depth missions.

Hydrospace Group Inc

Hydrospace Group is a North American provider of advanced subsea technologies and systems expertise, with a strong focus on deep-sea and manned submersible applications. With extensive experience in subsea engineering, safety, and system integration, Hydrospace Group helps operators implement proven technologies that enable safer, deeper, and more capable subsea vehicles.

BRIGHT PROSPECT:

All images © Laserline

Blue Lasers for the Deep Sea

From cutting and drilling to paint stripping and removing maritime fouling, underwater tasks in the maritime environment are as numerous as the grains of sand on the beach. Some of these applications are carried out at depths of several thousand meters. A new laser system based on blue diode lasers now promises a contact-free, low-maintenance, and cost-efficient solution for a wide range of underwater operations.

By Dr. Simon Britten, *Senior Technology Manager at Laserline*

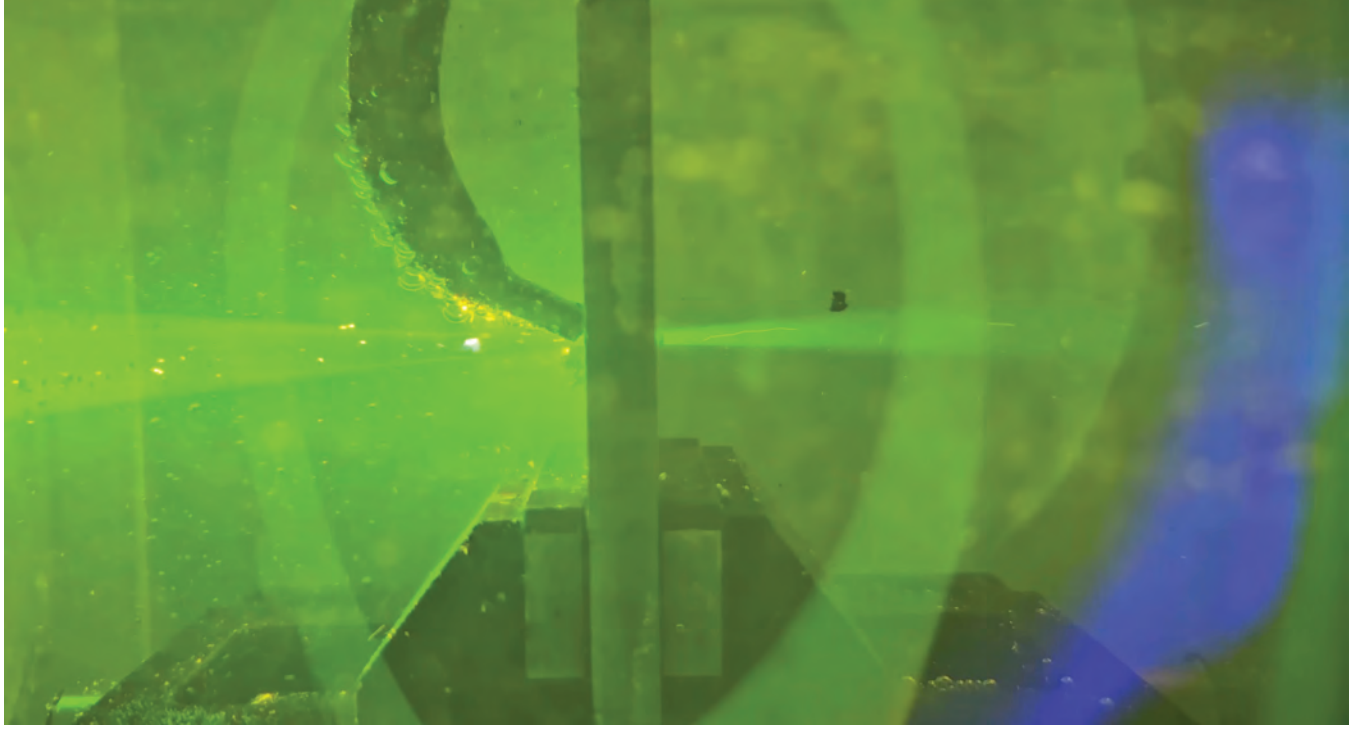
Whether in the maintenance of offshore platforms, the decommissioning of old oil rigs, or the inspection of underwater structures, the demands for precision, efficiency, and environmental compatibility in subsea operations continue to increase. At the same time, conventional methods quickly reach their limits here. Common pressure-based processing methods, such as high-pressure water jets used to remove algae growth, lose their effectiveness with increasing depth due to the high counterpressure of the water. Additionally, many of these systems require intensive maintenance and are prone to wear. Mechanical tools such as circular saws, in turn, generate recoil forces upon contact with components, which destabilize remotely operated underwater vehicles (ROVs) and often cause them to drift away.

Consequently, the industry shows great interest in contact- and force-free, low-wear, low-maintenance alternatives – possibilities that laser technology in particular can offer. Initial attempts, however, were not very successful. Early efforts to use conventional infrared (IR) lasers to cut structures during oil platform decommissioning proved only partially practical. The primary reason: infrared radiation (wavelength 1000 nm) is completely absorbed by water within just a few centimeters, resulting in significant energy loss. For subsea applications, IR laser cutting can therefore only be performed using an air nozzle or an air-filled chamber – a complex and cost-intensive process that also prevents use at greater depths.

Blue Lasers as Key Technology

A newly developed underwater laser system based on blue diode lasers from Laserline now promises a solution to this challenge. Unlike IR radiation, the blue light emitted by these lasers, with a wavelength of around 445 nanometers, is barely absorbed by water. The lasers thus offer excellent transmission, with the ef-

Image above: Underwater processing with blue diode laser – Perforation / Penetration through 8 mm steel plate.



fect that (almost) the entire laser power is available – even when distances of up to one meter or more have to be bridged during processing. Combined with laser powers of up to 6 kilowatts, this physical advantage opens up numerous new possibilities for force- and contact-free material processing directly underwater – without an air chamber or other complex infrastructure.

Laserline diode laser systems also offer maximum precision: for example, the laser spot size can be adjusted with micrometer accuracy, and the power can be precisely controlled within milliseconds. This ability to quickly adjust the power makes the system particularly suitable for complex tasks at great depths.

Efficient, Flexible, Economical

The combination of high efficiency and precise controllability makes the new laser system both technologically and economically highly attractive. Contact-free processing underwater significantly reduces wear on tools and components, lowers energy requirements, and minimizes the release of potentially harmful particles or substances. Contact-free processing underwater significantly reduces wear on tools and components, lowers energy consumption, and minimizes the release of potentially harmful particles or substances. In terms of environmental protection and resource conservation, the diode-laser-based process clearly outperforms conventional mechanical or chemical methods—which often cause environmental damage and material degradation. This is especially relevant for removing marine fouling, which until now has often been treated with such methods, posing risks to both the environment and the components.

The system also offers new logistical advantages. While conventional heat treatment processes in the deep sea often require the use of large, specialized ships with daily costs in the five to six-figure range, the diode laser system can also be operated from smaller supply ships thanks to its simpler system architecture. This not only reduces maintenance and operating costs and significantly shortens travel times, but also significantly increases system availability and the responsiveness of operational teams. Especially for short-notice maintenance tasks or emergency repairs, companies gain a notable operational advantage.

From Cutting Processes to Algae Removal

The range of possible applications is diverse: cutting sheet metal and pipes during the decommissioning of oil rigs, removing coatings, paint, and marine fouling, inspecting and maintaining valves and load-bearing structures on pipelines or offshore platforms. The latter in particular are often completely overgrown with algae after a few years of service. Here, an ROV equipped with a laser and a camera can remove the growth and restore clear visibility to critical components in a single dive – a decisive advantage for maintenance companies and underwater integrators. Robot-assisted systems for pipeline inspections can also be equipped with a diode laser as a useful add-on.

System Technology

Depending on the application, different integration approaches for diode lasers have been developed. One option is to mount the laser system onto a Workhorse ROV, remotely operated from a supply vessel via a traditional umbilical cable. The laser system, with an output power of up to 6 kW, is specially enclosed to permanently protect it against water, pressure, and dirt. The consistently low water temperatures between four and seven degrees Celsius that prevail in the deep sea make the integrated laser cooling system especially efficient.

Depending on the scenario, the laser systems can be customized to meet customer-specific requirements. The underwater vehicles can be equipped with laser scanners or fixed optics as well as diode lasers in different power classes, depending on the specific application. However, development in this area is far from complete: modular single components, for example, are expected to enable even more compact system designs – ultimately also reducing ROVs size. Further optimizations are anticipated: laser power and energy efficiency will continue to increase, and image recognition systems have the potential to be combined with AI in the future for the automatic identification of fouling or corrosion spots.

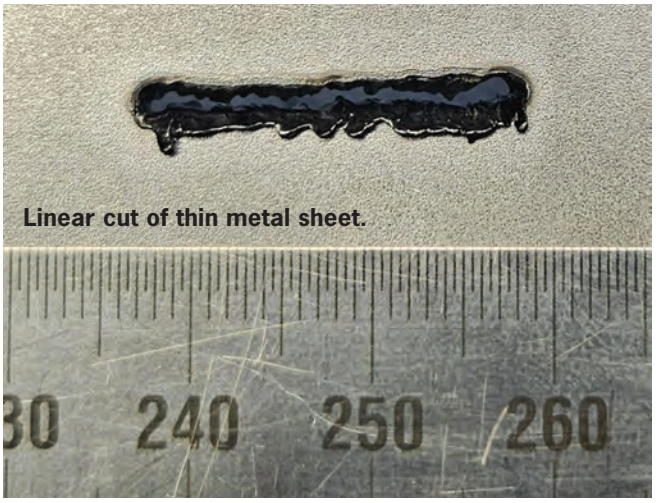
Case Study: Cleaning Ship Hulls with Blue Lasers

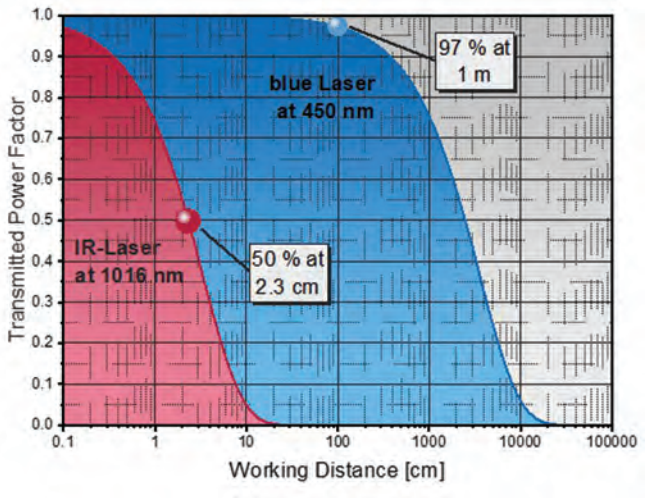
The outstanding transmission properties of blue wavelengths in water can also be leveraged to combat biofouling on ship hulls. In the research project "FoulLas," funded by the project agency Jülich using resources from the German Federal Ministry for Economic Affairs and Climate Action (BMWK), the project partners Fraunhofer Institute for Manufacturing Technology and Applied Materials Research IFAM, Laserline GmbH, and Laser Zentrum Hannover e.V. (LZH) demonstrated for the first time that targeted underwater laser irradiation can lethally damage marine fouling such as algae, mussels, and barnacles without harming the protective coatings beneath. After treatment, the dead fouling naturally detaches during the vessel's next voyage due to the shear water forces. The method is a promising alternative to mechanical processes, which often cause damage to coatings and release living organisms.

A follow-up project called "FoulLas2" is now transferring these laboratory results into practice: a semi-autonomous, magnetically adhering underwater crawler equipped with integrated laser optics will systematically sweep the ship's hull and irradiate the fouling directly.

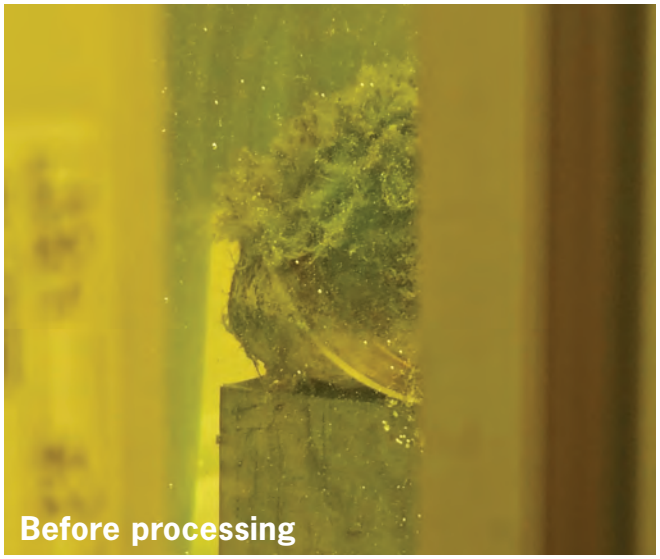
Conclusion: Setting New Standards in Underwater Technology

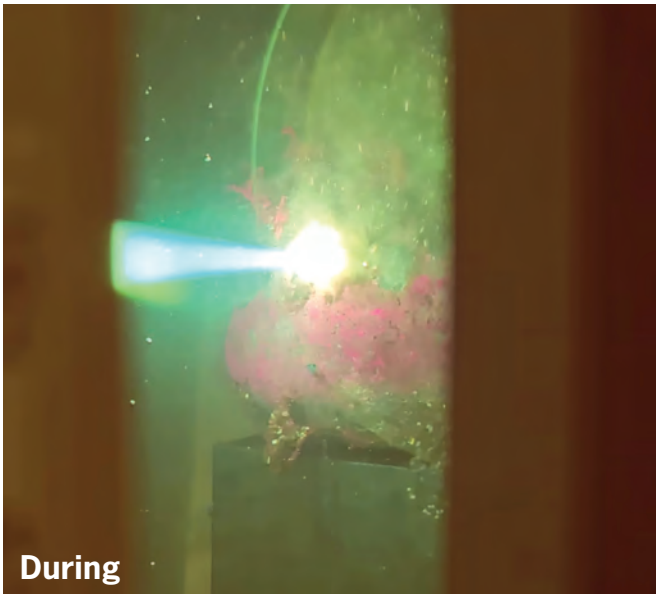
Overall, the blue diode laser marks a technological milestone for the maritime industry. It combines efficiency, precision, and environmental friendliness in a compact system and opens new possibilities for underwater processing. Whether for the maintenance of offshore platforms, the inspection of pipelines, or the removal of marine fouling, the laser provides a powerful and sustainable solution for numerous application scenarios. For service, maintenance, and supply companies in the subsea sector, the system opens new technological horizons and may replace many established methods of underwater processing in the medium to long term.

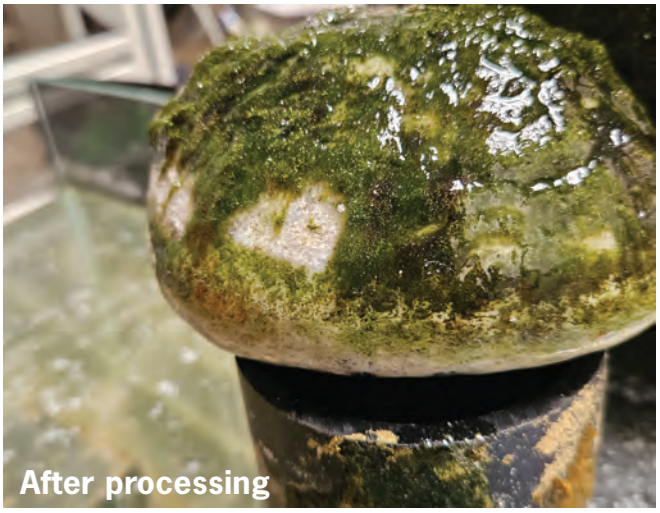




Underwater processing – Removal of algae growth on stone with blue diode laser.







Automatic docking as an enabling technology for the operational autonomy of underwater systems

For a long time, the operational autonomy of underwater systems has been constrained by the inability to ensure persistent operations without direct human intervention. Autonomous Underwater Vehicles (AUVs), while capable of carrying out pre-programmed missions along the water column or on the seabed, have historically required physical recovery at the end of each operational cycle for energy recharging, data transfer and mission reconfiguration.

This dependence on surface operations has represented one of the main bottlenecks in the development of long-term marine observation infrastructures, significantly limiting their effectiveness, continuity and scalability. Within this context, underwater docking technology emerges as a key enabling factor: the introduction of docking stations makes it possible to overcome the traditional operational paradigm, radically extending the autonomy of AUVs and enabling the deployment of persistent, distributed monitoring architectures with a high level of operational reliability.

Underwater docking technology

Underwater docking enables an AUV to perform approach and berthing manoeuvres towards a dedicated subsea station, designed to support automatic alignment, battery recharging, bidirectional data transfer and the updating of mission parameters. Docking stations constitute key infrastructural nodes within advanced marine observation systems, allowing a reduction in dependence on surface operations and an increase in the overall duration of data acquisition campaigns.

Docking station developed by EdgeLab, integrated on the ATLANTIS lander developed by CEiiA, Matosinhos, Portugal.

The evolution of docking technology has followed a gradual path: from early manual or assisted solutions, which required significant operator support, to more recent implementations of automatic docking. The latter are based on precision navigation systems, acoustic and optical proximity sensors, advanced control algorithms and autonomous decision-making logics, capable of robustly managing the approach, capture and disconnection phases even under challenging environmental conditions.

Automatic docking does not represent a mere incremental improvement, but rather a paradigm shift, as it enables the transformation of the AUV from a mission-based platform into an element of a persistent system, capable of operating for extended periods without human intervention.

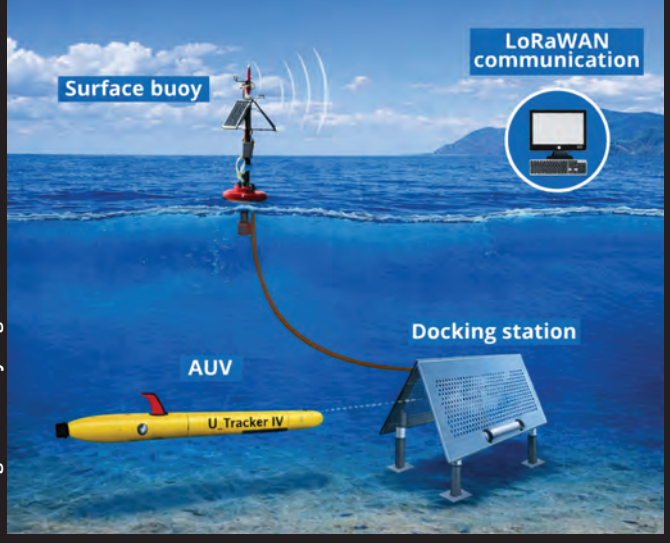
EdgeLab and the progressive development of docking technology

EdgeLab S.p.A., an innovative SME with its operational headquarters in La Spezia, operates in the field of advanced marine technologies, with a particular focus on the design of autonomous underwater vehicles and integrated systems for scientific, industrial and security applications. Over recent years, EdgeLab has systematically addressed the challenge of underwater docking through participation in European Union–funded research and innovation projects, developing a progressive technological pathway that has led from the implementation of manual solutions to the validation of automatic docking architectures.

Two projects, in particular, represent the main milestones of this technological evolution: NAUTILOS and M.A.R.E.

NAUTILOS: validation of manual docking in the context of sustainable marine observation

The NAUTILOS project, funded under the European Union's Horizon 2020 research and innovation programme, is focused on the development and demonstration of innovative technologies for the measurement of Essential Ocean Variables (EOVs), with the aim of addressing existing gaps in the observation of physical, chemical, biological and deep-ocean variables. The project seeks to strengthen and complement existing European observation infrastructures through the use of low-cost sensors and



Integrated platform: AUV, docking station, ground control station, and surface buoy.

Autonomous docking pool test developed by EdgeLab, La Spezia, Italy.

All images courtesy EdgeLab

samplers, integrated on a range of autonomous platforms and validated through large-scale demonstrations in European seas.

Within this context, EdgeLab played an active role in the development, adaptation and validation of technological solutions for autonomous platforms, taking responsibility for sensor integration, on-board system optimisation and the operational testing of underwater docking solutions as a functional element for extending AUV operational capabilities. In NAUTILOS, docking was implemented in a manual or assisted form, representing an initial testbed for the validation of mechanical, electrical and communication interfaces between the AUV and the docking station.

These activities enabled a critical analysis of operational challenges related to alignment in the presence of currents, vehicle stability, and the reliability of power connections and data flows, providing a solid technological and operational foundation for the evolution towards higher levels of autonomy.

M.A.R.E.: automatic docking as an enabling element of an autonomous ecosystem

Building on the experience gained through NAUTILOS, EdgeLab developed the M.A.R.E. project (Machine Learning Applied to Marine Ecosystem Research via AUVs), funded by the European Union – NextGenerationEU and implemented within the framework of the National Recovery and Resilience Plan (PNRR). The project is aimed at the development of an integrated system for advanced marine observation, designed to enable the coordinated measurement of Essential Ocean Variables across the entire water column through the interaction of multiple platforms.

The M.A.R.E. platform integrates an AUV, Docking Station, Lander, Hub Buoy and Ground Control Station within a modular and interoperable architecture, supported by a coherent communication network and by calibration, testing and validation procedures conducted both in laboratory environments and in controlled operational scenarios. Within this framework, automatic docking technology represents a central and distinctive element: the docking station enables the autonomous return of the AUV, energy recharging, continuous data transfer and mission reprogramming without the need for surface recovery.

The docking system is supported by advanced control algorithms, system diagnostics and autonomous management logics, which allow the closure of the vehicle's operational cycle and enable persistent and adaptive missions. While incorporating machine learning techniques for environmental data analysis, M.A.R.E. primarily represents a demonstration of the technological maturity of automatic docking, consolidating docking as an enabling technology for autonomous, scalable marine infrastructures with a high level of operational reliability.

Technological and operational implications of automatic docking

The evolution of underwater docking has implications that extend far beyond the individual vehicle. The availability of AUVs capable of autonomously returning to a subsea station enables the deployment of persistent marine infrastructures, characterised by a reduced need for logistical support and greater continuity in the data acquired.

From an operational perspective, automatic docking makes it possible to reduce the costs associated with the use of support vessels and specialised personnel, while simultaneously improving operational safety. From a systems perspective, it represents a key enabler for the scalability of observation networks, making it possible to coordinate multiple autonomous platforms within distributed architectures.

Conclusion

The development pathway undertaken by EdgeLab, from the manual docking validated within the NAUTILOS project to the automatic docking implemented in M.A.R.E., demonstrates how the operational autonomy of underwater systems is the result of a progressive evolution based on experimentation, system integration and technological maturation.

Today, automatic docking is no longer merely an ancillary feature, but a strategic enabling factor for marine observation, the sustainability of operations and the development of intelligent underwater infrastructures. Through these projects, EdgeLab has made a contribution to the advancement of a technology that is set to play a central role in the future of autonomous marine systems.

CADDEN

Hytech-Pommec

RTsys

CADDEN Becomes the Official Distributor of CHASING ROVs in France

CADDEN, a French company in the manufacture, distribution, integration and support of advanced technological solutions for geosciences, hydrography and robotics, announced that it is now an official distributor of CHASING underwater drones in France.

This new partnership allows CADDEN to expand its portfolio of robotic ROV solutions (Remotely Operated Vehicles), by offering remote-controlled underwater vehicles adapted to numerous scientific uses.

CHASING ROVs are known for their quality, performance and maneuverability. The range includes lightweight off-road ROVs as well as more sophisticated models for inspection (pipes, docks, pipelines, wrecks, etc.), observation, scientific research, aquaculture or underwater maintenance operations.

These systems combine:

- Precise control and omnidirectional movements
- High-resolution cameras with powerful lighting
- Variable depth operation capabilities
- Accessories and expansion options to adapt to business needs

CHASING ROVs are valuable tools for those involved in hull inspection, aquaculture, search and rescue missions or even underwater exploration, offering a balance between performance, portability and ease of use.

Joris Vogels Succeeds Eric Lamkin as Hytech-Pommec CEO

Hytech-Pommec announced that Joris Vogels has been appointed Chief Executive Officer as of January 1, 2026. He succeeds Eric Lamkin, who has led the company in recent years and will remain closely involved in its strategic direction as a shareholder.

Several years ago, Hytech – originally a spin-off from Royal IHC – was acquired by a group of investors together with Pommec Diving Equipment. The successful integration of both companies resulted in the current Hytech-Pommec, boasting a broad portfolio of products and services in hyperbaric technology. The post-merger integration has now been fully completed.

During this period, the company has demonstrated growth across the sectors in which it operates: medical, tunneling, commercial diving, governmental & defense, life support and yachting.

“I am excited to lead Hytech-Pommec into this next phase. We have deep expertise, a talented and committed team, and a solid position in several attractive and growing markets. Together, we will continue to invest in quality, innovation and sustainable growth. I am proud to carry this forward with our entire team," said Vogels.

The SeaVorian Group Becomes RTsys Group

SeaVorian, a player in the field of marine and underwater technologies, announced that the group will now operate under the name RTsys Group, effective January 1, 2026. This change reflects the company's strategic vision for the coming years.

RTsys Group supports clients worldwide across the scientific, research, and offshore industry and security and defense sectors, offering products, custom solutions, offshore services, and underwater data analysis.

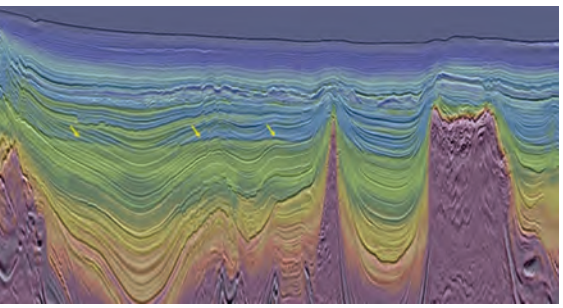
The new organization is structured around three specialized business lines:

- RTsys Underwater Technologies (formerly RTsys): the group's proprietary products built around three core areas of expertise — passive underwater acoustics, underwater robotics, and marine electromagnetism.
- RTsys Monitoring Solutions (formerly Neotek): customized monitoring solutions for understanding and observing marine and underwater environments, leveraging the group's expertise along with partner technologies integrated into tailor-made systems.
- RTsys Survey & Data Services: offshore data collection services using towed, remotely operated, or autonomous underwater systems, complemented by data analysis and processing for end users.

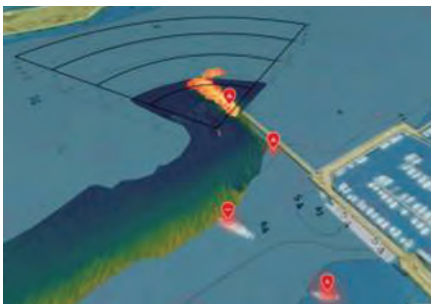
This new identity coincides with the relocation of all Lorient-based teams to a new site as of January 2026, tripling the group's production capacity.

The company Mappem Geophysics, specializing in marine electromagnetism and acquired by the group in September

Viridien



FarSounder



Vatn Systems

2025, further enhances these offerings and will retain its site in Saint-Renan.

To support the achievement of its ambitions, RTsys Group strengthened its long-term financing in 2025 by more than USD$4.69 million (€4 million), including USD$2.35 million (€2 million) through a capital increase to accompany the group's industrial transformation while reinforcing its R&D investments in order to maintain its technological lead.

Viridien Completes Reimaging of BM-S-2 Multi-Client Survey in Santos Basin

Viridien has successfully completed the BM-S-2 seismic reimaging project in the southern Santos Basin, delivering a high-fidelity 3D dataset across 8,468 sq km to support growing exploration activity in one of the most strategic, emerging offshore regions of Brazil.

The project upgrades a large legacy survey with the latest advanced imaging technologies, including time-lag full waveform inversion (TL-FWI), to provide clearer definition of post-salt stratigraphy, improved visibility of potential direct hydrocarbon indicators (DHIs), and new insights into underexplored pre-salt plays.

The reimaged BM-S-2 survey seamlessly integrates with Viridien's broader Constellation Extension survey, creating unified regional coverage that supports both play-scale screening and detailed prospect assessment across South Santos.

FarSounder Awarded Manufacturing Innovation Voucher to Advance AI-Based Sonar Capabilities

FarSounder, a leader in 3D Forward Looking Sonar technology, has been awarded a Manufacturing Innovation Voucher by the Rhode Island Commerce Corporation. The award will support advanced research and development focused on integrating automatic target recognition into FarSounder's end-user sonar software.

Under the Innovation Voucher program, FarSounder will build on an existing proof-of-concept to bring machine-learning target recognition into a fully integrated software prototype. This work will introduce automated classification of key sonar targets, focusing on seafloor features, wake-related bubbles, engine noise interference, and in-water objects such as whales, ice, rocks, and coral. The underlying framework is designed to expand over time, enabling additional target classes as new data becomes available

FarSounder's work leverages more than two decades of sonar expertise and a proprietary data set of over 80 terabytes of real-world sonar recordings collected globally. Using this data, FarSounder has already demonstrated a convolutional neural network (CNN) capable of processing raw sonar data in real time with performance comparable to existing classical algorithms. This foundation offers greater flexibility to expand object recognition capabilities through additional training.

The research supported by this award will benefit FarSounder's existing customer base through future software updates, while also enabling new integrations across emerging maritime applications. These include pilot-assist systems for high-speed passenger vessels, autonomous and minimally manned platforms, advanced collision-avoidance systems, and enhancing autonomy for USV platforms.

Vatn Systems Acquires Crewless Marine

Vatn Systems, a defense technology company building autonomous underwater vehicles (AUVs) for the US military, allied nations, and commercial customers, announced the acquisition of Crewless Marine, a Rhode Island-based company specializing in advanced underwater acoustic sensing and signal processing.

Founded by former Navy engineers, Crewless Marine brings experience in torpedo acoustic systems, hydrophone manufacturing, and real-time signal processing. The acquisition strengthens Vatn's strategy to vertically integrate its tech stack to control critical technologies, reduce supply chain dependencies, and accelerate development cycles for autonomous systems. Additionally, Crewless is executing on a Navy SBIR for "AI/ML Multi-Sensor/Multi-Target Localization."

As part of the transaction, Crewless Marine co-founder Steve Bordonaro, PhD, will join Vatn as Chief Engineer for Systems, and co-founder Philip

■ Sercel

■ PGZ Naval Shipyard

Caspers, PhD, will join as Director of Acoustics. Bordonaro brings over 30 years of experience in acoustic signal processing and autonomous systems, including senior leadership roles at the Naval Undersea Warfare Center where he served as Chief Scientist for the Sensors and Sonar Department and led torpedo guidance and control development.

Terms of the acquisition were not disclosed. This announcement comes on the heels of Vatn's $60 million Series A fundraising announcement, and their first international sale to Singapore's Defense Science and Technology Agency (DSTA), where the company is supporting the enhancement of Singapore's national defense with scalable, next-generation underwater capabilities.

■ Smart Seismic Solutions Selects Sercel Node Solutions for Energy Exploration

Sercel has supplied Smart Seismic Solutions (S3) with a comprehensive nodal seismic acquisition solution for multiple energy exploration projects in Europe. The order equips Smart Seismic Solutions with an additional capability of 4,000 WiNG DFU land nodes and 450 GPR300 ocean bottom nodes and marks the first large-scale deployment of Sercel's land and marine nodal technologies on the same seismic surveys.

Smart Seismic Solutions has already started deploying this mix of Sercel land and shallow-water nodes on geothermal surveys in Amsterdam, with additional projects planned across Europe in 2026. This milestone for seismic acquisition demonstrates the adaptability of Sercel's technology to a wide range of terrain and operational complexities.

At the heart of this success is Sercel's QuietSeis MEMS sensor technology, which delivers increased data quality and ensures full compatibility between land and ocean bottom node data. Thanks to a single, integrated digital architecture, seismic operators can deploy Sercel nodes across onshore and offshore environments while continuing to achieve consistent high-quality data standards. This unified approach eliminates recording format discrepancies, simplifies processing workflows, and delivers uninterrupted data continuity from acquisition to interpretation — a clear advantage for complex hybrid onshore-offshore surveys.

■ JFD Global Awarded Contract to Provide Deep Saturation Diving, Submarine Rescue Capability to Polish Navy

James Fisher (JFD Global), a global provider of specialist marine and defense solutions, has secured a contract with PGZ Stocznia Wojenna. The agreement will see JFD Global integrate a combined, hyperbaric and saturation diving system into the Polish Navy's new salvage and rescue vessel, Ratownik.

Scheduled to be completed in late 2029, Ratownik will become one of the largest ships in the Polish Navy's fleet, playing a role in the protection of critical underwater infrastructure (CUI) in the Baltic Sea, and responding to disabled submarines in both territorial and international waters.

This award follows a study completed by JFD Global in 2019 to undertake pre-engineering of the vessel and assess the feasibility of integrating such a complex technical solution.

During the design and construction phase of Ratownik, JFD Global will utilize its combined submarine rescue and saturation diving expertise to enable seamless integration with the vessel's systems. This will ensure rapid deployment in the event of an incident.

JFD Global will integrate the NATO Submarine Rescue System (NSRS) onto Ratownik, a system which it has managed since 2015, providing a 24/7 global submarine rescue service. This In-Service Support contract includes the maintenance and operation of the system to ensure it is in a rescue ready state on behalf of the French, Norwegian and Royal Navies. JFD Global ensures the system is kept mission-ready and can be mobilized at speed to reach a disabled submarine anywhere in the world.

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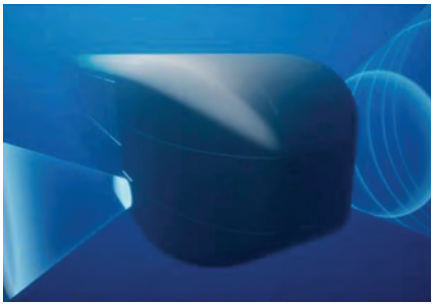


Golden Software

NORBIT Introduces WINGHEAD X Sonar

Building on the success of its WINGHEAD sonar platform, NORBIT has introduced the latest addition to its multibeam WINGHEAD X.

The WINGHEAD X multibeam sonar delivers 0.5° beamwidth resolution and combines all the features of the WINGHEAD series into one adaptable system. Built on NORBIT's innovative modular platform, it offers complete operational flexibility, allowing users to configure their sonar to meet specific survey applications and hydrographic requirements.

The company offers Long Range or Standard configurations, Integrated GNSS/INS or Non-Integrated options, and software features such as yaw stabilization, pitch stabilization, dual swath and more.

Thales Introduces New Sonar 76Nano for the Underwater Battle Space

Thales has introduced the prototype of Sonar 76Nano, a miniaturized acoustic detection system intended to redefine maritime security for the UK, NATO, and their allies. Building on the world-class legacy of the renowned Sonar 2076, the Sonar 76Nano directly supports the UK Government's Strategic Defence Review and Defence Industrial Strategy ambitions to strengthen national security and UK industrial capability.

Thanks to its modular and flexible design, Sonar 76Nano can be deployed onboard a wider range of uncrewed underwater vehicles (UUV) and seabed monitoring systems rather than being limited to large high value platforms. It empowers flexibility and responsiveness across naval operations through a hybrid fleet.

Key features and breakthroughs:

Miniaturized technology: leverages Sonar 2076 capabilities in a compact, versatile form factor.

Modular deployment: integrates across the full spectrum of platforms — uncrewed systems to crewed systems.

AI-enhanced acoustic detection: artificial intelligence accelerates target identification and decision-making with unprecedented precision.

Digital native integration: fully compatible with existing defense infrastructure, enhancing interoperability across UK and NATO forces.

On December 17, Sonar 76Nano made its official public debut with the Royal Navy at a technology demonstrator, marking a pivotal moment for maritime defense. This will allow naval personnel and experts to witness the prototype's capabilities first-hand and engage with Thales' leading engineers and scientists.

Golden Software Makes Upgrades Grapher Scientific Package with Enhanced Templates

Golden Software, a developer of mapping, plotting, and visualization software, has enhanced the Template experience in its Grapher scientific graphing package with improved ease of use and an online Template library. The completely redesigned Template functionality streamlines data preparation, analysis, and graphing for Grapher users at every level.

Grapher enables users to make better decisions by visualizing and communicating complex data sets in ways that simply can't be accomplished with spreadsheets. Enhancements in the latest release of Grapher gives users faster and deeper insights into diverse data sets, including chemical, physical, geologic, and geospatial data, through 80 different 2D and 3D plotting types. The package is used extensively by scientists and engineers in environmental services and consulting, climate research, exploration, and academic pursuits.

The newest release of Grapher, which is downloadable now to all users with active maintenance or subscription agreements, includes these enhancements. The first three relate directly to Templates while the others improve overall ease of use.

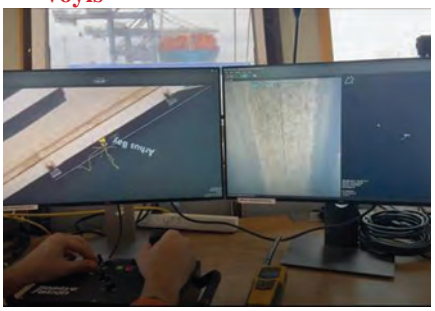
New Template Experience

Templates will become the most powerful and frequently used features in Grapher moving forward. The new Templates give users a visual preview of how their final graph will look and provide guidance in inputting their data or linking to an Excel file. The graph can be generated in minutes. All settings related to graph appearance, such as line style, colors, and font type, have been pre-selected, but the software also allows for customization. Custom templates can be saved for repeated use, and long-time Grapher users can revert to the same workflows used in the past to re-create, update, and modify existing projects.

The Golden Gallery

Grapher users may choose from over 30 Templates available either inside the software package or online via the Golden Gallery. Users can browse the Gallery to find the Template that visually presents their data most favorably or to receive recommendations on which graphs are best for specific industries, applications, or data types. Users even get tips on structuring their data sets to produce optimal results. The Golden Gallery will soon al-

Voyis



low users to upload their own Templates for sharing with other Grapher users.

Drillhole Data Templates

Grapher now offers users of the retired Strater subsurface mapping package an opportunity to continue visualizing their wellbore and drillhole data. Grapher drillhole Templates enable users to quickly create and customize professional subsurface graphs of their drillhole logs and cross sections with consistent visuals for their reports.

Document Comments

Users can now add comments to the Grapher documents, visible to others or only themselves. This is a major benefit to users who regularly update projects and need to leave reminders on how the graph was set up or should be changed in the future. Additionally, Comments make it easier to collaborate with colleagues and stakeholders by sharing notes and receiving feedback directly inside the document.

Default Scripts

Grapher has always given users the ability to write their own scripts for repetitive workflows, but many didn't know how to create them. The software now comes with Default Scripts for two of the most common graphing workflows – creating color scales for class plot legends and changing the font for all objects in a document. Users will soon be able to build scripts for sharing with other Grapher users.

Object Grouping

Users can now group objects throughout the Grapher document making it faster to edit objects and easier to get the layout they want. For example, the user can change the color or font style of all objects in a group or realign them for better appearance in the graph with a single click. Grouped objects can also be edited individually for deletion, copying, and realignment.

The next Beta cycle for the Golden Software Grapher package is now open. As always, users are invited to send their ideas for new or updated features and capabilities. Send an email to support@goldensoftware.com with any suggestions.

Voyis, EIVA Introduce Geo-Located Camera-Based Mapping

Voyis and EIVA, both part of the Covelya Group, announced an update to Voyis VSLAM Powered by EIVA NaviSuite. This technical advancement brings absolute geo-located mapping to real-time camera-based 3D reconstruction for subsea inspection and metrology. This new capability enables VSLAM-generated point clouds to be projected directly into global coordinates, from the moment an inspection mission begins.

This marks the first time that real-time visual mapping is natively aligned to global geodetic frames, bridging the gap between camera-based navigation and established industry survey standards.

Extending EIVA's Geodesy to Camera-Based Mapping

For more than 40 years, EIVA's NaviSuite geodesy computational tools have underpinned professional subsea survey and inspection workflows. The new update extends these same trusted geodetic capabilities directly into Voyis VSLAM Powered by EIVA NaviSuite, enabling visual point clouds to adhere to the same coordinate handling, consistency, and reliability expected in offshore operations.

By embedding NaviSuite's geodetic engine, users can now define geodetic settings, including selecting coordinate systems from the full EPSG Library, before data acquisition begins. This ensures that every 3D point generated by the VSLAM solution is immediately tied to a known global reference frame.

Absolute Geo-Located Mapping from the Start of a Dive

Voyis VSLAM Powered by EIVA NaviSuite reads the initial global position from a connected INS, such as a Sonardyne SPRINT-Nav, and places the map into the selected geodetic frame at mission start. This global placement is preserved throughout the dive, even after relocalization or loop closure events. While the SLAM engine continues refining local map geometry, its global alignment remains stable.

This advancement transforms how pilots and surveyors interact with real-time camera-based 3D reconstruction:

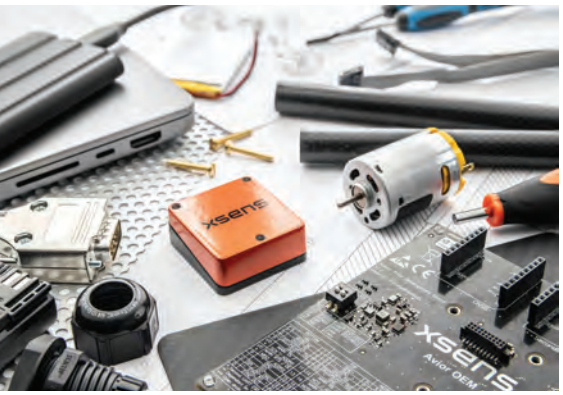
- Situational awareness improves, with the ability to load background maps, reference charts, or seabed models directly beneath the live VSLAM point cloud.
- A priori models, such as CAD drawings of subsea structures, can be overlaid for immediate comparison and navigation.
- Inspection targets and points of interest can be marked in absolute coordinates and revisited across dives, days, or vessels.
- ROV navigation becomes more intuitive, enabling safer maneuvering, cleaner tether management, and easier return-to-start positioning.

Operational Impact: Consistency, Efficiency, and Repeatability

The updated VSLAM solution elevates visual mapping from a purely relative model to a globally consistent dataset, enabling:

- Cross-dive continuity: Operators can resume inspections exactly where they ended, with the VSLAM map already aligned to the global frame.
- Faster data interpretation: Global positioning simplifies correlation between inspection data, engineering drawings, and historic survey datasets.
- Improved mission efficiency: Aligning to known structures and reference frames reduces redundant coverage and streamlines planning.
- Enhanced safety: Pilots benefit from live context by seeing real-time visual data within the surrounding geospatial

Xsens



environment.

This step reduces the operational burden traditionally associated with reconciling visual reconstructions against external positioning data, making camera-based inspections more robust and survey-ready.

Once collected, point clouds generated by Voyis VSLAM Powered by EIVA NaviSuite can be further managed through NaviModel, where users can reproject datasets into alternative reference frames as project needs evolve, ensuring compatibility with engineering standards and long-term inspection archives.

Xsens Upgrades IMUs With Heave Feature for Wave Motion Compensation

Xsens announced a capability upgrade for its industrial-grade Xsens Sirius and Xsens Avior inertial measurement units (IMUs). The new Heave feature delivers centimeter-level vertical displacement measurement, enabling real-time stabilization and wave compensation in a wide range of marine applications.

Marine engineers can now access comprehensive motion data – roll, pitch, yaw, and Heave – from a single compact sensor. This eliminates the need for external processing or for oversized tactical-grade systems while maintaining the precision required for offshore platforms, vessels, docking systems, marine robots, buoys, and surveying equipment.

The Heave output operates at up to 100Hz, providing the real-time response needed in active stabilization and wave compensation systems. All processing happens on-device, simplifying system integration and reducing latency.

Xsens Motion Reference Units (MRUs) – IMUs with Heave capability – deliver real-time Heave accuracy better than 5cm for wave periods up to 29s. This covers most marine applications. For longer wave periods up to 40s, accuracy is approximately 6cm, twice the range supported by comparable industrial-grade MRUs.

The algorithm uses proprietary phase correction and bias estimation to mitigate the effect of drift over extended operating periods. Users can also define offset points – Center of Rotation (COR) and Point of Interest (POI) – ensuring that Heave values reflect the true motion of the vessel or payload, even when the MRU is installed away from the POI.

The Heave algorithm is available for download immediately as a firmware update for existing Xsens Sirius and Xsens Avior units in the field, with no hardware modifications required. All new units ship with the feature integrated. Heave output is enabled with a single setting in the MT Manager software or the Xsens Software Development Kit (SDK).

Xsens Avior is a compact OEM module for embedded system designs, while Xsens Sirius is a standalone MRU in a rugged IP68 housing for harsh environments. It meets MIL-STD-202 requirements. Both products support RS-422, CAN, and UART interfaces. Development kits are available for prototyping, with free SDKs for C/C++, Python, ROS1, ROS2, and MATLAB. All units meet CE, FCC, and RoHS regulatory requirements, and are ITAR-free.

RTsys

The French Hydrographic & Oceanographic Service Orders New Maritime Drone

Following a seven-month bidding process, the French Hydrographic and Oceanographic Service (Shom) placed an order at the end of December for a new autonomous underwater micro-drone (µAUV), the NemoSens model, manufactured by RTsys. This order is part of a plan for hydrographic and oceanographic data acquisition methods launched by Shom in 2024.

NemoSens is a micro autonomous underwater vehicle (µAUV) designed for scientific, industrial, and defense applications. It is compact at less than one meter and lightweight at less than 10 kg. Its various payload configurations allow for flexibility and maximum usability.

NemoSens incorporates the latest hardware and software updates from the RTsys product line, making the micro AUV the most powerful of its generation. NemoSens is composed of four sections: a removable nose with onboard connectors for integrating different payloads; a central section including a multifunction mast (GNSS antenna, Wi-Fi antenna, UHF communication, flasher) as well as onboard sensors such as a 900 kHz Side Scan Sonar, an acoustic transducer for real-time tracking from the surface, and various internal sensors; the battery section; and finally, a rear propulsion section allowing it to reach speeds of two to six knots depending on the configuration.

Due to its versatility, the use cases of NemoSens are varied, ranging from two to 300m in depth, and from coastal mapping needs, diagnosis and monitoring of submarine cables, and pipelines, to port structures, detection of suspicious objects (UXO, underwater mines) and reconnaissance/securing of areas, water quality measurements and monitoring of biological studies.

NemoSens will be delivered in the first half of 2026.

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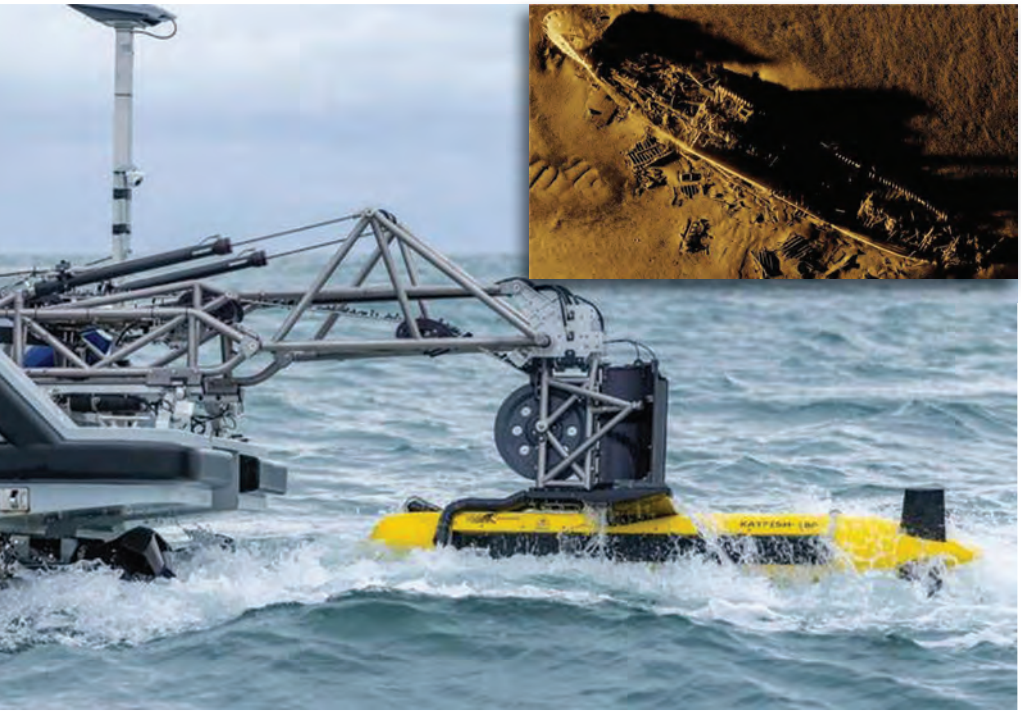
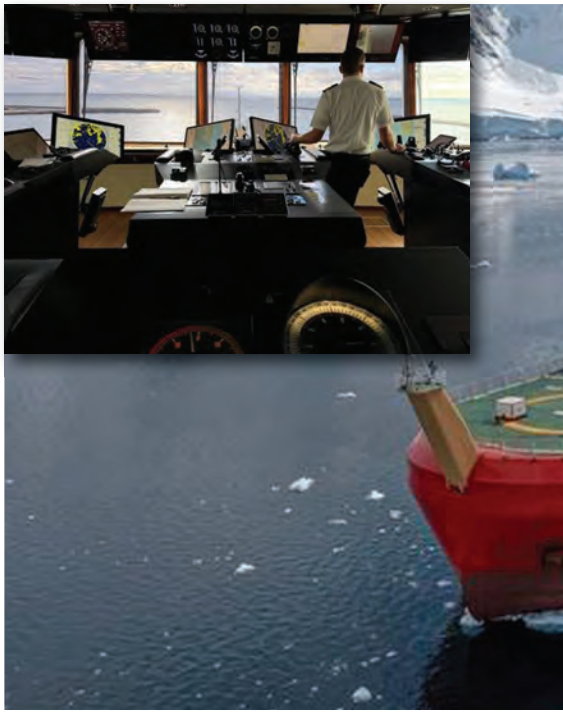


■ Anschütz



■ Kraken Robotics, TKMS ATLAS UK Demonstrate KATFISH USV Launch and Recovery System

Kraken Robotics Inc. announced the successful demonstration of its KATFISH Unmanned Surface Vessel Launch and Recovery System (USV-LARS) from TKMS ATLAS UK's (ATLAS UK) 11-meter ARCIMS USV. The systems offer a comprehensive autonomous survey package for maritime security missions including mine countermeasure operations and critical underwater infrastructure inspection. Together, ARCIMS and KATFISH USV-LARS provide the industry's first air-deployable, 300-meter depth rated autonomous towed SAS survey system.

The LARS footprint was designed to fit ATLAS UK's ARCIMS common deck interface, enabling rapid rerole and seamless integration with the platform. Sea state three conditions were encountered during operations, demonstrating the system's robustness and readiness for real-world naval environments.

This joint integration marks a major step forward in delivering agile, modular, and cost-effective mine countermeasure capabilities for modern naval operations. By combining ARCIMS' proven USV with Kraken's cutting-edge towed synthetic aperture sonar and recovery system, navies can deploy advanced technologies faster and more efficiently, strengthening maritime security in increasingly complex environments.

The system was demonstrated off the coast of Portland, UK, November 18-19, for NATO navies. Attendees witnessed the ARCIMS USV autonomously navigate and plan missions with the KATFISH towed system collecting high resolution SAS and bathymetric surveys in very shallow water. Data was live streamed via satellite communications to the command center on shore, enabling real-time classification of contacts by operators.

Kraken's KATFISH collects high resolution synthetic aperture sonar data at up to a 200-meter range per side at a depth of 300 meters, with real-time data streamed at 3 cm x 3 cm resolution. Kraken's KATFISH USV-LARS was designed specifically for small vessels, with an all-titanium construction for low magnetic signature and low weight.

KATFISH and USV-LARS were rapidly mobilized on the ARCIMS, with integration, testing and the demonstration happening over a period of just two weeks. Together, ARCIMS and KATFISH USV-LARS provide the industry's first air-deployable, 300-meter depth rated autonomous towed SAS survey system.

■ Polar Research Vessel Gets Nav System Refit

Since entering service in 2021, the polar research vessel RRS Sir David Attenborough has been equipped with navigation systems from Anschütz. As part of a recent refit, Anschütz has now supplied the vessel with a new SYNAPSIS NX Integrated Navigation System (INS), along with upgrades to the radar systems. The new technology enhances the stability and performance of the bridge system, supporting safe navigation even under the most challenging polar conditions.

Built by British shipyard Cammell Laird, the RRS Sir David Attenborough is among the world's most advanced polar research vessels. Measuring 129 meters in length, the vessel operates in Antarctica under the requirements of Polar Code

Credit: Jenna Plank – BAS

ice class 4 and the LR NAV1 IBS notation.

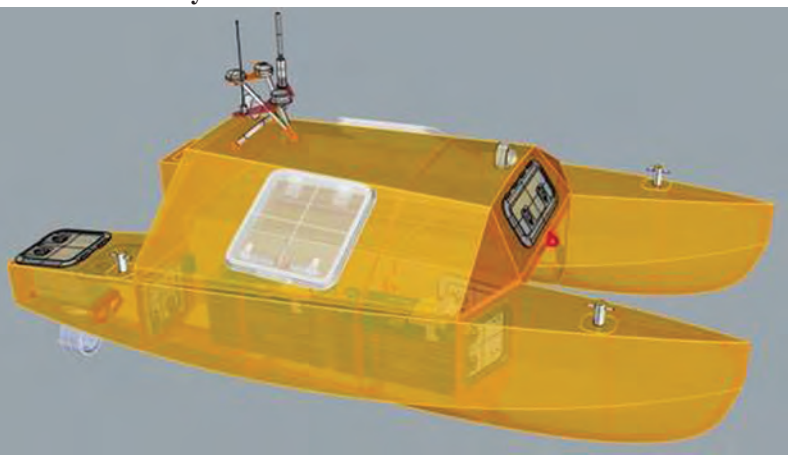
Following the initial delivery of navigation systems in 2017, Anschütz has now completed a comprehensive refit of both the radar systems and the INS. This included the installation of the latest generation of compact marine computers and software upgrades. Five multifunctional workstations were equipped with the newest edition of the SYNAPSIS software, offering improved user-friendliness and enhanced system stability.

The updated software provides the bridge with improved situational awareness and an expanded set of navigation tools, presented via modern, intuitive user interfaces. Advanced features for route planning, voyage management and positioning are available via the ECDIS, supporting safe and efficient navigation.

SYNAPSIS NX is type-approved in accordance with the Performance Standards MSC.252(83) and IEC 61924-2 for INS. It meets current regulatory requirements and complies with demanding class notations. Based entirely on LAN architecture, SYNAPSIS enables full control of all functions from any workstation. The multifunctional system ensures a consistent user experience with harmonized data, alerts and terminology—reducing distractions and supporting clear situational awareness. The INS integrates radar systems, precision autopilots and a redundant gyro compass system.

The RRS Sir David Attenborough is owned by the Natural Environment Research Council and operated by the British Antarctic Survey for both scientific research and logistical support.

■ HydroSurv



■ ACUA Ocean

■ **Clear Water Systems to Tackle Algal Blooms with HydroSurv USV**

HydroSurv announced a new vessel order from Clear Water Systems Limited, supporting a technology development project that addresses a critical environmental challenge facing freshwater ecosystems—harmful blue-green algae (cyanobacteria).

The pilot project, funded under a Small Business Research Initiative (SBRI) for the Department of Agriculture, Environment and Rural Affairs (DAERA), focuses on mitigating harmful algal blooms (HABs) in Lough Neagh, Northern Ireland's largest inland lake. Over recent years, Lough Neagh has faced increasing prevalence of cyanobacterial blooms, which threaten aquatic life, and the water quality for local communities.

As part of the project, Clear Water Systems is developing a novel in-line water treatment system designed for targeted, mobile disruption and toxin reduction of blue-green algae directly in situ. The company's SlipStream processor will be used to evaluate treatment approaches for HAB scums, with the objective of exploring the potential for reductions in algal concentration and potential toxin reduction.

To enable in-field testing and large-scale deployment, Clear Water Systems sought a zero-emission, uncrewed vessel platform capable of operating efficiently and safely within sensitive freshwater environments. To support in-field testing, HydroSurv is providing its REAV-35 Uncrewed Surface Vessel (USV), offering a capable and adaptable platform for hosting specialist environmental payloads, including Clear Water Systems' SlipStream processor, during trials

The 3.5-meter electric vessel features a 24kWh battery-electric powertrain driving twin 5kW steerable pod drives from Rim Drive Technologies, delivering quiet, emission-free operation with exceptional maneuverability and endurance. The REAV-35 builds upon HydroSurv's established family of USVs proven in environmental monitoring and water quality applications across the UK.

This initiative marks a step toward climate resilience and ecological restoration, showcasing how technology-driven collaboration can harness innovation and autonomy to enhance freshwater management for the benefit of communities and environments alike.

■ **UK Backs Development of 145-ft Uncrewed Offshore Support Vessel**

A consortium led by UK unmanned vessel developer ACUA Ocean has secured government support to develop a new 145-foot uncrewed offshore support vessel, aiming to scale up autonomous operations for offshore energy, logistics and surveillance.

The Project MROS consortium, which includes Houlder, Ad Hoc Marine Designs, Trident Marine and the University of Southampton, received funding earlier this year under the UK Department for Transport's Clean Maritime Demonstration Competition. The partners are now progressing with resistance and seakeeping tank tests led by the Southampton Marine & Maritime Institute and the Wolfson Unit.

The medium-sized vessel will feature hybrid-electric propulsion and operate autonomously, remotely, or with a small embarked crew. Designers are evaluating methanol fuel for efficiency and emissions reduction, alongside hydrogen, ammonia and diesel variants.

Building on ACUA's 14-meter Pioneer-class USV, the new platform incorporates a Small Waterplane Area Twin Hull (SWATH) design to reduce motions in high sea states. Pioneer became the first uncrewed surface vessel to receive UK MCA Workboat Code 3 approval this year, providing key operational data for the larger MROS design.

The 43-meter vessel will offer DP1 station keeping, a 2,500-nautical-mile range, endurance of more than 20 days and sprint speeds above 20 knots. It is designed for roles such as offshore logistics, surveillance, subsea inspection, intervention and offshore commissioning and decommissioning. Payload capacity will reach 80 tons, including space for ISO-standard containers and a moonpool configured for twin launch and recovery systems for ROVs and XUUVs.

ACUA Ocean will announce additional system-integration partners in the coming months as it develops modular mission payloads for both the Pioneer and MROS fleets.

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