MARINE TECHNOLOGY REPORTER

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Vehicles
UUV Integration Transforms Submarine Tactics

In the Spotlight
Chris Hearn & The Center for Marine Simulation

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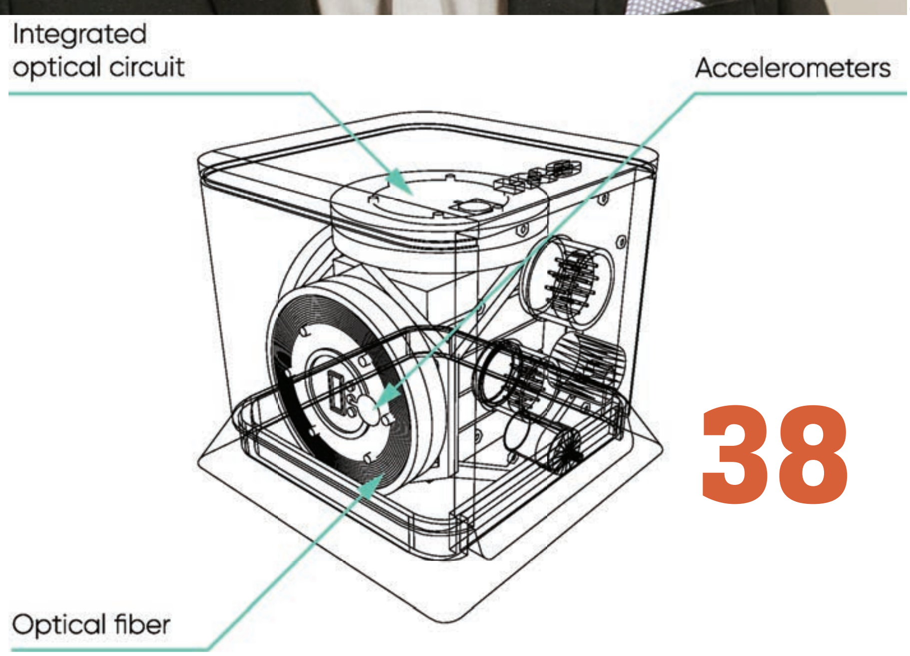

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On the Cover

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Memorial University Maritime Simulation Center

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Editorial

In late May 2024, I was afforded the chance to visit again the bustling St. Johns, Newfoundland & Labrador cluster, which you will read much more about in mid-September when we release a special eMagazine supplement on the region.

Justin Zuure

As we amass all of the interviews with government, industry and academia that will help to paint the picture of the expertise and opportunity that exists in the unique portion of the planet, I could not help but share in this edition our one-on-one conversation with **Captain Chris Hearn,** who is Director of the **Center for Marine Simulation, Fisheries & Marine Institute, Memorial University**. I've known Chris Hearn for many years, but the trek north in May 2024 was the perfect time to reconnect as he embodies the spirit and expertise of the region. A native son, a Memorial University graduate and an experienced mariner that brings real-world insight and experience to his role, Hearn summarized the spirit and attitude of this dynamic and capable cluster when he said:

> *"We are innovative by nature because we had to be. I heard a great quote one time about Newfoundland & Labrador: it has a landscape that makes you want to live up to it, but it doesn't provide you the resources to do it! We've had more than 500 years of living here, and because we're isolated, we had to grow something here in order to be able to deal with things."*

Read more about Hearn, the Center for Marine Simulation and the Newfoundland & Labrador region starting on page 22, and look for the "Newfoundland & Labrador" eMagazine to release mid-September 2024 in advance of the OCEANS show in Halifax.

Another contributor in this edition is someone who possesses not only a rich career and a deep love of the sector, but someone who works continually to advance the science and the business and inspire the next generation. **Kevin Hardy** is the author of our regular **'Lander Lab' feature**, and this one – number 11 which starts on page 38 – is particularly near and dear as it documents the **STEM Lander** and its role in helping to shape the future generation of ocean explorers, scientists and business leaders.

Gregory R. Trauthwein
Publisher & Editor

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SAAB

MTR Editorial Advisors

Gallaudet

The Honorable Tim Gallaudet, PhD, Rear Admiral, U.S. Navy (ret) is the CEO of Ocean STL Consulting and host of *The American Blue Economy Podcast*. He serves on several boards, is a fellow at The Explorer's Club, and is a strategic advisor for a few dozen startups, research institutions, and nonprofits in the ocean, weather, climate, and space sectors. Gallaudet is a former acting Undersecretary and Assistant Secretary of Commerce, acting and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA), and Oceanographer of the Navy. He has a bachelor's degree from the U.S. Naval Academy, and master and doctoral degrees from Scripps Institution of Oceanography.

Hardy

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*.

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Lundquist

Konowe
Celia Konowe is from Reston, Va., and has a bachelor's degree in environmental studies. She has study abroad experience in France and Ecuador. Currently, she is pursuing her master of environmental studies degree at Dalhousie University.

Laursen
Wendy Laursen has 20+ years of experience as a journalist. In that time, she has written news and features for a range of maritime, engineering and science publications. She has completed a Master of Science research degree in marine ecology as well as diplomas in journalism, communication and subediting.

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Edward Lundquist is a retired naval officer who writes on naval, maritime, defense and security issues.

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Rhonda J. Moniz is host of Marine Technology Reporter's DEEP DIVE podcast. She is an underwater forensics expert specializing in diving technologies and subsea systems. She has more than 25 years of experience as a ROV pilot, master dive instructor, scientific diver, and dive safety officer. She is the president of the board of directors for the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS).

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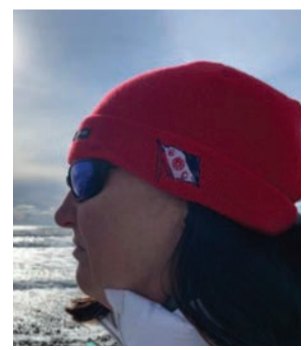
David R. Strachan is a defense analyst and founder of Strikepod Systems, a research and strategic advisory focusing on autonomous undersea systems.

von Xylander
Nora von Xylander is a Biodiversity Specialist and Sustainability Scientist at Tunley Envrironmental, whilst currently conducting a PhD, at the University of St. Andrews, on 'understanding the role of lipids on coral biomineralization and the effects of future climate change'. In her spare time Nora enjoys travelling, scuba diving, soap making, photography, and all things revolving around being in nature (e.g. hiking and camping).

Moniz



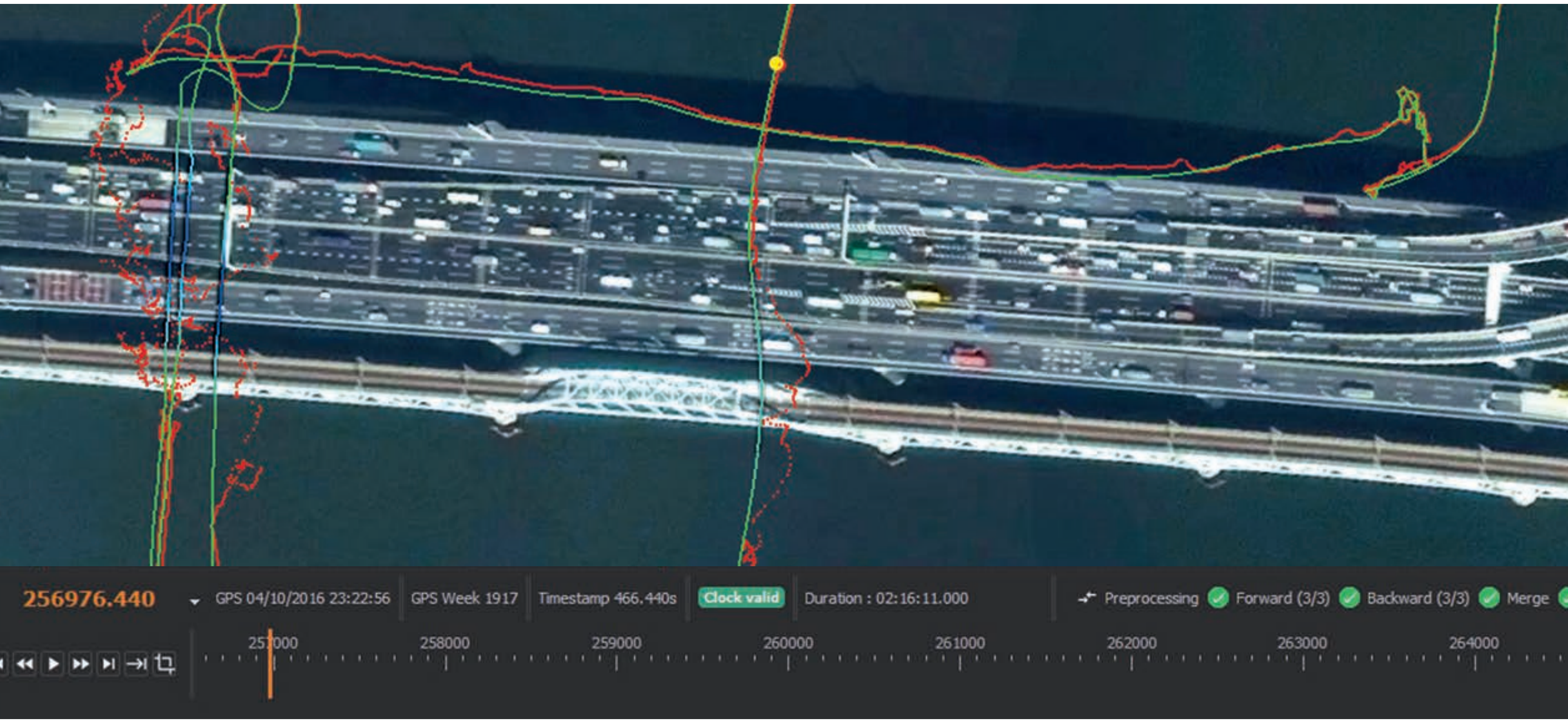
Strachan

von Xylander

Qinertia

The Next-generation INS/GNSS Post-processing Software

Data Sheet



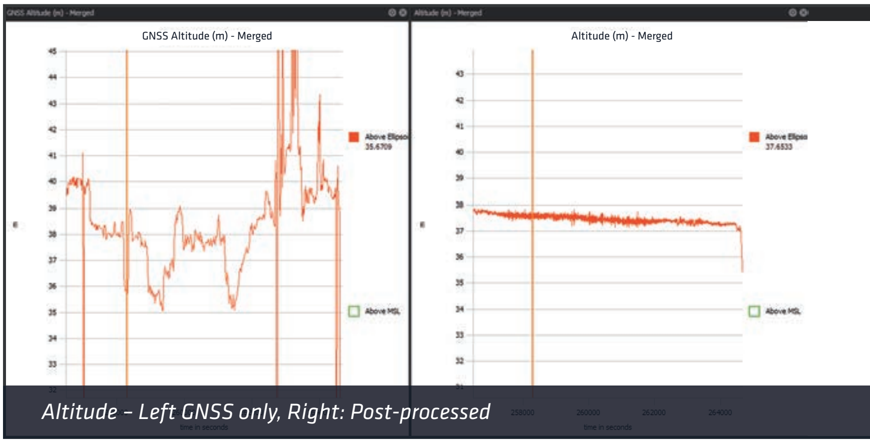
Quality: *Green -> centimetric position; Blue -> decimetric < 30cms; Red -> Raw GNSS data*

SURVEYING UNDER BRIDGES MADE EASY

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

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

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



Altitude – Left GNSS only, Right: Post-processed

The Fastest PPK Software	Long GNSS Outages Handling	Easy & Powerful Exporter
Log duration: 2h15 Processing Time: < 2 mins	Example: up to 80 seconds *outages and multi-path effects* 95% positions < 2 cms Max error < 30 cms	Easy export to third party software (SBET/ ASCII)

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

Full data available upon request at marketing@sbg-systems.com
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PREPARING FOR FLOATING WIND – LEVERAGING THE OIL & GAS SUPPLY CHAIN

Examining similarities and differences between the deepwater oil & gas and the emerging floating wind segment.

By Philip Lewis, Research Director Intelatus Global Partners

There has been much excitement around the potential for the offshore wind industry to access deeper water sites through the deployment of floating wind technology.

Further, there has been much discussion around the development and deployment of disruptive technologies to leverage the opportunity of floating wind. However, in the short- to medium-term, there is insufficient time to mature early-stage concepts to the high degree of technical readiness that will satisfy classification societies, banks, insurance companies and others. This means that floating wind will need to lean heavily on the supply chains developed to support the offshore oil & gas industry.

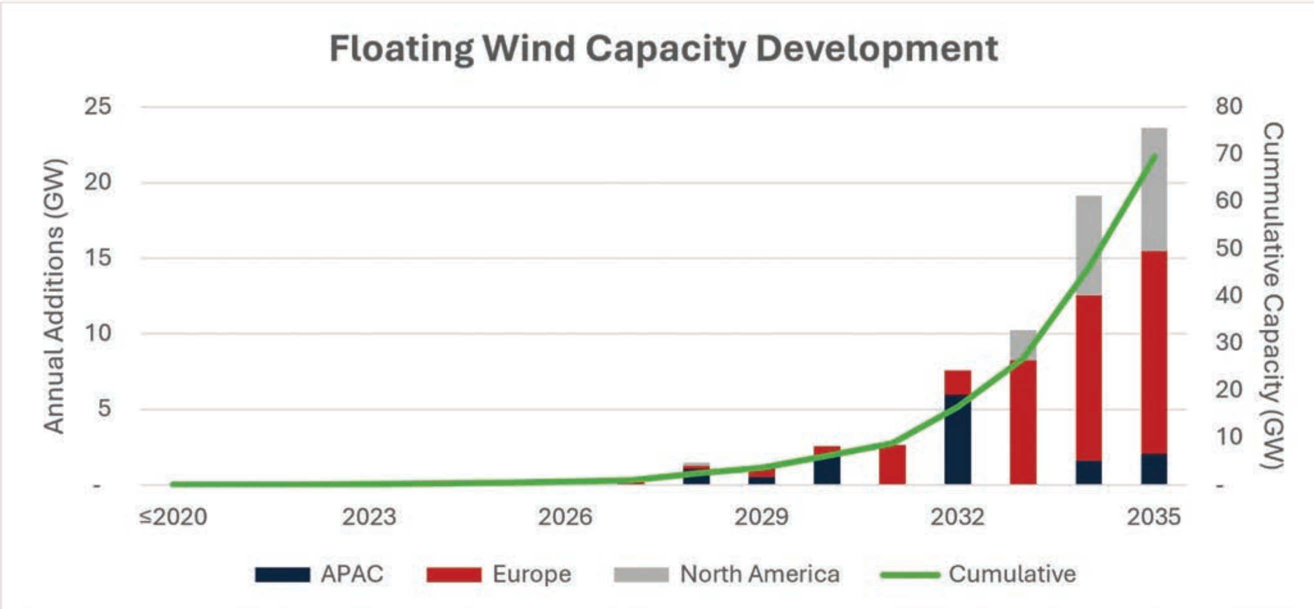
In this article we look at some of the similarities and differences between the deepwater oil & gas segment and the emerging floating wind segment, concluding with our concern that we do not have the right number or the right type of vessels for the efficient construction of commercial scale floating wind farms.

What does deeper water mean when talking about floating wind?

The current floating wind hotspots are found in the APAC, European and North American regions.

In APAC, we look to China (100 -125 meters), South Korea (130-275 meters) and Taiwan's pilot arrays (~100 meters). Australia and India hold significant potential, but commissioning of commercial scale floating wind projects is unlikely until around the middle of the next decade.

Global Floating Wind Forecast



Source: Intelatus Global Partners

Europe will see floating wind deployment in the Atlantic, Baltic, Mediterranean and North Sea, with the UK (80-150 meters) and Norwegian (200-400 meters) markets likely to drive activity through this and the first half of the next decade.

In the U.S., the first commercial scale projects will be off California (500-1,300 meters). Future activity is planned off Oregon (550-1,500 meters), the Gulf of Maine (190-300 meters) and the Central Atlantic (over 2,000 meters). Canada is also investing floating wind, but this is at the early stages.

The oil & gas industry has much experience working in the water depths discussed for floating wind. The bigger challenges come in the quantities involved.

The numbers in Commercial Scale Floating Wind

Floating wind is an emerging technology. At end of 223, total global floating offshore wind capacity was less than 250 MW out of a total offshore wind capacity of 64 GW. We forecast total installed floating wind capacity of ~6.25 GW by the end of 2030 and close to 70 GW by 2035.

To achieve the forecast, commercial scale projects will need to commence offshore mooring and array cable pre-lay operations three-to-four years before final commissioning. Currently there are concerns that the supply chain cannot cope with the quantities required.

A commercial scale floating wind farm will generally be anything larger than 500 MW and likely be ~1 GW. At a high-level, we can say that the 1 GW floating wind farm will have a similar order of magnitude capital expenditure to an FPSO. The pre-lay of moorings and array cables and the towing of the turbines will leverage skills developed in the offshore oil & gas industry.

The table establishes that the global quantities of mooring lines, anchors and array cables are significant. The quantity is not the only challenge for the existing installation fleet of anchor handlers and subsea vessels, but also the physical size of the components. The size of the mooring components is also generally larger than that seen in the oil and gas industry. In fact, project planning is calling for mooring chain sizes that challenge and even exceed the capabilities of the world's largest deepwater anchor handlers. Given that today's fleet of large anchor handlers was not designed with floating wind in mind, it is not surprising that many are not the optimal tool for floating wind. Chain sizes can be reduced, but that results in the need for more mooring lines which accentuates the prob-

1 GW FLOATING WIND FARM QUANTITIES

	Number	Note
Turbines	~67	Nacelle, hub, blades and rotor ~1,500-2,000 tonnes. Land-based cranes needed to lift components, required hook heights of ~180 meters.
Floating structures	~67	~5,000 tonnes for a steel semi-sub. Semis are currently the most popular of three main concepts (semis, TLPs and spars). Completed turbine and structure assemblies may need to be wet stored in sheltered areas up to six months and even longer.
Mooring lines	≥201	Minimum 3/floater. Compares to 16± mooring lines for an FPSO. Global forecast ~6.5m (2031-2035) and ~37 m meters (2031-2035).
Anchors	201±	Generally, one anchor/line but mutualized anchors possible (fewer larger anchors). Compares to 16± anchors for an FPSO. Global forecast ~30,000 anchors by 2035.
Dynamic array & collector cables	≥67	Will depend on turbine spacing (assuming at least 1 nautical mile) and water depth. Will generally be pre-laid and dry stored along with the mooring system. Global forecast >15m meters by 2035.

Source: Intelatus Global Partners

lem of vessel shortages.

What vessels do we need to build floating offshore wind farms?

Projects in planning will need large anchor handlers and subsea vessels to pre-install moorings and array cables and hook-up up the turbines, which have been towed by large anchor handlers supported by smaller anchor handlers.

Flexibility will drive floating offshore wind construction vessel utilization. Vessels will need to accommodate a variety of anchor types, chain, fiber rope and steel wire mooring lines, and tensioning operations.

Apart from one large vessel suitable to support floating wind projects that was delivered in China last year, there has basically been no large anchor handling vessel ordering since 2014, including the last big vessels delivered in 2018-20. This asset class is seeing increasing demand from oil & gas work and was generally not built with floating wind in mind and so most vessels can be classed as suboptimal for floating wind.

Subsea vessels are being used to support oil & gas and bottom-fixed offshore wind vessels. Utilization in the segment is high and there has not been some new building activity, with orders placed for at least three new subsea vessels with 250 tonnes AHC cranes, the minimum required for floating wind projects.

As with bottom-fixed wind, floating wind projects will be supported by walk-to-work vessels (CSOVs or MPSVs and PSVs with active heave compensated gangways), CTVs and other support OSVs.

Is a Spike in New Building Coming?

New building of vessels suited to efficient floating wind construction is needed.

Increasing utilization and competition for key vessels is translating to higher rates and, at least for subsea vessels, ordering.

However, barriers to vessel FID still exist through technical, regulatory, and financial uncertainties. Until these barriers are cleared, vessel ordering will remain low and impact on floating wind projects.

In closing, we wish to extend the debate from hardware issues (vessels) and talk about the software (people). Attracting and retaining the next generation of talent and building sufficient technical competence in a timely manner is a key industry challenge and one that needs every bit as much attention as the vessel numbers and capabilities.

Conceptual visualization of a port location with vibrant marine life following successful coral restoration efforts.

Adobe Firefly AI Image Generator

RESTORING MARINE HABITATS FOR MARINE NET GAIN, CARBON SEQUESTRATION, AND PORT DECARBONIZATION.

By Nora von Xylander, Biodiversity Specialist & Sustainability Scientist, Tunley Environmental

Considering the global initiatives to become nature positive by 2030 [1] and the United Nations (UN) Sustainable Development Goals [2], the concepts of Biodiversity Net Gain (BNG) [3] and Marine Net Gain (MNG) are gaining traction [4,5]. Here we explore the potential of marine restoration in contributing to MNG, carbon sequestration, and port decarbonisation, addressing the critical need for effective marine restoration strategies in the face of climate change, marine pollution, and overfishing [6,7,8]. We find that the positive impacts of restoration and reviving marine habitats are wide-ranging, from enhancing biodiversity and supporting sustainable fisheries [9], improving water quality [10], to contributing to carbon offsetting efforts [11]. All helping to combat climate change, mitigate its effects on our planet, and secure a more sustainable future.

The Importance of Marine Restoration

The Ocean, covering 71% of the Earth's surface, is home to approximately 80% of all life on Earth [12]. Healthy marine ecosystems generate 50% of the oxygen that we breathe and absorb 25% of all CO_2 emissions [13]. The Ocean and its marine habitats also play a crucial role in regulation the

Earth's climate by absorbing up to 90% of the additional heat generated from anthropogenic CO2 emissions [13]. Accordingly, marine restoration holds immense importance in safeguarding the health and vitality of our oceans [9]. As human activities continue to take a toll on marine ecosystems [14,15], restoration efforts offer a glimmer of hope. A wide range of methods and techniques are employed in marine restoration projects, depending on the specific ecosystem and the restoration goals (see Figure 1). By restoring damaged habitats, such as coral reefs, seagrass beds, and mangrove forests, we can create resilient ecosystems that can withstand the impacts of climate change and support a diverse array of marine life [16]. On top of being crucial for marine biodiversity, these restoration efforts can provide shoreline protection [17], carbon sequestration [11,18], and the provision of food and livelihoods for coastal communities. Several marine restoration projects have achieved remarkable success in recent years, showcasing the potential for positive outcomes and significant carbon sequestration potential [19,20,21]. In the United States, oyster reef restoration in Chesapeake Bay has improved water quality and biodiversity [22]. These projects highlight the benefits of dedicated restoration efforts, which can act as catalysts for positive change and provide valuable insights for future proj-

Coral Restoration

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ects. Through restoring and protecting marine ecosystems, as well as engaging with local communities and stakeholders in marine restoration projects, we can raise awareness about the importance of ocean conservation and foster a sense of stewardship, all ensuring the long-term sustainability of these services, benefitting both the environment and human societies.

Potential Benefits of Marine Restoration for MNG and Carbon Offsetting

The Science Based Targets for Nature (SBTN) states that "There is no net zero without meaningful action on Nature" [23]. Marine restoration efforts offer significant opportunities for integrating Marine Net Gain (MNG) and carbon offsetting to effectively address climate change. MNG, a relatively new concept being discussed in the UK [24], aims to enhance marine habitats through development projects [4,5], moving beyond traditional methods of merely minimizing harm to the environment. Under the MNG approach, similarly to biodiversity net gain (BNG), developers would be required to deliver measurable improvements to marine habitats to compensate for any loss to marine habitats that may occur due to their projects. This can be achieved through the restoration or creation of new habitats, as well as the implementation of measures to reduce impact and protect vulnerable species. By prioritizing MNG, marine development projects can contribute to the conservation and restoration of marine ecosystems, even in areas where habitat loss is unavoidable. This approach not only benefits the environment but also ensures the long-term sustainability of development activities by integrating environmental considerations into their planning and implementation. Simultaneously, marine restoration and MNG efforts represent a significant opportunity for carbon offsetting. This being an approach which allows individuals, organizations, or governments to compensate for their carbon emissions by investing in projects that reduce or remove greenhouse gases from the atmosphere. While mostly associated with land-based activities, such as reforestation and land-based renewable energy projects, marine habitats play a major role in carbon sequestration [11,16]. Healthy marine ecosystems have the capacity to sequester and store vast amounts of carbon. As such, there has been an exponential increase in marine restoration efforts [9] and marine renewable energy projects [25,26,27], both playing a critical role in carbon offsetting. Marine restoration projects can also indirectly contribute to carbon offsetting by reducing the need for destructive practices that release large amounts of carbon, such as bottom trawling or dredging [28]. By restoring and protecting these marine ecosystems, we can enhance their biodiversity and carbon storage potential. Thus, contribute to global efforts to help mitigate the biodiversity loss crisis [29,30] and carbon emissions, both promoting a more sustainable future.

Exploring the Possibilities within Ports

Anthropogenic activities such as fishing and shipping have significantly impacted marine habitats around ports [31,32,33]. Direct engagement with these industries offers an opportunity to alleviate environmental pressures and adopt sustainable practices, yielding extensive environmental benefits. As such, we explore the feasibility of restoring and reviving marine habitats within port locations as these subsea habitats hold significant potential for both biodiversity conservation and carbon offsetting. Targeted restoration efforts should be considered due to the typical impact of fishing and shipping activities on marine ecosystems, including habitat degradation and pollution. By revitalizing subsea habitats, such as seagrass meadows (or coral reefs depending on location), we can create essential corridors that support a rich tapestry of marine life. The restored habitats act as natural buffers, enhancing biodiversity by providing shelter, breeding grounds, and feeding areas for a myriad of species (Figure 2). The revitalized ecosystems can also contribute to carbon offsetting, with the potential to sequester substantial amounts of carbon dioxide. It is crucial to integrate a variety of species suited to the specified habitat to maximize biodiversity gains, ecosystem resilience, and carbon offsetting potential. Habitat restoration efforts often go hand in hand with the removal of invasive species and the implementation of stricter regulations to prevent further degradation such as MNG. These measures help create a conducive environment for the success of restoration projects and ensure the long-term sustainability of restored ecosystems. By investing in marine restoration projects that incorporate the concepts of MNG and carbon offsetting at port locations, governments, businesses, and organizations can enhance their social responsibility and demonstrate their commitment to sustainable practices. As ships traverse these rehabilitated areas, they not only will navigate through healthier marine environments, but will also support the creation of marine biodiversity and carbon offsetting credits contributing to global climate goals.

Challenges and Limitations

While the promotion of MNG and carbon offsetting through marine restoration projects within ports holds great promise, it does not come without its challenges. Key hurdles include ensuring long-term sustainability and securing substantial funding necessary for such projects [34]. Similarly to BNG in England [3] and the enforced long-term management plan [35], the success of marine restoration projects combining MNG and carbon offsetting, would depend on accurate measurement and long-term monitoring of the restored habitats, as well as securing funding from various sources. Success relies on collaborative efforts involving governments, organizations, and individuals. Governments play a crucial role in creating and enforcing regulations that protect marine ecosystems and incentivize restoration efforts. Additionally, they can provide financial support and facilitate partnerships between different stakeholders. Non-governmental organizations (NGOs) and research institutions also play a vital role in advancing the science and practice of marine restoration. By conducting research, raising awareness, and advocating for policy changes, these organizations contribute to the overall success of restoration initiatives. Furthermore, businesses and corporations can make a significant impact by integrating marine restoration, MNG, and carbon offsetting into their strategies. By adopting sustainable practices, investing in restoration projects, and engaging in responsible coastal development, companies can contribute to the preservation of marine ecosystems and help build a more sustainable future.

Marine Restoration for a Sustainable Future

Marine restoration holds immense potential for mitigating climate change and addressing the challenges facing our oceans. The urgent need for marine restoration is evident, given the escalating impacts of human activities on marine ecosystems. The examples of successful projects discussed in the article illuminate the tangible benefits of these endeavours, not only for biodiversity but also for climate mitigation and community livelihoods. The potential of integrating marine habitat restoration, MNG, and carbon sequestration in port developments, presents an innovative way to promote port decarbonization as well as minimize our environmental impact and promote sustainable practices. However, the challenges of financing, long-term sustainability, and effective monitoring must be addressed through robust partnerships among governments, NGOs, businesses, and local communities. By fostering a collaborative and inclusive approach we can secure a healthier future for our oceans and our planet.

Read the full white paper on this subject at:
https://www.tunley-environmental.com/en/white-papers

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All images courtesy CMs GeoScience

PROJECT INSIGHTS: THE CONVEX SEASCAPE SURVEY

CMs GeoScience partnered with the Blue Marine Foundation, the University of Exeter and Jersey Marine Resources on The Convex Seascape Survey project. This initiative is a collaboration of scientists working to quantify and understand blue carbon stored in the coastal ocean floor, and the effects of marine life upon it. Its aim is to deliver new, reliable open-source data designed to educate, inspire and enable informed decisions on ocean use, to harness the power of the sea in the fight against climate change. The role of CMS's specialized geotechnical team was to collect 55 vibrocores and eight multicores across various locations in the waters around Jersey.

They collected undisturbed samples of sediment and supernatant water using a multi corer at eight locations on the south and east of the island. One core from each location was transferred back to shore where the research team could perform eDNA testing.

Dr Richard Tennant established a field molecular laboratory that allowed the team to both extrude and subsample the cores, as well as purify and sequence the DNA in Jersey. This data was then taken back to Exeter where they will investigate which flora and fauna are contributing to carbon stocks and determine how they have formed over the past two centuries. As the survey team were able to conduct on-site analysis, the data they generated can be validated once the other cores have been received in Exeter, to better understand the impacts of storage and/or transportation.

The project also looked at how protection from trawling and dredging activities might affect the capacity of the seabed to accumulate and store organic carbon. Researchers had a particular interest in how this protection affects the biodiversity of seabed habitats, as it is likely that the animals that live around jersey may play an important role in the flux of carbon through these environments.

The CMS team collected cores both inside and outside of the Jersey Marine Protected Area where mobile fishing gear is prohibited. This will allow academics to compare the differences in seabed organic carbon content and biodiversity according to different levels of seabed disturbance. The samples they cored will be analyzed alongside short sediment cores of 30-60cm that they survey team gathered by hand using SCUBA.

Researcher, Dr Ben Harris, used a range of techniques to measure differences in biodiversity. Baited Remote Underwater Video Systems (BRUVS) were deployed to collect information on the abundance and body size of different fish and highly mobile invertebrate species such as crabs or lobsters. ROV and photo-quadrants were used to quantify the density and species diversity of less mobile animals living on-top of the seabed, these include sponges, ascidians and hydrozoans. The third approach was collecting sediment grabs for counting the biodiversity of animals, like worms and bivalves, living within the sediment itself.

CMS GeoScience worked with Anna Smith and the Convex team to design this survey. Jersey is a challenging place to operate, having the third-largest tidal range in the world with a range of >10m and 5-6 knots. Looking at sediment types as well as potential obstructions and limitations, CMS advised on sample locations to ensure that the needs of the project were met. With more interest in the top layers of sediment, it was decided that the HPC corer would be deployed in 3m mode, with a smaller corer aiming to help mitigate some of the tidal restrictions. After consultation, the project scope was defined as 55 vibrocores, predominantly around the south and east of the island.

Jersey is a busy tourist destination, attracting many small craft, sailing and leisure boat users. This is always a challenge when working close to shore, but particularly trying in such a picturesque location. The team consulted with Jersey Harbor Authorities and local agents to establish a plan that avoided any major maritime events, as well as using moorings and quay space around the island to limit steaming time.

Hayley Santer, the Senior Surveyor on the project, highlighted the need to remain fluid in approach to a project such as this. Each location was assessed and categorised depending on whether they were exposed to weather or tidally restrained. Weather forecasts were changeable and so it was vital that the team acquired the more weather sensitive sites, with contingency plans in place for operations to go ahead depending on the observed sea conditions at the time.

Hayley spoke about the level of preparation needed:

'To maintain efficiency, and with several tidal locations spread in various bays around Jersey, it was crucial that we worked to minimize time spent waiting on the tide when trying to access more shallow locations.

In addition to significant tidal ranges and rocky coastline, many of the reefs were poorly charted. With the team finding that there were large discrepancies in the data, it was important for us to take the additional time to capitalize on rising tides as well as note and mark a safe route into shoal areas, paying particular attention to locations that, while technically deep enough, were enclosed behind prominent, sometimes awash, rock. Using these proven routes, and ensuring we received regularly updated tidal information, enabled real-time assessment of the observed depths both on approach and when were deployed at each location. This also allowed us to establish what depths we could expect on completion of the sampling.

Communication went beyond those involved and extended to local power companies who had seabed assets within our remit. Consultation was key in carving out exclusion zones, with these companies requiring our assurance that any instance of seabed touch-down, be that from a sampler or sound velocity profiler, was logged outside of the reduced cable zones.

We were often operating within busy shipping routes, and St Helier VTW and the Jersey Coastguard were instrumental in reminding other vessels of the requirements of space and safe passing. To add to the intricacies of this project, our team were working over a number of weekends which meant that the increase in recreational club activities added to the difficulties of working in an area where marine traffic was already saturated. Our choice of a smaller, more compact vessel enabled us to work alongside these clubs and societies and we were able to complete the campaign safely with minimal disruption to us and the public'.

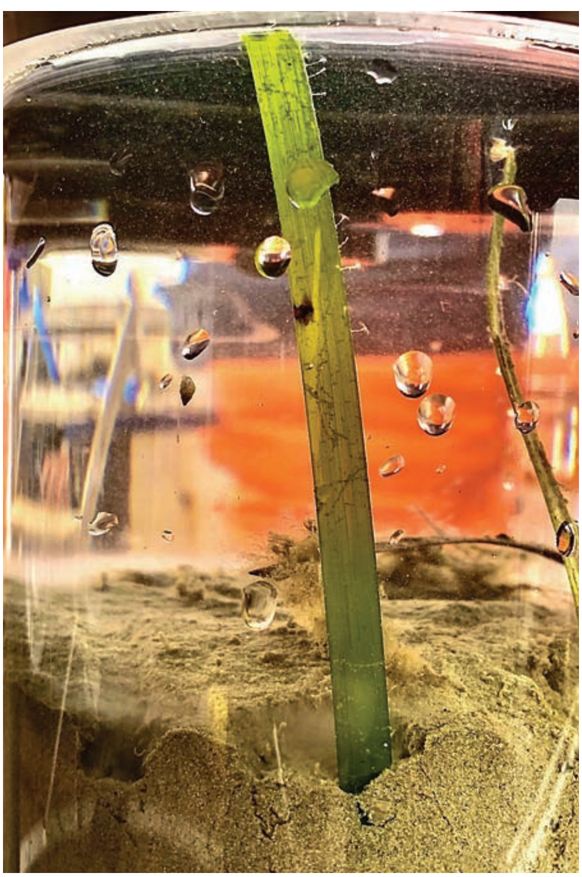
The geology around Jersey also presented a specific challenge to the team, with rocky outcrops being exposed by the high tidal range. Extensive planning using tidal and weather forecasts, as well as water depths, enabled the team to maximise working windows.

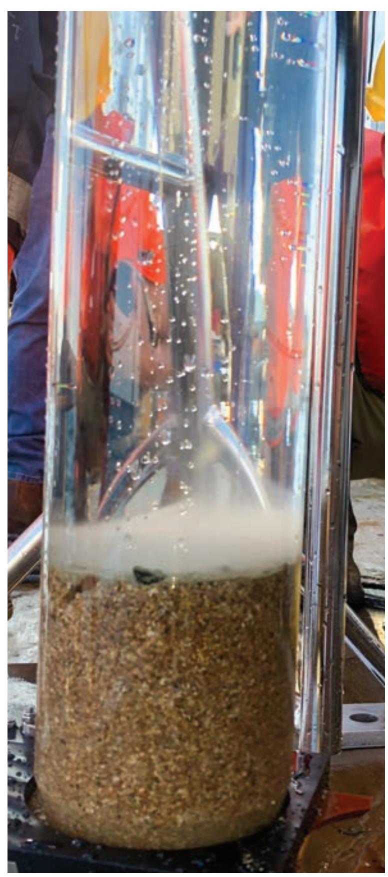
Owing to the unique tidal movements around the island, Rory Bardner, CMS Marine Geologist, found it interesting to discover such variation in the geology sampled throughout the campaign:

'Cores recovered deposits ranging from silty sands to coarse gravels, often in proximity, and igneous bedrock was samples in many cases. Using the multi corer to recover undisturbed samples of the shallow seabed gave a real insight into the sediments, marine life and seagrass below us.

Due to the testing required, the cores had to remain at a constant temperature of between 4-5 degrees, which was made more difficult as many of the locations were >4-hour steam away from harbour. By working with the client and the vessel, a solution was found which allowed for onboard chilling facilities, as well as a space to safely operate the vibrocoring system, the multi corer and other equipment. Through creative thinking, the CMS team were able to meet this requirement to guarantee the quality of the samples and the subsequent data.

Mechanical Design Engineer, Jack Foll, reported on the difficul-



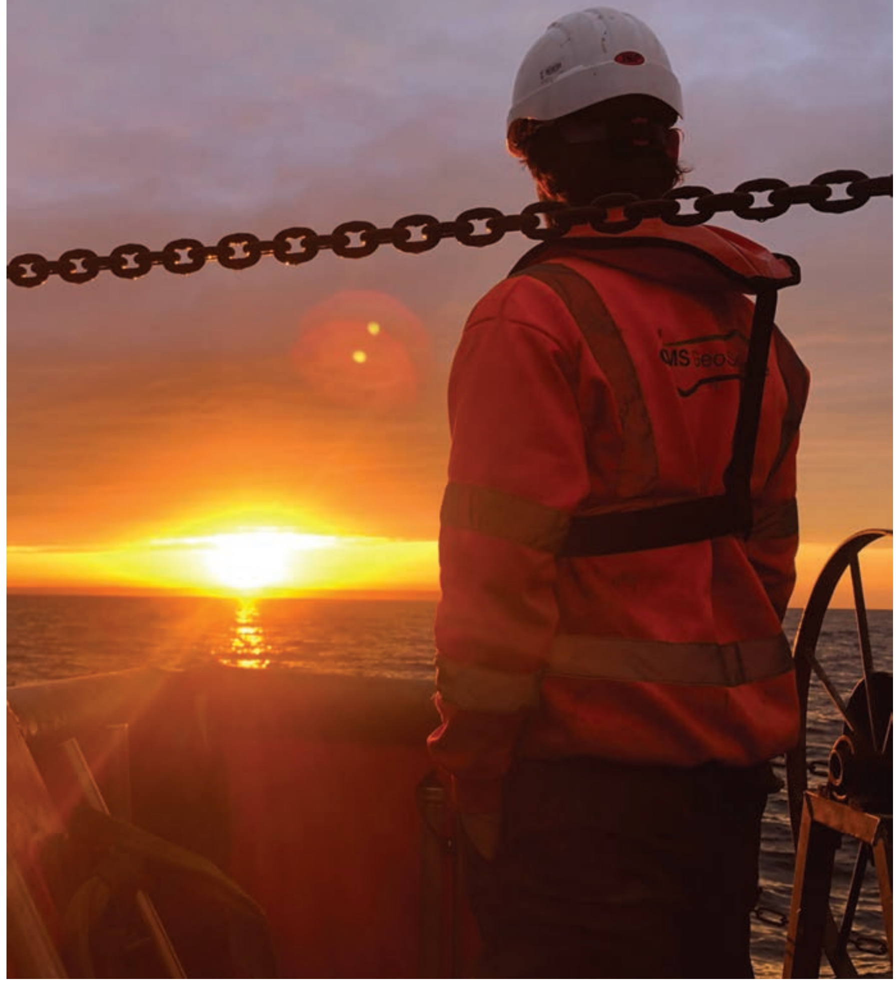


All images courtesy CMs GeoScience

ty in operating the geotechnical systems and the performance of the team overall:

'There was a great deal of preparation in anticipation for this campaign as we knew we would be working within a demanding environment. The waters in which the team were deployed experiences a tidal height of up to 12m, and this meant that our HPC corer had to operate in 3m to compensate for the strength of the tide. As well as this, we experienced unseasonably inclement weather throughout our time on the island which meant the team had to work within tight windows of opportunity, adding even more to the complexity of the project.

We worked to ensure that our systems were tested, checked and serviced prior to commencing the project, and everyone onboard carried out their duties safely and effectively. The extensive planning from all involved meant that the contract was completed without any system breakdowns, and the team operated the equipment well, without incident, despite the many difficulties they faced.'



CHRIS HEARN

DIRECTOR OF THE CENTER FOR MARINE SIMULATION FISHERIES & MARINE INSTITUTE, MEMORIAL UNIVERSITY

Images courtesy Memorial University Maritime Simulation Center

Memorial University in St. Johns, Newfoundland & Labrador, Canada, is a microcosm of how this unique regional cluster has parlayed its geographic locale and harsh, unique operating conditions into world leadership in the maritime, offshore energy and subsea tech spaces. An alumni, a professional mariner and now the Director of the Center for Marine Simulation, the Fisheries & Marine Institute at Memorial University, ***Chris Hearn*** *has his hand on the pulse of the tectonic changes reshaping maritime and offshore energy simulation training today. From artificial intelligence to autonomy to fuel transition, Hearn and the Center for Marine Simulation are invested today to help train the current and future generation of seafarers.*

By Greg Trauthwein

MARINE TECHNOLOGY TV

Watch **Marine Technology TV**'s full video interview with Chris Hearn here:

While Chris Hearn is a graduate of the Memorial University nautical sciences program, he never anticipated being back at his alumni as the Director of the Center for Marine Simulation. His post-graduation career took him to sea, at first as a third mate on through to captain, sailing domestically and abroad under a variety of flag states on a variety of ships, from operating ships in the Arctic to tankers to cable layers.

"I came ashore first as Marine Superintendent, which was interesting in that when you're onboard, you're always wondering, "Why are we doing this?," said Hearn. "When you're on shore and dealing with all the other sides, you get to [literally] see a [the many pieces that make up the other side], helping to understand why decisions are being made."

Coming ashore put Hearn in touch with all aspects of marine operations, and he gravitated toward the training side. "Coming from Newfoundland, I can tell you there was nothing worse than getting off the ship and trying to make your way home, only be diverted to go fly somewhere for training," said Hearn. "So when an opportunity came for a change, I came back to the institute to take over as a director at the [simulation] center, and I had the mindset that we can do anything here in terms of training and simulation. Nobody needs to leave here [to get training], and in fact, people can come here to obtain job training."

With his education plus his career experience at sea and onshore, Hearn saw the new opportunity as the perfect chance to leverage the investment already made in the simulation center with the cumulative experience of the Newfoundland & Labrador cluster, which has a unique proximity to the ocean and the Arctic that has given generations of seafarers and companies first-hand experience working directly in some of the world's harshest conditions. "I saw the opportunity to leverage that into more special type applications that really reflected the operating conditions that we face here in Newfoundland in terms of harsh environment, the challenging conditions, and how people react in really high stressful situations," said Hearn. "I always say that anybody with the time and money can buy all this [simulation equipment], but it's how people use it, how they overcome the shortcomings that are inherent to simulation to make it more compelling."

With that, the center has a fairly modest 400 students coming through in a given year, but that doesn't count the companies that come in and rent the entire facility to prepare for a complex project.

"Some might say that [number is] a bit small, but for our facility, given what we're doing, that's a pretty good number," said Hearn.

Simulation Technology Evolves

Since Hearn started his position more than 15 years ago in 2008, there have been "several waypoints in terms of [simulation technology] improvements that I've seen," said Hearn. "Simulation technology vendors generally have a lot of similarity between them, what they're delivering and their customer service. There's a lot of parity there. You have some new people coming from the gaming technology and gaming background, because they've seen this opportunity now to bring some of the really interesting stuff. I've certainly seen improvement in the visual engines, making the visuals richer and more realistic; like the cloud shadowing and the way the water curls, for example."

As in most aspects of business and life, the details matter, and the inclusion of small points that closely mimic nature are critical to keep trainees establish presence and believe that they are in fact on a vessel.

"I can also say that there have been improvements in the fidelity of the modeling of ships, the modeling tools themselves have dramatically increased," said Hearn. "The ability to produce full 3D models is quite a powerful thing. Now we have the ability to build a one 3D hull and include the tanks and be able to adjust fluid levels in the tank, and then adjust the trim and draft. That's a powerful tool, because it not only reduces the amount of ships you actually have to build, but it also improves the fidelity of the ship you are building."

Another improvement has been with the fidelity of controls in the instructor station, who have now more than ever the ability to make small, nuanced changes to adjust something as simple as daylight, for example, "and to make changes that would reflect what people would actually see, and be able to interact closer inside the model itself is much better," said Hearn. "To have the ability to swing and maneuver cranes and ship's equipment that people would be expected to use onboard, that's tremendous too."

Not only can the center combine its cumulative simulation assets into one project, it can connect too to a facility remotely, to dramatically enhance the scope and realism of a given operation.

"The big simulation vendors recognize that their clients are giving a lot of feedback, and they've also recognized that they can distribute simulation now," said Hearn. "They can do simulation on the cloud. The engine is essentially on the cloud, you can pull data down to a laptop and have a very good high-fidelity simulation. That was unheard of 10 or 15 years ago, but it's there now, which makes it a much more distributed system. So you and I can be here pulling a simulation event out of the cloud to run on our laptops and be in the same scenario. That's pretty profound."

Hearn's simulation center is comprised, simply put, of a lot

Image courtesy Memorial University Maritime Simulation Center

"We are innovative by nature because we had to be. *I heard a great quote about Newfoundland & Labrador:* ***it has a landscape that makes you want to live up to it, but it doesn't provide you the resources to do it!*** *Because we're isolated, we had to grow something here in order to be able to deal with things."*

– Chris Hearn

Director of the Center for Marine Simulation, Fisheries & Marine Institute, Memorial University, discussing the unique value of the Newfoundland & Labrador maritime, subsea and offshore energy cluster.

Images courtesy Memorial University Maritime Simulation Center

of equipment.

"The center's main focus is around three Class A ship's bridges: the Full Motion Bridge, the Offshore Operation Simulator, and the Heritage Bridge," said Hearn. "The Full Motion Bridge, which you were on, and the Offshore Operation Simulator are both sitting on these six-degree motion beds; it moves just like the ship will move, whether it's in a storm on the Grand Banks or you're battering your way through Lancaster Sound in ice, everything is replicated there. The Heritage Bridge is very specialized towards the shuttle tankers which serve the offshore industry, and the big three bridges are interconnected."

In addition, Hearn and his team can also connect additional simulators, such as the full mission engine room simulator, the full mission ballast control simulator for an offshore drilling rig and several additional smaller units to deliver the most realistic training scenario.

"One of the unique things about that interoperability, that connectivity, is that we run large multi-party exercises all in the same scenario," said Hearn, "which [is a big assist when planning big offshore structure] tow-out projects.

Ship to ship operations, with tankers coming alongside to load, utilizes multiple bridges, too."

Planning Ahead

Though somewhat remote and unique in experience, the maritime and subsea professionals in St. Johns, Newfoundland & Labrador face the same megatrends driving maritime: energy transition; digitalization; automation and autonomy. When Hearn looks at the landscape around him, he sees artificial intelligence and the increased use of autonomy as pervasive trends that will continue to evolve and change not only the role of mariners on ships but the training they receive. That said, with those two, he sees maritime cybersecurity "as the gorilla in the room."

"With AI, it's finding out how it's going to be used and when it's going to be used," said Hearn, noting that as of now there are far more questions than answers. "Does AI assist with collision avoidance? Does AI assist with cargo preparation and cargo loading? Does AI work with weather routing and navigation or voyage planning? How do those things actually look? Where is the AI sitting to? Is it onboard the ship? Is it a tool? Or is it almost like another crew member not under articles, but it's there to be used? I'm very interested to see how that plays out."

When it comes to autonomy, Hearn points out that there is autonomy onboard already: "the good old autopilot versus autonomy 101, and unmanned engine rooms and these sorts of things."

"[To be clear], I am absolutely not advocating for replacement of people onboard the ships, and I don't think that'll happen realistically," said Hearn. "We may get to a point where you have a combined scenario where we have the smaller MASS operating in areas where there are people onboard; I think that's the more likely scenario. But autonomy is present and it is growing. So here at the Marine Institute, we're interested in how autonomy is played out in terms of remote operations." To that end the Marine Institute is setting up an autonomous test zone at one of its facilities to help test the use of MASS in different crewed and uncrewed environments.

An he mentioned, the 'gorilla in the room' is cybersecurity with an inextricable link to automation and digitalization. "As I said to somebody the other day, a rudder angle indicator doesn't care where the information is coming from, its job is just to report what the rudder is doing," said Hearn. "Using the simulators as part of the training to allow people to experience that is a really interesting opportunity. We're playing our way into this bigger thing around the cybersecurity, maritime cybersecurity, and how we can participate with other agencies or entities."

Last, but certainly not least, is the fuel transition and the inclusion of new fuels – LNG, ammonia, hydrogen, amongst others – to the shipboard environment. "Again, for the propulsion plant, for the marine engineering program, how do they deal with changing fuel sources, preparing for effects of power management onboard the ship, and that interconnection between what the bridge is asking to have done and what the propulsion plant needs to do." To keep pace, Hearn and his team will add components or new engine models that can represent – whether it be ammonia or hydrogen, or a combination fuels, how that works. And again, how do the skills of the people coming into the industry now [and for the ones that are already here] … how do their training need to be changed?"

It Takes a Village (or a Cluster!)

The Newfoundland & Labrador maritime, subsea and offshore energy community is truly unique in its collective experience and collaboration, a fact hammered home time and again when you visit leaders and companies where they live and work or at trade events globally. Memorial University sits

"What has happened is we've grown this tech sector to be primarily focused on the maritime and oceans industries because we needed to. **There were opportunities to grow it here because a lot of technology that was available didn't reflect, or couldn't deal with [our unique] operational challenges,** *the reality of our conditions: this mixture of weather, ice, sea state and isolation, as well as the variability and quick change in the weather patterns here."*

– Chris Hearn,

Director of the Center for Marine Simulation, Fisheries & Marine Institute, Memorial University

as a central hub, and world-class facilities like its Center for Marine Simulation an indispensable driver.

The reason that the province developed such an array of unique maritime expertise is actually fairly simple: they had to be.

"We have a long history of maritime trade, including the fishery and through to what we have now [with a long-established offshore energy industry]," said Hearn. "We have this in our DNA, it's part of what we are. So there's this connectivity between all these different entities.

What has happened is we've grown this tech sector to be primarily focused on the maritime and oceans industries because we needed to. There were opportunities to grow it here because a lot of technology that was available – or not available – didn't reflect, or couldn't deal with [our unique] operational challenges, the reality of our conditions: this mixture of weather, ice, sea state and isolation, as well as the variability and quick change in the weather patterns here."

"We had a provincial government that recognized that very early, but again, it reflects life here. We are innovative by nature because we had to be. I heard a great quote one time about Newfoundland & Labrador: it has a landscape that makes you want to live up to it, but it doesn't provide you the resources to do it! We've had more than 500 years of living here, and because we're isolated, we had to grow something here in order to be able to deal with things."

When people first think of Newfoundland & Labrador, it's a good bet that the first thing they think of is not technology. But with a proven track record and leaders like Chris Hearn, that is changing fast now.

"The companies that grew out of research projects, that are either at the university or here at the institute, whether they be in the ocean tech or whether they be in fisheries and resource gathering or they're in maritime or offshore," said Hearn. "Radar systems [like Rutter's] that are able to do an amazing job in ice, came out of projects and then grew into companies that are now very successful and doing work all over the world. You have this self-sustaining circle of the education and training pieces, like we would do here at the institute or at the university, spilling out these really bright minds of these people who are working with the industry, and see a really good idea and say, "I have to do that."

Then, to support all of that you have the groups like Oceans Advance and the techNL's and these other associations that are really blowing air into this fire that's growing here all the time for the tech sector. It's this combination of the need to do it and the want to do it that sustains it in an isolated place with a small population. We're not that far away, but we're far enough that it drives the spirit of "let's find a way to do this."

Image courtesy Greg Trauthwein

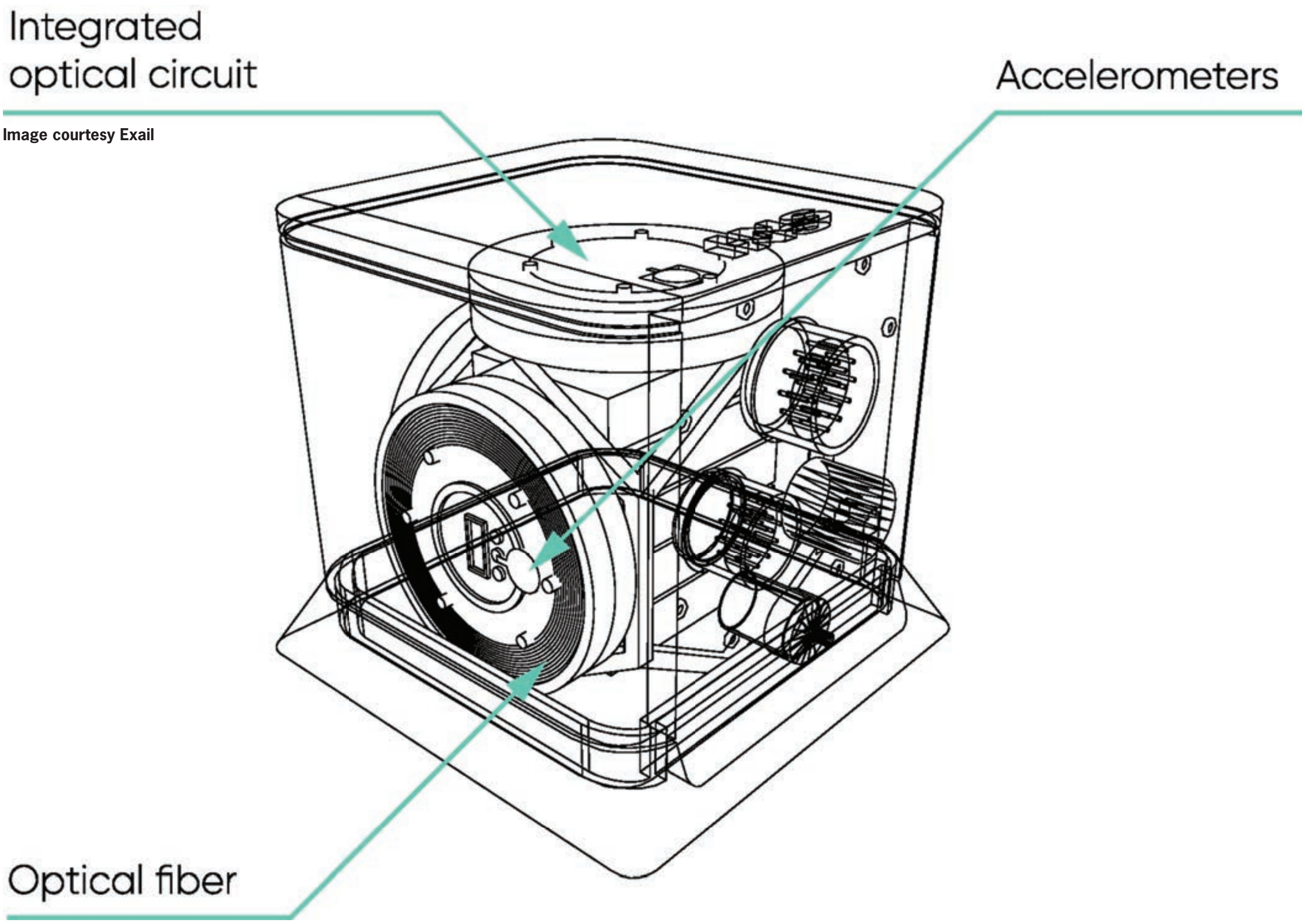


Image courtesy Exail

LESS IS MORE WITH GYROSCOPES

A NEW GENERATION OF FIBER OPTIC GYROSCOPES IS TAKING THE ACCURACY OF INERTIAL NAVIGATION SYSTEMS HIGHER AND THE PAYLOAD LOWER.

By Wendy Laursen

A fiber optic gyroscope (FOG) can now weigh less than three kilograms, less than two kilograms even, and be less than 200mm in diameter.

As their host AUVs themselves shrink, FOGs are following suit, and as the AUVs go deeper and perform a wider range of data collection tasks, FOGs continue to be part of the GNSS-denied navigational systems that enable them to do it.

The FOG sensors in an inertial navigation system measure changes in orientation of the AUV to support navigation by dead reckoning as satellite systems such as GPS are not available subsea. FOGs operate by monitoring the difference in propagation time between beams of light traveling in clockwise and counter-clockwise directions about a closed optical path. Two beams of light are sent in opposite directions in a fiber optic coil. As the vehicle rotates, the beam travelling against the rotation experiences a slightly shorter path delay than the other beam, a phenomenon called the Sagnac effect. The difference in phase shift between the two beams is used to estimate the rate of rotation. In an inertial navigation system, there will be three FOGs, each aligned orthogonally and combined with accelerometers to provide the sensed acceleration and rotation across six degrees of freedom.

The goal of minimizing size, weight, power and cost (SWaP-C) is driving much of the innovation underway with these systems.

Earlier this year, Exail released a new highly birefringent fiber for military-grade FOGs, featuring what it claims is the highest birefringence and shortest beat length available in the industry (1mm at 633 nm). The inertial measurement unit including fiber coil is now less than 30mm in diameter, and the material enhancements maximize the length of fiber that can be used, thereby maximizing accuracy, whilst ensuring the mechanical reliability of the coils. This fiber is available with a standard 80µm cladding but also with a smaller cladding of only 60µm for even smaller footprint gyros.

Subsea, Maxime Le Roy, Subsea Inertial Navigation Systems Product Manager at Exail, says the market is moving to smaller AUVs that are versatile, powerful and agnostic to any situation. Exail sold the first of its latest model, Phins 9 Compact, to Bedrock for a new modular AUV designed for swift deployment in geophysical surveys and monitoring. Equipped with multibeam echosounder, side scan sonar and magnetometer, the AUV boasts a 300m depth rating and 12-hour endurance surveying at three knots with all systems operational.

The Phins 9 Compact adds just 1.2kg to the payload and features a power consumption of less than 7W. It has a Doppler Velocity Logger-aided position accuracy of heading accuracy of 0.07° and pitch and roll accuracy of 0.01°. “The Phins 9 Compact is an ideal solution for new generation AUV manufacturers and e-ROV operators looking to save power without compromising on data processing capabilities,” says Le Roy. Its applications include survey-grade coastal and offshore seabed mapping, inspection repair and maintenance and defense.

The latest models added to Advanced Navigation’s DFOG range are the Boreas A Series, including A90 and A70. The A Series is designed for surveying, mapping and navigation across subsea, marine, land and air applications. Both of the new models are strategic-grade inertial measurement units (IMU) that contain ultra-high accuracy DFOG and high performance closed-loop accelerometers.

All the measurements are combined into a proprietary neural network algorithm which removes sensor errors and filters out interference. Advanced Navigation’s sensor fusion algorithm is more sophisticated than Kalman filters. Kalman filtering

Image courtesy Exail

Image courtesy Advanced Navigation

The Advanced Navigation Boreas A Series is designed for surveying, mapping and navigation across subsea, marine, land and air applications.

Image courtesy Advanced Navigation

An inertial navigation system can output data much faster as well as provide orientation, roll, pitch and heading data which the GNSS system is incapable of achieving, says Xavier Orr, CEO and co-founder of Advanced Navigation.

provides estimates for unknown variables that are primarily statistics-based. The sensor fusion approach is more accurate at determining and removing sensor errors, which results in a higher performance navigation solution.

The technologies that have been developed for the DFOG include digital modulation techniques that allow in-run variable errors in the coil to be measured and removed from the measurements. The "learning" capabilities of the AI enable it to accumulate sensor error data and associated conditions during erroneous measurements and post-measurement corrections. The AI can then use this accumulated knowledge and apply sensor error offsets that are tailored to the prevailing conditions. This allows for a smaller FOG with reduced coil length that can achieve the accuracy of one with a longer coil.

"The coil lengths in our Boreas DFOG systems range from 300m on the smallest systems to 5km for the ultra-high accuracy systems. The most popular unit we sell currently is based on 1,000m coil length. The coils are very precisely wound by specially designed robots at our high-tech manufacturing facility in Sydney, using the quadrupole winding method," says Xavier Orr, CEO and co-founder of Advanced Navigation.

Additionally, an optical chip is used to integrate the sensitive components into a single chip, thus removing all the fiber splices and reducing SWaP while increasing reliability and performance. "The Boreas DFOG technology has a custom-made optical or photonic chip at its heart, which replaces what would typically be five individual components and gives us significant advantages of improved performance with reduced SWaP consumption. In addition, it allows us to be more tolerant to shock and vibration as well as offering improved mean time before failure and reliability."

Orr says that the widespread use of GNSS jamming and spoofing technologies means defense organizations are moving away from GNSS-only solutions and adopting inertial navigation systems solutions that can provide the necessary precision. An inertial navigation system, as well as operating in GNSS-denied environments, updates at a higher rate than GNSS. "An inertial navigation system can output data much faster as well as provide orientation, roll, pitch and heading data which the GNSS system is incapable of achieving."

He says the next frontier for FOG technology will involve integrating the various components of a FOG into a planar photonic chip rather than a printed circuit board. "This means the FOG system's SWaP-C will be significantly reduced, enabling manufacturing simplicity and commercial viability across the mass market."


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Photo by Richard Allen, Naval Undersea Warfare Center Division Newport

Passive and Aggressive:

UUV INTEGRATION WILL TRANSFORM SUBMARINE TACTICS

By **David Strachan,** Strikepod Systems

Snakehead is a modular, reconfigurable, multi-mission underwater vehicle deployed from submarine large ocean interfaces, with a government-owned architecture, mission autonomy and vehicle software.

The Los Angeles-class fast-attack submarine USS Annapolis (SSN 760) departs Guam, March 3.

U.S. photo by Lt. Eric Uhden

For decades, submarines have been the apex predator, roaming the oceans largely unmolested, gathering intelligence, providing a sea-based nuclear deterrent, and conducting clandestine missions with impunity. As such, these versatile and lethal platforms have been highly sought after by navies around the world, and with advancements in underwater propulsion and quieting technologies, it is perhaps more challenging than ever to detect, localize, and track them. But even as submarines become stealthier, and the ocean depths continue to offer many ways to hide, emerging underwater capabilities are poised to reorder the undersea battlespace, and will force the development of new tactics to successfully employ and counter them.

Recently, the U.S. Navy announced a critical step toward operationalizing one of these capabilities. By the end of 2024, the USS Delaware, a Block III Virginia-class attack submarine (SSN), will put to sea with an integrated torpedo tube launch and recovery (TTLR) UUV system. The announcement comes just eight months after the Delaware successfully deployed and recovered a medium UUV using the "Yellow Moray" system, and a year after L3Harris announced the successful launch and recovery of an Iver4 ("Rat Trap") from an underway submarine. The Yellow Moray UUV is a Huntington Ingalls Remus 600, and is likely a modified Razorback UUV, originally designed for littoral battlespace sensing operations. Razorbacks have deployed aboard Navy submarines in the past, however they required stowing in a dry deck shelter, with launch and recovery performed by trained divers. A TTLR capability would enable more streamlined and seamless UUV operations, as well as greater mission flexibility.

This is a significant achievement, and represents a game changing capability that would greatly enhance a host submarine's organic sensing capability and enable high risk missions to be conducted more clandestinely and at standoff range. For example, UUVs could conduct intelligence, surveillance, and reconnaissance (ISR) and intelligence preparation of the operational environment (IPOE) missions in contested or denied areas. This might include localizing seabed sensor or communications infrastructure for a follow-on strike, or reconning enemy coastal installations and operations at close range. UUV-enabled mine countermeasures (MCM) would enable covert minefield mapping and/or mine neutralization, which would be valuable in environments where surface mine countermeasures would put manned assets at risk, or reveal operational intentions. SSNs will also need to contend with sea mines laid specifically to impede their passage through strategic waterways and chokepoints. UUVs could remotely map out a safe passage, or "Q Route," or be teamed with smaller, neutralizer UUVs deployed from the host submarine's countermeasure launchers. And as their convergence with mines and torpedoes continues, UUVs will increasingly assume the role of standoff weapons, such as the U.S. Navy's Mining Expendable Delivery Unmanned Submarine Asset (MEDUSA), with its ability to strike seabed targets, or transit to enemy ports, sink to the bottom, and await its prey.

One of the more urgent missions for a TTLR UUV system is anti-submarine warfare (ASW), including the ability to counter enemy ASW operations via tactical deception. While the primary missions of U.S. Navy SSNs during full-scale conflict would likely be anti-surface and strike, they will still be called upon to seek and destroy enemy submarines. UUVs could augment a host submarine's organic sensor capability by acting as an offboard, distributed bistatic acoustic array, employing active sonar to illuminate enemy submarines with acoustic energy, while the host submarine receives and processes the returns to localize and engage targets. UUVs could also be used to augment the host submarine's passive sensing by structuring a wide aperture, offboard array, relaying contact data to the host submarine via secure burst acoustic communication. For this role, UUVs could be fitted with advanced, miniaturized passive sonar technologies, such as the KraitArray, a thin line towed array from Systems Engineering & Assessment Ltd (SEA).

Should war come, attack submarines will be high on the enemy's target list, and for the U.S. Navy, with its looming SSN shortfall, shipbuilding woes, and overburdened fleet, safeguarding these high-value assets and their crews against enemy ASW operations will be paramount. In a counter-ASW role, UUVs could jam enemy passive sensors by flooding them with ambient noise or false active sonar returns, or act as decoys by emulating the acoustic signature of the host submarine to distract enemy ASW assets and enable escape. Conversely, they could be used to lure enemy submarines into a subsea killbox where a submarine, XL-AUV, or field of encapsulated torpedo mines lie in ambush.

But the many benefits of an integrated TTLR UUV system will not come without costs – most notably, a tradeoff in weapons loadout. The Delaware, for example, has four torpedo tubes, with a capacity for 25 torpedoes and/or TTL mines. The number of UUVs required to generate operationally relevant gains in sensing or effects is unknown, but in general, more sensor nodes equals more robust situational awareness.

Ohio-class ballistic-missile submarine USS Henry M. Jackson (SSBN 730) in the vicinity of the Hawaiian Islands.

U.S. Navy photo by Mass Communication Specialist 1st Class Devin M. Langer/Released

Vehicle endurance would also be a factor in the number of UUVs required to maintain persistent, wide area coverage, as recovery and recharging will impact on-station time. The Remus 600 can operate for approximately 70 hours, but this will vary depending on battery loadout and the power requirements of its sensor/effector payload and onboard processing. Unless there are stowage modifications, each TTL UUV would displace a weapon, which in peacetime may make little difference, but would be a serious consideration should war break out. One workaround could be a system that leverages the flexibility of Virginia-class payload tubes, such as the Universal Launch and Retrieval Module from General Dynamics, which utilizes a retractable platform to deploy and recover UUVs of varying displacements.

Whereas in the past, submarines have relied on passive sonar and stealth when carrying out their missions, continued success – and survivability - will hinge on how artfully new technologies and unmanned systems can be integrated into subsea operations. It will also necessitate a more aggressive posture, whether targeting enemy submarines using offboard active sonar, neutralizing seabed targets, laying minefields at standoff range, or deceiving and disrupting enemy ASW. Onboard integration of UUVs will greatly enhance these mission sets and others yet to be conceived, making submarines even more capable sensor/effector platforms, and prompting the development of innovative submarine tactics, techniques, and procedures to meet the challenges of tomorrow's undersea domain.

Meet ‘Super GPS’

XONA Ups the Space Race Ante

*With a mission to power the current and next-generation of GPS-enabled products and systems, XONA Space Systems keeps the mantra ‘precision, power and protection’ in all that it does as this 2020-start-up designs, builds and launches its fleet of low earth orbit satellites. We spoke with **XONA CEO Brian Manning** for his insights on how this could impact the maritime, offshore energy and subsea sectors.*

By Greg Trauthwein

Thanks for joining us today Brian. To start … XONA Space Systems … when and why was it founded?

The founding team all met back at Stanford, Stanford Aerospace engineers that all [studied] together 10 years or so ago. A lot of the company has formed around the work of our CTO, Dr. Tyler Reid. After his PhD, Dr. Reid went to work at Ford in its autonomous driving group. A lot of the challenges that he was trying to solve there was what types of navigation, sensors, systems, et cetera, can support [autonomous driving]. What he was finding is that they were able to get these vehicles to work in certain environments, but when you take a $30,000 sedan and add $500,000 worth of sensors on top of it … not something that’s scalable. [So he starts to look for a technology that is scalable, the use of technology not for a luxury item but something that is really making a difference in everyone’s life]. At XONA, we are believers in the potential of modern technology, but also believe that for it to be able to scale you need to have the infrastructure available to support these things.

[Foundational for modern, autonomous products] to operate safely is knowing where they are to a very high degree of accuracy. GPS can generally tell you what road you’re on, but

© DC Studio/AdobeStock

> *"GPS is amazing service, but it is a government service first, and that means the government gets the goodies. Civilians certainly get a service, but they don't get access to all the toys that the DOD side has. And one of those toys that the DOD has today is a protected service, one that's encrypted and authenticated."*
>
> **– Brian Manning, CEO, XONA**

that's not good enough when you need to know, 'am I on the right side of the road'? That's the system that we're building.

So can you give a 'by the numbers' look at XONA today?

If you look at some of the other incredibly impactful technologies in history; the iPhone with 2-3 billion iPhones sold; Facebook and 3 billion users – there are more than 5.5 billion people in the world that have access to the internet, and there's more than 6 billion active GPS devices. It's on a scale that very few, if any, technologies have ever gotten to. That's what gets us excited is that all of these are looking for better performance or would like to have better performance in different areas.

That's something that attracted me – and I think attracted a lot of the people we have here at XONA – the ability to make impact on a global scale. So we're about five years old. We're about 25 people. We just closed our latest funding round so we are growing and hiring. We launched our first satellite in 2022, and now we're on track to launch our next, the first production class one coming up next year. And then from there we'll be growing up and building up a system to get the full service up and active within the next few years.

When you say you're going to be full service, what does that look like?

We can start services with basic capabilities available in a few areas of the world with less than 20 satellites. The final system is about 250.

With this new satellite network, what exactly will XONA be offering?

The best way to think of it is super GPS.

There are a couple big challenges that you can boil down into three major pain points: precision, power and protection. From a precision standpoint, it's going from something that is several meters down to several centimeters. The power and protection side are fairly closely tied that from a protection standpoint. GPS is amazing service, but it is a government service first, and that means the government gets the goodies. Civilians certainly get a service, but they don't get access to all the toys that the DOD side has. And one of those toys that the DOD has today is a protected service, one that's encrypted and authenticated. Ours will be the first civilian available service that has that encryption and protection layer, which is incredibly important, especially as you move into things that are not just safety critical, that it's human lives on the line, but also even just liability critical.

On the power side, power is tied to protection. There's a lot of jamming and spoofing, especially in the Black Sea areas around Russia right now. If you're in the middle of the open sea and all you've got is GPS and someone starts jamming it or sending out fake signals, it can put you in a pretty bad situation. Our signals are substantially stronger with some other protection characteristics built in to make them more resilient to interferences.

LANDER LAB #11

Figure 1

Sawyer Granados, a fourth grader in San Diego, California, hauls in his STEM Lander after a successful dive to 15-ft in Mission Bay. His STEM Lander has yet to dive the blue Pacific Ocean. The pre-publication boat trip was scrubbed by high surf. Something to learn there, too.

STEM LANDER

By Kevin Hardy, Global Ocean Design LLC, MTR columnist

The STEM Lander is a small free vehicle intended to introduce curious students to marine technology and ocean exploration. The basic unit drops to the seafloor up to 100-ft deep taking video images, then releases a weight to become buoyant and float back to the surface. A flag helps locate the lander on the surface. Submerged time is under 15 minutes.

Since its debut, the little untethered lander has turned into something extraordinary.

We first wrote of the small untethered ocean lander in Lander Lab 3, *MTR* (May/June 2022, after proposing the design to a curious young French student, **Jonah Royer**. He called it *"Le petit baigneur"*, the little bather, from a still popular 1960's French film.

The STEM Lander has since been built by several 10-year old elementary school students, by college students in their 20's, and by university researchers. SCUBA divers have used the vehicle to preview bottom conditions before they gear up. More applications are described below.

The quality of the image depends on the camera. Several models of waterproof action cameras have a setting for underwater photography that color correct for the loss of reds and oranges. We found the **Akaso EK7000 camera** was affordable, came with an underwater housing, and provided reasonably good photos.

The STEM Lander is cheap enough to build several, but it won't break the bank if one gets lost. They are reliable because they are simple. They can be built from a bag of parts in about 10 – 15 minutes. And they are just plain fun.

They work in fresh or salt water.

The 5-lb iron drop weight could be junk steel hardware or chain. It could be an equivalent water weight in gravel, but since stones have a smaller specific gravity than iron, it'll weigh more in air. Estimate the weight of rock required by the ratio of specific gravity of stone (2.7) and iron (8). Subtract the buoyant force of water (1) from each. Estimate to predict, then measure actual water weight to confirm. Record your data. The final test to confirm your hypothesis is attaching the gravel anchor to the STEM Lander, and lowering the whole assembly into seawater. Using a postal or fishing scale, you're looking for about 2-2.5-lbs negative weight.

The release is a dissolvable **Life Saver®** or ice release as we

described in Lander Lab 4 (Sept/Oct 2022).

Different color Life Savers can hold different weights and have different release times. You can pick up a bag of multiple flavor LifeSavers at a local market. You might think of them as "dissolvable release elements". As another experiment, try stacking two or three life savers together, test for release time, and document the results. Experiment to get your data and confidence in your machine. For reference, a typical release time for a single hard LifeSaver is 6-10 minutes depending on water temperature.

You can also test to see how much air weight the LifeSavers will hold. Consider whether the LifeSavers can hold the heavier air weight of the rocks, and how to transfer the load to the anchor to the LifeSavers out of the water, or after the anchor is submerged. Be careful to not snap load the LifeSavers by dropping the weights before the line is tight.

A recent UCSD graduate in ocean and atmospheric science, **Jillian Cerbasi**, is building an OpenCTD (**https://oceanographyforeveryone.com/**) designed to reach 1,000m for about $1k in parts. It comes with calibration fluid. It's perhaps not as precise as commercial units, but gives reasonable results. She has found the sensor elements pass pressure testing to 1,250m. Once complete, she will be able to profile the water column down to 1km and back again for the cost of a couple of life savers. I suspect she'll be the subject of a future Lander Lab article.

Conor Hardy, a San Jose fifth grader modified his STEM Lander to be used as a tethered **Drop Cam**. He did not use a release, but tied the anchor weight to the bottom of his lander. The length of the rope between the anchor weight and the lander determines how far above the seafloor the lander will float. Using a long rope tied below the float, he then lowered

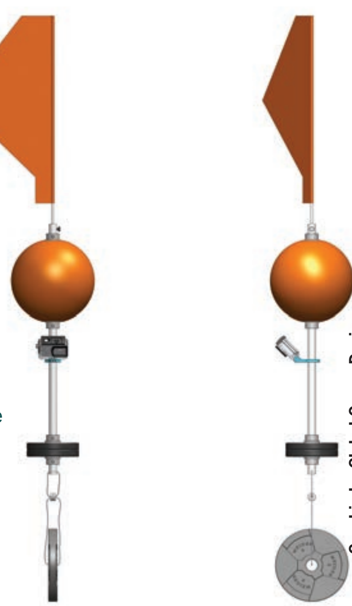
Photo by Sawyer Granados

Figure 2

A Kelp Bass hides among a seaweed holdfast in this photo taken with a STEM Lander.

Figure 3

The STEM Lander is composed of an 8" plastic trawl float with a center hole, a ¾" Outside Diameter ABS or PVC center shaft, a 2.5-lb bar bell weight with a 1" Dia center hole, and a bicycle flag on a ¼" Dia fiberglass mast. The position of the sphere and counterweight are fixed by using hose clamps above and below the items. Another hose clamp is used to hold the recovery flag. A hole drilled through the bottom of the center shaft provides a place to tie the Life Saver release. A waterproof action camera in a housing, good to 100-ft/30m depth is the payload. A Bill of Materials is on page 45.



Graphic by Global Ocean Design

Figure 4

Jillian Cerbasi, a recent UCSD grad in ocean and atmospheric sciences, holds a conductivity probe adapted to a bulkhead fitting for an OpenCTD. The sensor has just passed pressure testing to 1,250m.

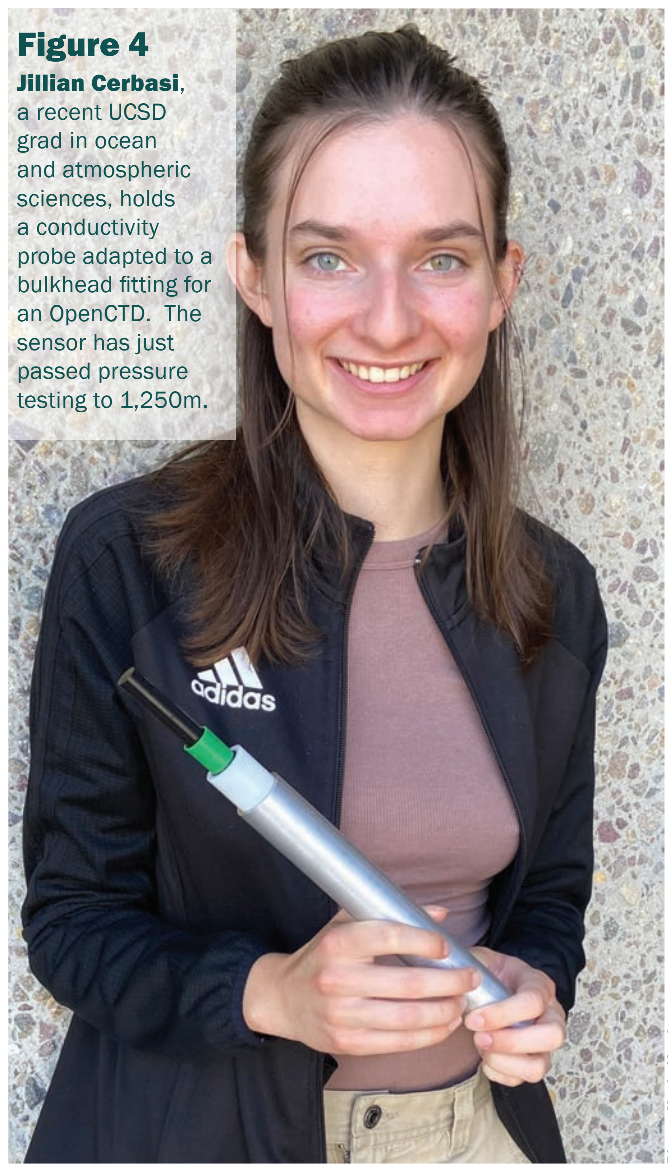


Photo: Kevin Hardy

it by hand from a tall pier. He caught some great images of the pier pilings, pile perch, and other near shore fish.

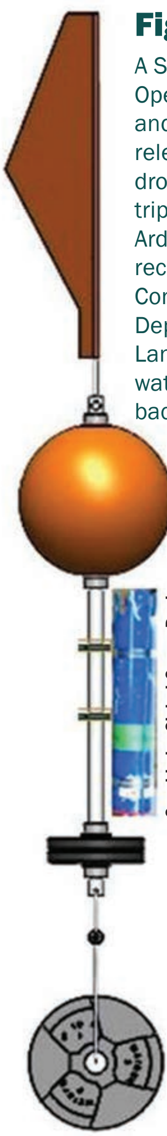
A variation of Conor's idea is tying a known length of the lowering line to a surface float. The surface float will suspend the camera at that specified depth in the water column, perhaps to observe fish gathering beneath a kelp paddy.

The **Marine Technology Society-San Diego Section** is helping spread the word about the STEM Lander as a tool of education and research. MTS-SD member **Beto Campos** is taking his son, **Gabriel** and his STEM Lander out to a local fresh water lake to learn about limnology. They strapped a small underwater flashlight onto their STEM Lander to help their waterproof action camera capture better images in darker deeper water.

This author is working with the Marine Technology Society-San Diego Section, and **Steven Granados**, Math and Science teacher at Saint Augustine High School, San Diego, CA, to develop an intersession class using the STEM Lander as a teaching tool to demonstrate underwater physics, ocean engineering, marine science, and the history of exploration. Perhaps we can connect other teachers to Steven and start something fun and interesting.

If you build one, send us your best photo, including where it was launched, how deep it went, and what you think is interesting about the photo. We can print a few every so often.

Reader Feedback: Comments on this article, abstracts of personal stories for possible publication, or suggestions for future topics are welcome. Please write to Kevin Hardy <**khardy@marinelink.com**>.



Graphic by Global Ocean Design

Figure 5

A STEM Lander carries an OpenCTD to 1km depth and back. Lifesavers release an expendable drop weight for a return trip to the surface. An Arduino data logger records time synchronized Conductivity-Temperature-Depth data as the STEM Lander glides through the water column down and back again.

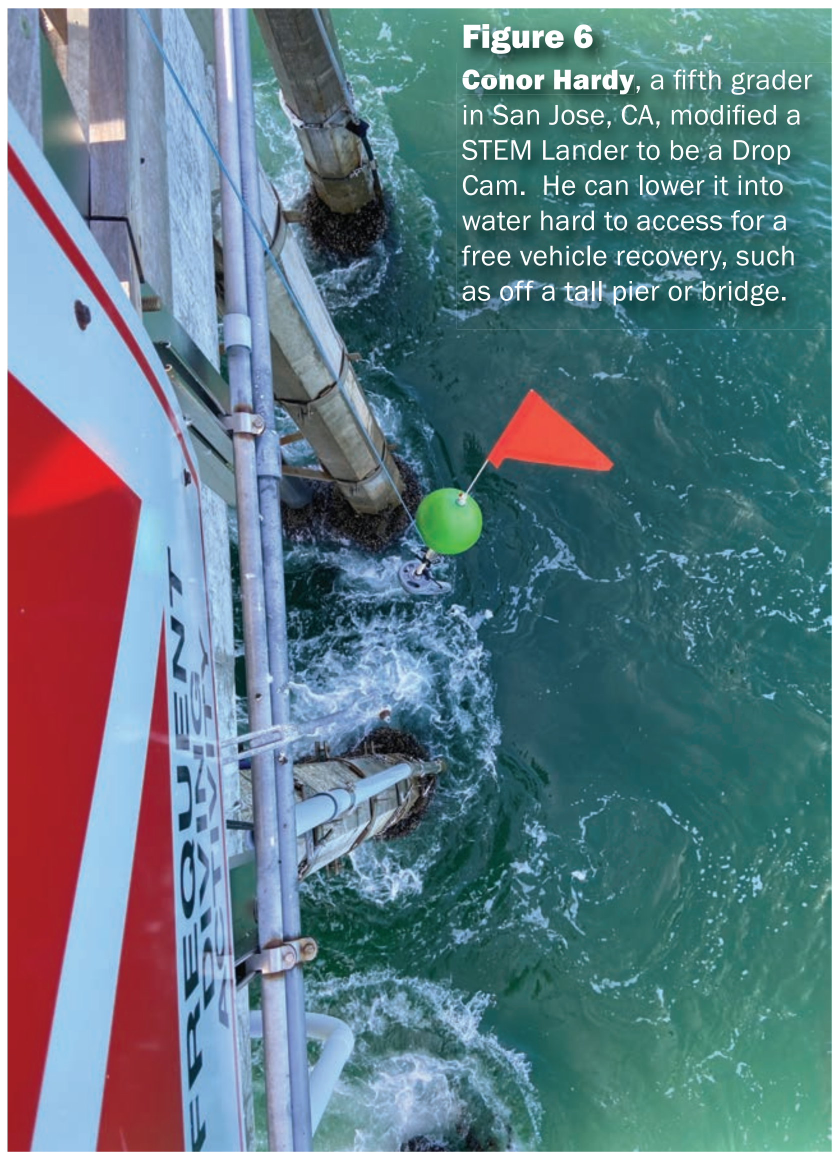


Figure 6

Conor Hardy, a fifth grader in San Jose, CA, modified a STEM Lander to be a Drop Cam. He can lower it into water hard to access for a free vehicle recovery, such as off a tall pier or bridge.

Photo by Jason Hardy

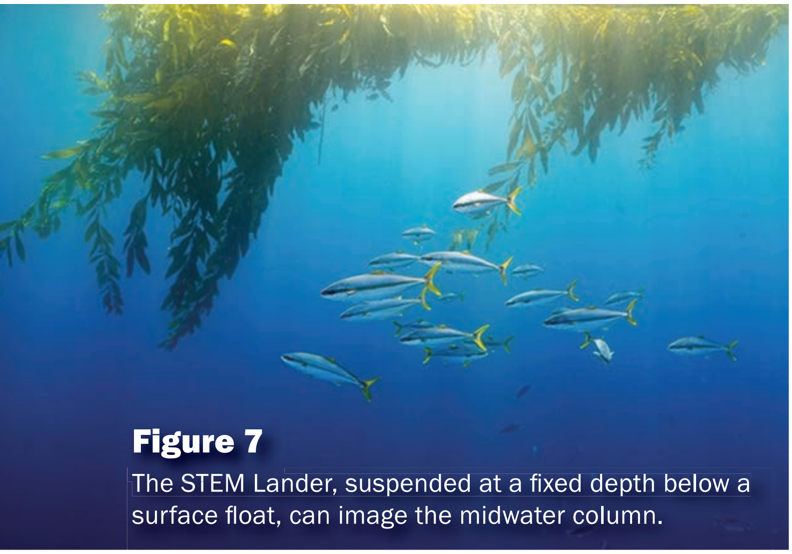


Figure 7

The STEM Lander, suspended at a fixed depth below a surface float, can image the midwater column.

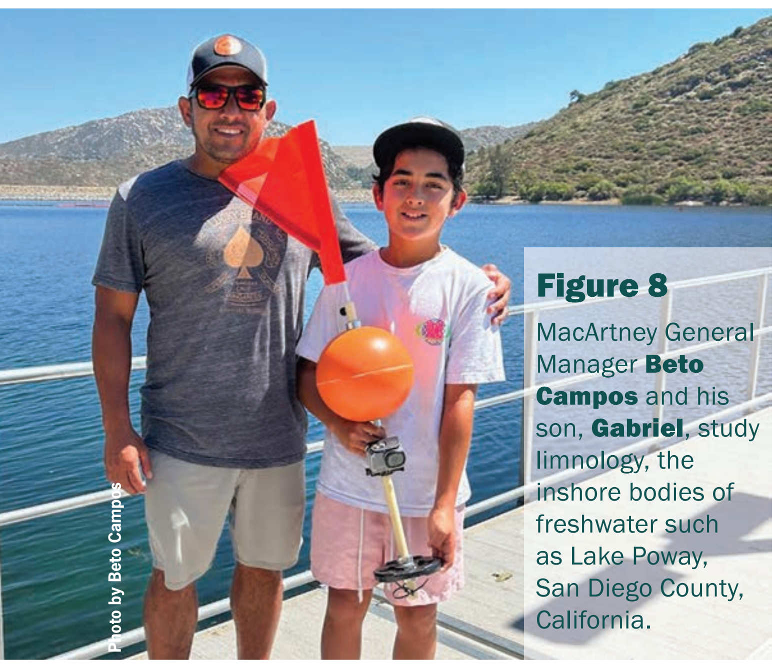


Photo by Beto Campos

Figure 8

MacArtney General Manager **Beto Campos** and his son, **Gabriel**, study limnology, the inshore bodies of freshwater such as Lake Poway, San Diego County, California.

Figure 9

The Bill of Materials to build a simple STEM Lander.

STEM Lander Bill of Materials		
Float (p/n 08-1200-CO)	Atlantic Floats	8" Trawl float with center hole
Center Shaft	McMaster-Carr	3/4" Dia x 3-ft long, ABS or PVC rod
Counterweight	Sporting goods	2.5-lb with 1" centerhole
Flag	Bike shop	small flag, with 1/4" Dia mast
Hose clamp, SS	Hardware store	5 ea, opens to 1-1/2" Dia
Camera and mount	Amazon	Akaso EK7000 4K
Micro SD card, 128Gb	Amazon	*SanDisk 128GB Ultra microSDXC*
LifeSavers, hard candy		release
Drop weight, expendable		5-lbs water weight
String		to tie drop weight to anchor

Graphic by Global Ocean Design

Teledyne Honors Doug Webb

Douglas Webb, an esteemed Oceanographer Emeritus from Woods Hole, MA, and founder of Teledyne Webb Research, received recognition for his lifelong contributions to science at the Teledyne Marine facility located inNorth Falmouth, MA, in early June. Teledyne staff members **Clara Hulburt**, **Shea Quinn** and **Clayton Jones** delivered an informative and historical talk about Webb's legacy as an engineer, scientist, innovator, and world changer.

Webb contributed significantly to developing low-frequency acoustic sound sources such as SOFAR, RAFOS, and Tonpilz for water mass tracking, long-range navigation, and tomography. He played a key role in the development of Vertical Current Meters (VCMs) to measure water chimney convection and profiling floats (ALACE). He commercialized this development (APEX) which became part of the ARGO program. He invented and developed the Teledyne Slocum gliders. Webb pioneered the development of the buoyancy systems used in these floats and gliders, revolutionizing how scientists approach ocean data gathering. Argo is the most successful ocean observing program, contributing critical information about climate and sea level change.

Webb was also honored by Rutgers University's undergraduate class of 2024 with a letter of appreciation after the

Standing Left to Right: Karl Boettger, Brian Maguire, Shea Quinn, Clayton Jones, Clara Hulburt, Kathi Sheehan and Andrey Morozov. Sitting: Doug Webb.

Rutgers University Center for Ocean Observing Leadership (RUCOOL) received the 2024 TOS Ocean Observing Award for innovation and excellence in sustained ocean observation at the 2024 Ocean Sciences Meeting in New Orleans, LA.

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SeaBat T20-S Module

Sonar operating frequency	400kHz	**Max range(CW)[3]**	225m
Across-track receiver beam width (nominal values[1])	1° (center)	**Typical range (FM)[2]**	0.5-180m
Along-track transmit beam width (nominal values[1])	1"	**Max range (FM)[3]**	300m
Number of beams	Min 10, Max 1024	**Ping rate (range dependent)**	Up to 50 pings/s
Swath coverage (up to)	140° Equi -Distant (170° Equi-Angle)	**Pulse length**	15-300µs (CW) 300µs - 20ms (FM)
Typical range (CW)[2]	0.5-150m	**Depth resolution**	6mm

SeaRaptor AUV

Osprey AUV

With the addition of the Teledyne RESON SeaBat T20-S MBES Module, GAVIA AUVs are a powerful platform for gathering cost effective, high-resolution bathymetric data from vessels of opportunity. The modular design of the Gavia, combined with an array of sensor options including SAS, SBP, Magnotometer, SSS, Camera and now multibeam, ensure these AUVs are perfectly suited for a variety of commercial, military and scientific applications.

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