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March/April 2023
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On the Cover

Argeo CEO Trond Crantz is driving efficiencies in discovery and recovery of data from the seas.
Image courtesy Argeo

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Editorial

CBS' *'60-Minutes'* recently offered an interesting feature on the health and readiness of the U.S. Navy to potentially meet and beat a long list of traditional global powers, as well as a growing list of asymmetric threats. Chief of Naval Operations Admiral Mike Gilday was succinct in discussing the future of the U.S. Navy:

"I think unmanned is the future, and I believe about 40% of our fleet in the future is going to be unmanned."

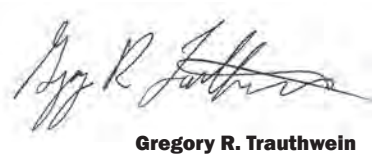
While the USN ORCA 'Extra Large Unmanned Undersea Vehicle' program is more than three years behind schedule and about $242 million over budget according to the U.S. Government Accountability Office (GAO), in his interview with CBS Gilday expressed strong optimism for the platform, saying, "I expect a very high return on investment. It will be among the most lethal and stealthy platforms in the arsenal of the U.S. military."

Despite continued geopolitical unrest – or perhaps because of it – these are some exciting and fast-moving times in subsea circles. Russia's invasion of and continued war with Ukraine has effectively served a s a catalyst to fast-track a number of subsea initiatives, including:

• **Subsea Defense:** With the mystery surrounding the explosion that took out the Nord Stream pipeline, protection of critical underwater infrastructure … from pipelines to communications cables … has come to the fore.

• **Offshore Energy:** Sanctions on Russia following the invasion coupled with energy flow cuts from Russia to Europe have re-energized offshore oil and gas, as energy security is a top agenda item for most countries. As offshore oil and gas production comes back online following six years in the doldrums, it too looks different, with a decided emphasis on autonomous solutions.

On the former, contributing author **David Strachan** writes on subsea mines this edition. Sea mines have always been a major burden and concern to both commercial and military shipping, as they are a relatively cheap and effective means to disable critical sea routes. In this edition, Strachan takes a closer look as modern sea mines, stealthier and ever more lethal including encapsulated torpedo mines and rocket-propelled rising mines.



Gregory R. Trauthwein
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ADVANCED NAVIGATION

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 important 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. Hardy was the Lander Team Leader for James Cameron's DEEPSEA CHALLENGE Expedition. He writes for the Journal of Diving History and the Marine Technology Reporter.

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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.

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Going on the Offensive: ADVANCED SEA MINES WILL FIGURE PROMINENTLY IN FUTURE CONFLICTS

By David R. Strachan, Senior Analyst, Strikepod Systems LLC

Sailors assigned to the Los Angeles-class fast-attack submarine USS Annapolis (SSN 760) load a MK 67 submarine launched mobile mine (SLMM) onto Annapolis, May 4. Annapolis will be conducting maritime operations in the U.S. 7th Fleet area of operations to maintain a safe and open Indo-Pacific.

U.S. Navy photo by Mass Communication Specialist 2nd Class Zachary Grooman

When it comes to war, the old adage that the best defense is a good offense rings true. Nowhere is this more the case than naval warfare, where initiative can make the difference between victory and defeat. As an integral part of naval warfare, mine warfare – both mine countermeasures and mine laying, or "offensive" mine warfare – will continue to influence naval operations. Yet the latter of these sub disciplines - the "other" mine warfare, as Admiral James Winnefeld, Jr. calls it – has often been missing from mine warfare discussions. But as defense strategists assert that sea mines will play a role in future conflicts, particularly in a war over Taiwan, attention is increasingly being paid to this critical, if unglamorous, aspect of maritime operations.

From the Revolutionary War to the present day, offensive mining has been a significant factor in warfare at sea, sending ships and sailors to the bottom of the ocean, influencing enemies to alter or abandon operations, or even forcing belligerents to the negotiating table. Mines are cheap, easy to deploy, and capable of generating tactical, operational, and strategic effects. Although highly destructive, they can also be highly disruptive; the mere presence of mines can impede merchant shipping, rattle global markets, or grind naval operations to a halt. And they don't have to be advanced to generate far-reaching effects, as we've seen recently in the Black Sea, where unsophisticated, Soviet-era contact mines have threatened grain shipments, and may have staved off a Russian amphibious assault on Odessa.

Estimates of sea mine stockpiles vary, but Russia is thought to possess as many as a quarter million, with eighty thousand for China, fifty thousand for North Korea, and between three and six thousand for Iran. China has demonstrated a particular interest in offensive mining, and may possess as many as 30 different variants in its inventory, including encapsulated torpedo mines and rocket-propelled rising mines.

Lying in stark contrast is the US. Navy's mine inventory, with just two types of mines currently available – the Quickstrike and the Submarine Launched Mobile Mine (SLMM) – while two additional models, the Clandestine Delivered Mine (CDM) and the Hammerhead encapsulated torpedo mine, are under development. Quickstrikes are shallow water, air-dropped mines which are actually 500, 1000, and 2000 pound general purpose "dumb" bombs fitted with target detection devices (TDDs). SLMMs are essentially heavyweight torpedoes

that transit to a preprogrammed waypoint, sink to the seabed, and lie in wait like a standard bottom mine. The status of the SLMM inventory is unclear, but an improved version, called MEDUSA (Mining Expendable Delivery Unmanned Submarine Asset), which the Navy actually refers to as a medium-class UUV, is under development.

Little is known of the CDM, which has been under development for over five years. Images in circulation suggest that it is a standard bottom mine, while budget documents indicate that it is capable of acoustic communication to enable remote command and control. The CDM has undergone testing with the Navy's large displacement UUV (LDUUV), Snakehead, and, according to budget documents, it could also be deployed by the Orca extra-large UUV (XLUUV).

The Hammerhead is actually a throwback to a Cold War-era weapon – the CAPTOR (EnCAPsulated TORpedo) mine. It is a deep water, anti-submarine mine that can detect, classify, localize, and engage enemy submarines with a Mk-54 lightweight torpedo. Unlike the Quickstrike or CDM, the Hammerhead is being purpose-built for clandestine deployment by a single platform – the Orca XLUUV. Given the technological complexity of unmanned mine laying operations, as well as Orca's production delays and cost overruns, it is likely that the Hammerhead will be fully tested and in production before the Orca is ready to join the fleet. Whether other Hammerhead variants are in the works that would enable deployment from air, surface, or manned undersea platforms is unknown.

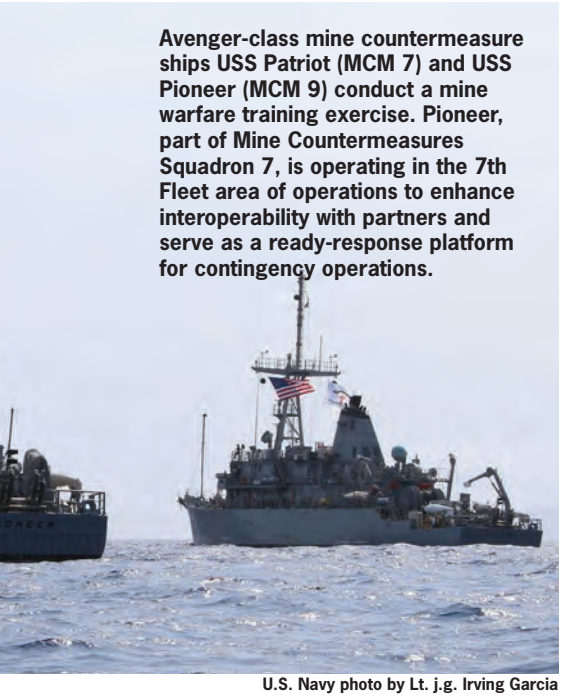
Advanced minelaying isn't only for well-capitalized great powers. Recent commercial innovations are making offensive mining accessible to maritime nations seeking an affordable, viable sea denial capability in the face of growing threats from Russia and China. Italian company RMV Italia, for example, a division of German auto and arms manufacturer Rheinmetall, markets the Murena and Asteria bottom mines, and is rumored to be a possible future supplier to the Royal Australian Navy as Canberra seeks to deter Chinese maritime aggression. Finnish company DA-Group produces an advanced bottom mine, the Turso MM20, which can be fitted with a range of sensors, and operates at depths of 10 to 200 meters. DA-Group also markets a modular minelaying system called Sumico, which is essentially a 20-foot shipping container that enables twelve mines to be deployed from any vessel of opportunity. Another Finnish company, Forcit Defence (part of Forcit Group), markets the Blocker bottom influence mine, which can be deployed for two years at depths of up to 200 meters. (In 2021, Estonia took delivery of Blocker mines to strengthen its coastal defense capabilities against an expansionist Russia.) And Danish company SH Defence markets a containerized minelaying system as part of its Cube series of modular defense payloads. Each container can accommodate between 20 and 50 mines, which can be deployed at a rate of two to four per minute. (In February of this year, Forcit, DA-Group, and SH Defence joined forces, signing a memorandum of understanding to jointly develop and market a fully integrated, modular mine warfare system.)

But even as sensor, communication, and deployment capabilities advance, sea mines remain what they have been for over a century – weapons that wait. Once deployed, they remain in place, awaiting the necessary sensor inputs that will trigger their destructive payload. But this is about to change – dramatically. For over half a century, a quiet, slow-motion convergence of mines, torpedoes, and UUVs has been underway, beginning during the Cold War with the development of the encapsulated torpedo mine. Although its modern-day descendant, the Ham-

U.S. Navy photo by Mass Communication Specialist 2nd Class Zachary Grooman

merhead, now has a high-density energy source, more sophisticated sensors, algorithmic processing, and the ability to communicate, it still remains tethered to the seabed. What if the Mk-54 liquid fuel propulsion system were replaced with a high density battery-driven system, transforming it into a loitering, armed UUV? Such a weapon already exists, in the form of battery-powered torpedoes like the F21 (which was inspired by Naval Group's D19 UUV), the Black Shark, the Sea Hake, the MU90, and the Saab Lightweight Torpedo (SLWT), all of which can reach speeds of 50 knots and have an endurance of nearly an hour. Endurance is perhaps the greatest challenge in the development of persistent, mobile minefields. Last year, Chinese scientists published a paper exploring the idea of miniaturized nuclear reactors powering heavyweight torpedoes. While largely aspirational, it underscores the broader, accelerating trend toward autonomous, self-organizing, high-endurance torpedo-mines.

By all indications, offensive mine warfare will play an important role in future conflicts. But the "mines" of tomorrow will be radically more dangerous than those of today. They will combine the persistence and coverage of conventional mines, the speed, lethality, and maneuverability of torpedoes, and the modularity, mobility, and autonomy of UUVs. Yet even as this convergence continues, our very understanding of what constitutes a sea mine may need to change. The recent Ukrainian armed USV attacks on the Russian Black Sea ports of Sevastopol and Novorossiysk suggest that mobile "surface mines" could come to be pose a uniquely dangerous threat to surface warships. We may soon find that offensive mine warfare is no longer confined to the undersea domain.



Avenger-class mine countermeasure ships USS Patriot (MCM 7) and USS Pioneer (MCM 9) conduct a mine warfare training exercise. Pioneer, part of Mine Countermeasures Squadron 7, is operating in the 7th Fleet area of operations to enhance interoperability with partners and serve as a ready-response platform for contingency operations.

U.S. Navy photo by Lt. j.g. Irving Garcia

Image Credit: NOAA Thunder Bay National Marine Sanctuary

HISTORIC SHIPWRECK FOUND IN LAKE HURON

By Stephanie Gandulla, NOAA's Thunder Bay National Marine Sanctuary

Researchers from NOAA, the state of Michigan, and Ocean Exploration Trust discovered an intact shipwreck resting hundreds of feet below the surface of Lake Huron. Located within NOAA's Thunder Bay National Marine Sanctuary, the shipwreck has been identified as the sailing ship Ironton. Magnificently preserved by the cold freshwater of the Great Lakes for over a century, the 191-ft. Ironton rests upright with its three masts still standing.

"Using this cutting-edge technology, we have not only located a pristine shipwreck lost for over a century, we are also learning more about one of our nation's most important natural resources—the Great Lakes. This research will help protect Lake Huron and its rich history," said Jeff Gray, Thunder Bay National Marine Sanctuary superintendent.

The Sinking

In September 1894, Ironton sank in a collision that took the lives of five of the ship's crew. Accounts from the wreck's two survivors provide details about the loss of the vessel in "Shipwreck Alley"—an area of Lake Huron known for its treacherous waters that have claimed the lives of many sailors.

The 190-foot steamer Charles J. Kershaw departed Ashtabula, Ohio, on Lake Erie, with the schooner barges Ironton and Moonlight in tow. The vessels sailed empty, destined for Marquette, Michigan, on Lake Superior.

At 12:30 a.m. on Sept. 26, while sailing north across Lake Huron under clear skies, Kershaw's engine failed, leaving the ship without power. A few miles north of the Presque Isle Lighthouse, a strong south wind pushed Moonlight and Ironton toward the disabled steamer. To avoid entanglement and

a possible collision, Moonlight's crew cut Ironton's tow line, detaching the steamer from the schooner barges.

Ironton's crew found themselves suddenly adrift in the dark and at the mercy of Lake Huron's wind-blown seas. Under the direction of Captain Peter Girard, they fought to regain control of the ship, firing up the vessel's auxiliary steam engine to help set the struggling ship's sails. Despite their efforts, Ironton, propelled by the wind from astern, veered off course into the path of the southbound steamer Ohio. The 203-foot wooden freighter Ohio was headed to Ogdensburg, New York, from Duluth, Minnesota, loaded with 1,000 tons of grain.

By the time Ironton's crew spotted the approaching Ohio through the darkness, it was too late—a head-on collision with the steamer was unavoidable.

The two vessels separated after the impact, both fatally damaged. Ironton's bow tore a 12-foot diameter hole into Ohio's wooden hull. Heavily laden with cargo, Ohio sank quickly, with all 16 crew escaping on lifeboats. Nearby ships rescued the sailors. The damaged Ironton, however, drifted out of sight of the responding vessels. By the time Captain Girard realized he could not save the ship, Ironton had drifted for over an hour, far from the view of any surrounding vessels.

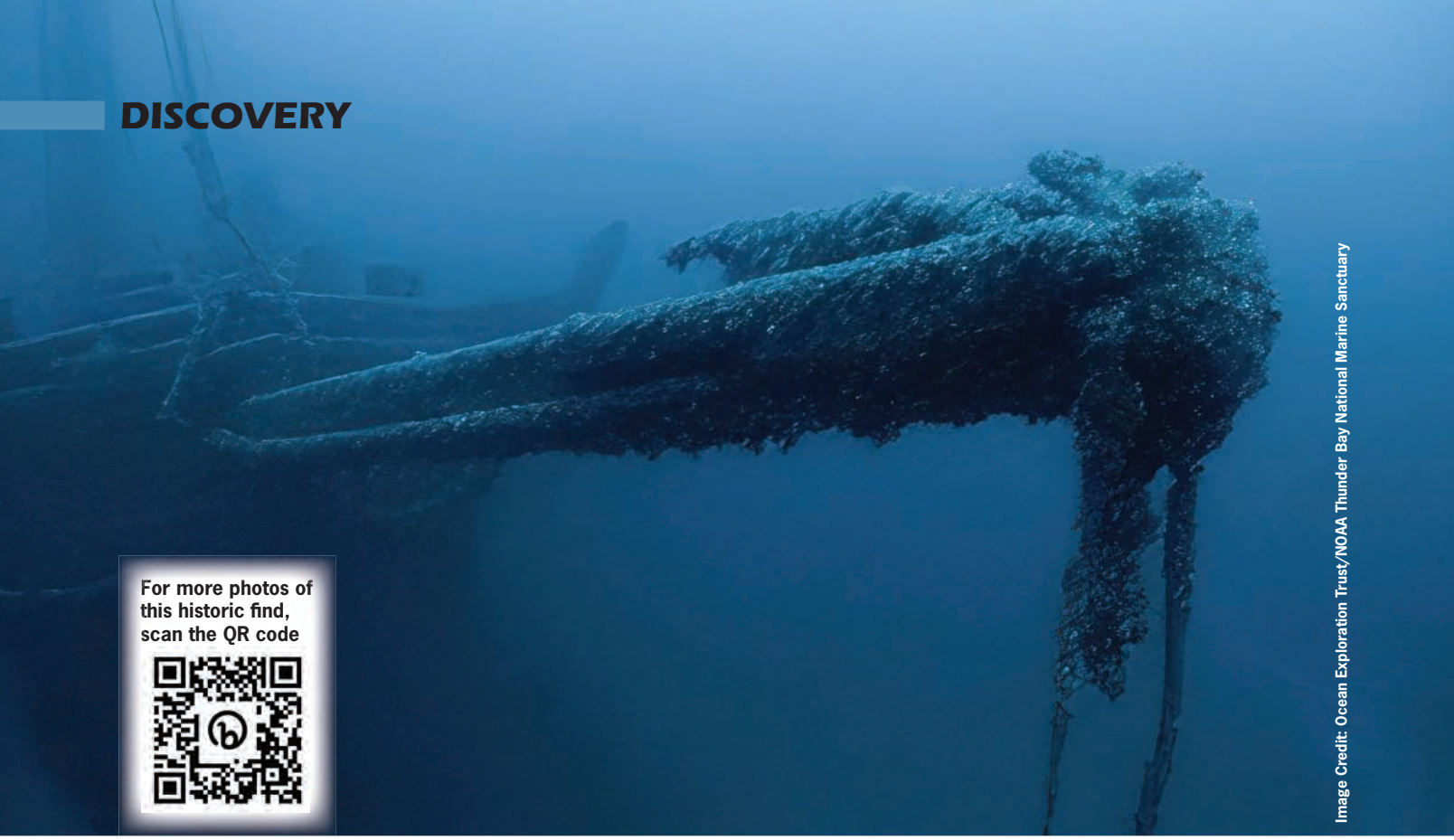
As the schooner barge slipped swiftly beneath the waves, Ironton's seven-man crew retreated to their lifeboat. However, in the commotion, no one untied the "painter," a line that secured the lifeboat to Ironton. Survivor William W. Parry of East China, Michigan, recounted:

> *Then the Ironton sank, taking the yawl with her. As the painter was not untied, I sank underwater, and when I came up grabbed a sailor's bag. Wooley was a short distance from me on a box. I swam to where he was. (Duluth News Tribune, September 27, 1894)*

Wooley and Parry clung to floating wreckage as they battled the wind and waves in frigid Lake Huron. Within hours the passing steamer Charles Hebard spotted and rescued the men. Lake Huron claimed Captain Girard and four other Ironton crew: Mate Ed Bostwick, Sailor John Pope, and two unidentified sailors.

A Piece of History

The three-masted Ironton represents the fleet of wooden schooner barges that once traversed the Great Lakes as the



For more photos of this historic find, scan the QR code

Image Credit: Ocean Exploration Trust/NOAA Thunder Bay National Marine Sanctuary

workhorses of the region's wheat, coal, corn, lumber, and iron ore trades. The Niagara River Transportation Company built Ironton in 1873 as a towed schooner barge.

Known as the "consort system," steamers towed one or several schooner barges and enabled companies to transport greater quantities of cargo across the Great Lakes at a lower cost. Either converted from older sailing vessels or purpose-built, schooner barges had masts and sails to save fuel in the towing steam vessel and in case of emergencies where they needed to sail independently. These iconic Great Lakes vessels were a link in the evolution of sail-powered shipping to mechanized transportation systems of the modern world.

Measuring 190 feet, 9 inches in length and 35 feet, 4 inches in breadth, the 772-ton Ironton boasted a carrying capacity of more than 48,500 bushels of grain or 1,250 tons of coal. During the ship's nearly 22-year career, Ironton changed ownership multiple times, transporting iron ore, grain, and coal between ports such as Buffalo, Cleveland, Marquette, and Duluth.

Ironton's discovery may answer century-old questions surrounding the ship's final hours. Sandra Clark, director of the Michigan History Center and co-manager of Thunder Bay National Marine Sanctuary, described the importance of finding historical shipwreck sites such as Ironton: "Discoveries like this are fascinating because they connect people to Michigan's long history of maritime innovation and commerce. The more we discover, the more we understand the lives of the men and women who worked the Great Lakes."

Finding Ohio

Although contemporary reports and eye-witness accounts describe the general area of Ironton's sinking, the exact location remained a mystery for over 120 years. Researchers from NOAA's Thunder Bay National Marine Sanctuary, the state of Michigan, and Ocean Exploration Trust used cutting-edge oceanographic technology to discover and document the shipwreck.

In 2017, Thunder Bay National Marine Sanctuary and a group of partners led an expedition to survey 100 square miles of unmapped lakebed within the sanctuary. The team discovered the bulk carrier Ohio in approximately 300 feet of water. Despite the large area mapped, the location of Ironton remained a mystery.

In 2019, researchers from Thunder Bay National Marine Sanctuary set out on a mapping expedition in Lake Huron with Ocean Exploration Trust, the undersea exploration and education organization founded by famed explorer Dr. Robert Ballard, who has explored nearly every corner of the planet. Ocean Exploration Trust brought a team of world-renowned hydrographers and the latest innovation in underwater mapping technology to Michigan, including an autonomous surface vehicle named BEN (Bathymetric Explorer and Navigator).

"Our team is proud to partner with the Office of National Marine Sanctuaries to bring innovative technology and expedition expertise to map the Great Lakes," said Dr. Robert Ballard, President, Ocean Exploration Trust. "Ironton is yet another piece of the puzzle of Alpena's fascinating place in America's

history of trade and Thunder Bay National Marine Sanctuary continues to reveal lost chapters of maritime history. We look forward to continuing to explore sanctuaries and with our partners reveal the history found in the underwater world to inspire future generations."

The Discovery of Ironton

Armed with the location of Ohio and further research into the weather and wind conditions from the night of the fatal collision, the team defined the area to search, and BEN and RV Storm worked in tandem mapping the lakebed.

As the project came to its final days, the team had successfully mapped a large section of the search area, but Ironton remained undiscovered. The researchers expanded the search area. Persistence and determination were rewarded when the sonar returned an image from the lakebed of an unmistakable shipwreck—and one that matched the description of Ironton. The sonar images provided great detail, but the team had more work to do in order to confirm the identity of the discovered wreck. The following month, archaeologists from Thunder Bay National Marine Sanctuary teamed up with the Great Lakes Water Studies Institute at Northwestern Michigan College to explore the discovery. Utilizing a remotely operated vehicle (ROV) from aboard RV Storm, the team sought to confirm the ship's identity through video images. As the team watched the footage from the ROV, there was no mistake: Ironton had been found.

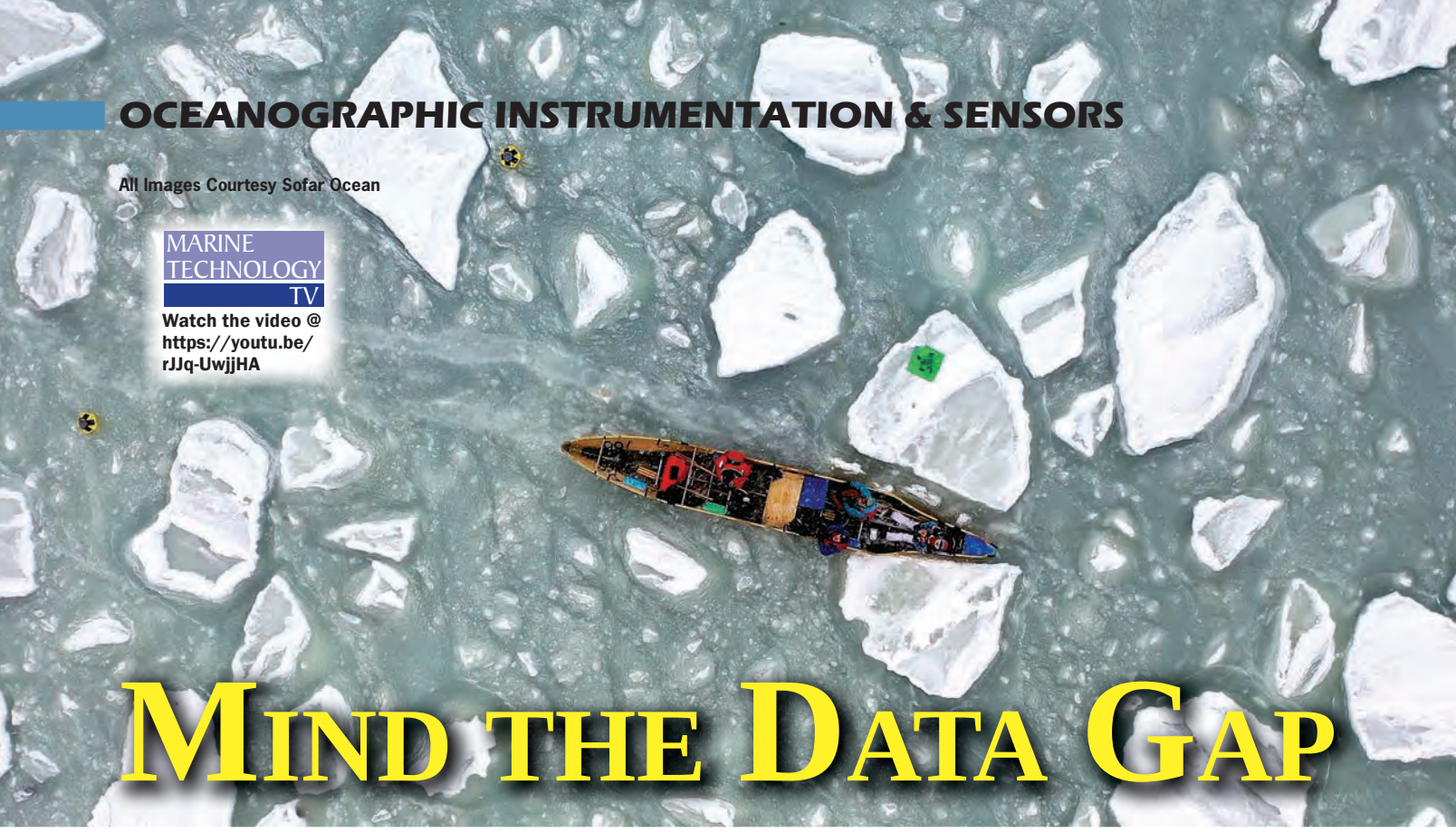
In June 2021, Thunder Bay National Marine Sanctuary and Ocean Exploration Trust returned to the site to carry out a more thorough investigation of Ironton. Conducting ROV operations aboard U.S. Coast Guard Cutter Mobile Bay, the research team partnered with the University of North Carolina's Undersea Vehicle Program to collect high-resolution video and further document the wreck. Resting upright and incredibly well preserved by Lake Huron's cold freshwater, Ironton looks almost ready to load cargo.

Project Partners

NOAA and the state of Michigan jointly manage Thunder Bay National Marine Sanctuary. This project was made possible with the support of Ocean Exploration Trust and with technologies from the Center for Coastal and Ocean Mapping, the Great Lakes Environmental Research Laboratory, the University of North Carolina's Undersea Vehicle Program, and the Great Lakes Water Studies Institute at Northwestern Michigan College. The documentation of the shipwreck Ironton would not have been possible without the dedication of the United States Coast Guard.

All Images Courtesy Sofar Ocean

MARINE TECHNOLOGY TV
Watch the video @ https://youtu.be/rJJq-UwjjHA



MIND THE DATA GAP

Sofar Ocean is on a quest to extract and put to use data from the world's waterways. Co-Founder and CEO Tim Janssen recently discussed with MTR the rapid growth of his company, and the burgeoning use cases for information from our oceans.

By Greg Trauthwein

As we wrote back in the November 2021 edition of ***Marine Technology Reporter***, Tim Janssen and his Sofar Ocean team were on an 'Epic Ocean Data Quest.' Fast track to February 2023, and we could easily call it 'Epic Ocean Data Quest – Part II', as Janssen and his growing team remain laser focused on doing its part to help extract and put to use increasing quantities of information from the world's oceans.

The mantra 'unlocking data from the ocean' is a common refrain in subsea circles, and while extracting information from more than 2/3 of the planet earth is a sizeable task, the first step is to accurately quantify the job itself.

"The ocean is so far behind in terms of data acquisition; I typically refer to it as an 11 orders of magnitude difference," said Janssen. He estimates that humanity collects about a trillion gigabytes a year of data. Using his best estimate of 11 orders of magnitude difference between total data collected compared to data collected from the ocean, he said it would look something like this. "If you think about the distance from here to the sun and you equate that to the total amount of data we collect every year, (the total amount of data collected from the ocean) gets us about one to 10 meters on the way! That's the difference, and it is a compounding problem," as every year the gap widens.

Enter Sofar Ocean

Janssen and his team, while young and still relatively small, think big. "Our mission is to connect the world's oceans to

contribute to a more sustainable future. That's really important to us in everything we do," said Janssen. "We are a company that does things at scale, and we are hyper-focused on collecting as much data as we can, as quickly as we can, complementing other organizations, both government and (commercial)." That said, he knows the job exceeds the bounds of any one company or organization. "There is so much need for more information," Janssen said. "We can't do everything ourselves, neither can anybody else. It's really about helping each other and trying to accelerate things forward."

For its part, Sofar will continue to build scalable networks to gather information premised on its Sofar Spotter buoy. Today, Sofar Ocean has more than 2,500 sensors deployed worldwide, an array that provides more than 200,000 daily updates on ocean weather globally, helping forecasters to improve their forecasts by up to 40%.

While Janssen admits that weather models do a reasonably good job, the key to making them even better lies in the amount and the quality of information being put in. "I think step one is acknowledging that models are only as good as the data you put into it," he said. "Assuming that the model can do that reasonably well, the way to make them better foundationally is put more information into them; that's why we are hyper focused on creating large networks of sensors … [the

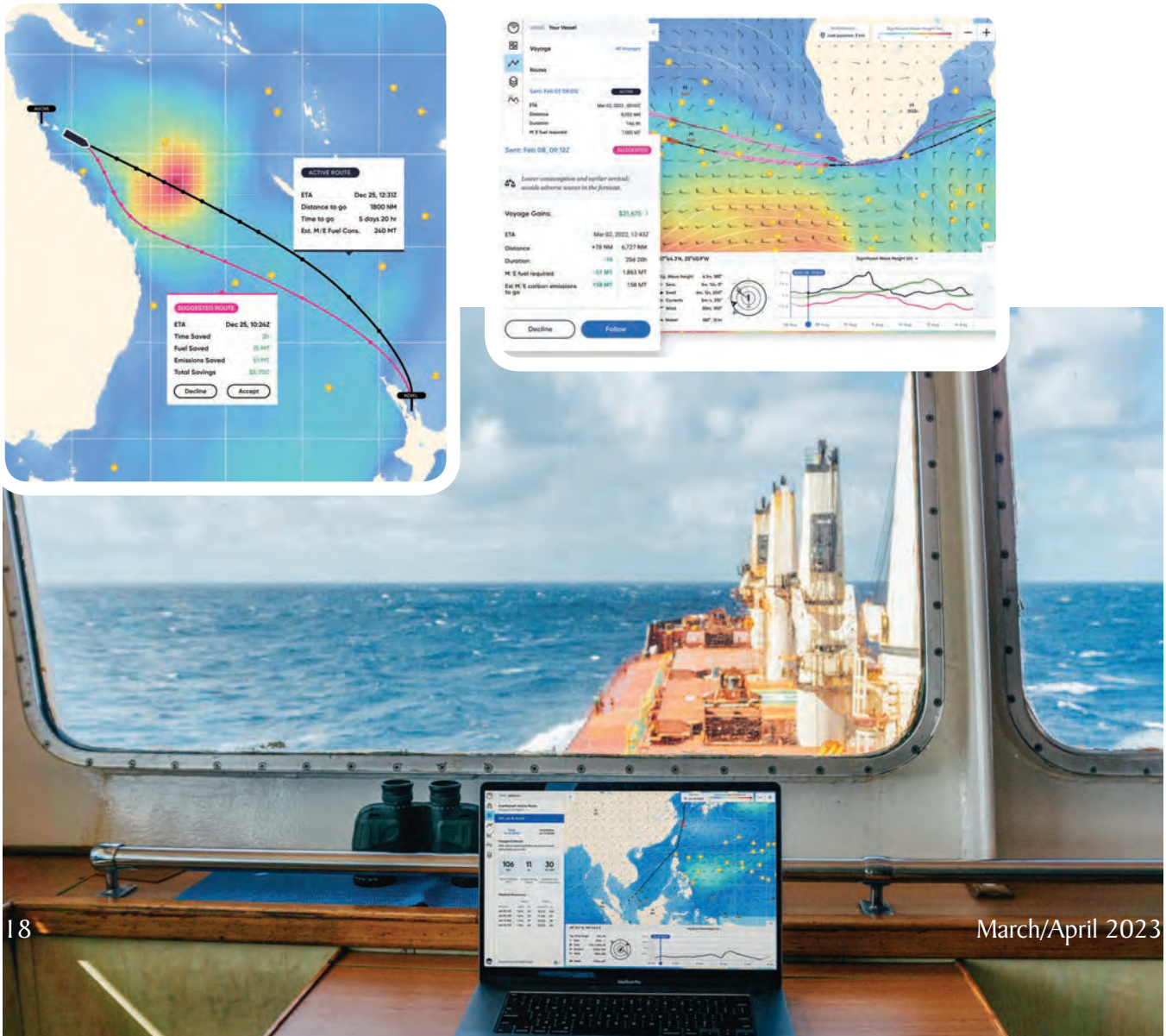
oceans are] a very big place."

"The principle's very simple, technically it's described as data assimilation, which basically means we're taking all the sensor information we can get our hands on … our own network of thousands of sensors worldwide, satellite data, data from public networks … and we put all of that information into our models on the 'now' state. We tell the model, 'look this is what we know about how the weather is behaving right now, take that, correct whatever you thought was going on, and translate that into what will be happening in the future.'"

"We run our own operational numerical weather forecast models in the cloud, gathering all of this information every six hours, getting everything together, running a forecast cycle, and basically improving the forecast, reducing the uncertainty. From the ground up, the whole system is designed to be a very effective way of reducing uncertainty in forecasts," said Janssen. He figures that one reason this hasn't been easy for government organizations is the fact that observations, modeling, and dissemination of the outcomes are separated rigorously, whereas Sofar Ocean has everything under one roof. "How cool is it that a small team like ours can actually run numerical weather forecasts in the cloud? That's cloud computing; it wasn't possible five years ago."

So melding sensors – sensors low cost enough to allow deployment at scale – with IoT capabilities plus real-time connectivity to drive that information to the models creates a dynamic and powerful value proposition.

Wayfinder is a dynamic voyage guidance system, designed to deliver the most efficient and least weather-restricted speed and waypoint recommendations to a fleet. Powered by Sofar Ocean's global network of ocean sensors, helping to produce accurate marine weather forecasts and inform detailed Vessel Performance Models (VPM).



All images courtesy Sofar Ocean

Wayfinder

Wayfinder is a dynamic voyage guidance system, designed to deliver the most efficient and least weather-restricted speed and waypoint recommendations to a fleet. Powered by Sofar Ocean's global network of ocean sensors, helping to produce accurate marine weather forecasts and inform detailed Vessel Performance Models (VPM).

"We built this platform for maritime shipping that's going to help reduce emissions. It's going to be tying into new CII regulations, and it's going to help the industry accelerate its journey towards a more carbon-free future," said Janssen.

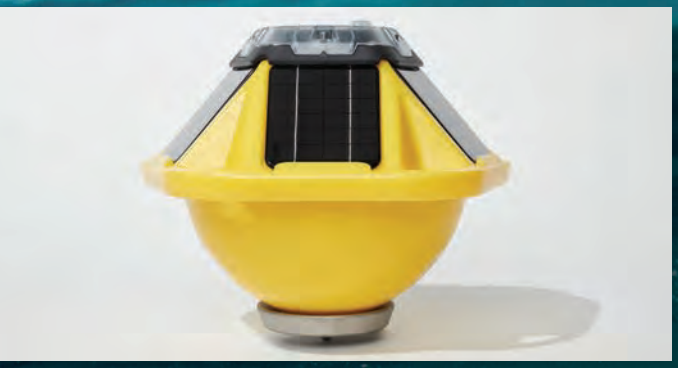
Core to Wayfinder's capability is the real knowledge of what weather is happening and is forecast to happen at certain spots in the ocean.

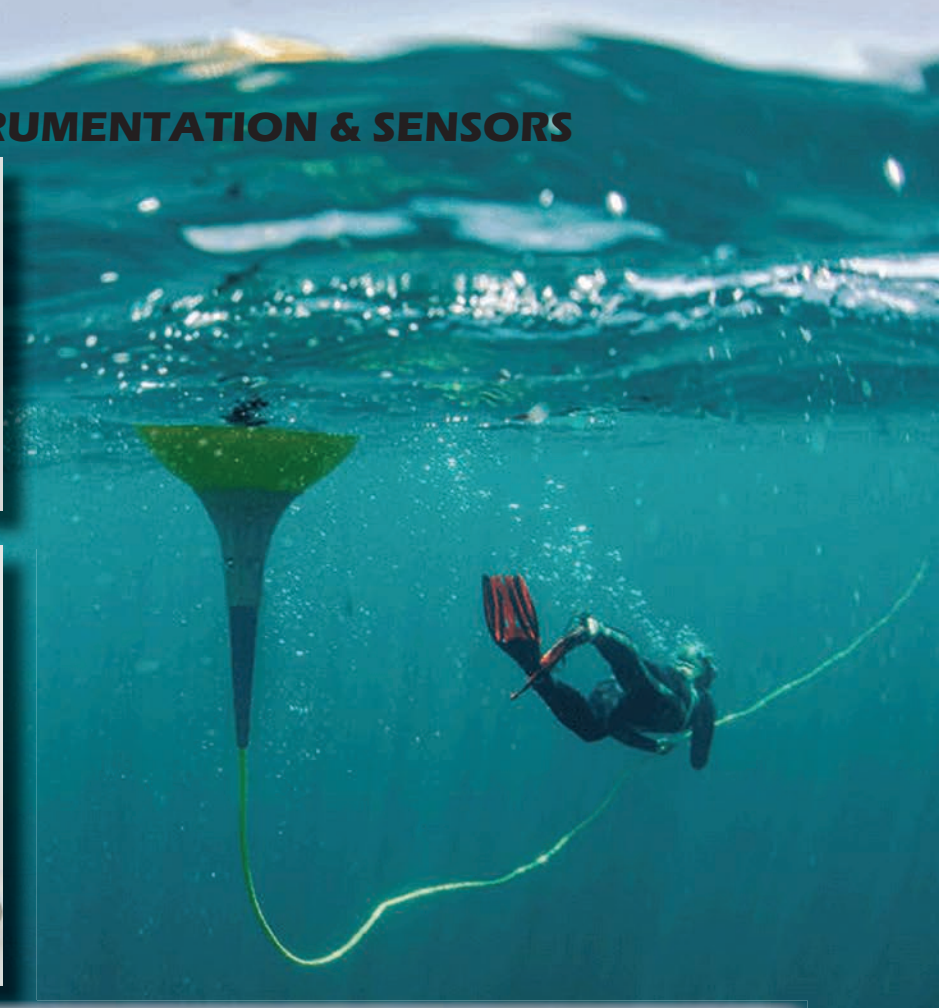
While he admits that Sofar Ocean may be late to the game – considering the amount of time, money and effort shipowners have already poured into optimization; from hull design to weather routing, to propulsion technologies and appendages, to coatings – Janssen believes the holy grail of true optimization is still a ways off for many companies. "I think a lot of ship owners have already invested quite big into technologies to improve their vessels without really knowing what it's going to do for the performance," said Janssen.

He sees the vessel voyage optimization conundrum as stretching far above and beyond simply knowing the weather, as the factors that go into the decision-making process are complex and dynamic, including the weather, vessel specific performance criteria and market variables too, such as the cost for arriving early or arriving late. By incorporating a vessel's specific business and safety constraints, Wayfinder continuously provides operators and crew with the most optimized speed and routes possible.

"What we're trying to do is change the paradigm altogether," said Janssen. "Every six hours is an opportunity for change. Market variables are volatile, fuel prices go up and down daily, weather changes every three hours. To 'set it and forget it' would be a very bad idea if you're thinking about a transoceanic voyage that could be 30 to 40 days."

Every six hours, Sofar Ocean runs through its optimizations based on the latest, comprehensive weather data integration, helping to deliver the next strategy. While getting the best data, processing and delivering strategy is the hard part, Janssen said "we solved that problem." The next challenge is engaging will all partners to both implement, execute and track the strategy to receive





Sofar Ocean's Spotter Buoy is designed to be low-cost and easy to deploy. Today there are more than 2,500 deployed worldwide, delivering more than 200,000 daily updateson ocean weather.

tangible results.

"Wayfinder is hyper focused on delivering the best routes and optimization of both waypoint selection and speed. It is optimized to make sure that everybody's looking at the same information, it is on board and onshore, and basically making sure that there is seamless interaction on the same information and that adherence of the best strategy is maximized," said Janssen.

Bristlemouth: Making Connections

While the Spotter buoy sits somewhat central to all that Sofar is doing, predictably Janssen and the Sofar team eye an even bigger prize: a community open hardware interface designed to allow cost-effective connectivity across subsea devices and platforms, helping to exponentially fast-track the discovery and recovery of data from the ocean.

"We're launching Bristlemouth this year, which is much bigger than Spotter," said Janssen, a development that will help to exponentially expand the Spotter platform. "The simplest way to think about [Bristlemouth] is it's a USB for the sea. It's basically a community open hardware interface that makes it incredibly easy to connect things together, not just a sensor to a Spotter, but if you want to build an ROV, for example, this is the easiest way to plug things together because it has a very low-cost waterproof connector, something that's very difficult, strangely enough in the marine space."

"That was a big pain point for us because we can't handle expensive connectors and we certainly can't wait a while," said Janssen. "So we built a connector protocol, which is similar to USB, not just a connector, but it actually has a modern software stack that allows easy integration of components in the marine space. Obviously, it's waterproof, so it's basically a USB modified to work well for marine applications."

Bristlemouth is an active partnership between the Office of Naval Research (ONR), DARPA, Sofar Ocean, and Oceankind.

"What we hope to achieve is to not necessarily for us, but for the community as a whole, for more innovation on sensor development to be unlocked so that we get more low-cost sensors, more low-cost components that are easily scalable to help accelerate ocean exploration and sensing," said Janssen.

Janssen said, importantly, that Bristlemouth will make it easier for Sofar Ocean to add new sensors to its Spotter platform. "Unlocking and accelerating the way in which and the pace at which we can integrate new sensors is really one of the main things that we're going to be focusing on this year on the hardware platform."

All images courtesy Sofar Ocean

HYDROMEA MOVES FAST FORWARD ON SUBSEA ROBOTICS, COMMS TECH

Photo courtesy Hydromea

Born eight years ago, **Hydromea** is a dynamic and fast-growing Swiss-based subsea technology company that aims to help solve some of the subsea industry's most vexing problems. Co-founder and CTO Felix Schill shares insights on the technical trends driving vehicle and communications tech development.

By Greg Trauthwein

Photos courtesy Hydromea

MARINE TECHNOLOGY TV

Watch Felix Schill's interview @ https://youtu.be/XngRp_ENJno

The offshore industry, particularly the rapid acceleration of offshore wind, is resulting in more structure going into the water than ever before, in a short window of time … infrastructure that has to be monitored and maintained. ***"We really see the potential for a drone revolution like we've seen with aerial drones happening subsea."***

Felix Schill, CTO, Hydromea

Founded in 2015, Hydromea recently celebrated its eighth year in business, and though still under a decade old, with 17 employees today the company has eight products in three different production lines. "The first is our disc drive thrusters, which are the thinnest rim driven thrusters in the world; we have two different models available," said Schill. "We have a line of high-speed optical underwater communication devices called LUMA with five different models going from ultra-low power to very high bandwidth for live video streaming. And we just launched EXRAY, which is a wireless inspection ROV."

Two Decades & Counting

While Hydromea was founded in 2015, its history stretches almost 20 years ago when Schill and Alexander Barr started

PhD research on underwater swarm technology. "Back then, we looked at the key enabling technologies to have underwater swarms," said Schill. "One of them is scalable communication between the robots because you would like to have 20, 30, 50 of these devices talking to each other."

The other big tech hurdle is positioning, to ensure that the vehicles know where they are with respect to the others. "I did my PhD in underwater communication for swarms, and Alex did his PhD on distributed localization using acoustics," said Schill.

The pair separated to pursue their individual academic projects, but a few years later met again in Switzerland at the EPFL University, mutually deciding that their work apart actually fit together.

And do Hydromea was founded.

"Initially we developed Vertex, which was an AUV for environmental monitoring, which started off as an academic project within the university," said Schill. "Then we spun that out into the company. In the meantime, we also developed the LUMA Optical Modems and the disc drive thrusters, which started off as a component on our AUV."

With the vehicle created and now on display at trade shows, the company started getting inquiries on it, as well as on the individual components. "Eventually, we pivoted from the AUV to the inspection ROV space with EXRAY, which is a wireless inspection drone, which uses LUMA for the wireless video link," said Schill. "You can actually get HD video in real time

wirelessly through the water without needing the tether. That's something we just launched and are now pushing forward."

From Idea to Prototype to Product … Quickly

Like many tech start-ups, Hydromea started small, with the trio of Schill, Barr, and eventually also Igor Martin, the company's current CEO. As anyone at any tech start-up can attest, the mantra was 'do everything ourselves', from software, to the electronics, to building the hardware, machining, assembling, business development, and fundraising … the list goes on. "It was a lot on our plate, and I used to joke that we had more products than employees, but that has certainly changed," said Schill. "The team has grown and things are going forward really well, but at the same time I think is this can-do attitude that we can build, develop and prototype everything in-house. We're proud that we have a well-equipped workshop and the know-how to very quickly go from idea to prototype to product, because we can machine and 3D print and solder everything in our workshop, and also make the initial quantities for early adopters" before taking the product to a mainstream production line, which is outsourced. The ability to go from design to prototype to product in-house was particularly instrumental during the pandemic, when the supply chain was constrained.

Underwater Optical Comms

As is well understood, the big challenge underwater is that radio waves don't penetrate through water. "So, that means there is no GPS, there's no 3G, 4G, no Wi-Fi, and the industry has so far relied on acoustic communication, which works great for a lot of applications, but it has a big limitation in terms of bandwidth," said Schill.

Lack of bandwith means you cannot get an HD video stream through acoustics, and also the latency is quite high, he said. Enter Hydromea's underwater optical communication, which uses pulses of blue light, which according to Schill gives you the high bandwidth and very low latency. "It allows you to get a 10-megabit HD video stream in real time at very high quality to the operator, and also the control signals from the operator back to the drone with millisecond latency so that you don't have that lag while you control it," said Schill.

A side effect of that high bandwidth is also a lot more power efficient. "Especially for battery powered devices, you can transmit a thousand times more data with the same energy that you need from the battery simply because it is so much faster," said Schill. "That's a great benefit to equip battery powered

Photos courtesy Hydromea

sensors or other devices with optical modems, to allow low power data transfer and get the collected data out to the surface or to an ROV that can go and harvest the data."

Schill and his team have seen a lot of the deployment for subsea sensors, such as gyro boxes or other devices which have to be monitored in real time during construction offshore.

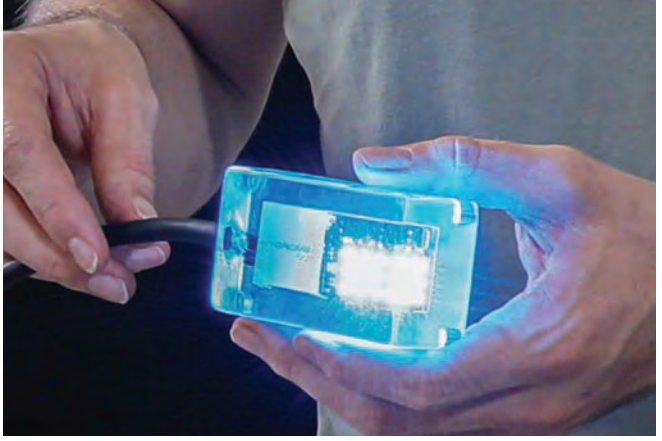
"Now they can get real time data feedback reliably and quickly," said Schill. "For LUMA X, our flagship modem, we now see the effort to put these access points, you can think of it like WiFi access points for underwater, to put these on infrastructure as it is installed so that if an inspection ROV gets close to one of these assets, that it's essentially getting high speed data communication to get live video and live control, just like when you go into an airport or a café and you have Wi-Fi. So subsea, this will be like that: once you get to an asset that you want to inspect, you already have high speed communication available."

Overall Schill, like many others in the space, have seen the ever-advancing miniaturization and immense computing power as drivers to shrink the equipment and make advances that were unfeasible 10-20 years ago.

Small size and smaller weight means users don't need ships and cranes, rather devices that fit in a suitcase or a backpack. "We think that will open up a lot of new applications where, up to now, the cost was prohibitive," said Schill. He points to the offshore industry, particularly the rapid acceleration of offshore wind, which is resulting in more structure going into the water than ever before, in a short window of time … infrastructure that has to be monitored and maintained. "We really see the potential for a drone revolution like we've seen with aerial drones happening subsea," said Schill.

As a CTO of a fast-moving tech company, Schill is excited by the possibilities ahead.

"Our goal as a company is to turn all of our research ideas into usable products, to take it step-by-step and de-risk the new technologies as we go," said Schill. "Now we've developed EXRAY as an inspection ROV for confined spaces, where we could demonstrate the wireless capabilities in a relatively controlled environment, like ballast water tanks or freshwater tanks on ships. The next step that we are starting now is to take this into the open water domain by extending the capabilities of the vehicle into open water navigation, and then take the next steps from there into autonomy and essentially eliminating the need for surface vessels and pushing the automation forward to make maintenance and inspection an easy task that can be automated. And in the optical communication domain, of course, we are also pushing the boundary constantly going into multi node networks and extended capabilities, more speed, more range, of course. So, there will be a lot of new products coming out [of Hydromea] over the next years."



Photos courtesy Hydromea

HAPPY TO BE BLUE

***Dr. Anya Waite** leads Ocean Frontier Institute's interdisciplinary marine research*

By Celia Konowe

Artist Jamie Neish helping to capture the themes discussed at OFI's Ocean Frontier 2022 event.

© Odum Idika

"There's something compelling about the color blue," said Dr. Anya Waite, scientific director and CEO of the Ocean Frontier Institute (OFI) and associate and vice president research (ocean) at Dalhousie University. As the bright sky shone through her office window and the waters of Halifax Harbor glimmered through the tree line, blue seemed to be even more inspiring. OFI, based on Dalhousie's campus, is an interdisciplinary research partnership between the university, Memorial University of Newfoundland (MUN) and the University of Prince Edward Island. As the climate warms and scientists race to better understand the role of oceans, Waite's position is an impactful one, thanks to critical knowledge and a lifetime of exploration.

A native Nova Scotian, she grew up curious and ambitious, first wanting to pursue music, then English to become a writer. Embracing her love for the natural world, Waite completed a Bachelor of Science degree in biology at Dalhousie. After volunteering on a research vessel, she knew she had found her calling: "When you're out at sea, and you're all trying to work together, it's a very exciting sort of teamwork. It's physically demanding labor, but you're all coming together to get something out of the research voyage. That did it for me—I fell in love with being at sea."

After Dalhousie, Waite completed her PhD in biological oceanography at the University of British Columbia and then held postdoctoral positions at Woods Hole Oceanographic Institute and Victoria University in New Zealand. She soon took a professorship at the University of Western Australia in Perth, where she taught and led research for 17 years. In 2014, Waite became section head of polar biological oceanography at the Alfred Wegener Institute for Polar and Marine Research before returning to Halifax and her alma mater in 2018.

Within your career, do you have a most valuable experience, or set of experiences?

I think the biggest thing I learned was that politics are very local. And you only need to step two doors down the road, and you're in a completely different atmosphere. For example, you can be in a situation where somebody who finds you difficult for some reason. That can be true or not true—it doesn't matter. Then, you go next door and there's a whole different behavior and culture.

For me, it was realizing that with these ground-level poli-

tics, you need to step up and see that almost from above and identify, "This is a pit, and this is a mountain. How do I navigate through that?" But to do that professionally, you need to take on leadership. And that I think was the biggest revelation to me—first, I had to take on leadership, and second, I could potentially be good at it because I just wanted to do science. I never had any interest in climbing this power structure. Then suddenly, I started to realize, "I'm in a pit. I want to be on a mountain." I think it's that for me, the crystallization of the need for good leadership, and that that might be me, which is a little bit confronting because you never think of yourself in that way. You're just getting on with the exciting science you're trying to do.

Speaking of exciting science—what was the rationale behind the creation of OFI and what are its goals for the future?

OFI was founded in 2016 on a major grant from the Canada First Research Excellence Fund called Safe and Sustainable Development of the Ocean Frontier, and the idea was to pull together researchers at a higher level to do larger-scale work and focus on bigger goals. The science community is generally a series of mini silos. Each researcher has their own kind of lab, if you will, and then they develop their own reputation, and their own group of grad students, and so on. And people do come together to work on specific projects, but very often the idea is that they're building their own publication record, and they're not necessarily focusing on bigger goals. OFI was supposed to get beyond that.

The first set of projects went to individual investigators. They were big projects and they pulled in lots of people, but they went into single leaders. And that made sense because you had to start somewhere, and you need to get things moving. But in the phase two, when I came in, we started to say, "You have to work in bigger groups. You need to touch base across engineering, natural sciences, and social sciences. You need to have that engagement with indigenous communities," which had not been pushed in the first phase. And so, the second phase of OFI really moved towards that more transdisciplinary vision—the vision of delivering to society. Once phase two research projects were launched, we started to pivot to ask how we were going to impact Canadian and international policy.

That's when it came out that many policymakers didn't understand the role of the ocean in the global carbon cycle, and that this cycle controls climate change. There's this gap that needed to be filled. And so, we created The Ocean is Missing campaign. It's starting with the research, understanding enough about the policy to identify a gap and then creating a campaign of information that's going to cross that gap. When people realize how important the ocean is in the climate, the question becomes, "Why didn't I know this before? What

could we do?" And then, we found as soon as we did that, we started to hear it from industry, too. I think it's that policy and industry conversation that's unique about OFI and that I'd like to see continue.

Part of the answer to that then becomes, well, we have to start in our own backyard. The North Atlantic is a place where 30% of ocean carbon annually is stored. Let's start there, and let's envisage something as big scale as the North Atlantic Carbon Observatory.

This is the first time I've heard about the North Atlantic Carbon Observatory—can you expand?

The North Atlantic Carbon Observatory is a big vision. I wouldn't say that the whole thing has been enacted, but there's

© Ocean Frontier Institute

certainly been the first few pieces put into place. We're doing some of the first work in mapping carbon data across the North Atlantic and asking, "What exists now? How is it used? Where does it go?"

There's some work being done between Dalhousie and Germany on measuring carbon input from a carbon dioxide reduction point of view. There are some carbon observation techniques that are being worked on at MUN. And so, little pieces of the big vision are slowly being pulled together. We're doing a lot of work internationally with the UN. We're working within Canada to make people aware of what's going on.

There are also two exciting things coming up. First, the Our Ocean Conference in Panama, where we're proposing a side event to start talking about the importance of ocean observation in reaching climate goals. And then independent of OFI, there will be a proposal to the Canada First Research Excellence Fund, which includes Dalhousie University, Memorial University and two Quebec universities: Université du Québec à Rimouski and Université Laval. We're coming together in a new constellation to address carbon and climate change.

Throughout your career, have you noticed an evolution of marine science and technology? What does the future look like?

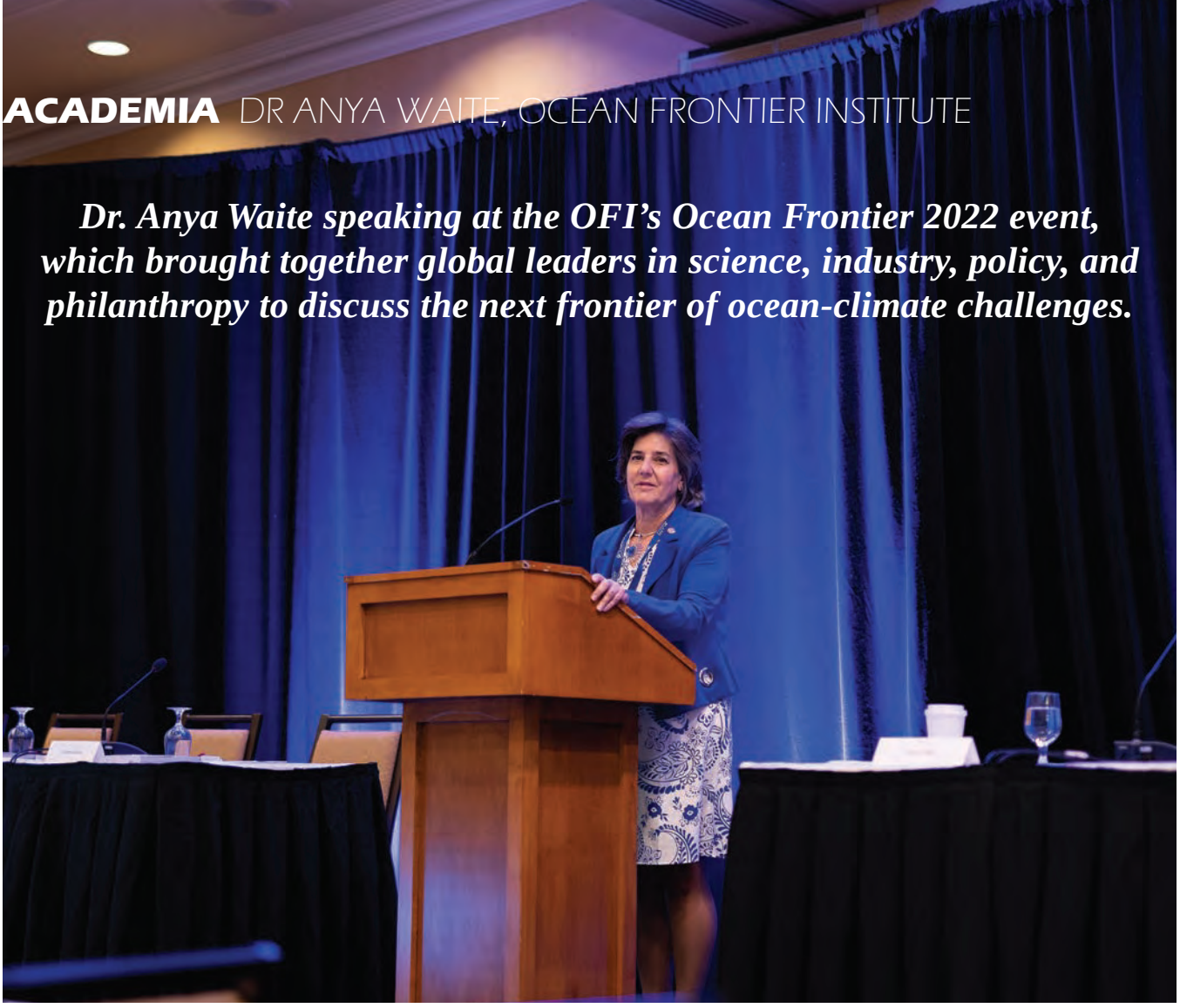
Well, the big change is big data, right? And that also has meant the programs and the papers have become bigger. It used to be very common to have a single-author paper. Now, you almost never have a single-author paper, unless it's an opinion piece. We've gone from three being considered a long authorship list to 100, and I think managing that complexity is the big challenge. At the same time, the new data that are available—genetic, imaging, sound—are transforming our understanding of the oceans as we speak. That's super exciting, but it means that we need to care a lot more about our data, the involved scientists and about using techniques to pull together this emerging picture of wisdom. And we need to become even better storytellers to do that. The whole narrative part of science has never been more important than it is now, but has never been more challenging because we have all these massive terabytes of data flowing in.

Q: In terms of the marine industry, are there any topics that you feel don't get enough attention?

What's interesting is just at the last couple of COPs, I've been talking to international financiers, and I think what the public needs to understand is that those people are trying to help. They're trying to create financial structures that will help save the world. That's the international conversation right now and I find it super interesting because they're saying, "What can we do to support these governments in going in the right direction for biodiversity and for climate change when the conventional financial products are inadequate?" That's an exciting conversation. And of course, not my area at all. I sit in those meetings as the ocean person, and I listen to all sorts of jargon and discussion that I barely can understand, but it's fascinating.

Lastly, I wanted to touch on something I heard you discuss during a keynote speech at the International Congress on Maritime Museums here in Halifax last September. You mentioned the importance of "deep blue carbon." Can you explain what this is and why we should care?

As you know, I believe that the carbon budget and climate change are the single most pressing issue that we face. The



Dr. Anya Waite speaking at the OFI's Ocean Frontier 2022 event, which brought together global leaders in science, industry, policy, and philanthropy to discuss the next frontier of ocean-climate challenges.

A SEASONED VETERAN

A pillar in the international marine industry, Waite remains passionate about science and dedicated to understanding the power of oceans. And while she shares a common sense of curiosity and exploration with other scientists, her OFI role presents a unique opportunity to challenge the way research is conducted and shared across labs, institutes and countries. Storytelling is critical, she emphasized—both in how the ocean is framed as a superpower, as well as garnering public attention despite recent extremist and anti-science trends. "These are deeply disturbing," Waite reflected. "We need to be smart enough to counter them, but I don't think we are yet." Her words, like the sea's deep blue, are compelling and hold undeniable weight as researchers in Atlantic Canada and beyond delve further into understanding the mysteries of the world's oceans—before it's too late.

ocean is where most of the carbon is stored, and it's where our attention needs to be. What's happened in recent years is that the attention has become focused on blue carbon, which is carbon that is held by organisms, mostly plants, and mostly in the coastal zone (sea grasses, kelps and seaweeds, mangroves, salt marshes). They hold in a lot of carbon and in some cases, like with sea grasses, you can have meters of root structures embedded below them, and that's another fossil carbon source that must stay locked down. We can't allow that to be disrupted and released. What happens, though, is because these are compelling biodiverse areas that bring a lot of values to communities, the story starts to change, and they become represented as good carbon sinks. Unfortunately, on an annual basis, those systems don't absorb much carbon. It takes thousands or tens of thousands of years for that carbon to be absorbed. It becomes even more important to not disrupt it because it's not going to go back anytime soon.

The place in the ocean that's going to help with annual emissions is the deep blue sea. First, the chemistry of absorbing carbon through dissolution, and then the physics of moving it down into the deep sea. And then, the biology of plankton growth, the formation of marine snow, and the sinking of marine snow. Those two major processes are the big carbon sink in aggregate. And I think the problem is, as soon as we start talking about that, people think that because we're advocating for the deep blue carbon sink, that we don't support the preservation of coastal carbon ecosystems.

My point is that we just need to be honest about our carbon accounting. We don't want to say all the work is done in the coastal zone, when in fact, it's done in the deep blue sea. It's about getting our math right and understanding that the deep blue sea is that annual increment, and the coastal zone is that 10,000-year store that you don't want to release to the atmosphere. That, again, may be a nuance of the story that's harder to get across.

ARGEO
Builds the Tools to Bridge the Data Gap

Photo courtesy Argeo

Argeo is an offshore service company, created in 2017 and on the move, driven by its mission to transform the ocean surveying and inspection industry via autonomous surface and underwater robotics solutions. We recently caught up with Argeo CEO **Trond Crantz** for a far-reaching discussion on the company and its recent innovations in the surface and underwater vessel sector, as well as insights on its digital platforms and patented electromagnetic sensor systems.

By Greg Trauthwein

Photo courtesy Argeo

"Bringing new sensor systems to the market is one of our key focal points, and it was part of our uniqueness when we started ... It's a whole family electromagnetic systems that is being developed and patented.

Trond Crantz, CEO, Argeo

Trond, can you give us a by-the-numbers look at Argeo today?

We now have 50 employees, and since the start of April 2021 we have amassed four AUVs. Two of them are from Teledyne (SeaRaptor 6000) and also a brand new Hugin 6000 from Kongsberg. We have also commercialized our first USV as well, to cover the near shore shallow water, typical offshore wind market.

Can you give us a quick breakdown of the markets that you serve?

Most of our management probably spent half a lifetime in oil and gas. So, the offshore energy market, if you divide that in half by oil and gas and offshore wind, those two are obviously the larger ones. Of those, I would say that oil and gas is probably 60-70%. But we are seeing a significant uptick in offshore wind as well, especially in Europe, but also in the US.

And then, we are probably one of very few companies who can maybe contribute both on an environmental side, and the geological assessment side in terms of the deepsea mineral market, which is also coming strong and steady.

Do you see a changing request or demand for automation, for services, for uncrewed services?

That's a good question. I see that there is a lot of interest. Many companies would like to see more of this, but at the same time there are a lot of [legislative] questions that still need to be answered, and we need to be careful not taking on too much of the CapEx responsibility. We can see that with some of the tools that we already employ, we can increase efficiency by a multiple of five or six, maybe even more in super deep water.

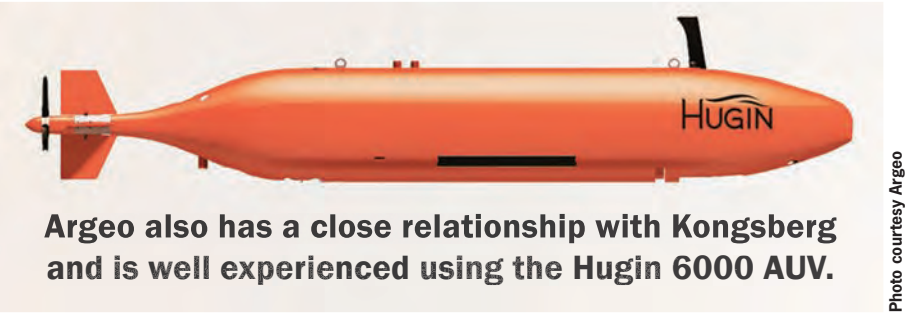
What we, as a company, are working on is building a bridge between our present situation and what is to come.

On the autonomy topic, Argeo Argus made headlines in mid-2022, as the first uncrewed remotely-supervised survey and inspection vessel.

We spent a lot more time to commercialize the whole system than we expected, but that paid off when we started the first project in November (2022), which was for our Norwegian renewable company. Our first USV is fully uncrewed, small enough to easily ship it anywhere. The client was very satisfied, as it provided fantastic performance and excellent data.

Looking at the crewed vessel side, I saw with interest that you took on a five-year bareboat charter for the RGO searcher. What was the impetus, and how is it being used today?

We saw the offshore energy [vessel] market tightening up in early 2022 [as more vessels went back to work, meaning the ability to put our containerized equipment onto a vessel of opportunity would suffer]. We started the [vessel search] process in Q2 2022, to identify the right vessel for the job, [we found it and] we have the option to buy the vessel. It is an ultra-deep water activity center. So it's a sub sea and IMR survey vessel, predominantly intended for South America, West Africa, the Caribbean, and also the deep sea mineral



Argeo also has a close relationship with Kongsberg and is well experienced using the Hugin 6000 AUV.

Photo courtesy Argeo

market. The vessel was prepared properly in the Middle East, and the in Las Palmas we rigged all of the AUVs and ROVs onboard. It was fully commercialized and ready at the beginning of February 2023.

We talked briefly at the beginning about your AUV fleet: Teledyne Sea Raptor, Kongsberg Hugin. Can you give us a little more insight on that AUV fleet: why those two brands proved attractive, and do you see that growing in the future?

The first AUV we bought was a Hugin system, as we have a good relationship with Kongsberg, and they have a lot of experience: the system is proven. But we also wanted a slightly different system [Teledyne SeaRaptor], one which was more of an open-source setup; one where we can choose the systems, and the integrators, and the sensors, one that we foresaw with the product development that we are ourselves doing on geo-robotics. It's a slightly different concept, in terms of how it's put together and how it can be used.

Both are capable of diving down to 6,000 meters water depth. So it's trying to be a bit more agnostic than the ordinary company, allowing us to have a bit of play in terms of what we are developing on our own front, connecting that with our digital platform, Argeo Scope, which allows us to seamlessly project data from the data acquisition platform into a cloud-based system.

Most of our discussions center around the ability to go out, collect, send, disseminate information more efficiently. What technological development do you

Photo courtesy Argeo

The Argeo SeaRaptor

Photo courtesy Argeo

RECENT ARGEO HIGHTLIGHTS

- *During the summer Argeo took delivery of its Unmanned surface vessel (USV) Argus USV.*
- *Argeo recently entered into a 5-year bareboat contract for the subsea vessel Argeo Searcher. The combination of Searcher, our own AUVs and the possible addition of onboard ROV's makes this a very attractive multi-purpose operational platform for subsea operations.*
- *Argeo has developed a recently patented portfolio of electromagnetic source and receiver systems for Autonomous Underwater Vehicles, Underwater Intervention Drones and ROVs. "Argeo Whisper" is an AUV and ROV system developed for localizing and tracking buried pipelines as well as detecting buried objects in a decommissioning survey. It can also be used for detecting unexploded ordnances. "Argeo Discover" is an application or detecting, delineating, and characterizing deep sea mineral deposits or other conductive objects below the seafloor utilizing an electromagnetic source integrated in an AUV or ROV.*
- *Argeo SCOPE (previously Digital Ocean Space) software platform reached a milestone when it was released as a commercial product. Argeo SCOPE is a fast and performant 3D visualization of vast amounts of ocean space data in the cloud, supporting a collaborative data sharing and interpretation workflow. The system allows for seamless data fusion from seabed measurements.*

see that has most increased your ability to do that job more efficiently and cost effectively?

That's a big topic. Bringing new sensor systems to the market is one of our key focal points, and it was part of our uniqueness when we started. We have a fantastic engineering department developing cutting edge technology on the sensor side [which can be leveraged across many markets]. It's a whole family of electromagnetic systems that is being developed and patented. So that's the one thing. The other thing is a deep understanding of AUVs. I think we have 10 sensors now, in the high-specifications AUVs, we have cameras, lasers, SaaS, navigation data, and so forth. So many sensors. Over the course of maybe two days, we amass up to five terabytes of data. Huge amounts of data.

Historically, a lot of that data becomes dead data on the client side. How do you make use of all of that information? That's why we also started developing a cloud-based digital platform, which allows the clients to look at all of the data that we acquire, and to correlate the different data types over a given project that they may have. This allows them to create value out of all the data types. So we can wave goodbye to PDF reports, and welcome the digital age.

You run a fast-moving company in a fast-moving business sector. What's the secret to long-term success?

As a company, our foremost obligation is to bring investor value, and there are many ways of doing that. We develop technology, which has a long-term value creation, and at the same time we have a huge focus on the service side. The challenge there is to balance the development of technology with business take up of all the things that we develop. It is abalancing act: you need to make sure that you are bringing technology and services out quickly, at the same time, not too quickly.

A SeaRaptor being launched

Photo courtesy Argeo

MANAGING WATER VAPOR IN SUBSEA HOUSINGS

By Kevin Hardy, Global Ocean Design LLC

Any closed fixed volume, such as a pressure case, sealed in a warm, moist environment such as a ship or dockside, will contain a quantity of water vapor. It's an invisible threat to your instrument.

As a housing descends deeper into a cold ocean, it cools. For a given amount of water vapor captured at the warm surface, the temperature in the deep sea can easily drop below the "dew point", the temperature at which the water vapor changes to liquid water. At the dew point, the relative humidity is 100%. (Figure 2.) No longer able to hold the water vapor as a gas, condensation forms on everything inside the housing: circuit boards, the backside of connectors, batteries, and viewports.

Thus, managing the dew point is high up the design checklist.

Ocean engineers must consider a means to proactively remove water vapor from a housing before deployment. It's important to remember in this discussion that it is water vapor we're trying to manage, not oxygen, nitrogen, CO2, or any other gas.

By reducing the amount of water vapor in the housing, the dew point can be lowered to well below the coldest temperatures expected in the subsea environment.

There are two primary approaches to reducing water vapor: 1) use of desiccants, and 2) dry air exchange. The simplest and safest of these is desiccants, and the one I've used successfully for decades in every ocean at any depth.

DESICCANTS

Desiccants are hygroscopic materials that bind water molecules on contact, reducing the amount of moisture in the air.

Desiccants can include a humidity indicator, which will change color with the degree of water saturation. One common indicator changes color from blue (fresh), to purple, to pink (used). This is very helpful in at-sea operations, giving a visual indication of remaining drying capacity to the person preparing the housing for deployment.

Desiccants themselves are chemically inert, and not HazMat (Hazardous Material). They can be carried on board commercial aircraft without concern, though it is advisable to have an MSDS to show the TSA what the granules are. The desiccant granules can also be recharged at sea in the galley oven following a simple procedure, so you'll never run out of the stuff that dries the housing interior air.

There are two methods of employing desiccants: 1) passive and 2) dynamic. I prefer the dynamic method as it means the instrument is ready to deploy immediately after the purging process is done.

The passive method involves strapping desiccant packs onto an interior frame using a cable zip tie. This approach relies

Figure 1

No surprise that marine air is moisture laden making condensation inside an undersea housing a real problem.

on diffusion to bring water vapor into contact with the desiccant, which can take a few hours. If you have the time, this approach has a lot less steps involved.

MultiSorb Technologies <https://www.multisorb.com/>, DryPack Industries <http://www.drypak.com/>, McMaster-Carr <https://www.mcmaster.com/products/desiccant-bags/> and others make these packages in a variety of sizes (Figure 3).

The dynamic method involves the use of a vacuum pump as part of a purge system to remove interior air. Care must be exercised to not damage any interior components by pulling too high a vacuum. A maximum of ½ atmosphere vacuum is recommended.

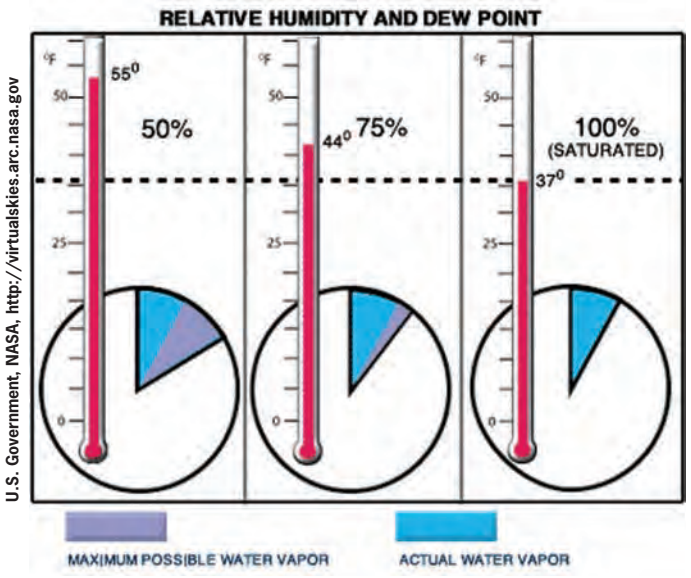
With half the air volume removed, half the water vapor is removed, and a partial vacuum is created inside the housing. A valve system allows the partial vacuum to draw external air back through a desiccant chamber, forcing it in contact with the desiccant granules, removing all the moisture. The dried air then enters the sealed housing, mixing with the residual interior air, thereby reducing the relative humidity on the interior.

The vacuum pump removes half the air for a second time. As half of the water vapor was removed the first time, half the remainder, or ¼ of the original water vapor, is removed. The valve system allows external air to be drawn back in by the interior partial vacuum, passing through the desiccant chamber, removing all water vapor, further reducing the interior relative humidity.

The vacuum pump removes half the air for a third time, removing half of the remaining moisture vapor, this time just 1/8 of the original amount of moisture vapor. At this point, 7/8 of the original moisture vapor has been removed, and the interior air is as dry as a desert.

I have successfully used this technique on deployments in all the world's oceans for decades, from inside the Arctic Circle to the bottom of a number of ocean trenches.

A passive desiccant pack or two zip tied to the inside frame are useful for capturing outgassing moisture from interior components such as printed circuit boards and cardboard covered battery packs. It's a double-check approach to controlling interior moisture.



U.S. Government, NASA, http://virtualskies.arc.nasa.gov

Figure 2

The relationship between relative humidity, temperature, and dew point is shown in this graphic. As the temperature falls, the air's ability to hold water vapor decreases. At the dew point temperature, 37 °F in this example, condensation forms.

Photo courtesy of Multisorb

Figure 3

Desiccant packs are available in many sizes, in either indicating or non-indicating absorbent, selected for the volumetric size of the housing.

With purge systems such as the Global Ocean Design Deck Purge Box (DPB-107), a vacuum leak test may be performed after the first draw down to ½ atmosphere. The vacuum gauge connected to the housing interior should show a static partial vacuum. If there is a slow loss of the vacuum, there is a leak somewhere. It could be the vacuum test unit, but it may be the housing itself.

A purge system based on dynamically drying the air using desiccants, such as the Global Ocean Design Deck Purge Box, Figure 4, is inherently safe. Once the interior pressure is equalized with the exterior pressure, the flow stops.

PURGE PORTS

Three purge port designs are currently in use: open port, self-sealing, and occasionally a pressure relief valve (PRV).

Of these, I prefer a self-sealing purge port, such as the Global Ocean Design PP-129 (Figure 5), as it leaves the interior vacuum at ½ atm, beneficially pre-loading the housing o-ring seals prior to deployment.

The self-sealing purge port includes a check valve that automatically closes when the purge system connector is disconnected. The self-sealing feature precludes moist exterior air from entering straight back through an open purge port, undoing all the work done to dry the interior air. The check valve provides the end-user with enough time to carefully clean, inspect and grease the final o-ring seal on the pressure proof cap. The check-valve will only seal against 10psi pressure by itself, so a pressure proof cap (PP-103) is required to protect the plastic valve from exposure to any ocean pressure.

One example of an open port purge port is found on EdgeTech releases. This purge port is simply a smooth bore with a small 1/16" diameter hole at the bottom that restricts air flow in and out of the housing. Before deployment a blanking plug with dual seals plugs the open port, restrained by a non-metallic crow's foot. An adapter fitting connects the housing to a purge system, including the Global Ocean Design Deck Purge Box. A vacuum leak test can be performed to check the seals are working as they should. Because there is no check valve in the purge port of the EdgeTech release, the end user is left with two choices for sealing.

The first is to allow the interior pressure of the release to equalize with the room ambient pressure, then remove the purge fitting, and plug the purge port. Since the interior/exterior pressures are equal no air is being driven in or out of the housing over greased surfaces that might catch airborne debris. This is more manageable, and therefore preferred.

The less desirable method is to pull the purge fitting with a partial vacuum still inside the release. The end-user must be ready to quickly plug the purge port with the dual seal blanking plug before much air is drawn in by the interior partial vacuum. It's a game of Ready-Set-Go!

Pressure Relief Valves (PRV) are important for over-pressure relief, but I do not use them as a purge port for good reason. PRVs have a cracking and a resealing pressure. Due to hysteresis, these are not the same. When the interior pressure of

Photo courtesy of Global Ocean Design

Figure 4
The patented Global Ocean Design Deck Purge Box (DPB-107) is compact, fully integrated, and dynamically dries the air during the purge process. A universal power supply allows operation in any port-of-call.

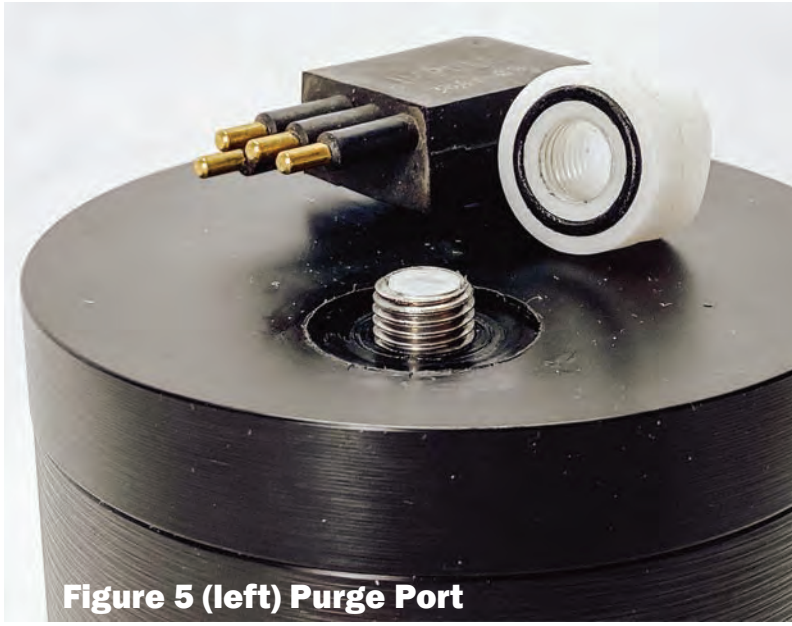


Figure 5 (left) Purge Port
The patented Global Ocean Design self-sealing purge port (PP-129), left, incorporates a check valve that closes when the purge system connector (PP-127), right, is disconnected. A pressure proof cap (PP-103) covers the purge port prior to deployment.

a housing exceeds the exterior pressure by some preset value, the PRV opens to relieve the high interior pressure. But this also means there is now a direct opening in the pressure hull between the interior and exterior. Thus, the best, the only, position for a PRV is at the bottom of the pressure housing. Like an entrance hatch to an undersea habitat, put the door in the floor. Put it anywhere else and right where the cracking or resealing pressure equals the exterior pressure, water will surely dribble in through the open PRV. However, the floor is also where crumbs fall. Bits of stripped wire insulation, tiny bits of solder splatter, flecks of debris of all kinds fall towards the place where the greased seals of the PRV are located. It is impossible to clean, inspect and grease the final o-ring seal in a PRV used as a purge port, leaving the condition of the final seal uncertain. We are left to hope rather than having confidence in the final seal. For these reasons, I use PRVs for what they were first intended, as over-pressure relief.

DRY AIR EXCHANGE

Dry air exchange is also a dynamic method involving the use of a vacuum pump as part of a purge system to remove interior air. The partially evacuated housing is then backfilled with a dry gas such as nitrogen, SCUBA tank compressed air, or CO2. Three cycles, as described above, will remove 7/8 of the original amount of water vapor.

This method presents several obvious problems: 1) safety: it is possible to over-pressurize and rupture a housing; 2) HazMat: high-pressure bottles cannot be shipped full, requiring the bottles be filled at the operations site; 3) weight and handling: high-pressure bottles are heavy and cumbersome to move about, and require proper restraint on a ship; 4) differences in international standards for high-pressure fittings present a challenge to interfacing U.S. tanks to foreign fill systems, and 5) when the high-pressure bottles are empty, you're done.

In fairness, when I first arrived at Scripps, every group did dry nitrogen backfills. By the time I retired, however, no group did that any longer. We learned that it is water vapor we're trying to manage, not any other gas.

Good design and fastidious execution raise the odds of success in your favor.

ACKNOWLEDGEMENTS:

Jack McLaughlin, HydroAcoustics (Henrietta, NY), makers of the HLF-5 and other low frequency acoustic sources, taught me a lot in my early days about placement of check-valves and burst disks relative to bottom centerline, pressure compensation systems, non-circular o-ring seal design, open sump hydraulic systems, zinc oxide as a stainless-steel fastener lubricant, and different approaches to corrosion control of aluminum. Great engineer, wonderful fellow, fond memories.

Photos courtesy of Global Ocean Design

Figure 5 (right) Purge System Connector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SAAB
SAAB

THE RISE OF ELECTRIC WORK CLASS ROVs

In this article, we look closely at the latest developments in the work class ROV space. Based on what we've gathered, the future is increasingly electric.

By Bartolomej Tomic, Managing Editor

Seaeye eM1-7 manipulator

Saab Seaeye eWROV

If you're a regular Offshore Engineer/OEDigital.com reader, Saab Seaeye is a company requiring no introduction. Saab Seaeye's vision of an all-electric future for underwater robotics led it to pioneer a wide range of systems that include powerful work robots such as the Seaeye Panther, Seaeye Leopard, and now its new, full-size work class vehicle, the Seaeye eWROV, along with an all-electric work-class electric manipulator.

"As the world's largest manufacturer of electric underwater vehicles, Saab Seaeye sees a future where electric robotics perform all tasks in the underwater domain, including those currently undertaken by hydraulic systems," Saab Seaeye told Offshore Engineer.

"It was the Seaeye Panther and Leopard that opened the market for electric work systems that could carry out a significant amount of tasks traditionally undertaken by hydraulic systems, yet offer greater precision and reliability - and are an environmentally responsible alternative," the company said.

According to the comapny, compared to a hydraulic ROV, the 3000-meter rated Leopard is typically 50% more efficient, 30% more compact, and 50% lighter, boasting unrivalled power-to-weight ratio.

"Indeed, it is the most powerful electric robot of its size in the world," the company says.

According to Saab Seaeye, operators of Panther and Leopard benefit from smaller umbilical cables and handling systems, smaller deck load requirements, smaller deck footprint, smaller vessel requirements and smaller transportation and mobilization needs, reducing operating costs considerably.

"They are easier to operate and maintain, more agile and responsive, acoustically quieter and more eco-friendly. The success of all Seaeye work systems sees them deployed globally for a wide range of work tasks, that can include survey, IMR, construction, drill support and decommissioning," Saab Seaeye said.

Saab Seaeye has recently developed a new system; the powerful electric work class Seaeye eWROV with an overall power and performance that exceeds that of a typical 250 HP vehicle.

In addition to what the company says are "significant advantages of electric over hydraulic the new Seaeye eWROV offers other key benefits.

Saab Seaeye says that the eWROV has been designed for onshore control for resident or unmanned vessel operations and will play an important role in future autonomous vessel fleets that will empower progress towards a sustainable future.

Designed to remain at sea for long durations eWROV can operate in either manual mode or supervised autonomous mode with human oversight and incorporates upgrading capability for increasing levels of autonomy and automation as technology evolves over time, Saab Seaeye explains.

The also stresses that electrification improves reliability and increases the mean time between failures (MTBF) thereby increasing levels of persistence and ultimately lower through-life operating costs.

"At the core of Saab Seaeye's future-flexible robotics vision is their intelligent distributed control architecture that enables easier adoption of evolving technologies," the company says.

During operation, the vehicles provide the operator and pilot clear and enhanced information while independently managing each device on the vehicle, including auto redundancy to keep the vehicle working even with multiple equipment damage.

Also, Saab Seaeye says eWROV has been designed with eco-responsibility in mind, with a significant reduction in carbon emissions.

Its greater efficiency and a need for less energy, results in

©Saipem

©Saipem

a significant decrease in CO2 emissions overall which, combined with an electric system that has minimal oil volume, makes eWROV a significantly environmentally friendly option," the company said.

Furthermore, the eWROV is fitted with two Seaeye eM1-7 seven-function all-electric work class manipulators.

The company says the manipulators are as powerful as a hydraulic equivalent, but more reliable and dexterous with millimeter precision and "extremely accurate" force and position feedback with each joint having its own intelligent microprocessor for intuitive and precise arm control.

Saab Seaeye said that the future would see significant growth in onshore controlled operations with vehicles deployed from subsea docking stations, or lightly manned, or unmanned vessels, where reliability and reduced maintenance will require all-electric robots for long-term deployment underwater.

"This requires increasingly intelligent robotic systems offering ever higher levels of operational capability, reliability and maintainability.

Images: ©SMD

Quantum WROV operated by Oceanica offshore

Quantum WROV over SMD workshop test tank

Atom WROV and LARS in SMD workshop

Quantum EV

Saipem's Hydrones

Italian company Saipem is known mostly for its large offshore construction and decommissioning vessels, pipelayers, drilling rig services, as well as for the construction of offshore production facilities. But it also develops ROVs and subsea drones.

In 2017, Saipem resolved to invest into a new generation of subsea robotics solutions and developed a program to enable new ROVs for subsea inspection and intervention.

Come late 2021, the first intervention drone, named Hydrone-R, was fully qualified and ready to go on a ten-years contract for a major operator offshore Norway.

Saipem is not resting on its laurels and is working on the next frontier of all-electric WROV, called Hydrone-W which combines high power, high efficiency, and unique capabilities as to station keeping and manipulation. This is planned to be commercialized late this year.

Hydrone-W is an all-electric Work Class ROV capable of working as a subsea resident vehicle tethered to a subsea base as well as in traditional ROV mode.

It is designed to be fully remotely controlled from the topside offshore or from an onshore control center. The Hydrone-W may also support the subsea construction activities carrying out tasks relating to construction, pre-commissioning, and commissioning of underwater infrastructures.

Hydrone-W is a 180 kW ROV said to be able to perform under the most difficult conditions. This ROV is also said to be equipped with a "revolutionary" propulsion and power management system to reduce energy consumption during operations.

It can be configured according to customers' requirements with bespoke accessory instruments and functions.

Main Characteristics: All-electric WROV (Work-Class Remotely Operated Vehicle), 3,000 mwd rated, full DP, 175 kW, heavy-duty, capable of interfacing & handling 2-tonne skids.

In 2019 the company secured a 10-year contract with Equinor for the use of Hydrone-R and Hydrone-W in the Njord Field development.

The scope of work encompasses ROV and UID services to support drilling activities, as well as the entire plan of inspections and interventions on the Njord subsea assets (such as Pipeline End Manifolds (PLEMs), flowlines, umbilicals, and riser bases, etc.).

Control of Hydrone-R and Hydrone-W will be ensured from both the floating platform Njord-A, which recently returned to its offshore location after an onshore revamp, and from shore via Sonsub's proprietary remote-control technologies.

Hydrones are designed, created, and developed by Sonsub, Saipem's subsea technology and equipment development center. Worth noting, Sonsub is understood to be working on the qualification of new materials and components in order to extend operability down to 6,000-m water depth.

SMD – Quantum EV and Atom EV ROVs

SMD is a subsea technology company that has been developing work-class ROVs for over three decades.

For 2023, the company's latest products are the electric Quantum EV and Atom EV ROVs which are more compact than previous generations, help reduce CO2 emissions, and can even operate autonomously when equipped for that.

According to SMD, Quantum EV is a 270hp heavy construction vehicle with a high payload and powerful thrust output. Atom EV is a 130hp light construction vehicle suited to shallow-water, high-current work in offshore renewables.

"Both vehicles are more compact than previous generations, so they will fit on smaller vessels or uncrewed surface vessels to help reduce CO2 and cut client costs," SMD said. SMD says the new electric vehicle range is bristling with new tech, and tech with a purpose, at that. The ROVs feature a new DC power transmission system that is said to be far more efficient and environmentally friendly than previous generations. Further, the ROVs employ advanced flight control computers to help do operations faster and maintain control in arduous conditions – such as high currents, SMD explains.

The flight control system can also link to other SMART systems unlocking autonomous functionality. They use unique electric propulsion technology that offers extreme performance in fast-moving water but not at the expense of fine control. "All this adds up to a range that can work where current generation vehicles can't, that opens up the operating weather window and delivers higher quality results. All while being more environmentally friendly," SMD says.

Looking to the future of work class ROVs, SMD said: "Work Class ROVs are a multipurpose tool. And as with any tool there is always a focus on how well it does the job, its reliability, and its dependability. But the offshore energy mix is changing. And we are also seeing changes to the way people work (and go to sea) with much more emphasis on work-life balance and the environment. So the robotic tools that construct and maintain energy infrastructure need to evolve.

"In the future, the tools we today call Work Class ROVs will need to be suitable for uncrewed vessel and resident work, we may see less cabled connections to the surface and onboard power systems, we will probably see AI start performing tasks, with a move from person in loop to person on loop – command to control. It will be easier and faster to undertake tasks and see the results - with real-time information at the fingertips of stakeholders anywhere in the world."

FRAMEWORK ROBOTICS WANTS TO BE YOUR "BUDDY"

Born during the pandemic, Nico Günzel, Managing Director, Framework Robotics and his team are today embarked on a journey to deliver a family of surface and subsurface vehicles that are modular and reconfigurable, leveraging cutting edge 3D printing technology. First out of the box is the ROV dubbed "Buddy."

By Greg Trauthwein

Framework Robotics was founded in 2020 in Rostock in Germany when Nico Günzel and his colleagues do what innovators in the subsea space do: they take their knowledge and experience, envision a better way to explore the world's waterways, and start a company, literally in a basement.

"We didn't have a lot of money for the first prototype, we didn't have the tools or the variety of 'stuff' we needed," recalls Günzel, "but we had a 3D printer and our know-how."

With the vision of designing and building a modular, scalable and transformable family of vehicles for work on and below the waters, Framework Robotics was off to the races, investing "thousands of hours" in designing and building its first prototype. "We wanted to build a platform for different solutions and different missions. Emerging from the basement, Framework Robotics today employs 13, with plans to offer it first market-fit ROV by the middle of 2023.

Broad Product Palette

Today Framework Robotics already has a broad palette of products in the works, all built on the modular/reconfigurable/scalable mandate, and including:

- Companion, a Remotely Operated Towed Underwater Vehicle (ROTV)
- Buddy, a Remotely Operated Vehicle (ROV)
- Scout, an Autonomous Underwater Vehicle (AUV)

"We want to play our role in challenging the market. We want to be a game changer for ROVs and for all robots underwater."

Nico Günzel
Managing Director, Framework Robotics

Images courtesy Framework Robotics

• Tracker, a Remotely Operated Crawling Vehicle (ROCV)

The ROTV is on the market as of 2022, and today Günzel said the company has its first pilot customer for Companion. The ROV Buddy – which is built with a 1000m depth rating, with an optional 6000m depth rating too – will debut in Southampton at Ocean Business 2023 in the test tank.

Günzel said that still today 95% of its vehicle components are made on its 3D printer, specifically an industrialized multi-jet fusion HP 3D printer.

Günzel stresses time and again the importance of modularity, in using the same components across multiple vehicle types and size configurations, allowing Framework Robotics to build and maintain vehicles that are custom designed and built but the mass market approach of being able to repair and replace components somewhat seamlessly via 3D printing.

The Path Ahead

Günzel and his team are well aware that the market they enter is somewhat limited in size, and also increasingly crowded, ranging from smaller start-ups to corporate behemoths occupying the space. "We do not wish to dominate the market," he said, rather "we want to play our role in challenging the market. We want to be a game changer for ROVs and for all robots underwater."

On the technical side Günzel wants to extend his company's portfolio with additional configurations and modules. "We are convinced that the future lies in autonomous systems," he said. "So we want to develop autonomous vehicles for underwater missions, and we will focus our long-term tech efforts particularly on the area of autonomy."

Today, though, the focus is on building brand and vehicle recognition, and the ROTV is out now on a scientific mission to monitor fish and fishnet behavior in an aquaculture environment, using high-resolutions cameras on the towed system. First tests it the ROV Buddy are happening now in the Baltic Sea, in advance of Ocean Business.

Finally, Günzel and his team are focused on the topic of nearly every start up, and that's money to move to the next level. "The challenge for a startup is to find money from investors, because you need money for your employees, you need money for development."

CASE STUDY

Dead Sea Coastal Erosion Research

Coastal erosion is reshaping our world, literally, threating homes and business. By taking advantage of the unique conditions in the Dead Sea and leveraging modern ADCP technology, scientists in Israel are exploring how wind-driven waves and currents shape the coastlines and transport sediments along shores.

This research could contribute to improving the design of boulder-based breakwaters, placed offshore to absorb wave energy and mitigate erosion across the world.

Every year, around 24 percent of the world's sandy shoreline erodes away,1 causing significant financial loss from damage to property and infrastructure. With around 40 percent of the global population living within 100 km of the coast, erosion presents a real and immediate challenge. Coastal erosion is a costly affair. In the USA, for example, coastal erosion causes an estimated $500m in property loss and damage every year.

Cutting-edge environmental research in Israel is taking advantage of new technologies and the unique environment of the Dead Sea to better understand the processes behind coastal erosion and sediment transport. "Understanding coastal erosion and the transport and sorting of coarse sediments along shores is highly important for assessing coastal stability," says Haggai Eyal, a PhD candidate at the Hebrew University of Jerusalem. He is supervised by Professor Nadav Lensky from the Geological Survey of Israel and Professor Yehouda Enzel from the Hebrew University of Jerusalem.

CAPTURING SEDIMENT MOVEMENTS DURING WINTER STORMS

Eyal's PhD focuses on the fluvial (relating to rivers) and coastal movements of sediments in the Dead Sea, a hypersaline lake located between Israel, Jordan and the West Bank. The Dead Sea is primarily fed by the Jordan River and does not drain or discharge to the ocean, making it a terminal lake. Sediments from the Jordan River and other channels make their way to the Dead Sea through a variety of sediment transport processes.

"Fluvial channels supply unsorted sediment to the lake during winter storms," says Eyal.

During these storms, waves transport sediments from the channel mouth along the shore, creating berms – beach ridges that extend along the shore.

During the dryer and hotter summer months, the lake level drops about 1 m.

According to Eyal, because of the dramatic seasonal drop in water level, these berms are unique to each winter season, creating an environment where sediments from each storm are preserved separately. This is unlike other areas where the water level is relatively stable from one season to the next.

COASTAL EROSION & ATMOSPHERIC AND OCEANOGRAPHIC PROCESSES

To understand the role different atmospheric and oceanographic processes play in coastal erosion and apply that knowledge to other parts of the world, real-world oceanographic measurements are necessary.

"This is where the science of coastal erosion is challenging, specifically where waves break," says Lensky. "You need the wind measured properly, which is easy enough, but then you need to measure currents and waves, which is very hard to achieve."

Left: Because of the Dead Sea's dramatic seasonal drop in water level, the berms – beach ridges that extend along the shore – are unique to each winter season, and sediments from each storm can be identified separately. (Photo: Josh Gold)

Center: Prof. Lensky and his student Shai Abir prepare the Signature1000 ADCP installed in a gimbaled tripod for deployment on the shore of the Dead Sea. (Photo: Nadav Lensky)

Right: Researchers in Israel take advantage of ADCPs and other advanced technologies deployed in the unique environment of the Dead Sea to better understand the processes behind coastal erosion and sediment transport. (Photo: Josh Gold)

Nortek's Signature ADCPs provide crucial quantitative measurements of the currents throughout the water column and directional waves simultaneously.

"The ability to measure directional waves with the Signature1000 enabled us to correlate the wind direction and the wave directions," Eyal explains.

Wave direction is an essential characteristic of sediment transport along the coast.

"The interaction between waves and coasts and the angle between them dictates the amount of longshore sediment transport," he says.

By using the Signature1000's three-dimensional current measuring and wave profiling capabilities, the researchers were able to measure nearly the full water column.

To account for the area closest to the seabed missed by the Signature because of its up-looking orientation, the researchers filled the gap by measuring currents using an Aquadopp 300 m current meter.

UNDERSTANDING COASTAL EROSION AND GRAVEL TRANSPORT

The measurements from the study revealed some key insights about the processes that dictate transport in the Dead Sea.

"We see that the transport is dictated mainly by the waves, not the current," says Eyal. "This combination of using measurement of wind as atmospheric drivers, directional waves and current profiles and turbidity profiles using the Nortek Signature1000, and motion measurements from smart boulders is unique. It allowed us to quantify the transition of momentum from wind to waves to coastal erosion and gravel transport along the coast," he adds.

APPLYING COASTAL EROSION RESEARCH TO THE REST OF THE WORLD

The study was published in Geophysical Research Letters2 in collaboration with researchers from the University of California in the USA and Technische Universität Braunschweig in Germany. This paper offers insights into sediment transport processes beyond the Dead Sea. Using the observations from the study, the researchers demonstrated how sediment sorting is directly related to the wave climate. They developed a new model for quantifying the wave height needed to move a given mass of gravel and formulated how the distribution of wave heights during a storm sorts gravel along the shore.

This information is helpful in designing boulder-based breakwaters, structures built from boulders placed offshore intended to absorb wave energy.

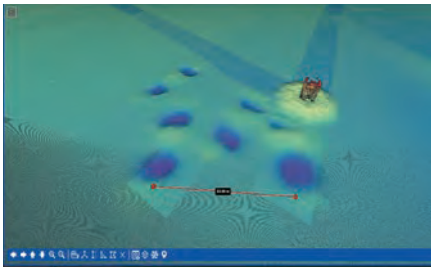
"You want these boulders to stay in place. In our research, we quantify the size of the boulders that move at a certain wave intensity distribution," says Lensky. "If we properly understand the physical relation between the waves and the underlying processes that move the boulders, you can generalize these processes to other regions."

Lensky notes the importance of repeating their findings in other areas. "To verify that these insights are valid for other coasts, we need to have similar measurements from coasts with a different wave climate," he adds.

[1] Source: https://www.nature.com/articles/s41598-018-24630-6
[2] Source: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GL095082

Tech Files

Innovative new vessels and technologies



UTEC launches "iSite Subsea"

UTEC launched "iSite Subsea", touted as a game-changing, cloud-based platform giving users a 360° visualization of subsea assets and data. It is developed from UTEC's iSite collaborative virtual asset and data management platform and is designed to meet the needs of the offshore renewable energy market, and oil and gas subsea asset owners. Through iSite Subsea, users can source, view, manage and report on seabed, survey and asset data using a single secure cloud-based interface, enabling interrogation and comparison of data over time, remotely, 24/7 and without specialist software knowledge.

Voyis Cameras for REMUS Vehicles

HII has selected Voyis Imaging Systems as the standard camera option for all REMUS UUVs (REMUS 100/300/620/6000). Voyis has developed the Recon UUV module, consisting of a highly advanced 4K stills camera and extremely efficient, high output external light bar, that enhances all REMUS platforms imaging capabilities in any operational situation. The Recon camera module offers extremely crisp stills imagery with on-the-sensor data processing for real-time, highly optimized datasets that improve in mission autonomy and analysis capabilities.

Mini Vibrocorer from OSIL

Ocean Scientific International Limited (OSIL) have developed a new self-contained sediment coring system for sampling dense or compacted sediments in off-grid areas or from vessels of opportunity with restricted handling capabilities. The 2m vibrocorer is a fully self-contained system, with sufficient battery capacity to power the system for four hours of continuous use, and has been designed for ease of deployment from small vessels with a winch or davit system, as the overall deployment/recovery height is only 2.75m. The corer can also be operated from 24VDC 12A vessel supply if available.

Harvest's Smart Buoy acts as a modem, securely transmitting live feeds 24-7 from subsea assets.

Harvest Smart Buoy

Harvest Technology Group developed a solution for an oil and gas exploration company, enabling access to real-time data from the sea floor. The system uses acoustic transfer technology to securely transmit data 24/7 from a monitoring structure on the sea floor to a "smart buoy" at the surface. The smart buoy acts as a modem to communicate data back onshore via mobile or satellite link – at a fraction of the bandwidth typically required, alleviating the challenge of relying on retrospective data to make critical operational decisions. The technology is self-powered so it can operate for several years without the need for in-person inspection and maintenance.

Valeport's 6000m Rated 'Deep' CTD

Valeport's range of SWiFT profilers has been extended with the launch of a new addition for those requiring CTD measurements to depths of 6000m. The new profiler provides survey-grade sensor technology coupled with the convenience of Bluetooth wireless technology, a rechargeable battery and an integral GNSS module to geo-locate each profile. SWiFT Deep CTD can operate to 6000m, delivering directly measured conductivity, temperature and depth. The unit has an operational battery life of up to five days and the convenience of charge via USB.

Wave Overtopping System to Improve Coastal Hazard Forecasts

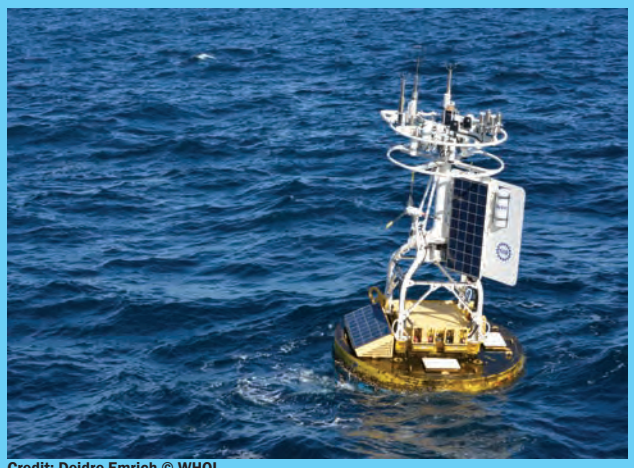
Photo courtesy NOC

The National Oceanography Center (NOC) developed WireWall, a system designed to measure the speed and volume of overtopping water on a wave-by-wave basis in the field. The aim is to reduce uncertainty in overtopping forecasts and improve hazard warning systems.

Previous field data has been obtained using large collection tanks which can only be deployed for short periods, and are only capable of obtaining data on the total volume of water that has overtopped during a storm, or a high tide event. The tanks used in previous field measurements can only be deployed on a few types of structures, such as, inland of a solid wall at the top of a coastal defence, which means that the amount of data previously obtained in the field is very limited – compared to WireWall which has been designed so that it can be deployed on almost any structure.

A paper published in the *Communications Engineering* journal highlights the validation of WireWall, and several of the results from the first trial deployments at Crosby, near Liverpool. The validation process took place in the flume facilities of the project partners at HR Wallingford, where a wave machine generated waves similar to those that might be expected at Crosby, and these impacted a 1:7.5 scale model of the Crosby seawall.

OOI's Pioneer Array Relocating to Southern Mid-Atlantic Bight



Credit: Deidre Emrich © WHOI.

A team of scientists and engineers from Woods Hole Oceanographic Institution (WHOI) left Charleston, SC recently aboard the R/V Neil Armstrong to begin test deployments in preparation for the installation of an Ocean Observatories Initiative (OOI) ocean observing system in its new location in the southern Mid-Atlantic Bight (MAB). The science team will deploy two test moorings off the coast of North Carolina, occupying shallow and deep sites of the proposed array. The deployments will supplement computer modeling to ensure the mooring designs perform as expected in the MAB environment. Once the array is fully operational in 2024, the ocean data collected will be available online in near real-time to anyone with an Internet connection at Oceanobservatories.org. The instrumented arrays gather physical, chemical, geological, and biological data from the air-sea interface to the seafloor, providing a wealth of information for research and education. This new Pioneer Array location in the MAB offers many opportunities for scientists to obtain data to further their research, and will provide better insight into conditions in the area for a variety of stakeholders," said Al Plueddemann, Project Scientist for OOI's Coastal and Global Scale Nodes group at WHOI, which is responsible for operation of the Pioneer Array. "We welcome researchers, educators, and industry members to reach out to us to explore ways we might work together to maximize the usefulness of the data."

The OOI's Coastal Pioneer Array was designed to be relocatable, and its first deployment was off the coast of New England at the Continental Shelf/Slope interface, where it collected data from 2016 until it was recovered in September 2022. The new location off the coast of North Carolina was chosen by NSF based on input from the science community during a series of NSF-sponsored workshops in 2022.

The new MAB site represents a different environment than the New England Shelf location and offers opportunities to collect data on a variety of cross-disciplinary science topics, including cross-shelf exchange and Gulf Stream influences, land-sea interactions associated with large estuarine systems, a highly productive ecosystem with major fisheries, processes driving biogeochemical cycling and transport, and fresh-water outflows during extreme rain events.

Show Preview

Ocean Business • April 18-20, 2023 • Southampton

In April 2023, Southampton, UK hosts Ocean Business '23, arguably the biggest and best subsea event on the calendar. Read below previews on some of the companies expected to participate.

aae technologies Q1
aae technologies specialises in the design and development of a wide range of subsea navigation, positioning and marine seismic survey products.

Advanced Navigation N8
Advanced Navigation is an innovator in AI robotics and navigation technology across air, land, sea and space terrains. Its mission is to be the catalyst of the autonomy revolution. Underwater, the submersible drone Hydrus is helping to restore oceans to a flourishing state supported by our various subsea navigation and communication technologies. Its navigation system is found in many Plus AI autonomous trucks. Its cloud-based drone management platform helps patrol beaches for emergency rescues and shark tracking.

AML Oceanographic K4
AML Oceanographic provides mission-critical instrumentation and solutions including SV, CTD, and other sensors and systems such as the Moving Vessel Profiler (MVP).

Aquatec Group R13
Aquatec Group has been a leading creator of subsea instrumentation for over 30 years.

Ashtead Technology T1
Established in 1985, Ashtead Technology has grown organically and through strategic acquisitions to become one of the leading providers of equipment rental solutions, advanced underwater technology.

Airmar Technology V77
AIRMAR is a designer, manufacturer and OEM supplier of multisensor technology for marine and industrial applications. It manufactures advanced ultrasonic and electromagnetic transducers, WeatherStation instruments, ACOMMs and low-cost arrays which integrate seamlessly into our customers' innovative products. It also specializes in custom designed and manufactured transducers. Visit Airmar to learn about ultra-compact 200m Mini Altimeter Kit Smart Sensor, designed to measure height off the sea floor and optimized for use on AUVs, ROVs and marine robotics platforms; our EchoRange 200 kHz Smart Sensor, a low-cost portable transducer for hydrographic survey; and our highly customized ACOMMs solutions.

Bayonet Ocean Vehicles
Greensea Hospitality Suite HS04
Bayonet Ocean Vehicles will be showcasing its autonomous underwater ground vehicle. Deployable from land or water, the Bayonet range of vehicles can transit from the beach, through the surf zone and into the ocean up to 100 metres, offering a powerful tool for a range of industries, including marine salvage, science and engineering, marine renewables, and offshore oil and gas, to perform and support a range of survey, inspection and clearance activities.

BIRNS C3
BIRNS is an ISO 9001:2015 certified global leader in the design and manufacturing of high performance lighting and connector systems.

Blue Robotics W1
Blue Robotics has developed hundreds of low-cost enabling components to open the door for others looking to explore, innovate, and create.

Blueprint Subsea M14
Blueprint Subsea's range of compact, robust and intuitive underwater acoustic products have been meeting the rigorous demands of the global subsea market.

Chelsea Technologies T8
Part of the Sonardyne Group, Chelsea Technologies designs and manufactures ingenious environmental monitoring technology to make the world safer, cleaner and smarter.

DeepWater Buoyancy S10
DeepWater Buoyancy Inc. is the world's largest producer of subsea buoyancy products for the oceanographic community.. This product portfolio has been built over the course of 40 years.

develogic E2
develogic develops and manufactures turnkey system solutions for subsea data collection and transmission for marine monitoring applications.

EdgeTech B9
EdgeTech is a leader in underwater technology solutions including: side scan sonars, sub-bottom profilers, bathymetry systems, AUV, USV and ROV-based sonar systems, USBL systems, and more.

EIVA B6
EIVA is an engineering company with more than 40 years' experience in development and delivery of solutions for surveys, inspections and other applications below and above the water's surface.

EvoLogics M4
EvoLogics are experts in underwater communication, positioning and innovative robotics and technologies for maritime and offshore industries.

Exail H9
iXblue is a global high-tech company specializing in advanced marine, autonomy and photonics technologies.

Falmat Cable F7
Falmat Cable designs and manufactures high performance cables for use in harsh and demanding environments.

Falmouth Scientific W41
Falmouth Scientific, Inc. (FSI): FSI products include; Bubble Gun seismic systems, CHIRP sub-bottom, and combined sonar imaging systems.

Fischer Connectors W66
Sealed and corrosion-resistant products to ensure reliability and performance of devices operating in extreme conditions.

Framework Robotics V18
Framework Robotics (FWR) was founded 2020 and is based at the Ocean Technology Campus Rostock/Germany. Stop by the Framework booth to meet

'Buddy' the ROV.

GeoAcoustics H4
GeoAcoustics Ltd is a provider of quality underwater acoustic solutions for professionals working in marine hydrographic and inland waterway surveying, dredging and marine.

Glenair B10
Glenair underwater connectors, custom high-pressure cable, Pressure Balanced Oil Filled assemblies, and connector terminations depth-rated to 10,000 psi.

Global Dynamix J10
Global Dynamix, Inc. represents some of the leading manufacturers of underwater equipment and marine technology.

Greensea Systems L13
Greensea provides its open architecture platform, OPENSEA, a scalable, user-friendly and low-maintenance operational system for robotics, offering advanced control and navigation technology for the subsea industry. OPENSEA enables easy integration of third-party robotic hardware, with around 2,500 robotic systems currently operating on the platform, including the Bayonet range of vehicles. With the addition of Safe C2, over-the-horizon command and control, for long-range operation of any vehicle from a distant location, is made practical.

GRi Simulations C9 / D1
GRi Simulations Inc. is a Canadian company focused on real-time simulation, modeling and visualization of critical marine activities.

HII - Mission Technologies P1
HII creates advanced unmanned solutions for defense, marine research and commercial applications.

Hydro Group Q8
Hydro Group designs and manufactures bespoke subsea electrical and optical connectivity solutions for use in harsh environments.

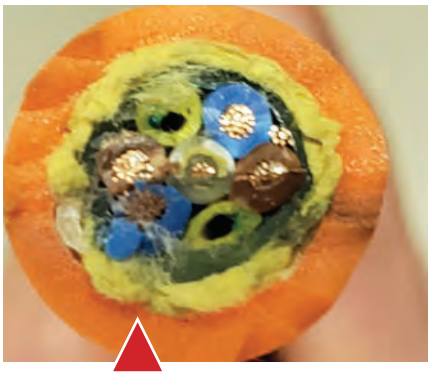
INNOMAR Technologie L1
INNOMAR provides parametric sub-bottom profilers and associated software, which are perfectly suited for hi-res sub-seabed visualization.

Klein- A MIND Technology Business E5
Klein, a MIND Technology business, is a leading supplier of side scan sonar systems.

Kongsberg Maritime P2
Kongsberg Maritime is a world leader in marine technology.

Kraken Robotics H3
Kraken Robotics Inc. is a marine technology company dedicated to the production and sale of software-centric sensors, subsea batteries, and underwater robotic systems.

L3Harris U3
L3Harris is an agile global aerospace and defence technology innovator, delivering end-to-end solutions that meet customers' mission-critical needs.



Linden Photonics V5
Linden Photonics manufactures high strength optical, hybrid and copper cables. It specializes in thin & strong, buoyant cables. Linden's fiber optic & hybrid cables are optimized for underwater use as well as use in larger umbilical. Combining high strength, low weight and small size we produce the ideal optical cable.

Maritime Robotics V50
Maritime Robotics is revolutionizing the ocean space with innovative uncrewed solutions.

McLane Research Laboratories A24
Join McLane in Stand A24 for a look at our NEWEST instruments, and enter to win the ultimate oceanographic fun pack for your lab.

Metocean Telematics C9 / D1
MetOcean Telematics develops and manufactures state-of-the-art data acquisition and end-to-end telematics solutions.

Miros V38
Miros is a technology company specializing in measuring the ocean surface. Miros provides real-time wave, current and weather data.

Moog Focal W61
Moog Focal, a Moog brand, has been innovating rotary and data transmission solutions for some of the world's most challenging marine and subsea applications for more than 40 years.

Nauticus Robotics V46
Nauticus Robotics, Inc. is a developer of ocean robots, autonomy software, and services delivered to the marine industries.

NORBIT Subsea V30
NORBIT Subsea designs and develops wideband multibeam sonars for hydrographic applications, forward-looking applications, as well as advanced subsea leakage detection. At OB Norbit will be demonstrating the NORBIT WINGHEAD i80S. The WINGHEAD i80S is the smallest form factor, high resolution, fully INS-integrated and fully stabilized multibeam on the market with dual swath capability. It will also be showing NORBIT Data Acquisitioning Software, which is both useful for real-time onshore monitoring of survey progress and for USV integration.

Nortek Nortek HS01
Nortek designs, develops, and produces acoustic underwater sensors that are used to measure motion in the marine environment.

NOVACAVI F12
NOVACAVI recently designed and manufactured a special coax double armoured cable for the German BSH Bundesamt für Seeschiffahrt & Hydrographie, the Federal Maritime and Hydrographic Agency of Germany, for its VWFS Deneb research vessel.

OSIL C1
OSIL manufacture instrumented data buoys and monitoring systems for use in all applications, and a wide range of sediment corers and grabs covering all aquatic sampling requirements.

Marine Technology Reporter A4
Marine Technology Reporter is the world's largest audited circulation publication serving the global underwater technology market. Combining the magazine (circulation 25,131) with websites, eNew, Mobile apps and social networks, MTR's cumulative, audited audience is 348,663.

Outland Technology 14
Outland Technology is a privately-owned, family-run manufacturer of high-tech, subsea robotics, imaging and lighting products.

RTsys K2
Specializing in underwater acoustics and autonomous vehicles, RTsys designs and manufactures solutions for underwater noise monitoring (acoustic recorders and acoustic buoys) and offers compact and modular AUV solutions dedicated to underwater inspection, offshore wind farm survey and oceanology. RTsys is now recognized as a world leader in the following sectors:
• AUV: micro and light Autonomous Underwater Vehicles
• PAM: Passive Acoustic Monitoring systems for science and industry
• ASW: Anti-Submarine Warfare systems
• MCM: Manned and Unmanned systems for Mine Counter Measures up to 300m depths.

Silicon Sensing E8
Silicon Sensing will focus on three high-performance MEMS-based inertial products: The DMU41 – FOG-comparable inertial performance from the highest-performing silicon MEMS IMU on the market today; The CRH03 - a compact, low power consumption, single axis gyro, ideal for platform stabilization, guidance and control and precision surveying; The CRS39A, a highly noise and vibration-tolerant gyro developed for use in severe, space limited-downhole drilling applications and for north finding tasks. Inertial sensing on any ocean.

R2Sonic L6
Leading provider of multi-beam echo sounder survey systems for all underwater applications.

RBR D11
Since 1973, RBR has been designing and manufacturing oceanographic instruments to measure the blue planet.

Rockland Scientific F2
Rockland Scientific is dedicated to the measurement of turbulence in oceans & lakes.

Saab Seaeye Q6
Saab Seaeye, leading supplier of electric ROVs; are known for its innovation, reliability, support and performance of its ROVs.

SBG Systems E4
SBG Systems is a leading supplier of miniature, high performance & cost-effective inertial motion sensing solutions.

SEABER G8
Micro-AUVs for multiple applications: 300m depth rated, less than 10kg in air, 2 to 6 knots.

Seafloor Systems W45
Seafloor Systems, Inc. offers complete survey solutions from hydrographers, for hydrographers.

Sensor Technology E6
Sensor Technology Ltd. is your proven OEM partner for underwater acoustics.

Sidus Solutions Q9
SIDUS is a manufacturer of observation/inspection video systems and components, robotic positioning, hazardous area and underwater products.

Sofar Ocean V73
Sofar is connecting the world's oceans to power a more sustainable future.

Sonardyne E1
Marine technology company Sonardyne appears in the main hall and outdoor demonstration zone with technologies and service.

SubC Imaging C9 / D1
SubC Imaging designs and builds industry-leading deep sea cameras, subsea systems, LEDs, lasers, and software for marine research, offshore energy, aquaculture, fisheries, and more.

SubCtech GmbH N10
SubCtech manufactures and offers underwater power solutions and ocean monitoring systems. We find solutions in close collaboration with our clients around the world. Li-Ion batteries (e.g. for offshore Oil&Gas applications, vehicles, buoys), pCO2 analyzers and system solutions (e.g. for yachts, ferrys) are our core products. Our reliable and precise "Made in Germany" products are easy to handle and efficient.

Teledyne Geospatial U12
Teledyne CARIS and Teledyne Optech have united to form the new Teledyne Geospatial offering holistic solutions to seamlessly map land and sea.

Teledyne Marine T7
Teledyne Marine is a world class Marine Systems business that is part of Teledyne Technologies Incorporated.

Trimble Applanix K13
Trimble Applanix is transforming the world of marine mobile mapping. It builds, delivers, and supports products and solutions designed specifically for the hydrographic survey industry.

Tritech International D6
For over 30 years, Tritech have provided the subsea industry with robust, reliable solutions for the harshest environments.

Tritex NDT J5
Tritex NDT are leading manufacturers of Ultrasonic Metal Thickness Gauges, for checking corrosion without removing coatings.

UTEC W65
UTEC, a Geo-services brand in Acteon's Data and Robotics division, provides global survey services across industrial sectors.

Valeport M1
Established in 1969, Valeport designs and manufactures instrumentation for the oceanographic, hydrographic and hydrometric communities.

VectorNav V10 VectorNav Technologies is a leader of embedded navigation solutions using the latest inertial sensor and GNSS technology.

Voyis K6
Voyis provides versatile optical solutions (lasers, cameras, lights) to expand underwater capability and enhance understanding of remote, challenging environments.

Source: MTR Staff & www.oceanbusiness.com

Taking ocean plastic seriously: It's Time

The oceans are choking on plastic waste, increasingly called petro-plastic garbage, so named for being derived from petrochemicals. The scope and scale of the problem is massive. By the middle of the century, marine plastic probably will outweigh all the fish in the sea.

A staggering 8 million tons of plastic wind up in the ocean every year. That's the equivalent of one garbage truck full every minute. Experts estimate that 182 dump trucks of U.S. plastic waste pollute the ocean every day. The plastic degrades and fragments from UV radiation, oxygen, and friction into macroplastics (5 to 50 cm) and microplastics (less than the width of a human hair).

The plastic harms or kills everything that lives in the water. We're now even concerned how nano plastics (1 to 1,000 nm) in the air are lofted into the sky from sea foam bubbles might travel long distances and be consumed by human beings.

Seventy percent or so of the plastic in the oceans is microplastics. Scientists think that the ocean contains 25 trillion pieces of microplastics. There are also the nanoplastics that are not visible to the naked eye.

Unfortunately, the broadest dimensions of the threat of plastic waste in the ocean is only now being taken seriously. Each year the oceanic volume of plastic grows larger. In short, more plastic waste is coming into the oceans than is being cleared, and production is continuing to grow exponentially as Big Plastics companies profit from making cheap plastic products from cheap fracked shale gas produced by Big Oil.

Macroplastics are well-known to cause detrimental effects for sea life. They are sometimes mistaken for food. Getting caught up in floating plastic and becoming entangled in plastic items can be injurious. Fishing nets, for example, can suffocate or starve to

death sea life.

There are iconic photographs of whales or turtles with nets, rope, plastic packing strips, and straws becoming entangled, reduced mobility, starvation, inflammation, growths, amputation, and suffocation are all possible. Plastic fishing nets and lines is a bigger threat for whales than whaling is.

Microplastics are so small that they will never be removed from the water. And the smaller plastic particles are, the greater chance that sea animals will swallow them. "A majority of the fish tested in the Great Lakes contained microplastics, writes New York Times columnist David Wallace-Wells," as did 73 percent of fish surveyed in the Northwest Atlantic." Investigators have found that mollusks (such as clams, mussels, oysters and scallops) contain the highest levels of microplastics. Any plastic, and the toxic chemicals they contain, are hazardous to human beings.

Because of food contamination, recent years have seen a growing interest and awareness of and concern about the crisis of plastics in the oceans, particularly as it involves seafood for human consumption.

But the dimensions of plastic's contribution to the climate crisis remains poorly understood.

Only 9% or so of all the plastic ever discarded has been recycled. The rest has been buried or has ended up in open yards for burning or dumping, in waterways and oceans, and littered or incinerated.

My focus is the plastic that enters the oceans but not so much because of the global abundance of plastic as an eyesore or threat to sea life or to human beings, but rather on oceanic plastic as a source of greenhouse gases (GHGs). Thus, climate change.

We know that the degradation and breakdown of plastic represents a previously unrecognized source of GHGs. A 2018 study by a research team led by Sarah-Jeanne Royer at the University of Hawaii demonstrated that low-density polyethylene, the most prevalent plastic waste in the ocean, releases methane, ethylene, ethane, and propylene at high rates. With increased fragmentation, surface plastic generates additional methane and ethylene. Sunlight increases the off-gasing.

An indirect effect of GHGs in oceans waters involves the potential impacts plastic may have on the health of plankton organisms that form the foundation of the oceanic food chain. Phytoplankton play an important role in the ocean's carbon cycle, capturing carbon dioxide at the surface and transporting carbon to the ocean floor, where it is sequestered long-term.

"Since the industrial era," writes Tim Devries in Nature, "the oceans have absorbed 30-50 percent of atmospheric anthropogenic ("human-made") CO2." It is because of phytoplankton's role that the earth's oceans provide a crucial natural sink for anthropogenic greenhouse gases. In short, a growing body of research indicates that microplastics affect the phytoplankton whose photosynthesis absorbs nearly half of the CO2 that is released in the earth's atmosphere.

The effect of both macroplastics and microplastics washing ashore is also troubling. They are absorbing the sun's energy and raising the temperature of the sand, which is likely to continue unabated. So beaches are getting both polluted and hotter.

Plastic in the oceans is overwhelming us. Ultimately, reducing plastic production is a must. Less plastic produced, less waste, less pollution, less death, and less misery in the ocean. It's time that we realize that less plastic leads to better living both for humans and oceanic species.

About the Author

Tom Thompson (Ph.D., Johns Hopkins) recently retired as the Maritime Environmental and Energy Technical Adviser at the U.S. Maritime Administration (MARAD). His essays have appeared in various publications, in both peer reviewed journals, Maritime Economics and Logistics, and Environmental Science and Technology, among others, in addition to various newspapers, including the Washington Post, the Wall Street Journal and the L.A. Times. He is writing a book on how plastics in the oceans harm our health.

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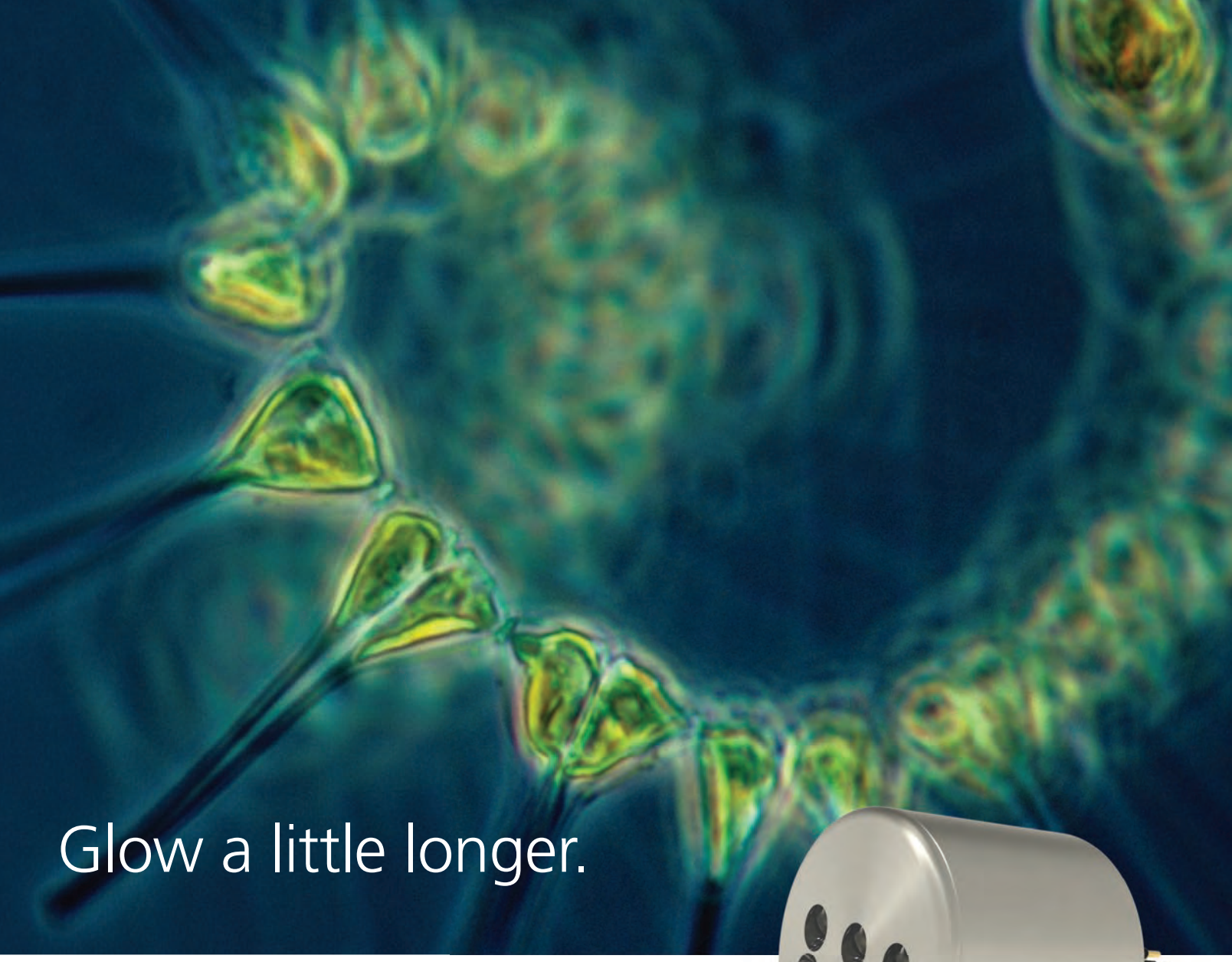

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