MARINE TECHNOLOGY REPORTER

March/April 2022
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Studying Nearshore Canyons

Carbon Dioxide Removal
To Clear the Air, Look Beneath the Waves

Eye on the Navy
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Exhibition Tech Preview
Oceanology International 2022

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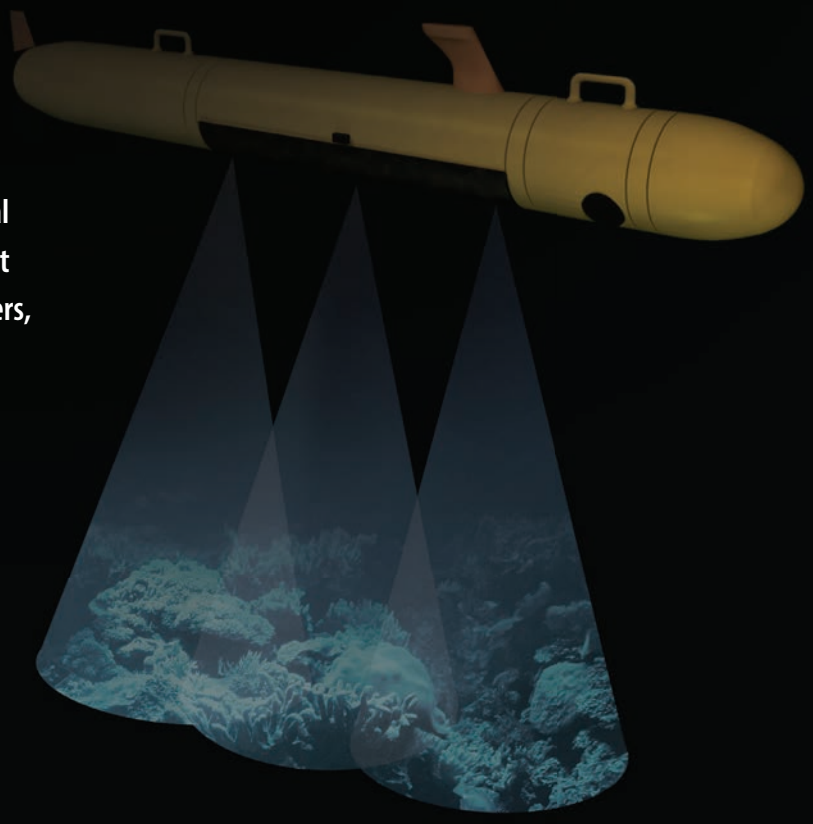

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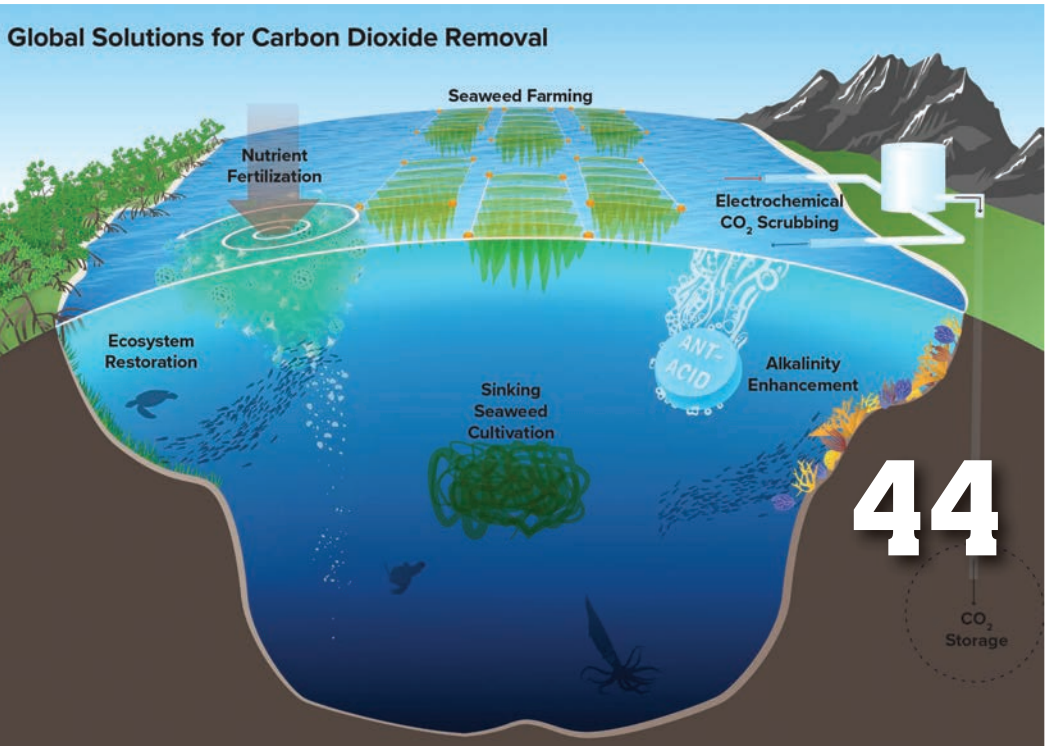
U.S. Navy photo by Mass Comm Specialist 1st Class Mark Thomas Mahmod



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On the Cover

Tritons waiting deployment from the firm's new Gulfport facility in Mississippi. **Image courtesy Ocean Aero**

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Editorial

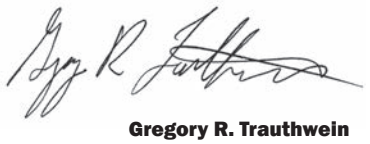
Sitting on the beach a few years ago at Davis Park on Fire Island, the waters were bustling with survey boats and dredging activity, much to the chagrin of the regulars, some who complained about the industrial scene sullying their ocean Zen. I, on the other hand, was walking up and down the beach, taking photos and trying to catch the names on the vessels, all the while advising the complainers that without this activity, you might not have a barrier island, let alone a beautiful beach. So when **JoAnne Castagna** of the USACE sent along her story *"Coastal Storm Splits an Island, Unites a Community,"* a story that goes into detail on the comprehensive coastal revitalization along the south shore of Long Island, it hit a nerve because this is where I live, boat and beach! Read all about the project starting on page 40.

Welcome to the edition that will distribute at Oceanology International, and my hope the edition that 24 months later marks the return to some sense of normalcy after the world went into a COVID-induced cocoon in March of 2020.

This edition is packed, starting off with "Lander Lab" number two from **Kevin Hardy** and **Ashley Nicoll**. This one looks at autonomous landers for studying the community ecology of nearshore submarine canyons, and starts on page 20.

Following on page 28 is **Elaine Maslin's** look inside the quest to provide power on the seafloor via fuel cells. While there are still many hurdles to cross, the advent of remote power to fuel up everything from oceanographic observatories to underwater vehicles is a technical trend that continues to gain steam.

Finally, **Celia Konowe** is back in our pages. Celia starting writing for us as an intern in the summer of 2020, and afterward has continued writing features as her study schedule has allowed. I'm happy to report that starting in the fall of 2022 she will commence her master of environmental studies degree at Dalhousie University. This month Celia examines the technology and techniques to remove carbon dioxide from the atmosphere. From seaweed farming to artificial upwelling, we examine the problem and the prospects for solutions starting on page 44.



Gregory R. Trauthwein
Associate Publisher & Editor

MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 65 *No. 3*
ISSN 1559-7415
USPS# 023-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

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

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

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Elaine Maslin is an offshore upstream and renewables focused journalist, based in Scotland, covering technologies, from well intervention to subsea robotics.

Nicoll

Ashley received her M.S. from Scripps Institution of Oceanography for her work using small autonomous landers to study the community ecology of nearshore submarine canyons. She is currently a Ph.D. student at Stony Brook University, New York.

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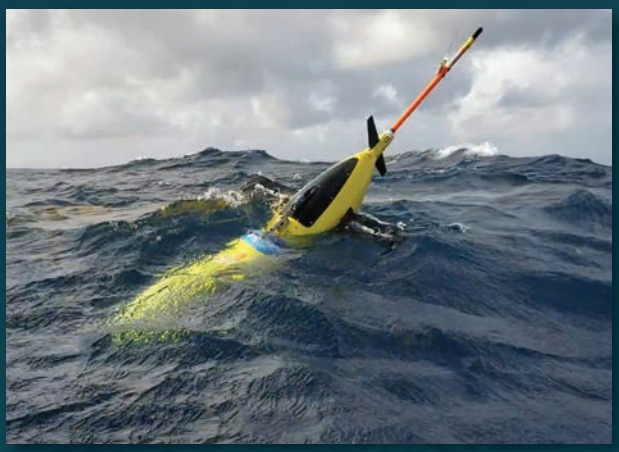

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Image courtesy Sailing Cargo

Quadriga Aqua: *Concept for the world's first zero emission mobile aquaculture.*

AQUACULTURE

Q&A: Uwe Köhler, CEO, Sailing Cargo

Is it true that Sailing Cargo is building the world's first mobile aquaculture ship?

That is correct. We at Sailing Cargo Inc. want to change the future of global fishing while proving the value of clean shipping. Our team of experienced professionals is building the world's largest zero emission sailing vessel in order to respond to the increasing global demand for healthy salmon and protein in the most efficient and environmentally sustainable manner. The conventional fish farming industry has faced incredible difficulties in the last decade due to the increasing destruction of coastal regions and the pollution of marine ecosystems. We want to create the most unique cradle-to-cradle platform for natural seafood farming on board of our CO2-Neutral sailing vessel "Quadriga Aqua" to become the world's most sustainable ship based fish production. At the same time we aim to deliver the best, healthiest, in sashimi-quality "Salmo Salar" that is available on the global market.

What is the main mission of the project?

The world is facing a rising increase in global fish demand. This results in a supply deficit of approximately 33 million metric tons expected by 2030. With our project Quadriga Aqua we not only aim to offer an efficient solution to the supply and demand gap of fish but we want to deliver the most sustainable alternative to RAS and NetCages as we are com-

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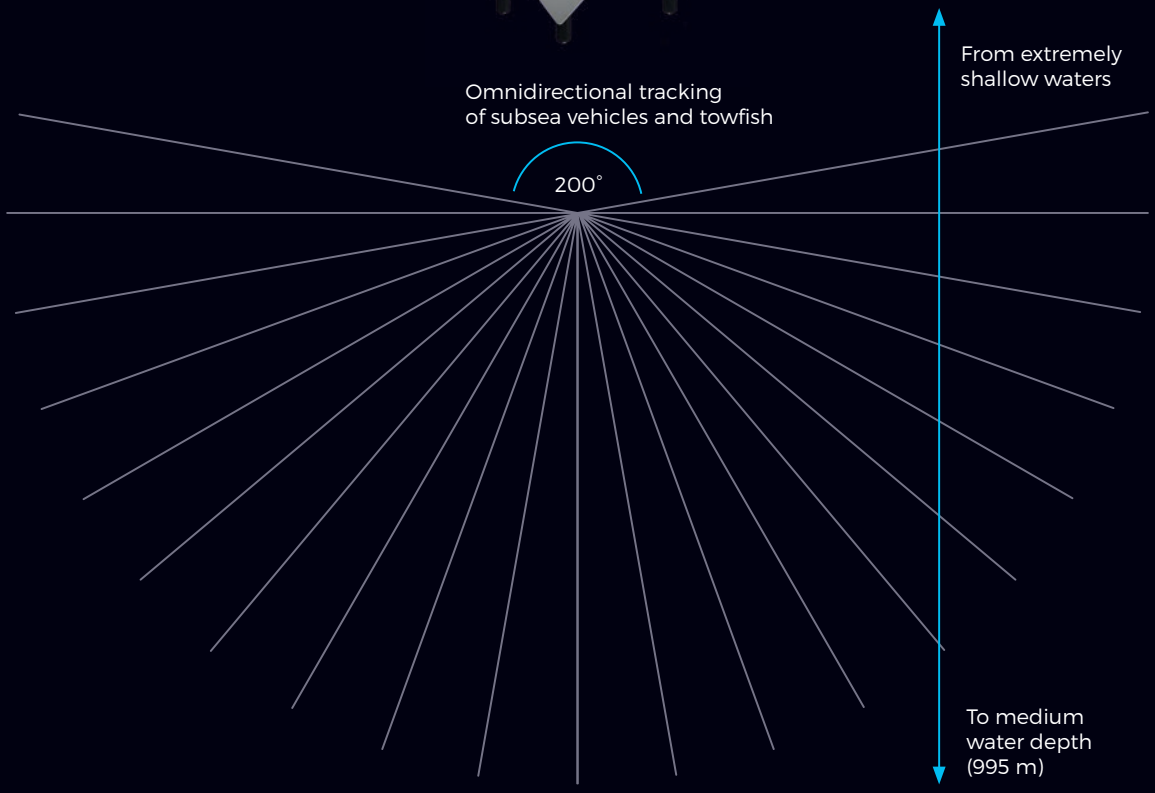

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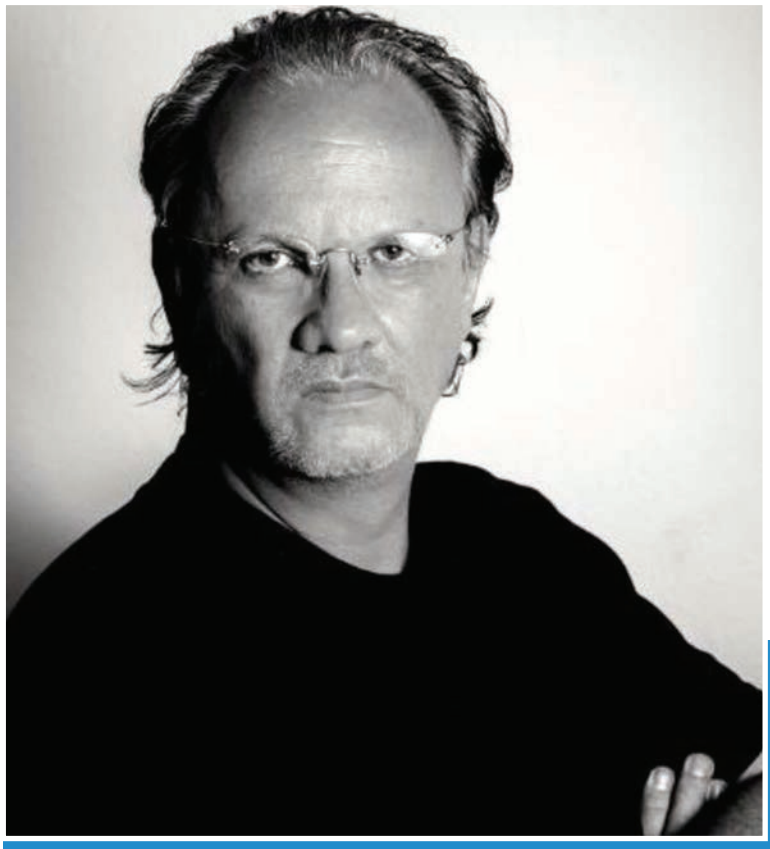


Image courtesy Sailing Cargo

"Our zero emission sailing vessel is the first of its kind. With a 7,200 qm sail area, a single controllable Dyna Rigg Sai lsystem, Quadriga Aqua will be the world's biggest sailing vessel completely powered by water and wind generators, allowing emission savings up to 98%."

- **Uwe Köhler**, Owner, Founder and CEO, Sailing Cargo

mitted to contribute to a carbon-neutral future. Our excellent team of experts wants to set up a holistic and sustainable value chain for partners and clients while offering 100% organic and naturally harvested fish.

What are the key features of the sailing vessel?

Our aim is to combine existing expertise and new ideas in sailing and seafood farming. Our zero emission sailing vessel is the first of its kind. With a 7,200 qm sail area, a single controllable Dyna Rigg Sai lsystem, Quadriga Aqua will be the world's biggest sailing vessel completely powered by water and wind generators, allowing emission savings up to 98%. We operate with the lowest impact on ecosystem services. Our sailing vessels can be fully automatically operated allowing us to sail all year around.

We combine the most unique technical facilities with modern fishing practices. On board of our vessel we operate with 15 independent production lines for fish breeding. We are implementing various sizes of fish tanks for different stages of growth allowing us to implement highly sustainable and careful breeding practices.

Where can you source your fish?

Our sustainable production process has proven effectively on land and can be adapted on waters across the globe. We have mapped our success of land fishing onto a ship based process cycle system. Operating on a sailing vessel gives us mobile flexibility to fish all around the world - all year around. Thanks to mobile farming we have the ability to offer a wide distributional range to produce salon salar in global waters where temperatures reach between 6 and 12 degrees C. This allows us to harvest our fish up to 4 times a year, resulting in a forecasted production outcome of 3,200 t fish per year. Our plannable quantities of fish production at guaranteed times gives us a major competitive advantage.

Can you explain the production flow on board of the vessel?

Our Co2 - Neutral Sailing Ship offers a new dimension of seafood farming by hosting the first sustainable seafood farm on board of its vessel. We guarantee the quickest and most sustainable production of fish - from our vessel directly to the consumer - whilst avoiding lengthy supply chains seen in con-

ventional fish farming.

Our fish is farmed and harvested in mobile fish tanks on board of the sailing vessel. The fish tanks will be continuously supplied with fresh seawater through opening flaps in the ship's hull, controlled by the natural pressure and constant movement of the ocean. Until marketability, which will be achieved within 12 month after stocking, the fish will be constantly monitored and subjected to veterinary examination at regular intervals. The fish will be held without any medication and is thus free from toxic floating algae, pollution and parasites.

The complete processing of the fish will be held out on board of the sailing vessel. The fresh salmon will be skinned, sliced, head on gutted and directly filleted on board to ensure a high quality and 90% boneless fish. The processed fish will be directly flash frozen and stored in reefer containers that can be shipped to all major ports around the globe.

What makes Sailing Cargo stand out from major players on the market?

Our key advantage is our high quality fish. Sailing Cargo is the first 100% emission-free & highly ecological producer of organic fish harvested in its natural environment. As a result of a clean and environmentally friendly fishing process we guarantee healthy and clean fish to our clients at an unbeatable fixed price with zero connection to oil prices, energy costs or charter rates. Our fish can be shipped and delivered to all major container ports worldwide. Our mobile aquaculture system gives us the flexibility to call at ports with the highest market prices at any given time.

What is the next step for Sailing Cargo?

We are seeking out for passionate partners and investors who want to be part in changing the future of fish farming in a carbon neutral environment whilst benefitting from an unbeatable fixed price guarantee. Alongside experienced professionals and outstanding partners, Quadriga Aqua is a profitable project that combines environment-friendly sail propulsion with innovative technology for seafood farming.

Subsea infrastructure security

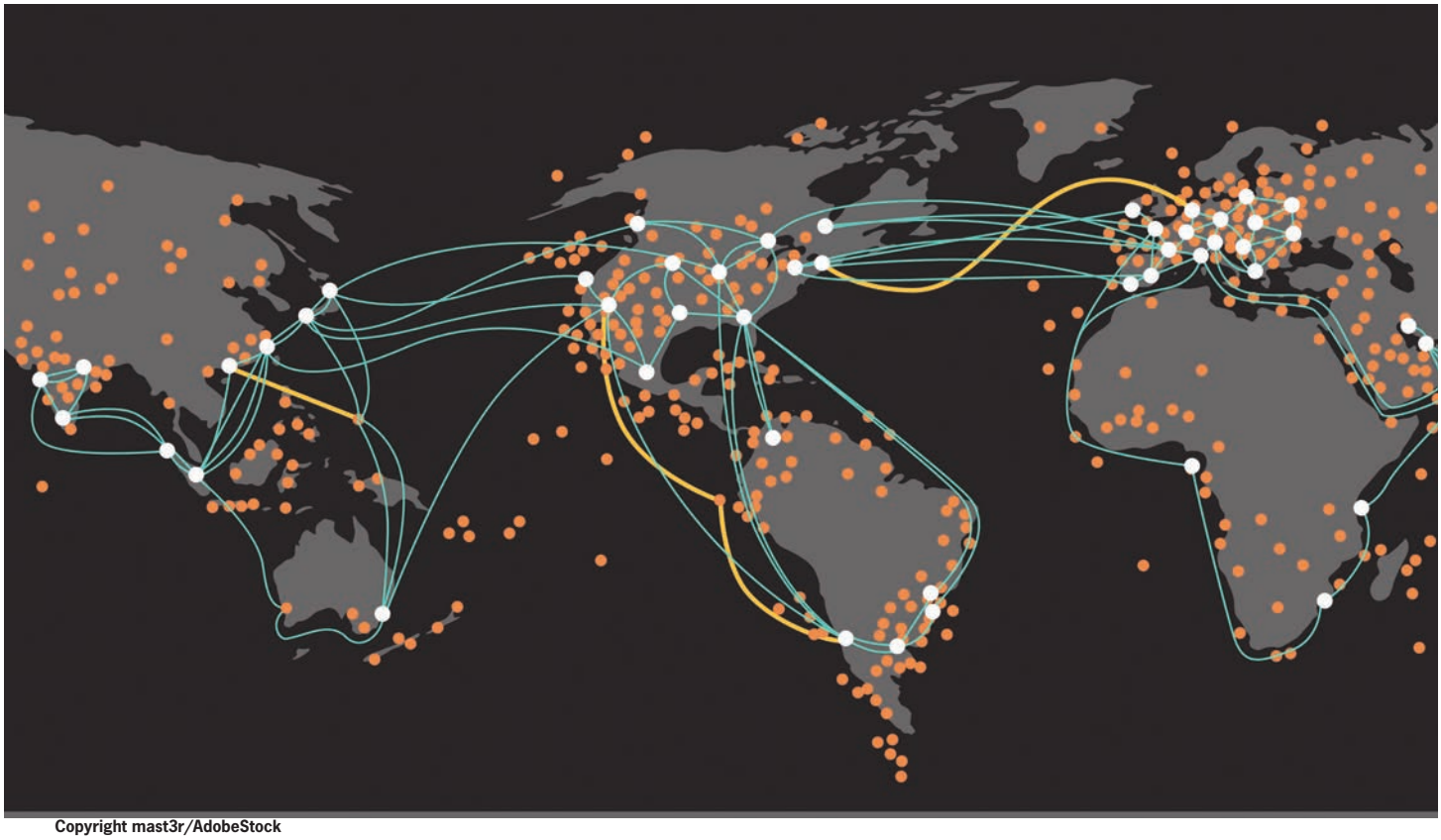
Overseas Communications Depend on Subsea Cables

By Edward Lundquist

A popular misconception is that when we make a call or send and email or text to someone overseas that our message instantaneously shoots up into space and bounces of a satellite, then comes back down precisely to the person we are communicating with. The miraculous and instantaneous part of all that is true. But that overseas call is a misnomer. Because the vast majority of international telecommunications — 99 percent — is carried by cables under the sea. Let that statistic sink in. More precisely, it should be referred to as an underseas call.

Underwater cables connecting continents are not new. Telegraph wires had already connected the country in the mid-1800s. Laid in the 1850s, the first underwater telegraph cables didn't last long; in fact, it was a matter of weeks before they broke apart. But that was a mere technical obstacle. Better insulation — namely India rubber and gutta percha — protected the lines.

By 1874, the transatlantic cable stretched from France to Cape Cod. In 1883, news of the eruption of the Krakatoa volcano in Indonesia was being followed in near real-time all over Europe. By the turn of the century, the cable from Orleans, Mass., to Brest, France was the longest in the world. Data could travel in both directions, and financiers could watch what was happening in markets around the globe. About this



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ADVANCED NAVIGATION

time, wireless communications were also established across the Atlantic, and both cable and wireless technologies would continue to advance.

The first undersea telephone cables were laid in 1955, connecting continents with voice communications. Now, twisted copper wire has been replaced by fiber optic lines. Bandwidth has increased exponentially.

Today's financial transactions fly between markets under the sea. If you travel abroad and use your ATM to get a little spending money, you are connected to your bank in seconds, and money miraculously comes out of the wall, thanks to the subsea lines.

The cables that cross the seas are laid on a seafloor that is still a mysterious place. Much is still unknown about the bottom of the ocean. Today, sheathed fiber-optic submarine cables are put in place by specialized ships between shore stations, and connected to the land-based communications network. While they are insulated and protected, the cables are still vulnerable to natural threats and manmade activity such as fishing gear or dragging ship anchors.

Dependence on the underwater network is relative. There are multiple cables that cross the Atlantic. The Kingdom of Tong in the South Pacific has just one that ties into a wider network at Fiji, 827 kilometers away. Tonga's sole subsea communications cable was knocked out by the January eruption of the Hunga Tonga Hunga Ha'apai volcano.

However, while there have been seismic activity, tsunamis and mudslides compromising lines, and even reports of sharks trying to get a charge out of biting cables, the instances of failure are few, and almost always the fault of shipping or fishing. Fixing a broken cable can be problematic, and costly, depending on the distance from land and depth of water, and required specialized ships and equipment.

Each year technology takes cable construction and capacity to new heights, or perhaps depths. Although the cables can be quite deep, and sometimes buried, their positions are known, and they are accessible with specialized ships, underwater vehicles and equipment. They may be relatively free from jamming like terrestrial or space-based communications are, subsea cables are subject to tampering.

Since so much traffic is carried on these cables, and we rely on that data so much, the potential for an adversary to compromise the cable network by cutting or tapping the lines is very real.

USNS Zeus is the only active cable laying/repair ship in the U.S. Navy.

Military Sealift Command photo

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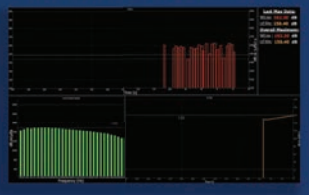

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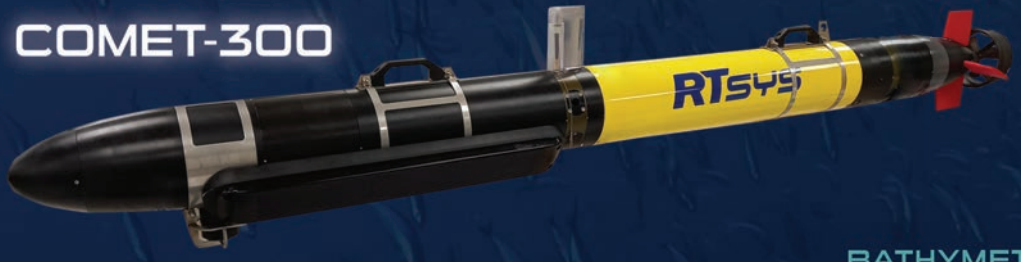

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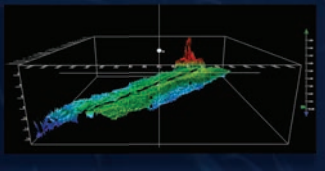

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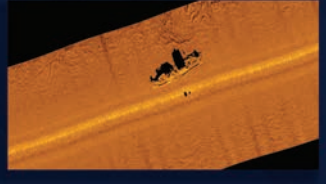

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The 2017 paper "Undersea Cables Indispensable, insecure," by Rishi Sunak, a member of Parliament, and published by the British think Tank Policy Exchange, states that the world is totally dependent on the half-million-mile undersea network. But as dependency rises, so do the security challenges.

"Funneled through exposed choke points (often with minimal protection) and their isolated deep-sea locations entirely public, the arteries upon which the Internet and our modern world depends have been left highly vulnerable," Sunak wrote. "Whether from terrorist activity or an increasingly bellicose Russian naval presence, the threat of these vulnerabilities being exploited is growing. A successful attack would deal a crippling blow to Britain's security and prosperity. The threat is nothing short of existential. Working with global partners it is crucial that we act now to protect against these dangers, ensuring that our century's greatest innovation does not also become its undoing."

A number of nations have the technical means of locating and compromising underwater cables. Physical intervention can be accomplished by manned or unmanned submersibles, or remotely operated drones, similar to those use to build and maintain underwater infrastructure for the oil and gas industry. Both the U.S. and Russia have trained marine mammals that could be used to find or act upon undersea cables. Russia has a number of assets that can be dedicated to the task of disrupting undersea networks, including its research ship Yantar and her deep-diving vehicles, ostensibly used for science, but often seen operating above known undersea cables. Seabed warfare—both defensive and offensive--is now a thing. It becomes a national priority and military necessity to protect undersea cable networks, and have the ability to exploit those used by adversaries. Cutting intercontinental communications by an adversary could be a fait accompli before anyone knew it was happening. The impact on people and markets would be immediate and potentially catastrophic. Those cables may be out of sight. But they must not be out of mind.

Photo courtesy US Navy

CS Global Sentinel is operated for the U.S. Navy by Transoceanic Cable Ship.

EXTENDED PROTECTION FOR MARINE RESILIENCE AND BIODIVERSITY

While much of the COP26 coverage last year relayed an urgency to act swiftly before the planet reaches a point of no return, some moments of hope shone through. One such announcement was made by Ecuadorian President Guillermo Lasso, who shared news of an expanded marine reserve, aiming to protect biodiversity and increase productivity and, in turn, natural carbon sink processes.

The current Galápagos Marine Reserve (GMR) stands at roughly 130,000 sq. km, with an additional 60,000 sq. km proposed. The expansion includes what is known as the Cocos-Galápagos Swimway, a "no-take" migratory marine highway that stretches 30,000 sq. km and connects the GMR with protected waters around Cocos Island off the coast of Costa Rica. The two countries, along with Panama and Colombia, have also agreed to link their respective marine protected areas (MPAs) to create the Eastern Tropical Pacific Marine Corridor, one of the largest MPAs in the world.

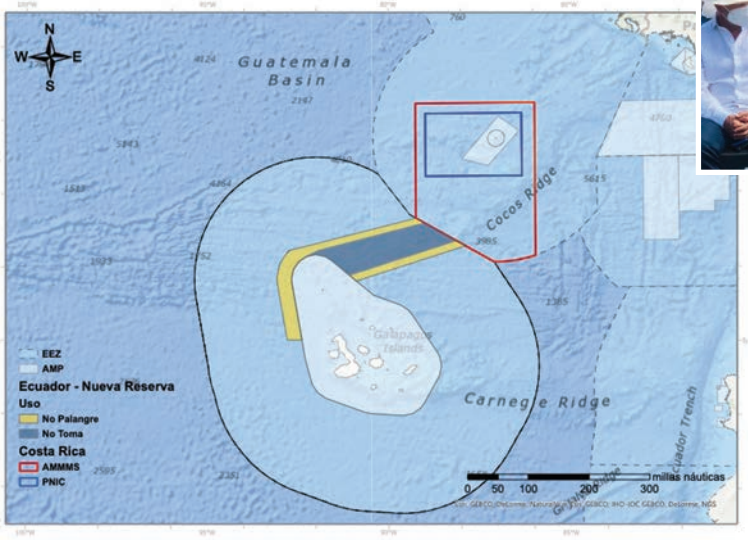
The news arrived in a timely manner as environmental experts and organizations grapple with the challenge outlined at COP26 of keeping global temperatures below the 2°C mark by 2050. Marine reserves, which are high in biological productivity thanks to protected species and limited human disruption, serve as significant carbon sinks. The archipelago also sits at the intersection of three ocean currents and El Niño, a climate phenomenon impacting weather patterns and events around the world. By protecting biodiversity and minimizing pollution and outside impacts, it is possible to increase the GMR's ability to absorb CO2 from the atmosphere, withstand climate change and contribute to the livelihood of the local communities.

Galápagos Conservation Trust, an organization that works closely with the archipelago and protecting its marine species, pointed out that the GMR also boasts one of the richest concentrations of biodiversity in the world. It's home to a wide range of permanent and migratory species like hammerhead, whale, and Galápagos sharks, green sea turtles, various tropical seabirds, Galápagos penguins and countless kinds of fish. The Cocos-Galápagos Swimway holds equally significant importance; as a migratory swimway, the area links the Ecuadorian and Costa Rican MPAs and provides a safe corridor through which fish, marine mammals and other migratory species can pass.

The expansion holds enormous significance for environmental conservation and in the fight against climate change. Protected oceans mean higher productivity, thriving biodiversity and a healthier environment—something that Ecuador knows well. "Today is a day that will remain in history for us, Ecuador, Galápagos and the world," Lasso shared at COP26, according to a New York Times article. "We are not only preserving the future of our country, but the entire humanity."

By Celia Konowe

The new marine reserve can be seen in yellow (no long-lining) and grey (no take-zone).



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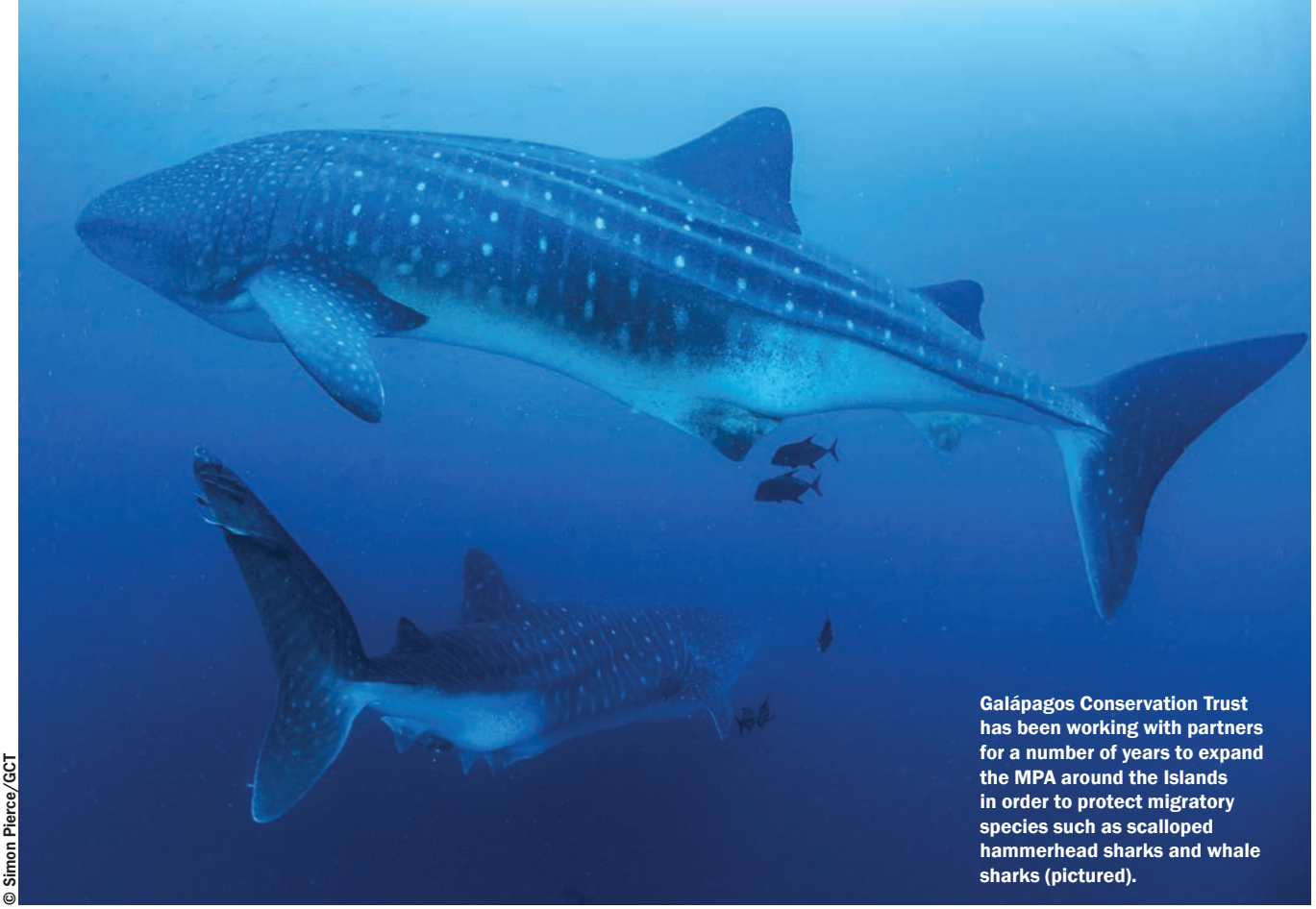
President Guillermo Lasso signing the official degree to expand the Galápagos Marine Reserve.



© Simon Pierce/GCT

Galápagos Conservation Trust has been working with partners for a number of years to expand the MPA around the Islands in order to protect migratory species such as scalloped hammerhead sharks and whale sharks (pictured).

LANDER LAB:

Figure 1.

Graduate student **Ashley Nicoll** with deep ocean vehicle DOV LEVIN after recovery from an exploratory dive into a nearshore canyon off San Diego, California.

Photo by Phil Zerofski, Scripps Institution of Oceanography/UCSD

CASE STUDY *SMALL AUTONOMOUS LANDERS FOR STUDYING THE COMMUNITY ECOLOGY OF NEARSHORE SUBMARINE CANYONS*

By Ashley M. Nicoll, PhD candidate, Stony Brook University & Kevin Hardy, Global Ocean Design LLC, MTR Columnist

Lander Lab will routinely feature field work by researchers from around the world using ocean landers. We begin with the 2021 Scripps Institution of Oceanography/ UCSD work of Ashley Nicoll, currently a PhD student at Stony Brook University, Stony Brook, Long Island, New York. Ashley's full Master's Thesis paper, "Nicoll Thesis 2021.pdf", may be found at <https://www.globaloceandesign.com/other-lander-reference-papers.html>.

Nearshore submarine canyons are unique features that bring the deep sea close to shore, potentially functioning as highways connecting shallow and deep-sea ecosystems. To study their ecology, we adapted two autonomous lander systems: a Global Ocean Design LLC 2-sphere Picolander for exploratory deployments (< 3 days) and a Global Ocean Design LLC 3-sphere Nanolander for longer deployments (> 1 week). Both landers were outfitted with a novel self-recording digital camera and LED lights system plus a Zebra-Tech environmental sensor to collect paired physical and biological time series. Eleven lander deployments were completed ranging in duration from 1-13 days at depths of 90-500 m, allowing assessment of how seafloor community diversity and composition changed with depth and time of day.

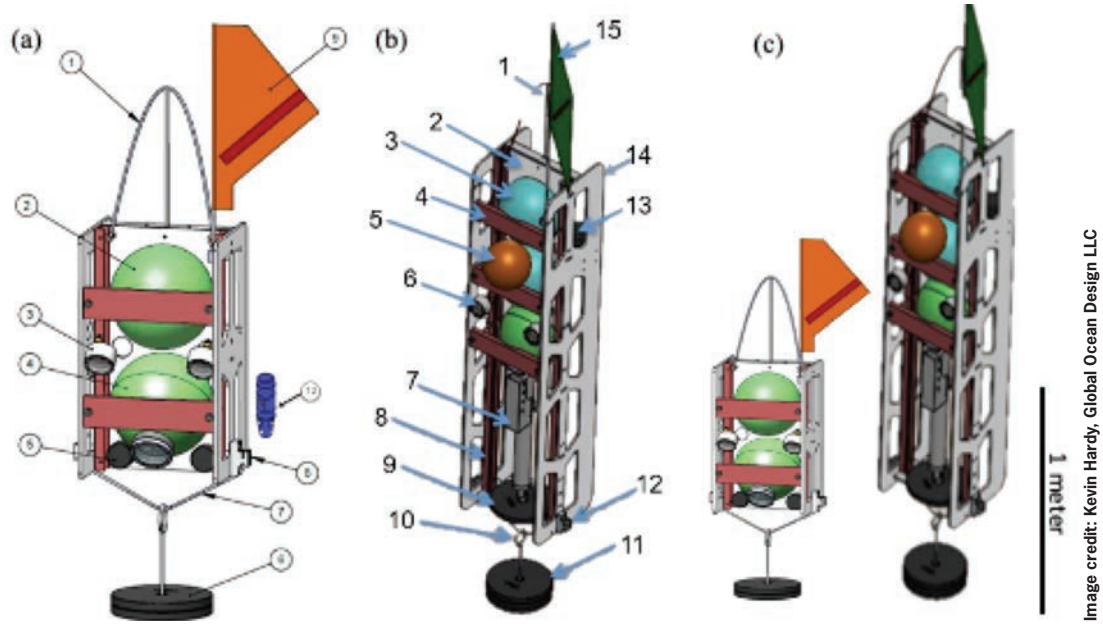


Image credit: Kevin Hardy, Global Ocean Design LLC

Figure 2.

(a) Diagram of the Picolander DOV JEAN. 1) Spectra lifting bale; 2) ~25cm polyamide control sphere containing the timed-release system; 3) oil-filled LED lights; 4) ~25cm polyamide camera sphere containing a GoPro Hero 4, CamDo Blink time lapse controller, V50 Voltaic Systems battery, 16mAh LiPo battery, and LiPo battery management system (BMS); 5) 1.5-lb counterweights x 2 sides; 6) 25-lbs expendable iron anchor; 7) chain connecting weights to the burnwires; 8) burnwire release and mount x 2 sides; 9) surface recovery flag; 10) Zebra-Tech Moana pressure and temperature sensor (fastened to the interior of the frame). **(b) Diagram of the Nanolander DOV BEEBE components from Gallo et al. (2020):** 1) Spectra lifting bale; 2) HDPE centerplate; 3) ~25 cm polyamide spheres stacked top, middle and bottom, top is the command sphere, middle has 32mAh LiPo battery, and bottom is the camera; 4) sphere retainer; 5) auxiliary ~18 cm flotation sphere; 6) oil-filled LED lights; 7) Seabird MicroCAT-ODO in the lower payload bay; 8) central fiberglass frame; 9) stabilizing counterweight; 10) anchor slip ring; 11) 40-lbs expendable iron anchor; 12) burnwire release and mount x 2 sides; 13) Edgetech hydrophone for acoustic command and tracking; 14) HDPE side panels; and 15) surface recovery flag. Not shown: drop arm on front. **(c) To scale images of the landers for size comparison**.

This study also aimed to document the number and area of small submarine canyons off the coast of California. Small canyons are defined as features with a minimum depth of 200m and incised 100m into the slope. Applying this, 23 small canyons were identified, with features concentrated on the Central and Southern coast. By area, 27% of large canyons and 23% of small canyons are protected, with the inshore reaches of canyons receiving more protection than offshore.

Because landers collect paired biological and physical data in hard to access areas, they may serve as powerful tools to inform management of these poorly studied deep-water habitats.

ABOUT SUBMARINE CANYONS

Scripps professor Francis Shepard defined submarine canyons as "steep-walled, sinuous valleys with V-shaped cross sections, axes sloping outwards as continuously as river-cut land canyons and relief comparable to even the largest of land canyons." Submarine canyons throughout the U.S. Exclusive Economic Zone (EEZ) and beyond are typically understudied because they are difficult areas to access due to their depths, narrow structure, and proximity to shore. Despite being understudied, these are not rare ecosystems. Professor Ulla Fernandez-Arcaya, Centre Oceanogràfic de Balears, Instituto Español de Oceanografía, Palma, Spain, identified over 9,000 large canyons that cover approximately 11.2% of continental slopes globally. One may presume smaller canyons are more prolific. On the Pacific coast of North America, submarine canyons cut over 20% of the continental shelf on average, and approach 50% at latitudes north of 45 degrees.

METHODOLOGY

Traditional deep-sea study methods include ROVs, towed cameras on sleds, or trawls, which typically require a medium or a large vessel equipped with an A-frame plus a winch with a slip ring and hundreds of meters of EM cable. The usage of such vessels is costly, time consuming, and logistically complicated when close to shore.

The biology of the deep-sea is traditionally studied using trawls. Because canyons are constricted areas with significant relief, trawls are both destructive and subject to getting caught in rocky outcroppings. In order to avoid dangers associated with trawling complex underwater features, autonomous lander sys-

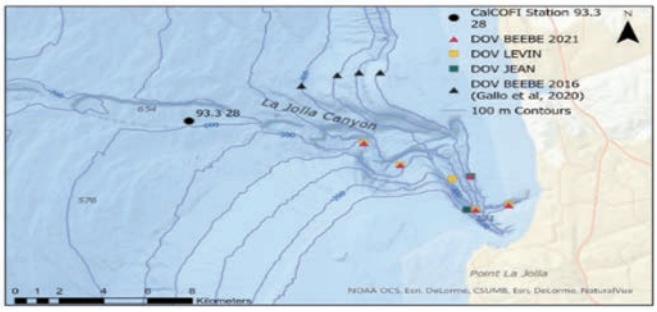


Image credit: Ashley Nicoll

Figure 3. Map of deployment locations in or near the La Jolla Canyon with contour lines plotted every 100 m. The red triangles represent deployments conducted with the Nanolander DOV BEEBE in 2021, the yellow squares represent Picolander deployments conducted with DOV LEVIN, the green square represents the successful deployment of Picolander DOV JEAN, the black triangles represent the DOV BEEBE deployments conducted by Natalya Gallo in 2016 (Ref: Gallo, 2018 <https://escholarship.org/uc/item/6bb6v4z8>; Gallo et al., 2020), and the black circle represents CalCOFI Station 93.3 28.

tems can be used to collect environmental and biological data in small nearshore submarine canyons with greatly reduced costs and environmental impact. This study aims to use the La Jolla Canyon as a testbed for using ocean landers as a tool to study nearshore submarine canyons.

LANDERS

Two low-cost, spatially flexible autonomous lander systems were used: a Global Ocean Design LLC Nanolander Deep Ocean Vehicle (DOV) BEEBE and Picolander DOV LEVIN (Fig. 2). The Nanolander has three spherical housings containing a camera system, an EdgeTech BART (Burnwire Acoustic Release Transmitter) acoustic communication system, and two additional LiPo batteries. A ZebraTech <www.zebra-tech.co.nz> Moana sensor is mounted to the frame for measuring temperature and depth. The smaller, two-sphere Picolander is equipped with a ZebraTech sensor, camera system, and timed release for up to 99-hour deployments. Both systems are positively buoyant and deployed by hand from a small boat (Fig. 1). The Nanolander can collect paired biological and physical data in the deep sea over a greater timescale (i.e., several weeks). The landers require only a low-cost sacrificial iron drop weight for each deployment.

The Nanolander, DOV BEEBE, was developed by Kevin

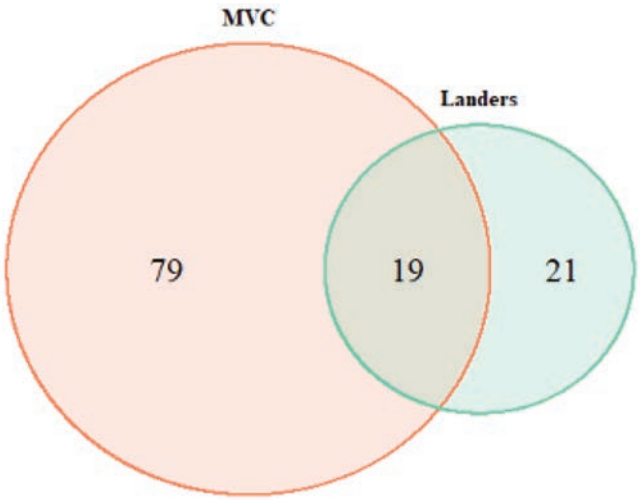


Image credit: Ashley Nicoll

Figure 4. A Venn diagram displaying the number of La Jolla Canyon specimens in the Marine Vertebrate Collection (MVC) at Scripps Institution of Oceanography (SIO) and the number of fish species observed by the landers in the La Jolla Canyon. The overlapping zone represents common species between the two methods.

Hardy for Natalya Gallo (Gallo et al., 2020 <https://doi.org/10.5194/bg-17-3943-2020>; Global Ocean Designs LLC) in 2016. The Picolander, DOV JEAN was developed by Kevin Hardy with Maré Sutphen, now an undergraduate engineering student at CalPoly-San Luis Obispo. The camera and lights systems of both landers were developed by Kevin Hardy with Ashley Nicoll.

Six successful exploratory deployments were conducted with the Picolander (Fig. 3). These deployments ranged in length from 26 to 51 hours and targeted depths from 100 to 500 m.

Five successful deployments of eight to 12 days were conducted with DOV BEEBE. DOV BEEBE re-occupied deployments sites from the Picolander except for one site, Pico-D370.

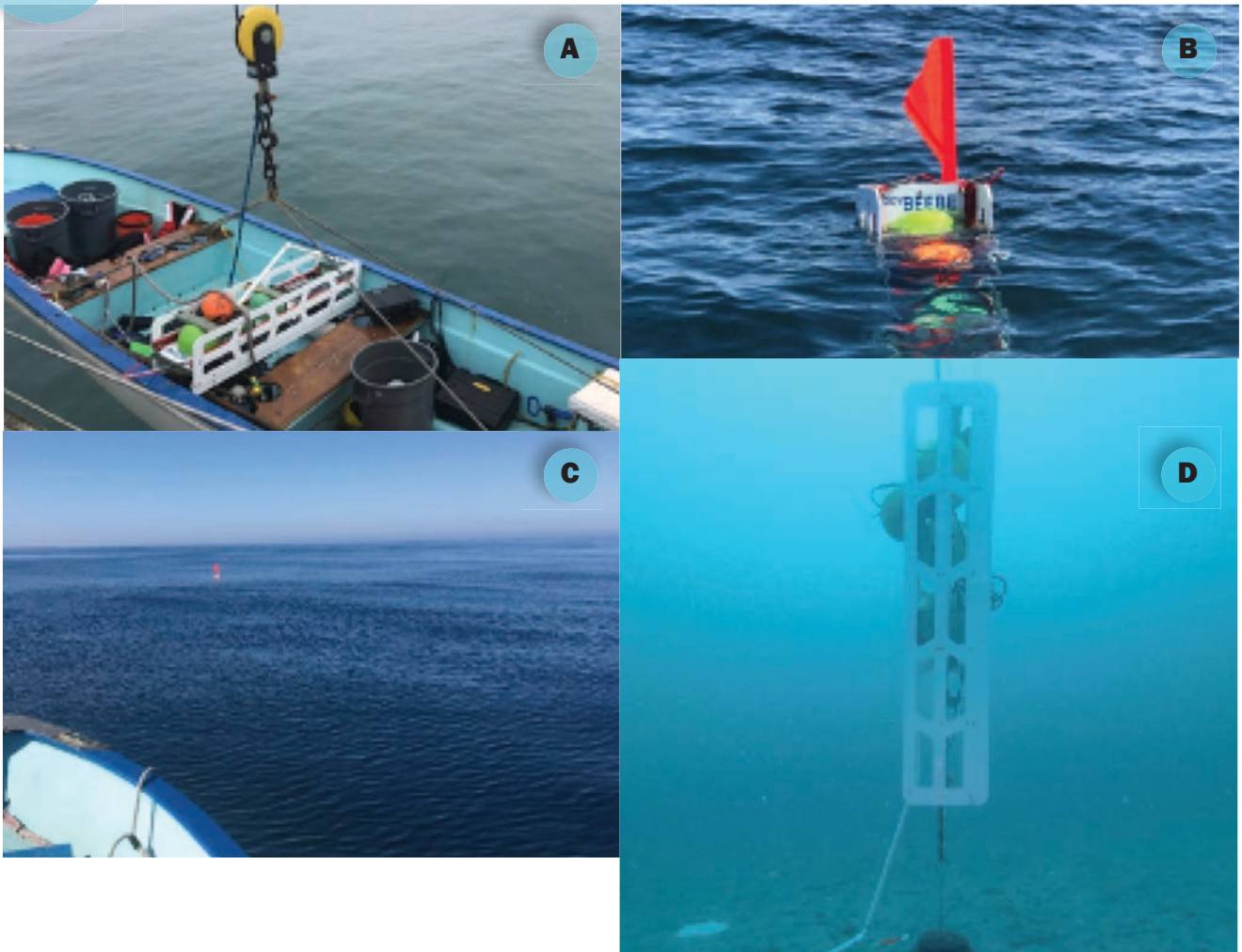
For all deployments, the camera was set to record video for 20 seconds every 20 minutes.

RESULTS

We found that communities at 100 and 500m were distinct from all other depths while the 300m community was transitional between these depths and had the highest diversity, despite unexpectedly high turbidity.

Additionally, we recorded clear diurnal patterns in fishes

Figure 5. Photos of the landers upon deployment and/or recovery: a) Nanolander DOV BEEBE in a small skiff; b) DOV BEEBE floating in the water during a recovery; c) The surface expression of Picolander DOV LEVIN, and d) DOV BEEBE deployed at ~ 24 m (80ft).



Photos by Ashley Nicoll and Phil Zerofski, Scripps Institution of Oceanography/UCSD

deeper than 300m, as well as vertical migration of larval flatfish.

LANDER PERFORMANCE

Due to their small design and relative ease of use, the Nanolander DOV BEEBE and Picolander DOV LEVIN made access to nearshore, deep-sea ecosystems straightforward from a small boat. We found the landers performed reliably collecting paired biological, physical, and biogeochemical data in hard to access areas. Because of this, they can serve as powerful tools to investigate a great diversity of questions from animal behavior to community responses to the environment.

The Picolander design proved to be a good tool for short-term exploratory deployments.

The Nanolander design functioned reliably, and the upgraded camera system accomplished the goals we had for power conservation.

Not surprisingly, incremental improvements for both landers were suggested by field experience.

The ZebraTech Moana Temperature and Depth sensor worked without any issues throughout all deployments and had sufficient power and memory capacity for all deployments.

CHARACTERIZING DIFFERENCES

Over the course of the five Nanolander deployments, 3,183 20-s video samples were annotated, and 614 20-s samples were annotated from the six Picolander deployments. Over the course of all the deployments, visibility was worse than expected due to turbidity in the water column. The 300 m deployment had the poorest visibility, where only 9% of samples had good visibility. The 100 m deployment had the best visibility followed by the 500 m deployment, the 400 m deployment, and finally the 170 m deployment.

Despite having the poorest visibility, the highest number of unique operational taxonomic units (OTUs), including invertebrates, vertebrates, and demersal fishes, were observed at the 300 m site with 27 OTUs recorded during of the Nanolander deployments and 16 recorded during the Picolander deployments. The 100 m Nanolander deployment observed the most demersal fish with 16 species observed. For both landers, the least number of OTUs occurred at the ~400 m deployment with the Nanolander observing 19 OTUs while the Picolander observed six.

COMPARING LANDER RESULTS

A comparison between local, canyon associated species in the Scripps Institution of Oceanography (SIO) Marine Vertebrate Collection (MVC) and the fish species observed by both the Picolanders and the Nanolander was conducted to investigate how many species were common between the two datasets, and how many were unique. This analysis was done with data from Hastings et al. (2014, https://doi.org/10.3160/0038-3872-113.3.200). Hastings' paper summarized the fishes of La Jolla and the local Marine Protected Areas based on records of specimens in the MVC, began in 1905 and continuing to the present day. Because the study area for the landers began at 100 m, fish whose depth range are shallower than 100 m were filtered out. This list was then compared to the fish species observed throughout all lander deployments. (Figure 4.)

The landers recorded 40 species of fishes throughout their deployments and ~47% of these were also preserved in the MVC at SIO, collected from the local canyon system. The remaining ~ 53% of the fish species observed by the lander were not preserved in the MVC with metadata indicating that they were collected from the local canyon system. It is possible that the disparity between what has been collected from the canyon and what was observed by the lander is due to the different sample collecting methods. Most of the samples from the local canyon system in the MVC were collected using rotenone or dynamite. It is possible that the species observed only by the landers were less susceptible to these methods or did not float up to the surface to be collected. Additionally, the specimens in the MVC

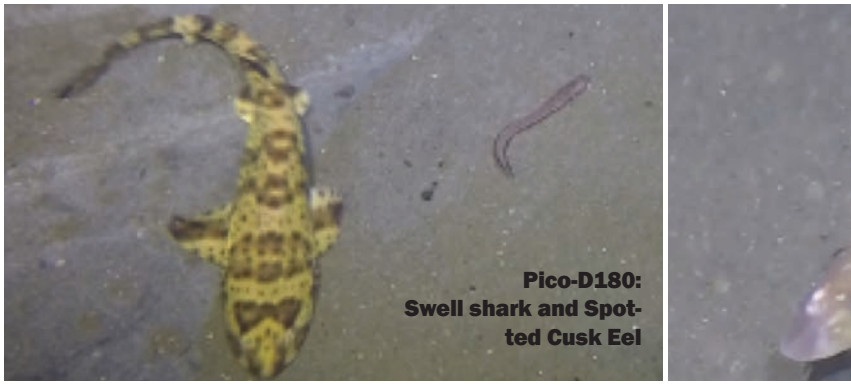
were collected over several decades ago and the difference in species observed by the landers and preserved in the MVC could be evidence of a change in the system. This result supports the need for more and diverse sampling efforts in ecological research and proves efficacy of the landers as tools to study nearshore submarine canyon communities.

DIURNAL PATTERNS

It is interesting to note that the species with the clearest diurnal patterns were observed at depths deeper than 300 m. We had expected the diurnal patterns of species to decrease with depth and be most obvious at the shallower deployments.

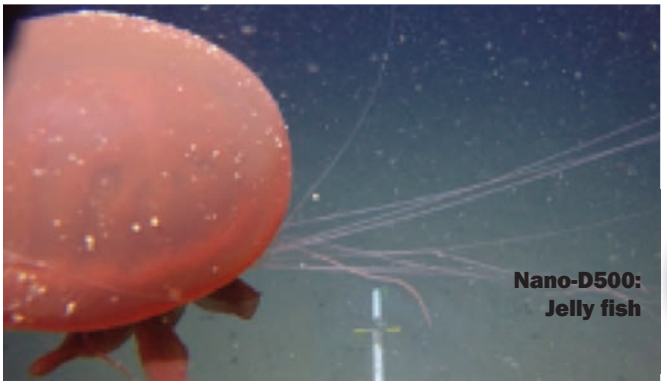
CONCLUSIONS

Nearshore submarine canyons play an important role in connecting nearshore and deep-sea ecosystems. Even so, they are hard to access with traditional deep-sea sampling techniques. Small autonomous landers offer a robust and cost-effective way to study these features, collecting physical, biogeochemical, and biological data.



Pico-D180: Swell shark and Spotted Cusk Eel

Nano-D300: Prickly Shark



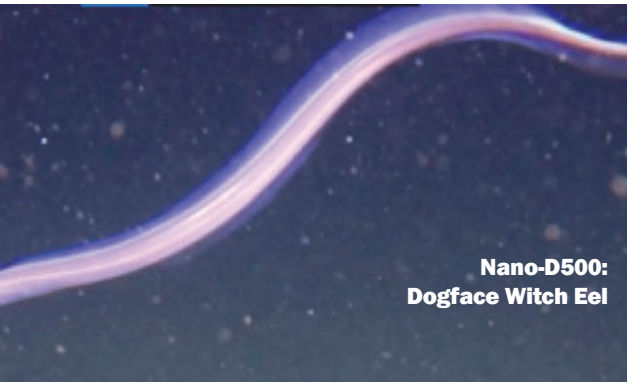


Figure 6.

Images from various lander deployments to provide examples of image quality and unique species observed.

Photos by Ashley Nicoll, Scripps Institution of Oceanography/UCSD

GEOMAR Testing the fuel cell at WTD71 in Eckernförde.
Photo: Finn K. Flögel.

A FUEL CELL FUTURE

Providing power at the seafloor

Two outfits, one in Germany and one in the U.S., are chasing a goal of supplying long-term subsea power in remote locations, via fuel cells, to users including oceanographic observatories to underwater vehicles. **Elaine Maslin** takes a look.

Long term operation of subsea equipment or instruments in remote locations poses something of a challenge. While battery technology has improved vastly, it's still not sufficient for long term deployments.

For a decade or so, a number of projects have been working on ways to provide seafloor based remote power systems. This could be to power subsea production systems, resident remotely operated vehicles (ROVs) or autonomous underwater vehicles (AUVs) or to provide power to long-term remote ocean observatories.

Some are trialling the use of wave energy or ocean current converters. Nuclear options have also been assessed. However, two promising projects which propose fuel cells as a solution to this challenge have recently passed significant milestones.

One is a research project led by Germany's GEOMAR Helmholtz Center for Ocean Research Kiel, which recently tested fuel cell technology for use on a long-term seafloor observatory, where it could also be required to power robotics. The other is Teledyne's Subsea Supercharger, which was recently put to the test over in Norway.

Powering up ocean observation

"The need for long-term observation systems on the seafloor has risen considerably and will continue to move into focus in the future", says project manager Dr. Sascha Flögel from GEOMAR. This could be to track environmental and cli-

mate trends or for exploration projects, where mobile, modular solutions would be beneficial. However, these are tending to be more power hungry, especially when energy-intensive robotic systems start to be added into the mix.

At the moment, power for underwater equipment or sensors tends to come from either batteries or cables. Cables are prohibitively costly for projects at any distance from the coast and no appropriate for systems only in place for a few years, while batteries are expensive and wasteful.

GEOMAR's solution is a fuel cell, developed in partnership with the Center for Solar Energy and Hydrogen Research, Ulm (ZSW), as part of the German Federal Ministry of Economics and Technology funded Autonomous Robotic Sea-Floor Infrastructure for Bentho-Pelagic Monitoring (ARIM-FUEL) project. It's a proton exchange membrane (PEM) fuel cell, in which hydrogen and oxygen are fed to a polymer membrane electrolyte and platinum based electrodes, to generate power with heat and water as a by-product.

GEOMAR's system comprises of 11 gas bottles of hydrogen and five bottles of oxygen and the fuel cell, developed by ZSW. "This gives us about 120 kW of power we can use for our monitoring efforts at the seafloor," says Dr. Flögel. In addition, the system has a 4 kW rechargeable battery, which the fuel cell charges. "If you wanted to generate the same amount of energy (using primary cells) you would need about 13,200 battery cells and that one charge costs about $22,400. It's very cost intensive and has an environmental impact." Most institutes use the same, although a few do use rechargeable batteries, he says. In comparison, to refill the fuel cell that GEOMAR has designed costs $1,400, a fifteenth of the cost, Dr. Flögel says.

The system can deliver 150 W to 1kW output, a significant increase compared to previous solutions that draw their energy from primary cells or rechargeable batteries, says GEOMAR. This will cover many requirements, which include for long-term deep sea monitoring, but also,

Photo from Teledyne Marine

in future, recharging autonomous underwater vehicles (AUVs) and a seabed crawler, using an inductive seafloor recharging unit, says Dr. Flögel. The system is currently rated to 1200m depth, due to limitations of some of the pH sensors and buoyancy foam that are part of the sensor suite GEOMAR wants to use with it, says Dr. Flögel. However, it's targeting 3000m by 2023-24.

A 48-hour test was carried out in the Baltic Sea in November last year, in cooperation with the Defense Technology Service Unit 71 of the German Army in Eckernförde. Further tests were run in February, and a further sea trial on RV Alkor, extending the test to 72 hours, is planned for March. These are mostly focused on stability and power management – efficiently recharging the battery in a way that limits switching the fuel cell on and off too much (something that's not great for them).

The next steps are to look to use the new system as part of a series of robotic monitoring projects in the coming years. "The new energy supply for under water systems creates completely new possibilities for us to use the devices over longer periods of time," concludes Dr. Flögel.

Teledyne tests its Supercharger

Over in Norway, working with Innova, Teledyne has put its Subsea Supercharger through validation testing at the Norwegian Center for Offshore Education, Tau Autonomy Center, a subsea testing facility not far from Stavanger, Norway.

The system is configurable for more than 3 MWh of energy capacity, says Teledyne, and is designed to be deployed down to 1,000m water depth and provide up to 8 kW of steady state power.

Teledyne first unveiled the concept in 2018. It's designed for energy storage requirements of at least 500 kWh or where cold temperatures are a possibility, says Dwight Warnock, Vice President, Teledyne Energy Systems, Inc. "This could be oil and gas fields, to provide an independent, stand-by energy source, but also as a research or observational platform in environmentally sensitive areas. "The Subsea Supercharger emits only water and a small amount of heat making it environmentally friendly and once the system has been recovered, no footprint remains. It can also provide power to a AUV recharging dock to support a persistent presence for performing surveys without the need for a support ship."

The Subsea Supercharger is also a PEM fuel cell, comprising of three major components: "the fuel cell stack, the water management section, and the reactant (hydrogen and oxygen) supply section," explains Warnock. "The oxygen and hydrogen gases are managed and supplied through an ejector-driven reactant (EDR) block [which eliminates the need for a mechanical pump]. The

reactants are supplied to the EDR manifold where the gas flow creates the positive feedback needed to ensure consistent supply of reactants to the fuel cell with no moving parts." It's also a "load-following engine," producing power to suit user requirements, without intervention, says Warnock, making it suitable for environments where routine access is limited.

The validation tests in Tau included putting the system to use powering a subsea hydraulic pumping unit developed by Innova. "The two systems were integrated and successfully deployed to a depth of 235 m (770 ft.) where subsea control fluid was pumped to a pressure of 180 bar (2,600 psi) for 30 minutes, six times a day," says Teledyne. "During the test, the Subsea Supercharger seamlessly transitioned from 'Sleep-mode' to 'On', in response to power demands from the pumping unit as it repeatedly cycled on and off," says Teledyne.

"The testing at Tau demonstrated the Subsea Supercharger is capable of meeting real-world applications without the need for operator intervention," says Warnock. "By integrating the system with a hydraulic pumping unit, this demonstration illustrated to the operators the feasibility of having a stand-by energy source for providing pressurized working fluid to oil fields for rapid intervention. The testing highlighted the flexibility of the Subsea Supercharger in terms of user load profiles by only supplying power as required. The demonstration also proved ease of deployment, set up and recovery. The entire system was loaded and deployed in a couple of hours without specialized equipment or training and recovered by a different boat crew with no technical representatives onboard."

Another validation test is planned for this Spring, when the Subsea Supercharger will be integrated with an AUV charging dock to demonstrate untethered, long-duration AUV operations.

Alternative Power Sources

A number of other projects have been working to harness wave or ocean current energy, from the surface or at the seabed, to provide a consistent power supply. Two will be getting their new systems wet alongside energy storage and management this year.

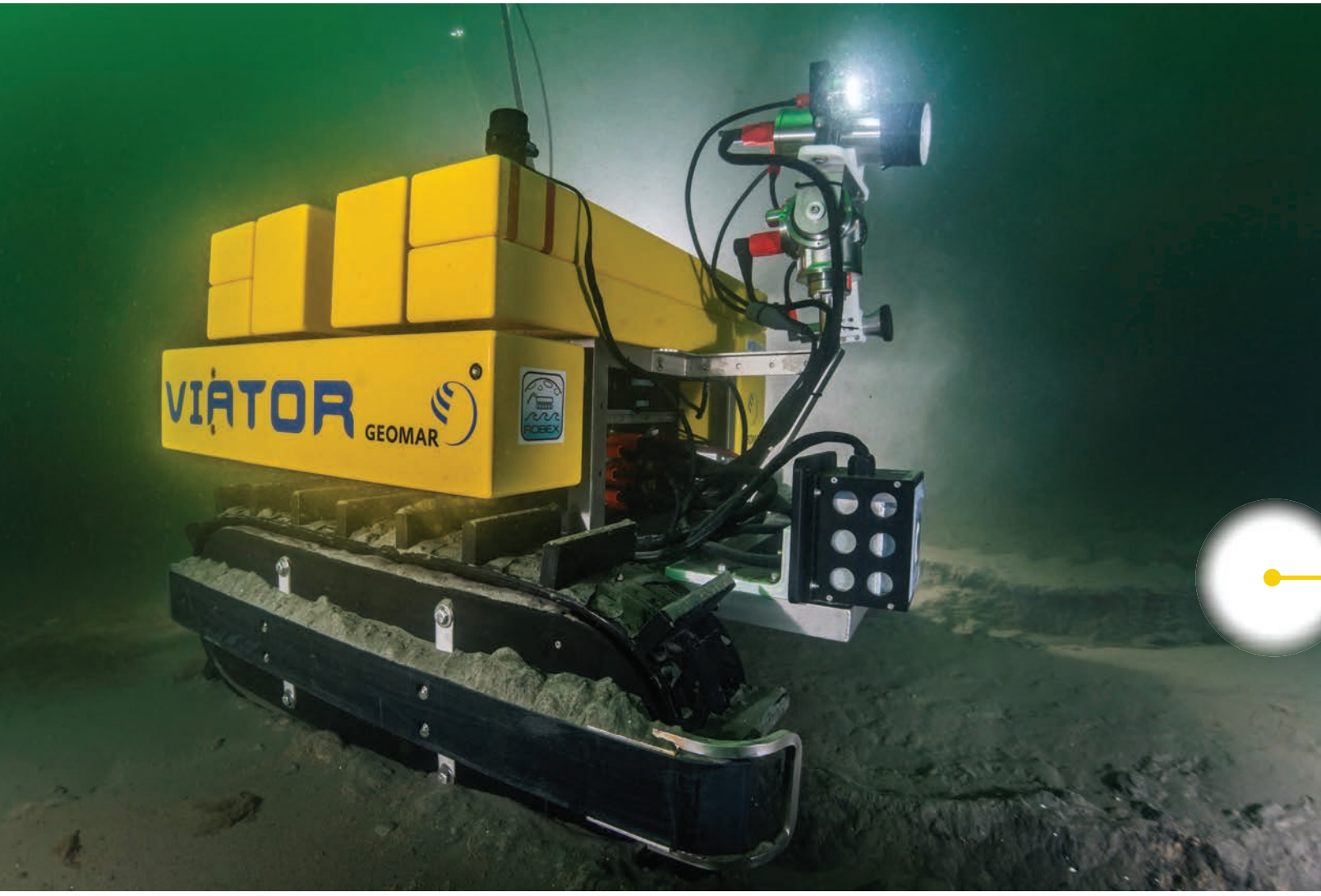


Photo from Geomar

U.S.-based C-Power is due to deploy its SeaRAY autonomous offshore power system (AOPS) at the U.S. Navy Wave Energy Test Site in Hawaii this year, for example. SeaRAY incorporates a wave energy converter and communications gateway at the surface, with power storage and delivery and communications at the seabed. The power delivery will be via a Halo subsea battery storage system from UK firm Verlume (previously known as EC-OG). A trial is set to demonstrate the ability to support resident underwater vehicles with power for recharging and communications.

Another wave energy technology company, UK-based Mocean Energy, is also working with Verlume. It's due to test its Blue-X wave energy device with a Verlume battery offshore Orkney this year. This is also to demonstrate operations with an AUV, as part of a project with oil major Harbor Energy, the Net Zero Technology Center and subsea inspection firm Modus.

US-based Ocean Power Technologies has been working in this space for a number of years, working with Premier Oil (now part of Harbour Energy) in the UK and Eni in Italy to trial its wave energy device in support of powering subsea wells at end of field life and supporting resident AUVs, respectively.

For those wanting somewhat more power, a more extreme example of potential power solution has been shared in Russia. There, Project Iceberg, presented back in 2017, proposed equipping seabed production facilities, in ice-bound areas, with nuclear reactors to provide power.

Crawler

GEOMAR's Viator seabed crawler, which could soon get its power from a fuel cell.

Tritons waiting deployment from the firm's new Gulfport facility in Mississippi.

Photo from Ocean Aero

SUN, SAIL AND SUBSEA —

not a holiday, but a hybrid UxV platform

Ten years ago, Ocean Aero's unique hybrid sailboat-submarine was a novel idea being developed in a San Diego garage. Today, the company has a growing fleet of vehicles on the water and a $14 million funding injection to take it the next level.

Elaine Maslin reports.

Earlier this year, a great illustration of the ongoing adoption of marine autonomous systems was made through the International Maritime Exercise (IMX) 2022, a U.S.-led training event involving 60 partner nations and international organizations. The event, held in the Middle East, was hailed as the largest unmanned exercise in the world with more than 80 unmanned/uncrewed systems (UxV) from 10 nations participating.

Most are designed for one mode of operation (e.g. subsea or surface). However, one has been designed to do both. It's Ocean Aero's Triton, a hybrid wind and solar powered vehicle that can operate on and down to 200 m beneath the waves.

"It's the only platform that both sails and dives which unlocks an incredible value proposition to customers in our target sectors," says Kevin Decker, Ocean Aero's CEO. "The versatility of having two modes of operation is very attractive to our clients. They're able to perform twice the number of mission types for their work, be it in offshore energy, defense, or science markets," Keith Blystone, Ocean Aero's Chief of Staff, adds.

Ocean Aero's commercial offering is the Triton, a 4.4 m-long vehicle with a 3 m-high retractable wing sail and 1.5 m-deep keel. It has 200W solar panels embedded on the hull and a 4kWh lithium-ion battery to support underwater operations. On the surface, it operates as a sail boat, using wind for forward propulsion while charging its batteries. If there's bad weather, above sea state

5 for example, or it wants to avoid detection or gather data, it can then fold together and retract its wing sail into the hull and flood the hull to dive. Underwater, it has a ballast system to support dives down to 200 m. It can also use a dynamic buoyancy system to loiter or operate something like a glider, and/or its dual thrusters to navigate at up to 2kts. To return to sail mode, it returns to the surface, where a bilge pump type system pumps out the flooded hull to return it to a sail boat.

On the surface, they can run for months and months, says Blystone. "We'd typically recommend bringing them in every 90 days for routine maintenance and get marine growth off of it," he says. "Underwater, it can last days, depending on the payload, and up to eight days in 'dark mode'."

AN IDEA DEVELOPED IN SAN DIEGO

The concept dates back to 2012, when Ocean Aero's founders got together in San Diego, California. Their first generation vehicle caught the eye of Teledyne, which invested in the company in 2014. By the end of 2015, further prototypes were built and they caught the interest of Lockheed Martin, which initially partnered with Ocean Aero on a multi-domain UxV demonstration in 2016, before also becoming an investor in 2017.

The initial design was to support extended autonomous ocean observation and data collection, initially down to 10 m water depth, where it could remain to avoid bad weather or detection, targeting the scientific community. In 2018, true to this goal, the first Submaran (it's initial name) mission saw it sampling seawater for harmful algal bloom (HAB) cells and toxins off Washington, as part of a pilot project. In 2020, this led to a full project, with the University of Washington's Applied Physics Laboratory and other partners using National Oceanic and Atmospheric Administration funding to improve early detection and modelling of these potentially harmful cells and toxins, reaching offshore areas using an autonomous vehicle in weather conditions too extreme for small boats. That year, the firm was also made a major step into the defence market, winning a contract to deliver six of its vehicles to the U.S. Department of Homeland Security.

SURFACE-SUBSURFACE TECHNOLOGY DEVELOPMENT

There's been a lot of work across a number of areas to get to where the company is today. "There are a lot of components on surface sailing vessels that work perfectly, such as an anemometer," says Decker. "But these aren't designed to go to 200 m beneath the surface, at that pressure, and come back up and

Crown Prince Salman bin Hamad Al-Khalifa of Bahrain, center, during IMX 2022.

U.S. Navy photo by Mass Communication Specialist 1st Class Mark Thomas Mahmod.

keep on working. Underwater marinizing of every component of a sail boat is actually a little tougher than you would think. Also, people don't always think about the enormous amount of software and autonomy that's required to have all these different systems work together and communicate back and forth with each other." The work that's been done in this space means Triton can run missions based on pre-programmed waypoints, with programmable parameters such as exclusion zones, with the vehicle using algorithms developed by the company to determine the fastest route to those waypoints.

Jordon Cousino, Chief Commercial Officer, at Ocean Aero, adds that, while there's a payload eco-system for uncrewed surface vessels (USVs), driven largely around Wave Gliders, and a payload eco-system created around AUVs, these eco-systems rarely break that water line in either direction. "So we've had to underwater marinize the USV payloads and the reverse on the AUV payloads. It's a very complex eco-system that we live in. It's literally a sailboat that's a submarine and the complexities that come with that are challenging." "The ability to push the envelope with battery technology, solar panel technology, and power management is also something we've also had to get good at pretty quickly," adds Decker.

They've also learned to simplify as much as they can. "We utilize a dual-element wing on the sail that had probably 20 feet of cable that wrapped around numerous pulley systems and when you start putting these out for long endurance missions, we would start to see these smaller stainless steel cables either bust or break at certain points," explains Cousino. "So we focused on creating a ruggedized vehicle for long-endurance missions, where we went to a single element wing that has 77 fewer parts and tried to simplify the engineering as much as possible to allow for persistent operations without failure points."

"One of the things we're proud of is user friendliness, the ability to launch

and recover," adds Blystone. "We've put a lot of focus on making it easy to launch and recover using just one to two people in a matter of minutes. It has a single pick point that allows you to lift it and place it in the water easily if you're using a davit lift system off another vessel or shore side. Because it's a submarine and there's oil in the boat to naturally balance it, when you go to pick it up it naturally balances itself. It's little things that make the process easier. But you literally can also go push this in from a shore side."

TRITON OUT IN THE WILD

The result of this work is a platform that's now in the hands of the Department of Homeland Security and the University of Washington, as well as the US Navy, another US agency, and a number of other organizations. "There are three big markets we're focused on, the defense community, the scientific community, and the offshore energy community, predominantly offshore oil and gas but also offshore wind. We're active in those three markets," says Blystone. "We have active deployments or programs in all of those three markets, with customers either owning systems or paying us to operate them with applications varying from monitoring marine life to asset inspection," he says.

A large current focus is on sensor and payload integration, working with other organizations. "What you do with the boat is really the most important thing. We've been really focusing our engineering efforts on making sure we have fantastic payload integrations, fantastic sensor integrations and partnerships as we move forward. Ultimately whatever payload and sensor packages the customer wants should be able to be incorporated into the Triton." says Blystone.

There's more the company wants to do, however. "Today, we can use many of our Tritons together on a mission," says Blystone. "In the future we'll continue developing more advanced AI/ML algorithms in support of true swarming and cross-platform coordination."

SET FOR GROWTH

All this is being done under quite a new staff and management team at Ocean Aero, most of whom have come in over the last 16-20 months to take the company forward as a commercial enterprise. A big part of that was a series C fund raise last year, which netted the company $14 million. To underpin its growth, the company has also moved from San Diego to the Port of Gulfport, Mississippi, where it will again move into a 63,000 sq. ft. facility by the end of this year. It's also staffing up. Decker says they had 17 staff in early summer last year and are looking to have increased that to 60 full time staff by the end of March. It has also built up an advisory board which includes a number of two- to four-star admirals and an impressive roster of technical specialists who're active in the advocacy of the group, adds Decker.

As Ocean Aero moves into a new commercial gear, some of its original founders are back doing what they do; working on new ideas. Co-founders Vance McClure and Mark Ott, who was CTO until 2016, have moved on, with Ott now a founding partner at SubSeaSail, along with partner Chris Todter, who was also at Ocean Aero. Another former member of the Ocean Aero crew is Ken Childress, who is now at AUV and data firm Terradepth.

Ocean Aero's **Triton** hybrid vehicle operating in sail boat mode at sea.

Photo courtesy Ocean Aero

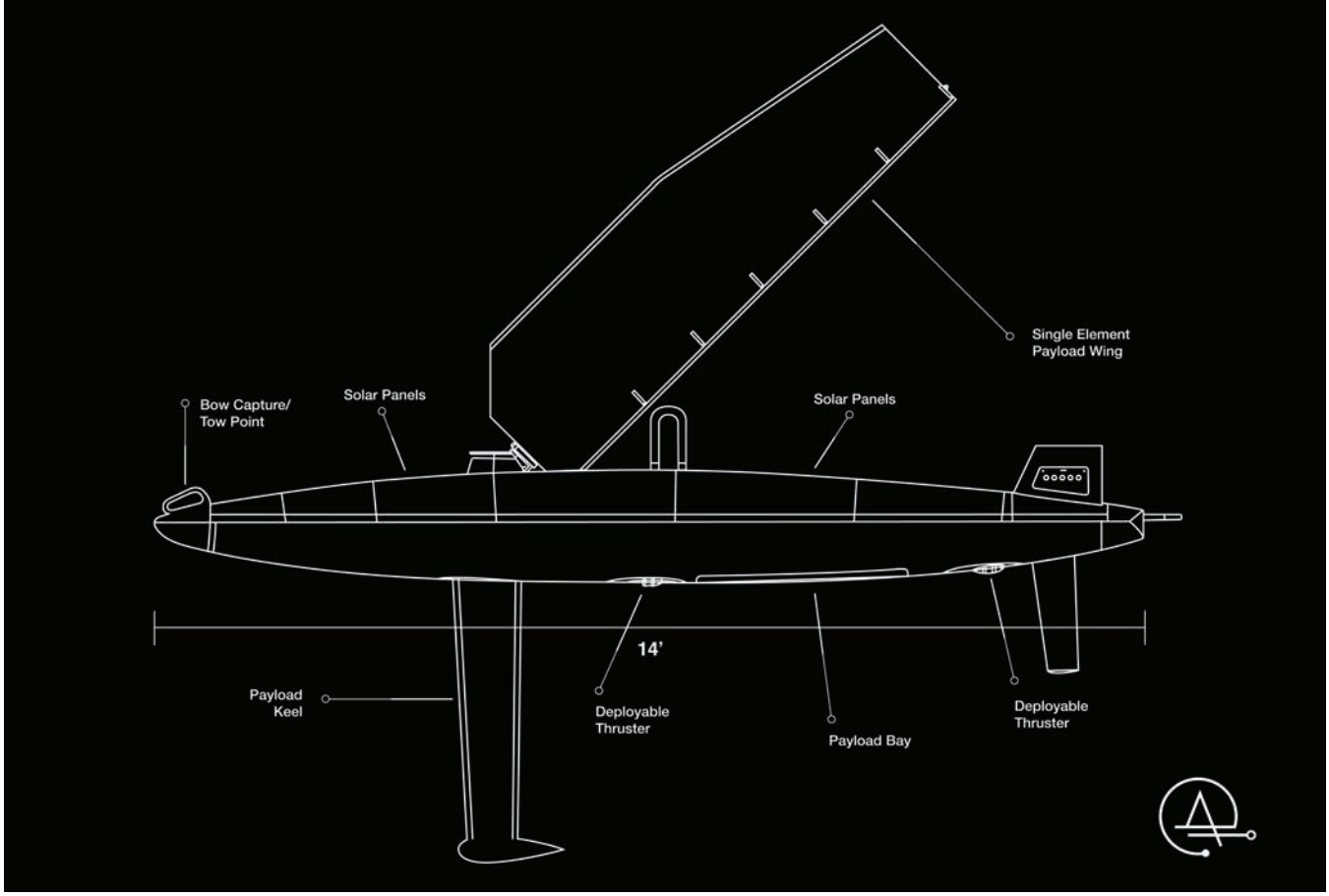


Image courtesy Ocean Aero

USACE

COASTAL STORM SPLITS AN ISLAND, UNITES COMMUNITIES

By JoAnne Castagna, Ed.D.

In 1992, Joseph Vietri, then a coastal engineer with the U.S. Army Corps of Engineers, New York District, was walking with a colleague and a coastal researcher around Westhampton Beach, a barrier island located on the south shore of Long Island, New York. "The island was recently beaten up by a Nor'easter. We were walking in ankle-deep water and started to wade into peat that must off broken off of a wetland. We looked at each other and said, 'If something is not done immediately, this whole island is going to unravel within a week.'"

In a matter of days this is exactly what happened. Water from the ocean side of the barrier island washed over and into the bay side, splitting the barrier island, creating a breach or gap that quickly turned into a full-blown major inlet that swallowed up dozens of houses.

Today Vietri is the Director of Coastal Storm Risk Management National Center of Expertise, North Atlantic Division, U.S. Army Corps of Engineers. To prevent this from happening again, the Army Corps in collaboration with numerous agencies and communities revitalized a stalled project – The Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project.

The comprehensive project will manage the risks of coastal storm damage and sea level rise for barrier islands and back bay communities on Long Island's south shore while at the same time preserve natural resources. After years of researching for the best measures for doing this, the project has begun.

Long Island extends out east into the Atlantic Ocean from New York City. Along the south shore of the island there are barrier island chains from Long Beach to Shinnecock Inlet.

In between Long Island's mainland and the barrier islands is bay water that includes the Great South Bay, Moriches Bay and Shinnecock Bay.

The project encompasses 83-miles of the south shore of the island - from Fire Island Inlet to Montauk Point and extends inland two miles. The area covers the Suffolk County portion of the island that includes the Towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton, 12 incorpo-

rated villages, the Fire Island National Seashore, and the Poospatuck and Shinnecock Indian Reservations.

Over the years, the south shore of Long Island has become very populated, with a large influx of seasonal beachgoers and visitors, too. The south shore is also very developed. Within the project area, there are 46,000 buildings that include 42,600 homes and 3,000 businesses, and critical infrastructures including 60 schools, two hospitals, and 21 firehouses and police stations.

In the past century, especially in the last 20 years, Long Island's developed coast has experienced storm damages. Elevated tides and waves from these storms caused extensive flooding and sand erosion, leaving communities and shore life vulnerable.

Most recently was Hurricane Sandy in 2012. Storm surge from Sandy eroded forty percent of the beach sediment from some areas and created three breaches in the barrier islands, leaving the area vulnerable to significant damages.

Anthony Ciorra, Project Manager, New York District, U.S. Army Corps of Engineers remembers Sandy, "What stands out in my mind, was the devastation I witnessed in the south shore communities in the aftermath of Sandy. It was a glaring and harsh reminder that these heavily developed and densely populated communities are at high risk to continued damages due to coastal storm events."

Over the years, the Army Corps would perform small projects to stabilize vulnerable areas, but it was realized, especially with Sandy, that a more comprehensive long-term project was needed for the entire region. The project would become The Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project. The project was created by the Army Corps in collaboration with numerous agencies and communities that include the New York State Department of Environmental Conservation, New York State Department of State, Department of the Inte-

rior, National Park Service, U.S. Fish & Wildlife Service, U.S. Geological Service, Suffolk County Government, the townships of Islip, Babylon, Brookhaven, Southampton and East Hampton, 12 incorporated villages, and the general public.

The project includes several measures to manage the risks of coastal storm damage and sea level rise. They include a breach response plan, home elevations, flood-proofing & acquisitions, coastal restoration, preserving natural resources, and adapting to sea level rise.

BREACH RESPONSE PLAN

After a storm or tidal surge, if a breach is created on a barrier island, it will be closed immediately. Closing the breach will be accomplished by dredging sand from federal navigation channels and placing the sand on the barrier island to build the island back up. Homeowners will be able to decide if they want their homes elevated or flood proofed by the Army Corps. The homes will be elevated so that the lowest floor is above the flood level. Approximately, 4,000 homes will be elevated. "This is the largest number of structures that have ever been considered for a raising on an Army Corps project," said Mark Lulka, project manager, New York District, U.S. Army Corps of Engineers, who oversees the home elevations, floodproofing and home acquisition aspect of this project and was the project manager for the entire project a few years ago.

Flood proofing is a technique used to reduce damages to homes that may be affected by floodwaters. Approximately, 650 homes will be flood proofed. One method the Army Corps is using to floodproof homes is constructing ringwalls. Ringwalls are walled structures that encircle homes to hold back floodwaters. Ninety-three homes will be provided with ringwalls.

COASTAL RESTORATION

Over the years, much of the project's coastal area has eroded, removing the natural beachfront and dunes that provide coastal protection to the communities from storm surge. To restore these beaches, sand will be placed back on them.

Approximately, 4.2 million cubic yards of sand will be dredged from several federal channels including Fire Island Inlet and shoals and Moriches & Shinnecock Inlets and shoals.

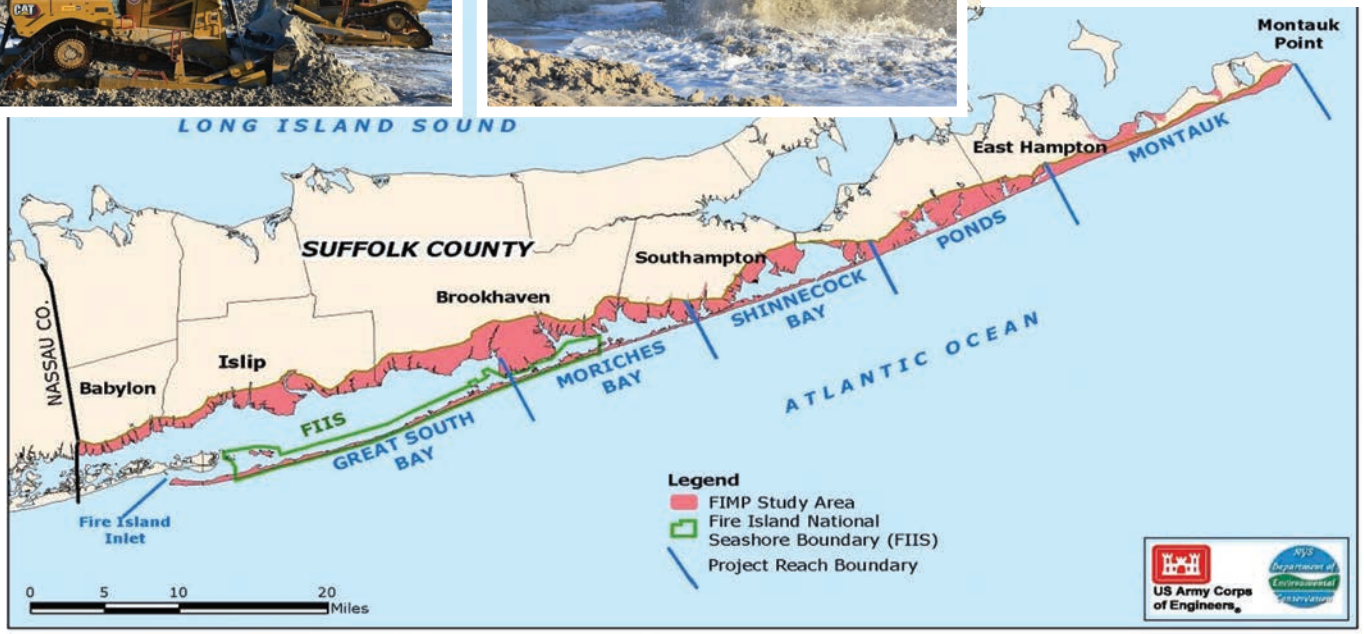
Ocean dredges gather sand from offshore sand borrow areas and pump it through pipelines onto the beach. The sand will be placed onto several beaches including Gilgo Beach, Robert Moses State Park, and Tiana and Montauk Beaches.

The sand can be placed in different areas of a beach depending on the project design. Sand can be placed to increase the height and width of a berm of the beach. The berm is a flat area of the beach between the landward shore and the ocean where beach goers typically sunbathe.

The sand can also be used to create sand dunes. Dunes pro-

Photos: James D'Ambrosio, Public Affairs

Sand being pumped through pipelines onto Gilgo Beach, one of several beaches receiving sand replenishment with the Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project.



Fire Island Inlet to Montauk Point Reformulation Study Area: Project Reach Boundaries

USACE

vide a natural barrier to the destructive forces of wind and waves. Dunes are areas of the beach where sand is elevated several feet to act as a buffer between the waves and storm water levels and the structures landward on the beach. Dunes will be built and planted with dune grass.

A sand replenished beach with dunes can prevent elevated ocean waters, caused by storms, from inundating coastal communities. According to Ciorra, "Post-Hurricane Sandy analysis showed that beaches that had previously received sand placement and dune construction sustained less damages and saved an estimated $1.3B in avoided damages on New York and New Jersey shorelines."

Lynn Bocamazo agrees with Ciorra. Bocamazo is a retired former senior coastal engineer and chief of the New York District's Engineering Division's Hurricane Sandy Branch. She added, "Immediately after Sandy, I visited the Fire Island to Montauk Point – Westhampton Interim Beach Nourishment Project on Long Island, New York. This is part of today's Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project." She continued, "I witnessed how the high dunes created by the Army Corps resulted in an estimated $107m in avoided damages."

To help these beaches retain sand in one location, a feeder beach will be constructed. A feeder beach is a beach that has been stockpiled with extra sand. This extra sand can naturally drift to other nearby beaches that may be losing sand. A feeder beach will be created along 6,000 feet of shorefront at Montauk Beach. To help facilitate the movement of this sand and restore the natural cross barrier island transport of sand in the region, two unneeded groins, or jetties, will be removed at Fire Island's Ocean Beach Village.

ADAPTING TO SEA LEVEL RISE

Climate change is causing sea levels to rise and because of this the project may have to adapt to these changing conditions overtime. The Army Corps will be monitoring sea level rise on a regular basis and make adjustments to the project.

"Based on our monitoring of seas level rise, this could mean over time increasing the volume of sand we place on beaches, increasing the height of berms and dunes to account for observed increased in sea level rise," said Peter Weppler, Chief, Environmental Analysis Branch, New York District, U.S. Army Corps of Engineers.

Vietri added, "It's predicted that future sea level rise could increase anywhere between one to six feet over the next 100 years, resulting in more frequent and severe storm damages."

Recently, the work began on The Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project. The first phase of work includes dredging sand from Fire Island Inlet and shoals and placing this sand onto Gilgo Beach and Robert Moses State Park.

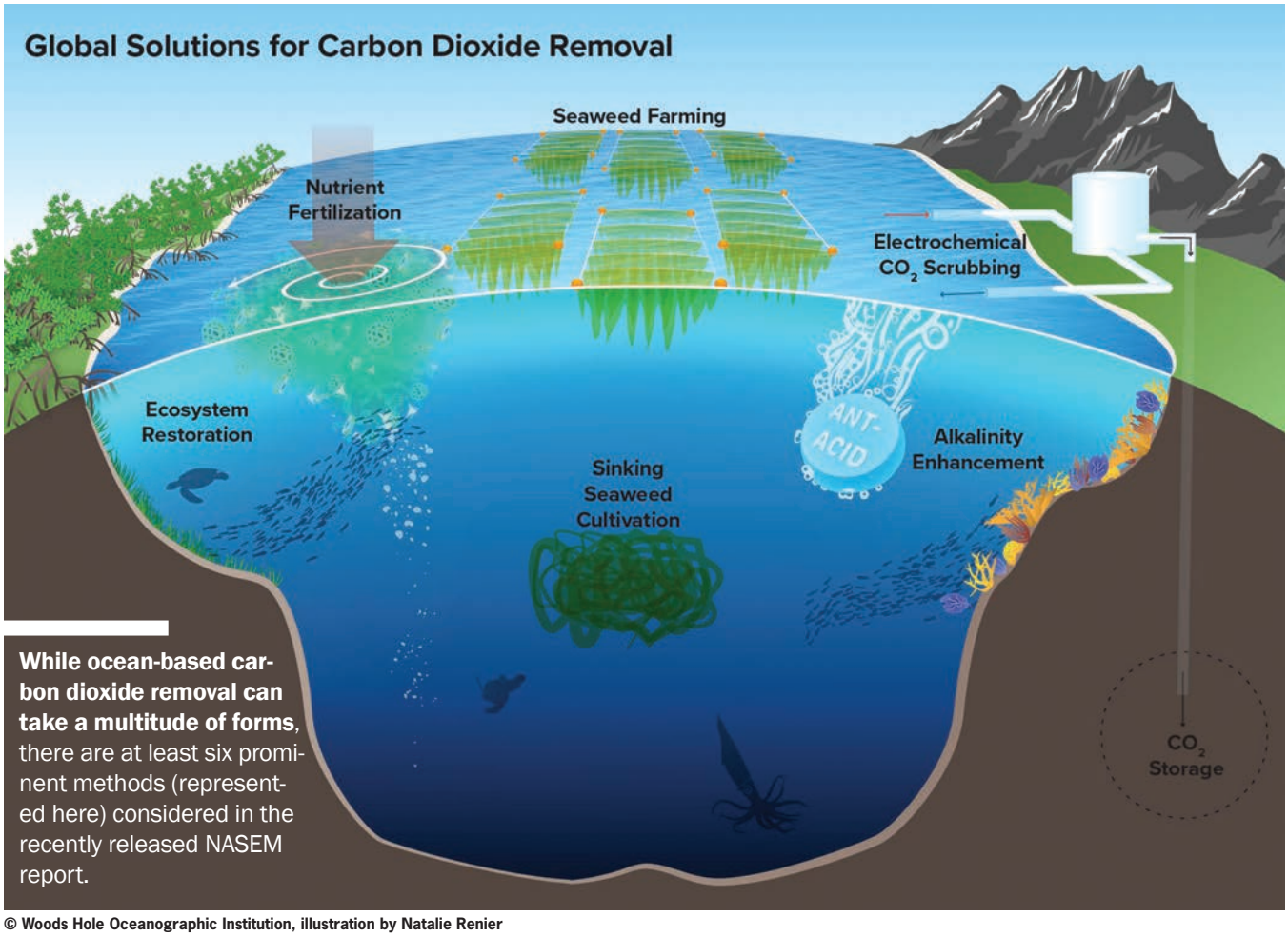
All work on the project will be performed during times of the year that would not harm wildlife. The entire project is expected to be completed in a decade and all sand placement work will be replenished every few years, beyond the completion of the project. James Tierney, Deputy Commissioner for Water Resources, New York State Department of Environmental Conservation said, "New York State is proud to partner with the experts at the U.S. Army Corps of Engineers on this critical initiative. The project takes a holistic approach to increasing coastal resiliency while enhancing aquatic habitat, recreational resources, and community aesthetics. In addition, the project sets the key elements of a resiliency framework that will be completed by technical experts in close collaboration with the involved communities."

Weppler, like Vietri, sees the 1992 Westhampton Beach breach as a pivotal time for the project. He remembers what the Army Corps did following the breach and says it was sort of a template for what would become The Fire Island Inlet to Montauk Point, New York, Coastal Storm Risk Management Project.

Vietri who lives on one of the barrier islands added, "This project will provide layers of protection against storm surge and sea level rise while maintaining and enhancing natural resources. It takes into account the ocean front, back-bay communities, barrier islands, inlets and estuaries in a way that is a collaborative effort. It is unique."

To Clear the Air
LOOK BENEATH THE WAVES

By Celia Konowe



While ocean-based carbon dioxide removal can take a multitude of forms, there are at least six prominent methods (represented here) considered in the recently released NASEM report.

Participants at the 26th United Nations Climate Change Conference (better known as COP26) late last year in Glasgow reiterated humanity needs to accelerate change in the coming decades to limit global warming to 1.5°C (or even to the 2°C as agreed up in the Paris Agreement). Meeting this goal by 2050, the formidable deadline agreed upon across environmental sectors to prevent dooming the planet, will require more than electric cars and veganism. In addition to minimizing emissions at the source, humanity needs to remove the atmospheric carbon that has collected over the centuries since the Industrial Revolution.

Carbon dioxide removal (CDR) can improve the atmosphere through natural and man-made processes. This differs from other techniques, like carbon capture and sequestration, which aim to collect carbon near the source, before it enters atmosphere. A newer phenomenon is ocean CDR—the field researching and developing technology to aid and expedite the ocean's natural carbon sink processes, remove significant amounts of carbon from the atmosphere and make the 1.5°C goal more attainable.

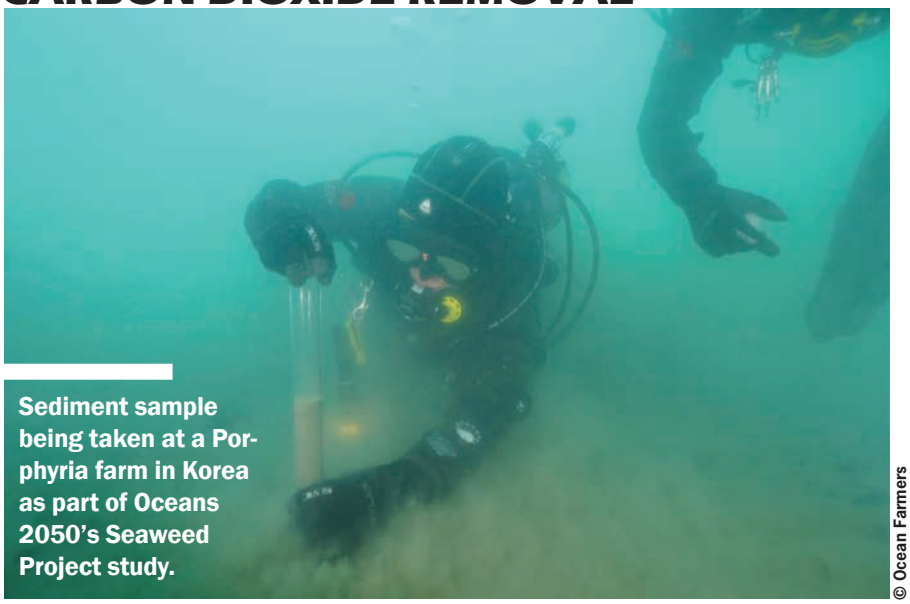
Six degrees of decarbonization

According to the National Academy of Sciences, Engineering and Medicine (NASEM), there are currently six main ocean CDR techniques: 1) seaweed farming to increase green space that needs CO2 to grow, 2) nutrient fertilization to enhance phytoplankton growth and uptake of CO2, 3) ecosystem restoration to move carbon dioxide through the food chain and into the ocean via fecal matter and organic matter, 4) artificial upwelling and downwelling to bring nutrient rich water to the surface and increase marine plant productivity, 5) alkalinity enhancement to raise the pH of seawater and increase its ability to absorb CO2 and 6) electrochemical CO2 removal to be buried in underground reservoirs. Not every technique is being pursued to the same extent, and experts throughout the field agree more research is needed to understand the full impacts and potential consequences of these processes. So, where does ocean CDR currently stand?

Priming the pump

Dr. Ken Buesseler, senior scientist in marine chemistry and geochemistry, plus a Woods Hole Oceanographic Institute and NASEM committee member, points out these six tactics are just a subset of options, moreover no approach can stand alone. Buesseler specializes in the measurement of radioactive elements in the ocean that track carbon as it's carried from the surface to deep sea by "marine snow," or the organic debris left behind by phytoplankton and other organisms in the food chain. This is a "biological carbon pump," carrying CO2 deep into the ocean where it's stored for a thousand years or more.

"We know ocean CDR happens naturally and the question is whether it can be enhanced," Buesseler explains. "What is key to keeping our planet temperatures below the 2°C threshold agreed upon in Paris is immediate greenhouse gas reductions,



Sediment sample being taken at a Porphyria farm in Korea as part of Oceans 2050's Seaweed Project study.

© Ocean Farmers

but along with that, the development of ocean CDR approaches to reduce CO2 already emitted into the atmosphere." Ocean technology stands ready to play a crucial role, he points out. "We've made great strides in the past decade on autonomous platforms and sensors to study the ocean. These technological advances are essential to assessing the state of the current ocean carbon cycle and to see what impacts there might be if we deliberately tried to enhance carbon storage."

CDR ASAP

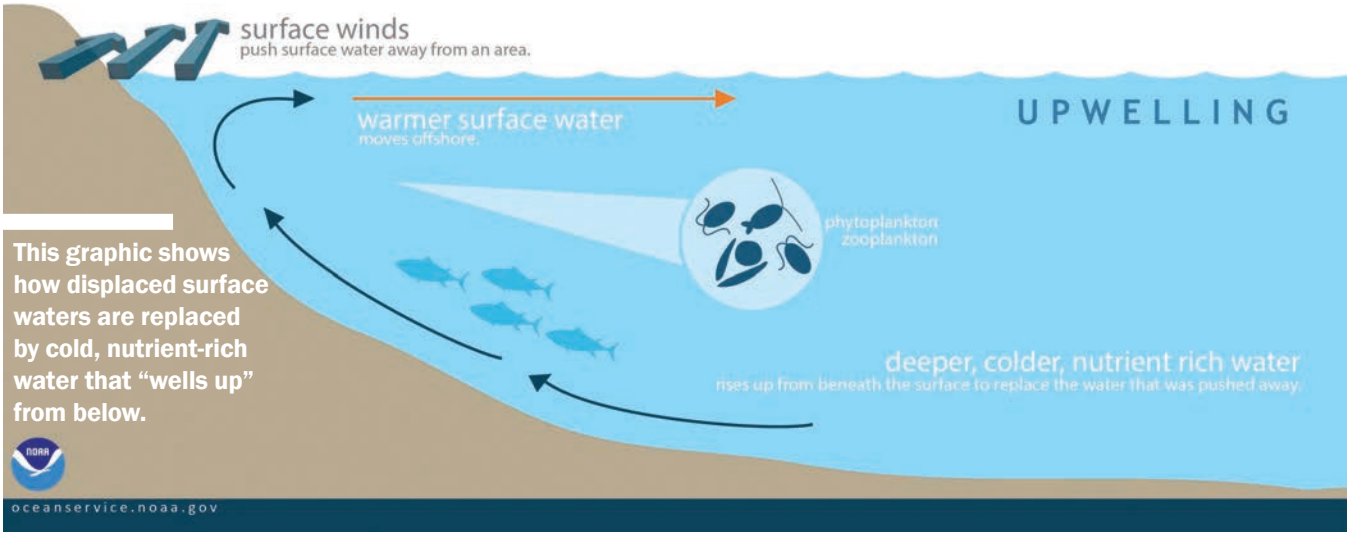
The urgency and scale are daunting. As emphasized by ClimateWorks Foundation program manager Frances Wang and senior director Jan Mazurek, recent research identified the need to remove 10-20 gigatons of CO2 by 2050—and keep this up for hundreds of years, alongside zero emissions to maintain a safe range of global warming. ClimateWorks supports research on and engagement with the development of both natural and technological approaches to CDR. The benefits of this work, according to Wang and Mazurek, are apparent in that the ocean has higher potential for carbon storage compared to land, ocean CDR doesn't compete for land use and accelerates natural sequestration processes, and some approaches offer opportunities to restore ocean ecosystem health.

"The ocean is a crucial element in our climate toolbox that cannot be ignored; it is one of the Earth's biggest carbon sinks," Wang and Mazurek explained. "However, natural processes of the carbon cycle are far too slow to lessen, let alone reverse, our climate change trajectory over the next decades. But if we can accelerate the rate by which the ocean can safely take up and store CO2 to help achieve climate goals, while also bringing current emissions to zero, it is a powerful opportunity to protect the environment and human life."

Seaweed savior

NASEM's recent report identified seaweed farming as one of the six ocean CDR techniques being actively pursued. Organizations like Oceans 2050, founded by activists Alexandra Cousteau and Fritz Neumeyer, is one leader in the industry. "Seaweed is a nature-based climate solution," program manager Joshua Boyce explained. "As the seaweed grows, it pulls CO2 from the atmosphere and top layer of ocean water and converts it into biomass. During its lifecycle, a significant amount of the seaweed detaches and falls to the ocean floor, where it is durably sequestered."

The benefits of seaweed aquaculture, according to Boyce, are plentiful. When growing seaweed, unlike other natural carbon sinks like trees, there's no need to add water or nutrients; the marine alga gets everything it needs from the surrounding environment. Seaweed is also quickly becoming popular for bioplastics, animal feed supplements and fertilizer replacement, which further offsets



This graphic shows how displaced surface waters are replaced by cold, nutrient-rich water that "wells up" from below.

© NOAA

emissions. Furthermore, seaweed farms provide refuge for local biodiversity, reducing ocean acidity and increasing oxygenation.

To advance seaweed farming as a competitive and effective CDR technique, Oceans 2050 is conducting a study to better understand the process and the rate at which carbon dioxide is removed from the atmosphere. The study, which covers 20 farms in 12 countries, is nearly complete, with results to be announced at the end of March during Monaco Ocean Week. With the study results, Boyce shares, "We intend to submit a carbon credit methodology, and generate Verified Carbon Standard carbon credits for the carbon sequestration work our partner farmers are already doing." And the future of seaweed farming for CDR looks bright. "There are clear guardrails to ensure alignment with Sustainable Development Goals and the local environmental health. Additionally, the biomass generated from these farms is used to offset carbon downstream through biopolymers, feedstock additives, bio-methane and other uses—all multiplying the benefit of this work."

A tidewater glacier in Prince William Sound. ClimateWorks recently awarded a grant to the Univ. of Washington School of Oceanography, U.S. Geological Survey Alaska Science Center and the Prince William Sound Science Center to measure the rate of alkalinity addition from mineral weathering and the link between alkalinity addition and atmospheric CO2 removal.

© Rob Campbell, Prince William Sound Science Center.

Upswell uptick

Elsewhere in ocean CDR technology development, Ocean-based Climate Solutions is dedicated to technique number four — artificial upwelling. Also called enhanced upwelling, this engineered process moves deep water to the surface to grow phytoplankton, the base of the ocean food chain. The natural process of biological pumping involves phytoplankton extracting nutrients from the surface water to trigger ocean photosynthesis, absorbing carbon dioxide and releasing 50-80% of the oxygen humans breathe. "Not many people know this, but the concentration of dissolved nutrients in deep seawater is probably the most important property in terms of its impact on marine life and carbon sequestration," explained Salvador Garcia, chief revenue officer. Nitrogen and phosphorus play especially crucial roles, stimulating the primary production of the phytoplankton that absorb CO2 in the oceans.

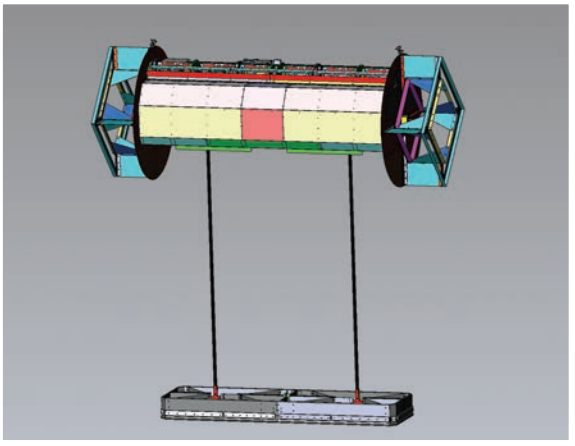
Inspired by the events of Hurricane Katrina, company founder and CEO Philip Kithil was moved to design a wave-powered ocean pump to cool the ocean's surface and in turn, lower the intensity of hurricanes. Coincidentally, this process also simulated artificial upwelling, and subsequent research by the University of Hawai'i and Oregon State found that pumping water from below 200 meters triggered phytoplankton blooms at the surface. The company's technology is designed for deployment in "ocean deserts," Garcia said. "We believe if the war on climate change is to be won or lost, it will be in our oceans. 71% of the Earth's surface is ocean. 65% of the earth's surface is ocean desert, or void of life. A blue ocean is a dead ocean."

The pump itself consists of three parts: a buoy at the ocean's surface with an

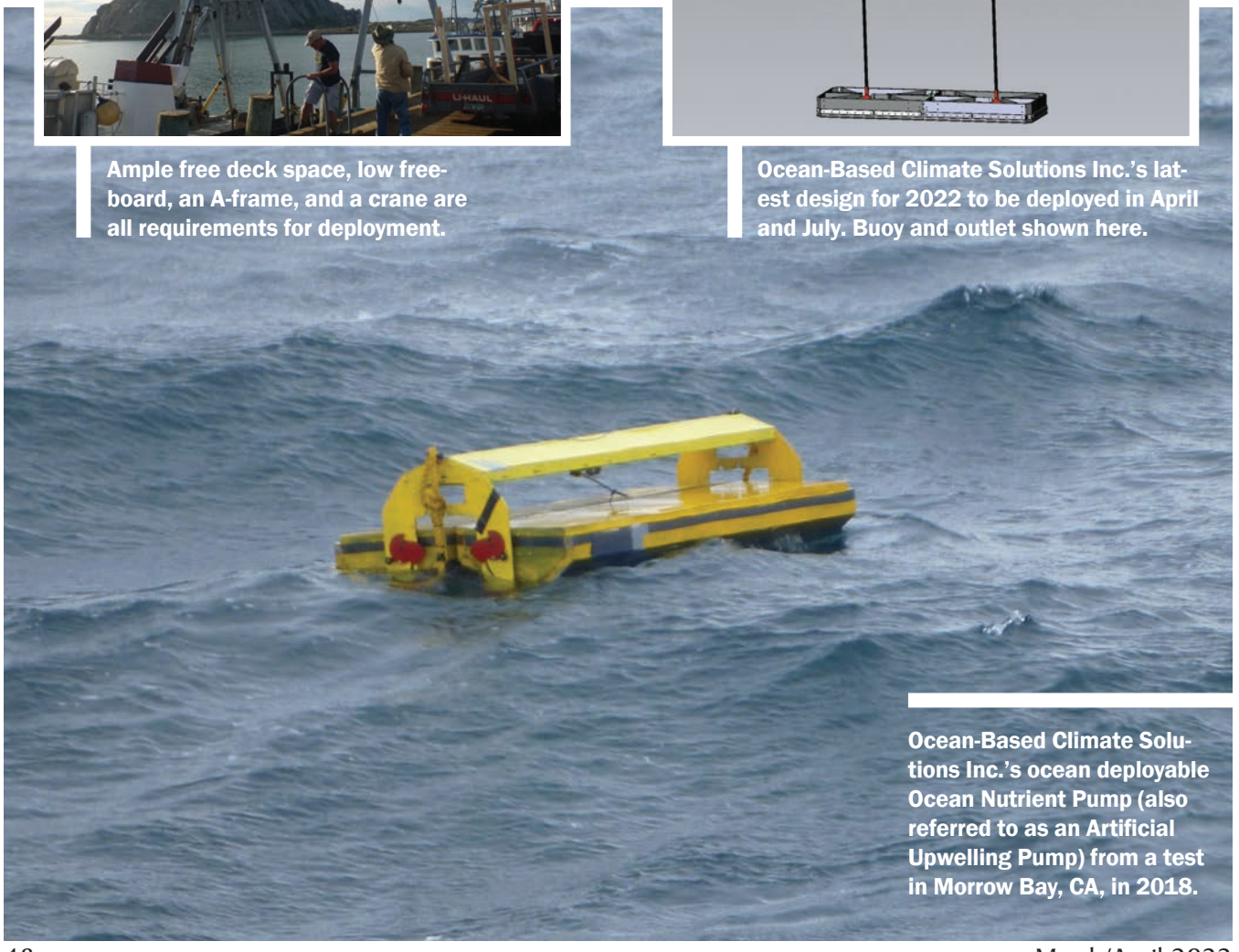
outlet five meters below the surface, a fabric tube (initially spooled around the buoy) that measures 500 meters long by 1.9 meters in diameter and is attached to the outlet and a one-way bottom-weight valve that primes the tube with seawater as it sinks to a half kilometer depth and helps keep the pump vertical in the ocean. "When the buoy falls on a wave, the bottom one-way valve opens, allowing the cold, nutrient-rich deep ocean water to enter from the bottom. When the buoy rises on a wave, the bottom one-way valve closes, and the water in the tube rises until it reaches the outlet," Garcia explained. The buoy is also equipped with scientific instrumentation to collect data like temperature, wave height, water flow rate, strain gauges and GPS location. The measurement of CO2 is gathered with a biogeochemical Argo that has a variety of sensors, like a fluorometer for chlorophyll that depicts the concentration of phytoplankton in ocean deserts. The algorithm then model phytoplankton growth during the next 48 hours.

Ocean CDR looks increasingly promising, from urgency driving current research to the foundation of active solution development. Techniques like seaweed farming are underway, boasting a comprehensive list of benefits. Artificial upwelling, Garcia predicts, could have

Ample free deck space, low freeboard, an A-frame, and a crane are all requirements for deployment.



Ocean-Based Climate Solutions Inc.'s latest design for 2022 to be deployed in April and July. Buoy and outlet shown here.



Ocean-Based Climate Solutions Inc.'s ocean deployable Ocean Nutrient Pump (also referred to as an Artificial Upwelling Pump) from a test in Morrow Bay, CA, in 2018.

All three images © Ocean-based Climate Solutions, Inc.

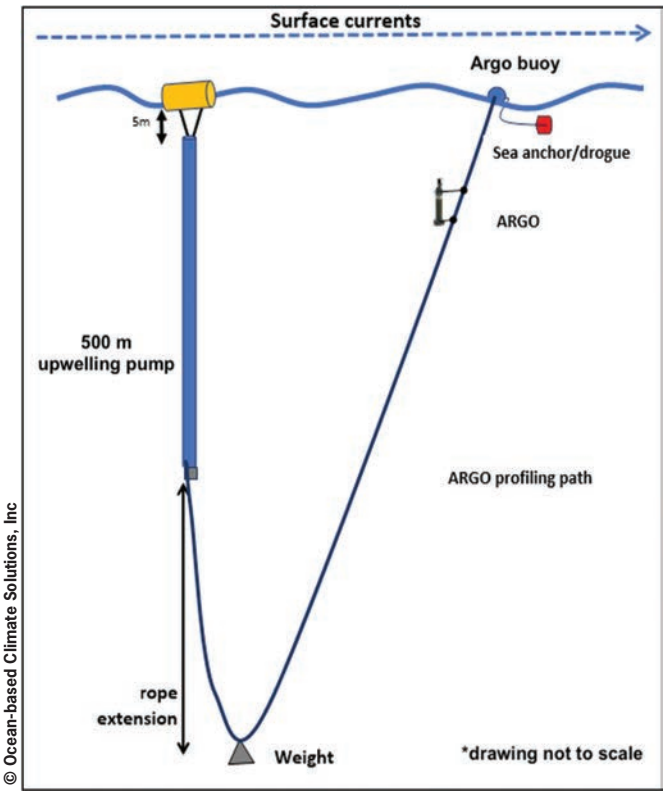
enormous impacts:

"If we deploy 4000 pumps—this will reduce approximately 1 million tons (a megaton) of CO2. We estimate that four million pumps deployed would sequester about 1 billion tons of CO2 (a gigaton)."

At the same time, only further investigation can make ocean CDR a reality. "We need more responsible experiments and deliberate and pervasive monitoring of the ocean carbon cycle. These experiments themselves would not cause irreparable harm to the ocean, but it's essential to make smart choices about how to reduce suffering and loss due to climate change," Buesseler said.

Federal, academic and philanthropic research and support are crucial for the commercialization and mass rollout of CDR techniques.

With only 28 years until 2050, the clock is ticking. Ocean CDR presents an attainable and effective way to enhance and accelerate natural carbon processes and a possible game-changing solution to reduce emissions. As Buesseler puts it aptly, "The alternative—doing nothing—is a path we are on today that has severe consequences for humanity."



The BGC Argo is designed to measure from a 1000 meters depth to the surface three to four times a day—measuring the amount of CO2 grown near the pump.

Advanced Navigation launches Micro-AUV

Hydrus is a fully autonomous subsea robot designed to make surveying easy and affordable.

Advanced Navigation, an AI navigation and robotics systems manufacturer, have launched Hydrus, an autonomous subsea robot that combines advanced navigation, sonar and communication capabilities. This technology suite is combined with a 4K60 camera in an incredibly small form factor. Hydrus was designed with the notion to simplify underwater data collection and inspection at a price point lower than the industry norm. It is targeted at applications requiring high-resolution images and video with precise geo-referenced data.

''We have seen a revolution occur in the aerial drone market, where smaller, easy to use drones have opened new opportunities in applications previously restricted by cost. Hydrus is intended to offer the same accessibility to the underwater world.'' said Xavier Orr, Advanced Navigation's CEO.

Hydrus is effectively an all-in-one surveying crew, alleviating the need for expensive ROVs/AUVs, survey vessels, highly trained operators and divers. Providing unparalleled flexibility, ease of use, and affordability, Hydrus is the drone revolution, underwater.

As an all-in-one autonomous solution, 3D missions can be planned in minutes, without specific knowledge or training. The acoustic communication capabilities allow users to monitor and adjust missions on the fly.

Hydrus is small enough to be carried on a plane, and can be launched and retrieved by a single person. No special watercraft is required. Upon mission completion, data can be wirelessly retrieved using a computer.

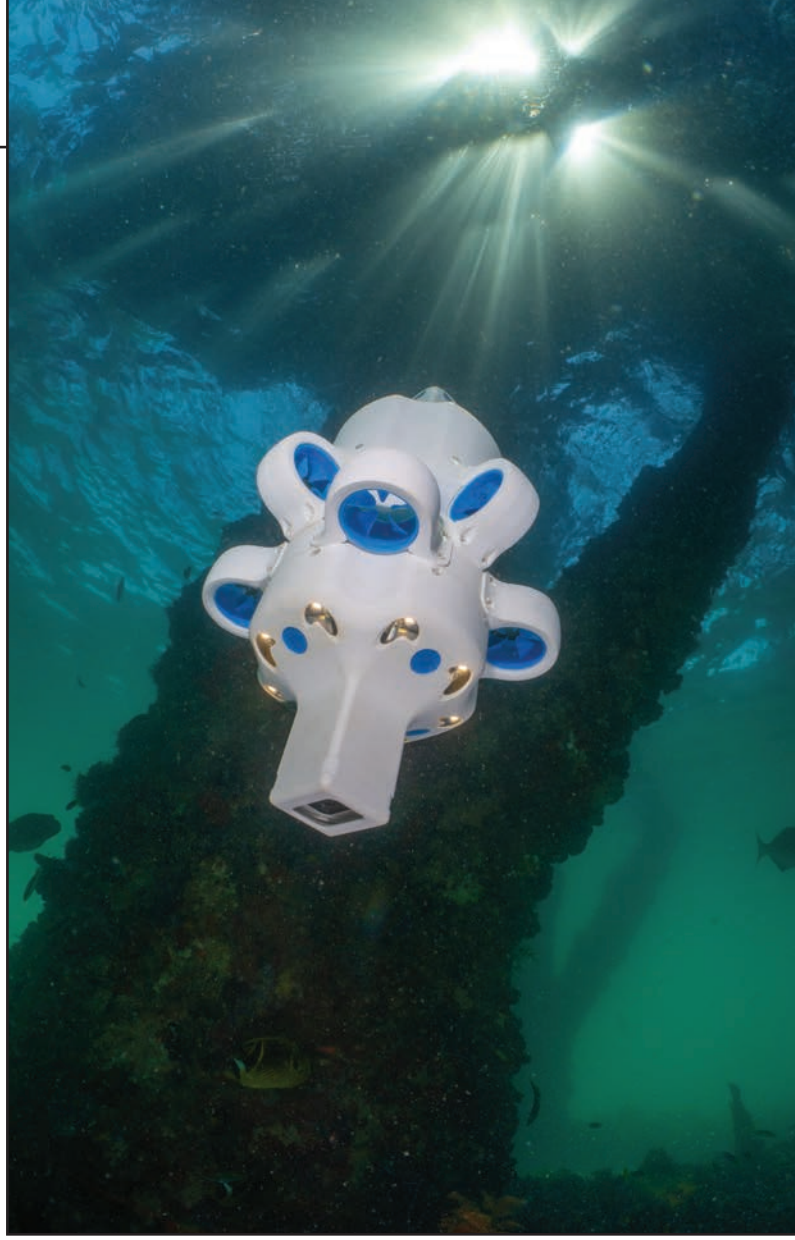
A 4K 60 fps camera coupled with a powerful lighting system ensures the highest quality video and photography. An AI image processing system dynamically balances the camera and lighting system, and compensates for turbidity, even in the most challenging conditions.

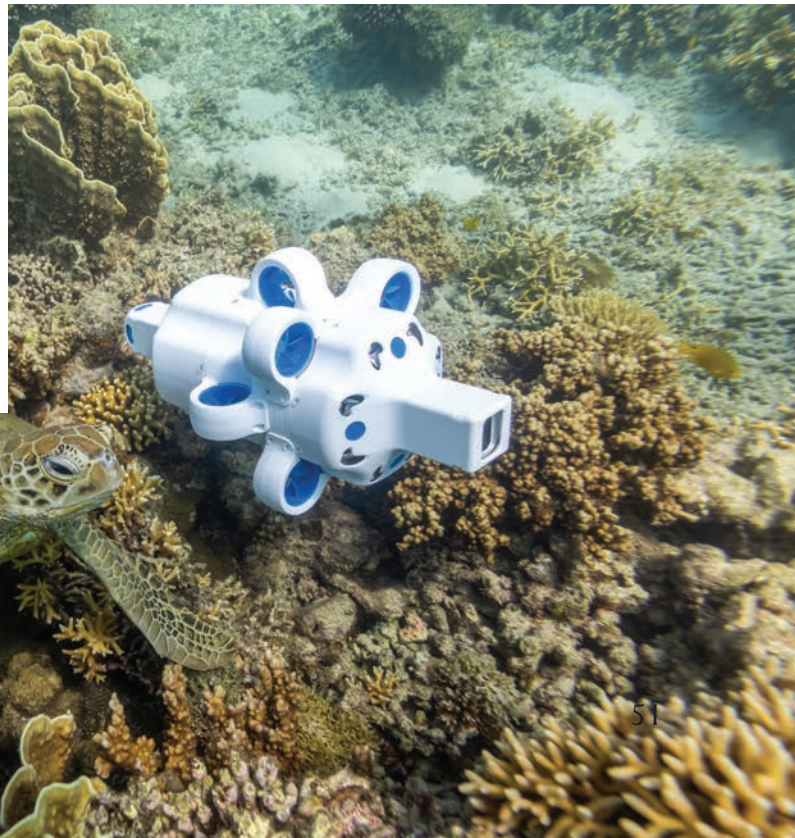
Hydrus features advanced dynamic AI guidance with obstacle avoidance, altitude control and image quality control. It features a USBL, DVL, INS, acoustic and optical modems all tightly coupled into one integrated package.

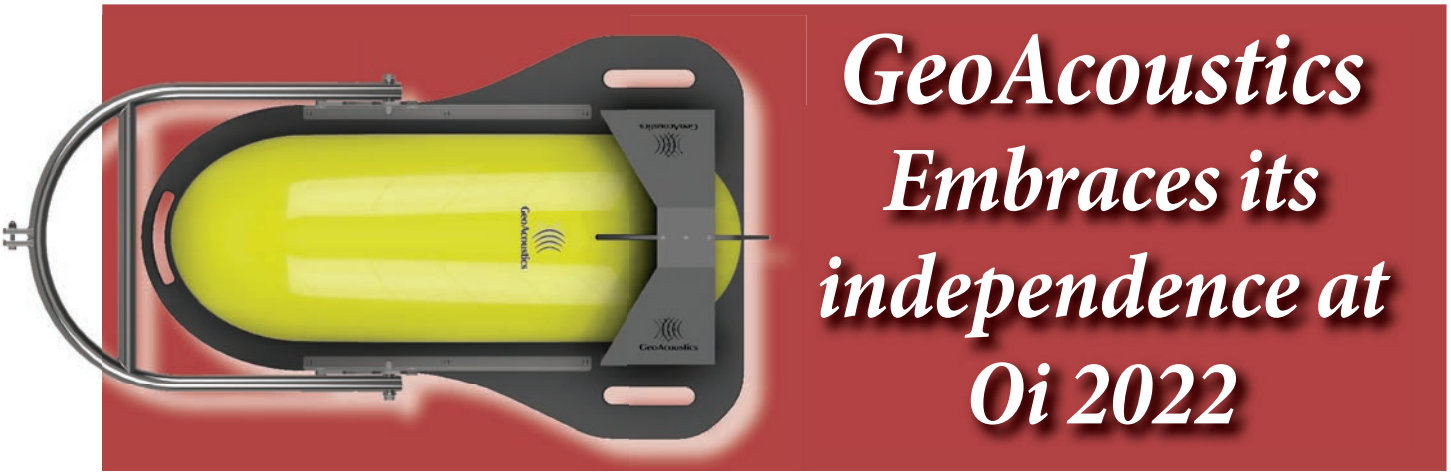
Hydrus is designed to undertake missions of up to three hours duration, has a range of 9 km (2.5 miles), with a maximum speed of 9 km/h (5 knots) and a 3 km (10,000 ft) depth rating.

Proprietary hubless thrusters prevent impellers from getting jammed with ropes or seaweeds. The fully sealed, connectorless design makes for the most reliable and low-maintenance AUV on the market.

Hydrus will be available in Q3 2022.







GeoAcoustics Embraces its independence at Oi 2022

Images courtesy GeoAcoustics Ltd.

*According to **Richard Dowdeswell**, General Manager of GeoAcoustics Ltd., a new era is underway for the British bathymetric sonar, side scan sonar and sub bottom profiler specialist that first opened for business 44 years ago.*

Last time GeoAcoustics products were represented at an Oceanology International event, the UK-based underwater technology manufacturer was owned by Kongsberg Maritime and its products were marketed as part of the Norwegian firm's Subsea Sensors & Robotics Division. Following its divestment in December 2020 however, GeoAcoustics is once again an independent company, with freedom to steer developments across its technology portfolio and act on the individual needs of customers.

"It's been four years since we were at an Oceanology International so we're looking forward to getting back to the ExCeL and meeting up with our customers and industry colleagues, especially as we are turning the page on a new chapter in the GeoAcoustics story," said Dowdeswell, the former head of Kongsberg GeoAcoustics and now co-owner and General Manager of GeoAcoustics.

Founded in 1978 as ORE Ltd. (Offshore Research Equipment), the company started out leasing advanced subsea technology such as side scan sonar, subbottom profilers, SBL/LBL positioning and acoustic telemetry systems. Its first taste of corporate ownership came when ORE Ltd. was acquired by Ferranti Industrial Electronics in 1983, becoming part of the Offshore Industries Group and renamed Ferranti ORE Ltd. In 1991 it returned to private ownership and continued to build a position as a Side Scan Sonar technology under the name, GeoAcoustics Ltd. Fast forward to 2008 and GeoAcoustics was purchased by Kongsberg Maritime AS; its products joining perhaps the largest underwater technology portfolio in the world.

Now back an independent company once again, and sporting the name first established in the nineties, GeoAcoustics is in the midst of a transformative process. Significant investment in its Great Yarmouth, UK, Headquarters and production facilities have set the scene for a more sustainable and agile approach to business. Going carbon neutral is on the cards, but primarily, the extensive building renovations and key appointments made in 2020 reflect a new vision and vitality for a specialist technology company in business long enough to have already had a 40th birthday party.

"Despite a challenging 2020 there's real positivity in the market and with the team, in part from the practical and sustainable improvements we have made to the working environment, but also due to the potential we have to grow and secure a long-term future as GeoAcoustics Ltd.," said Dowdeswell, adding that, "like everyone, we were in pandemic mode last year, but we were lucky enough to get a chance to take this positivity on the road with us to Ocean Business in Southampton, where we had a strong first showing of GeoAcoustics Ltd as it is today."

So, Oi 2022 will not be the debut industry event for GeoAcoustics as an independent company. Its size and potential for international visitors – though clearly not as many are as expected as in normal years – position Oi 2022 as a platform for Dowdeswell and his team to showcase GeoAcoustics' capabilities as a global player in the underwater technology market. "We were focused on the application of our technologies at Ocean Business, with on water demonstrations in collaboration with Unmanned Survey Solutions using the Inception MK II

USV as a survey platform proving particularly popular."

Since becoming independent at the end of 2020, GeoAocustics has continued to develop its global partner network, ensuring that its products are available and fully supported by specialist local companies that understand the challenges their customers face and how GeoAcoustics technology can help them. The company now has 50 sales and service partners in 71 countries, many of whom had already shown their commitment to GeoAcoustics products as Kongsberg Maritime partners, but several new key partners were brought into the mix last year. "Our partners are essential to our business performance and industry profile, which is why we have chosen to collaborate with knowledgeable companies that know their local market and the applications that are products are used in. We work closely with our global network and hope to meet up with both established and new partners at ExCeL in March," said Dowdeswell. He said the break-up with Kongsberg Maritime has been nothing but amicable and the opportunity to sit down with his former colleagues at Oi 2022 is incredibly positive. The companies continue to work closely together on sales and technology, with a brand new jointly developed solution close to completion, though sadly not in time to announce at Oi 2022. Dowdeswell concludes by telling us that, "Oceanology International allows us to present the technology portfolio that will keep GeoAcoustics at the forefront. While the products we will highlight on our stand are already established, and in some cases, viewed as de facto industry standard, we will be introducing new features and upgrades later in the year to ensure we continue to deliver the precision and capabilities our customers demand for efficient, accurate survey and monitoring applications."

At Oi 2022 @ Booth N400, GeoAcoustics will have on display its Bathymetric Sonar; Side Scan Sonar and Sub-Bottom Profiling.

RTsys: RUBHY Buoy

Designed for automated and intuitive operations, the RUBHY buoy can record, send and display real time underwater noise such as SEL – Sound Exposure Level and SPL – Sound Pressure Level over a 10 km distance. In combination of the sound monitoring and transfer, multi parameter sensors like CTD, O^2, turbidity, pH and any other oceanographic data can be simultaneously recorded and sent.

Specially adapted to offshore conditions, RUBHY is the optimal solution for underwater noise monitoring during pile driving and drilling operations on offshore wind farm constructions, hydrographic and scientific survey for protective areas surveillance and mammal monitoring and tracking, autonomous real- time noise surveying of port construction and dredging works.

RUBHY is robust and can sustain up to Sea State 5 conditions. The buoy can be easily and safely deployed from supply vessels and offshore platforms. The recorder device is placed into the dry section of the buoy assembly and is easily removable, interchangeable and rechargeable.

The intuitive user interface is easy to use and provides thorough data for rapid understanding.

Alerts can also be set through a cloud application named RESONANCE displaying real- time chemicophysical and acoustics data.

These alerts being sent automatically when defined thresholds are exceeded.

The remote control of RESONANCE application allows to set parameters from the user interface. Charts and reports also help to analyze assessments and monitor unlimited quantity of buoys simultaneously all over the world.

Dimensions:
Float diameter: 1250 mm
Buoy height: 2270 mm
Weight: 238 kg

Supplied hardware:
Rugged buoy
Up to 4 hydrophones and rugged cables
UHF and WiFi Receivers
Oceanographic sensors in option
Protective frame for hydrophones

Strong skills:
Real Time data transmission
Acoustics and multi parameter sensors
Radio: SEL/SPL transmission calculation results
WiFi: Data and system management
Iridium and 4G: pre-processed data transmission to web server

Images courtesy RTsys

Photo courtesy Oceanology International

OI '22 London

Preview of what you'll see March 15-17, 2022

aae technologies
At Oi aae will host live equipment workshops and demonstrations onboard the Solent Guardian.
Booth J301

Airmar
Airmar Technology pushes the boundaries of ultrasonic technology to develop advanced products that withstand the harshest ocean environments while reliably facilitating data gathering from surface to full ocean depth. Its WeatherStation instruments and marine, oceanographic and survey transducers deliver performance.
Booth B250

AML Oceanographic
AML Oceanographic provides ocean sensing solutions for hydrographic, environmental, and research applications. For over 45 years, AML has manufactured sound velocity/CTD profilers and multiparameter sondes. Patented field-swappable sensors give complete flexibility for their instrument configurations.
Booth D400

AutoNaut
AutoNaut USV's 16-week 4,000nm data mission in 2021 is presented at Oi. From August to No-vember 2021 the 5m wave propelled AutoNaut zig zagged down the continental shelf break from the Scottish Asso-ciation for Marine Science (SAMS) at Oban, to Penzance in Cornwall, deploying Nortek Signature500 ADCP, Seiche micro-PAM, Aanderaa Motus wave sensor, and SBE 49s CTD.
Booths Q100 & P501

BIRNS, Inc.
BIRNS is an ISO 9001:2015 certified global leader in the design and manufacturing of high-performance lighting and connector systems. Since 1954, BIRNS has provided solutions trusted in the planet's most demanding environments--from deep ocean and marine science applications to military programs.
Booth K300

Airmar

AML Oceanographic

Deepwater Buoyancy

EdgeTech

Blueye Robotics
This Norwegian company is a first-time exhibitor at Oi, and is keen to make a big impression with its Blueye X3 ROV with daily dockside demonstrations.
Booth D503

Blueprint Subsea
Blueprint Subsea's range of underwater acoustic products have been meeting the demands of the subsea, offshore and defense markets since 2006. Blueprint Subsea specializes in 2D imaging sonars, acoustic positioning beacons and diver navigation systems.
Booth K350

Chesapeake Technology, Inc.
Chesapeake Technology, Inc., are makers of SonarWiz software. SonarWiz is an all-in-one solution for geophysical, hydrographic, and archeological surveys. Collect and process sidescan, sub bottom, single beam and multibeam bathymetry and magnetometer data. Data acquisition is easy to use and works with most sonars in the market.
Booth F10

CSignum Ltd.
CSignum is a wireless communications provider designed to enable reliable transmission of data through and across the water-air boundary, water column, seabed and underwater structures using HydroFi technology.
Booth Q301

Deep Ocean Engineering, Inc
Deep Ocean Engineering, Inc. provides integrated robotic solutions and products for various underwater applications in diverse and harsh operating environments. DOE designs, builds and tests all of its remotely operated vehicles (ROVs) at its plant in Silicon Valley, CA, and to date it has provided more than 600 ROV systems in over 30 countries worldwide.
Booth F351

Deepwater Buoyancy
DeepWater Buoyancy is a supplier of subsea buoyancy to the ocean science community. At the heart of the DeepWater Buoyancy product line are the subsurface ADCP buoys. Originally consisting of spherical and elliptical buoys, the product line also includes the unique StableMoor Mooring Buoys.
Booth K20

Digital Edge Subsea Ltd
Digital Edge Subsea supplies the oil and gas industry with a range of digital video inspection systems, the EdgeDVR. It launched its new Version 5 software in 2020, and now offers three software and four hardware options. Edge Lite, Edge and Edge Pro on the software side. 4K, HD and SD 4U and Laptop.
Booth K551

EdgeTech
EdgeTech will be showcasing several new side scan sonar, sub-bottom profiling, bathymetry and acoustic release products at Oi, including the new 6205s2 fully integrated wide swath bathymetry and dual frequency side scan sonar system, the new 3400-OTS pole-mount sub-bottom profiler and new acoustic release-based ropeless fishing system.
Booth H201

Fugro

Hydromea

Oi Exhibitor in Focus: **Falmouth Scientific Inc.**

Falmouth Scientific, Inc. (FSI), a provider of sensor and survey solutions for applications in salt and fresh water environments, has a long and storied history, a history intertwined with many other companies and innovators. Celebrating its 33rd anniversary, FSI's sensor-based standard product areas include advanced seismic, sub-bottom, and side scan sonar imaging systems; current, wave, and tide meters; electro-acoustic transducers; and acoustic relocation systems. At FSI's core is innovative system and design engineering, on-site assembly and production operations, and electrical, acoustic, environmental and system testing facilities.

FSI's History

FSI was founded in 1989 based on a WHOI technology licenses, and is located in the heart of the New England marine technology cluster in Cataumet, Mass.

FSI acquired Hegg Marine Solutions (HMS) in 2010 to establish a geophysical line of acoustic products. HMS was founded by Fred Hegg, FSI's current VP of Business Development. Hegg's industry connection spans back to 1980 when he started as an intern at Datasonics in Cataumet, Mass., with a full-time stint in the R&D department of the company ensuing upon his graduation in 1982.

In 1986, Hegg joined the U.S. Marine Corps, spending his time working with anti-aircraft missile system radars. After six years of active service, he rejoined Datasonics in 1992, assisting the project team working on the early "CHIRP" geophysical survey systems. Hegg credits his leadership skills as a USMC sergeant as helping him to evolve into the position as the geophysical systems project manager. "John Baker and I worked together during this time (at Datasonics)," said Hegg. While at Datasonics, Baker contributed to the design and improvement of many of Datasonics products, including the Chirp 2 sub-bottom profiling system, SIS-1000 sea floor imaging system, SIS-1500 side-scan sonar system, and the ATM-800 acoustic modem product line. In 1999 Datasonics was sold to Benthos.

After the sale, Baker and Hegg parted ways, with Hegg following the Teledyne Benthos path while Baker and Bill Dalton formed an engineering company called Acoustikos, setting up shop at the original Datasonics location. Ac-

Images [starting top left and moving clockwise]: FSI's current custom 10,000 sq. ft. facility in Pocasset, Mass.; The original home of Datasonics at 1400 Rt.28A in Cataumet, Mass.; a current meter at ship terminal; and a Bubble Gun survey off Japan.

cording to Hegg, Acoustikossoon became involved with Falmouth Scientific Inc., and in 2002 the companies merged.

With the merger, Baker became President, GM and Senior Electrical/Acoustic Engineer of Falmouth Scientific, and continued operating out of the original original Datasonics locale producing custom engineered systems, CTD's, current meters and other oceanographic sensors. In 2008, Hegg left Teledyne Benthos to form Hegg Marine Solutions. "During this time, I worked on various projects with John Baker (and FSI)."

In 2010, FSI acquired Hegg Marine Solutions. "We began to develop products under the brand of Hegg Marine Solutions, or HMS, now wholly owned by Falmouth Scientific," said Hegg.

Today, HMS is a brand under the FSI umbrella for sub-bottom and side scan sonar system technologies as well as field support services. The main products are the HMS-620 Bubble Gun family of seismic systems, The HMS-622 CHIRPceiver Subottom and the HMS-624 Sidescan. There is also a combined sidescan and sub-bottom available the HMS-6x5 in 2000m-6000m configurations.

"Falmouth Scientific morphed into a company specializing in acoustic sensor and systems to include current meters, sub-bottom systems, seismic sources and custom acoustic transducers and projectors," said Hegg. Most recently, Falmouth Scientific moved into a new custom 10,000 sq. ft. facility to provide an efficient manufacturing and engineering workspace to continue the manufacturing and engineering of acoustic sensors systems and transducers.

For full insight on FSI technology, visit www.falmouth.com, or visit the FSI team at Oceanology International.

Booth Booth N10

Evologics

EvoLogics are bringing the company's latest highlights to Oceanology International 2022.

• EvoLogics qLBL, the ultra-fast positioning method for confined and shallow waters;

• Model S2C 30/60 - the new addition to the underwater acoustic modems range

• USBL Buoy, an all-in-one positioning device for easiest deployment on site

• Sonobot 5 surface vehicle and its new AI-based object recognition feature

• plus the upcoming bionic penguin AUV and other advances in novel robotics

Booth C251

Fugro

A 'first' for Oi this year is Blue Essence, an offshore-certified USV (uncrewed surface vessel) from Fugro. For Oi, Blue Essence will be carrying an electric remotely operated vehicle (eROV) and demonstrating the important and technologically demanding capability of autonomously launching and recovering the eROV with the vessel being controlled from Fugro's remote operations center (ROC) in Aberdeen.

Booth D100

Greensea

Greensea is revolutionizing the future of ocean robotics by providing an open architecture platform, OPENSEA, with access to the OPENSEA API through the OPENSEA Enterprise Partnership. OPENSEA enables more intelligent autonomy in any marine vehicle, which will disrupt current marine operations and lead to substantial leaps in new vehicle capabilities. Software makes all robotics processes possible.

Booth H551

Huntington Ingalls Industries

Unmanned Systems, a business group within Huntington Ingalls Industries' Technical Solutions division, creates advanced unmanned maritime solutions for defense, marine research and commercial applications. Serving customers in more than 30 countries, HII provides design, autonomy, manufacturing, testing, operations and sustainment of unmanned systems, including unmanned underwater vehicles (UUVs) and unmanned surface vessels (USVs).

Booth G400

Hydromea

Hydromea, a Swiss-based underwater communication and robotics company, is launching a pair of new products @ Oi London. First is its new rim-driven thruster DiskDrive 80, a patented thruster designed to deliver up to 60N of thrust in an extremely compact form. DiskDrive is a patented, ultra-slim, rim-driven brushless thruster with a thickness of just 25mm. The hub-less propeller prevents it from becoming tangled. Hydromea also is launching its new wireless optical modem LUMA X-UV, a device designed to enable low latency through water communication at up to 10Mbit/s even with high amount of ambient light.

Booth Q300

Hypack, a Xylem Brand

Hypack, a Xylem Brand has been developing HYPACK, HYSWEEP, and DREDGEPACK since 1984. With 38 years' experience, 10,000 users, and support for over 400 sensors and devices, HYPACK is a leading provider of hydrographic and dredging software worldwide.

Booth B350

Impact Subsea

Impact Subsea specializes in compact, subsea sensor solutions encompassing Sonars, Altimeters, Depth Sensors, AHRS and Flooded Member Detection Systems. All existing sensors, including the World's Smallest Imaging Sonar, the ISS360, will be @ Oi.

Booth Q150

iXblue

iXblue is a high-tech company recognized for delivering advanced navigation and marine autonomy solutions. The company develops innovative systems and solutions for inertial navigation, subsea positioning and subsea imagery. Leveraging cutting-edge expertise in the fields of shipbuilding

and robotics, iXblue also designs autonomous maritime platforms that are increasingly efficient, economical and environmentally friendly.
Booths E200, E100

Kongsberg Maritime AS
Kongsberg Maritime is a leader in marine technology. With an extensive portfolio of innovative and integrated products and solutions, Kongsberg Maritime delivers efficiency, reliability, flexibility, and environmental sustainability to enhance the business of its customers.
Booth D600

Kraken Robotic Systems Inc.
Kraken Robotics is a marine technology company dedicated to the design and production of synthetic aperture sonar (SAS) sensors, subsea batteries, and underwater robotic systems including launch and recovery systems. In July 2021, Kraken acquired PanGeo Subsea, a leading services company specializing in high-resolution 3D acoustic imaging solutions for the sub-seabed. Kraken is ranked as a Top 100 marine tech company by *Marine Technology Reporter.*
Booth D250

Miros
Miros specializes in measuring the ocean surface. We develop innovative sensor technology and systems for environmental monitoring to the global offshore and maritime industry. Miros' portfolio of dry, IoT-enabled and cloud-integrated sensors provides accurate, real-time data for weather sensitive operations offshore, as well as offering input to asset integrity systems and coastal monitoring accessible anywhere, anytime, on any device. The primary applications of Miros' sensors include wave and current monitoring and oil spill detection.
Booth N450

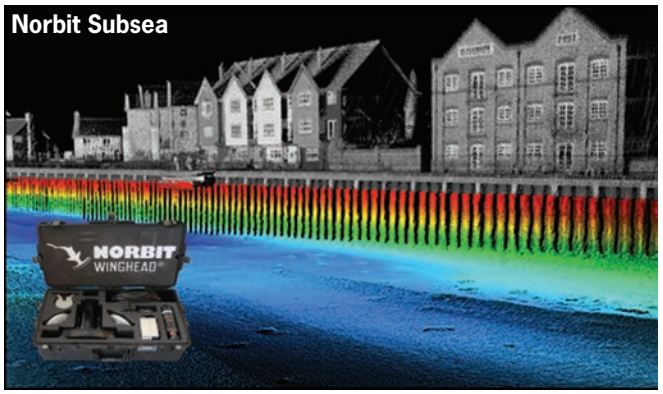
Nautilus Marine Service
Under the brand name VITROVEX Nautilus Marine Service designs and manufactures glass enclosures for deep water buoyancy and oceanographic instrumentation packages. Nautilus Marine Service product lines include: deep sea buoyancy products, bespoke instrument enclosures, housings for cameras and lightning, fibre connectors and heat sinks, hard hats / frames for protection, mooring equipment, and optical domes.
Booth A201

NORBIT Subsea
NORBIT Subsea designs and develops wideband multibeam sonars for bathymetric applications, forward-looking applications, as well as advanced subsea leakage detection. At Oi, NORBIT together with Port of London Authority (PLA), will welcome you aboard SV Thame – one of PLA's dedicated survey vessels. Built in 2011, Thame is a 14.25m catamaran now prepared for live NORBIT demonstrations showing the new WINGHEAD i80S model, which is characterised as an Ultra High-Resolution Integrated 3D & 4D Active Motion Stabilized Bathymetric Multibeam System. In addition, the data acquisition software NORBIT DCT will be shown, and NORdredge solutions discussed.
Booth H600

Novacavi
When a powerful ROV has to face tough offshore conditions, it has to be connected with the proper reliable umbilical cable. This is why Copenhagen Subsea addressed Novacavi for its Gorilla ROV new cable solution and Novacavi developed a custom neutrally buoyant fiber optic data umbilical cable for fast and noise immune transfer of data.
Booth N250

OceanAlpha
OceanAlpha, a USV developer and manufacturer based in Hong Kong, is uniting with its French distributor, Cadden, to present an enticing interaction space. In addition to usual product displays, various high-tech elements are introduced to maximize the visitor experience. Browse 3D product models through an interactive screen, or video-chat with a representative from the Hong Kong office to get first-hand R&D updates and technical advice. Also enjoy the fun of driving a USV in person at their waterfront demonstration, held from 11:30 to 12:00 every day in CABIN 1 at the dockside.
Booth G450

RBR
Since 1973, RBR has been designing and manufacturing oceanographic instruments in Ottawa, Canada. From the ocean abyss to the polar ice cap, our sensors track water parameters: temperature, depth, salinity, dissolved gases, pH, and many others. Visit the RBR booth at Oi to see new innovations in CTD technology, biogeochemical sensors, tide and wave recorders, compact tem-



Norbit Subsea

Sea Machines

Photo courtesy David Shopper

perature and pressure instruments, and ocean-floor seismic solutions.
Booth H251

RJE Oceanbotics Inc.
RJE are a leader in providing quality acoustic relocation systems for equipment moorings, AUVs and ROVs that include acoustic beacons/transponders and a full line of acoustic re-ceivers.
Booth C250

RTSYS
RTSYS designs and manufactures manned and unmanned systems run by underwater acoustics:
- Underwater recorders, buoys, stations and defense acoustics (sonar retrofit, sonar calibration)
- AUVs
- Diverheld sonar and nav systems

RTSYS addresses scientists, offshore consultants and Navies."
Booth J551

Saab Seaeye Ltd
Saab Seaeye is a leading manufacturer of Electric ROV systems, with more than 1,000 ROV systems sold. From the portable Falcon to the new revolutionary eWROV, each system is carefully configured to meet our customer's requirements using our in house team of experienced engineers.
Booth H100

SBG Systems SAS
SBG Systems is a supplier of miniature, high performance & cost-effective inertial motion sens-ing solutions. Its Motion Sensors and Inertial Navigation Systems are ideal for ship motion monitoring; SONAR, LiDAR, and Buoy orientation & position; ROV & AUV control, Qinertia, our new INS/GNSS post-processing software completes the solution.
Booth D300

Sea Machines Robotics
Sea Machines is a leader in the development of autonomous command and control technology and long-range computer vision perception for the maritime industry. By leveraging sensor expertise, artificial intelligence and machine learning we have created technology at the forefront of groundbreaking advancements in the maritime space.
Booth K501

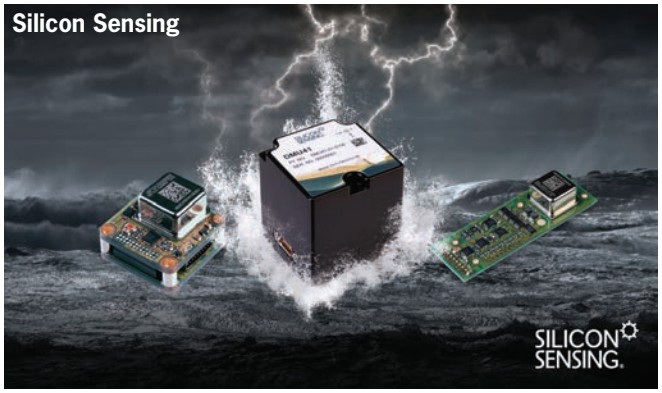
Seafloor Systems
Seafloor Systems will demonstrate its EchoBoat-240 Unmanned Surface Vessel dockside at Oi. The EchoBoat-240 excels in mapping confined, shallow bodies of water where traditional survey methods are not suitable. With new advancements in collision avoidance technology, the navigation abilities of the EchoBoat-240 have leaped into the fully-autonomous realm. Additionally, Seafloor will display a portable, multibeam survey vessel, a new platform combining high-resolution data quality of multibeam sonar with heightened portability.
Booth P300

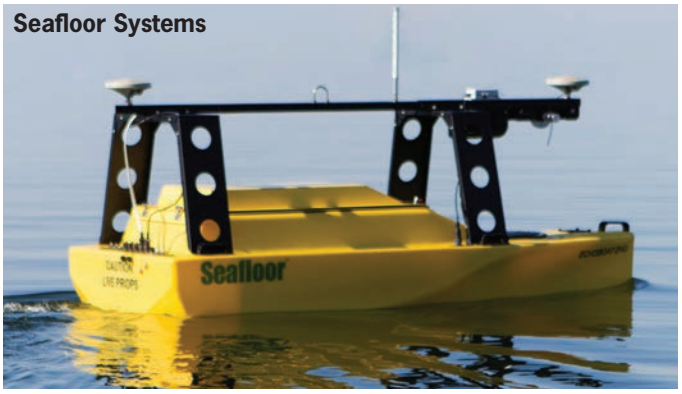
Seamor Marine Ltd.
SEAMOR Marine are pioneers in the global inspection class underwater ROV market, tracing our roots back to the first prototype, developed in 1989. Proven time and again in the toughest environments worldwide in the commercial, government and science sectors, our hyper modular ROV systems are expandable, reliable, adaptable, and easy to use and service.
Booth P351

Sensor Technology Ltd
Sensor Technology is a leader in piezoelectric acoustic tools and systems. Its market penetration is global in scope, and it specializes in these industry sectors: defense, aquaculture, energy, oceanography and hydrography.
Booth C151

SIDUS Solutions
SIDUS Solutions is a certified integrated systems provider of security and video surveillance systems for worldwide businesses in the research, heavy industry, commercial, military, and energy markets. Sidus equipment, operational in blue water and to 6500-m depths, is available alone or to integrate with existing systems. SIDUS products are used in hazardous areas, industrial processes, and subsea environments to provide real-time and archival situational awareness.
Booth A100

Silicon Sensing
Silicon Sensing will focus its exhibit on three new MEMS-based inertial products: The DMU41 – FOG-comparable inertial performance from the highest-performing silicon MEMS inertial measurement unit (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; And the CRS39A, a highly noise and vibration-tolerant gyro developed for use in severe, space limited-downhole drilling applications and for north finding tasks.
Booth F570

Sonardyne
Sonardyne will be performing dockside demonstrations with a C-Cat 3 USV on loan from the University of Southampton from 12:30-13:00 and 2:30-3:00 every day of the show. Demonstrated technologies will range from the industry-leading SPRINT-Nav Mini hybrid navigator to the Mini-Ranger 2 USBL system, all working together in real-time to output commercially useful navigation and positioning data, including high elevation tracking.
Booth F300

SubC Imaging
SubC Imaging's mission is to continuously create the most technologically advanced and intelligent subsea imaging equipment and software for marine research, offshore oil and gas, aquaculture, fisheries, and other industries.
Booth E401, E400

SubCtech GmbH
SubCtech will be part of Oi'22 with a team of six to discuss possible projects involving ocean monitoring or ocean power. SubCtech will also have two speaker sessions:

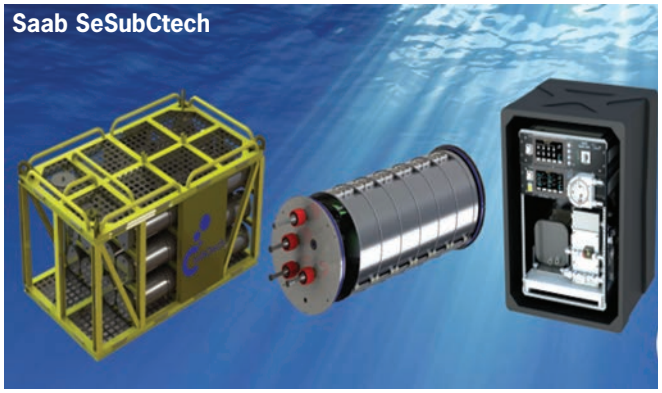
- Ocean Observation March 15, 2022 (11:40-13:20): *Measuring greenhouse gases and other essential ocean parameters presented by Jana & Nuno*, &
- Low Carbon Initiatives March 16, 2022 (13.55 - 15:35): *The Future of All-Electric subsea exploration presented by Gilbert.*

Booth G300

Subnero
Subnero will be at Oi showcasing its software-defined acoustic modems and software framework to help solve subsea problems
Booth A103

TDI-Brooks
TDI-Brooks is a research and service company specializing in high-end environmental chemistry; multi-disciplinary oceanographic and environmental projects; surface geochemical exploration; geotechnical and offshore survey projects for federal and state agencies as well as oil & gas and offshore wind.
Booth M390

Teledyne Marine
With 23 brands and more than 400 products, Teledyne delivers something for everyone. Teledyne's booth has been designed to serve as a collaboration zone, with ample space for customers to relax and reconnect with their OneTeam members in a comfortable, open and engaging setting. To help customers navigate their many solutions, they've dedicated a theater space for presentations that will enlighten and inspire, showing how and where their products are being used alone, and in combination, to solve the difficult challenges customers face in key markets, including: Oceanographic, Energy, Infrastructure & Civil Engineering, Defense & Security, and Marine Life. Teledyne also invites you to experience their products first-hand via daily dockside demos. Get a hands-on look at



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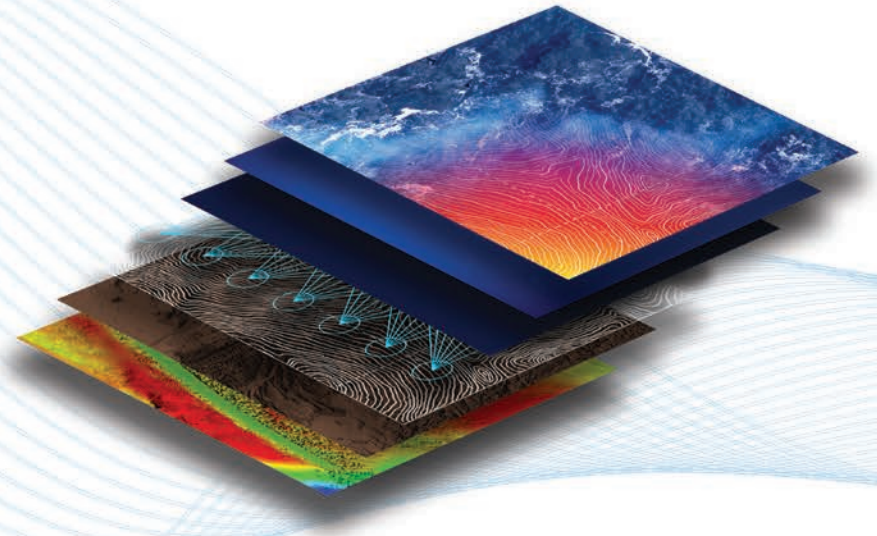

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Teledyne Marine


Valeport

Teledyne Oceanscience's Z-boat 1800 equipped with one of their newest multi-beam sonars, the SeaBat T20-ASV. This sonar has been designed as a fully integrated solution, delivering high-quality SeaBat data from an ASV for fast and easy shallow water surveying.
Booths F100, G100

Tritech International Ltd
Tritech, a Moog Inc company, is a high-technology business dedicated to providing the most reliable imaging and ancillary equipment for use in underwater applications and remains an industry leader in the provision of sensors and tools for ROVs and AUVs.
Booth H400

Valeport Ltd
With more than 50 years' experience in the design, manufacture and integration of precision instruments, Valeport returns to Oi to launch new environmental sensors and showcase a comprehensive range of innovative instruments for ROVs/AUVs and subsea construction and survey. The new Bathy2, an evolution in the collection of bathymetric data, will be shown ahead of its formal release later this year. Also on show are the new miniIPS2 and uvSVX, the new SWiFT CTD and SWiFT CTDplus.
Booth H301

VectorNav
VectorNav Technologies will display its line of RTK/PPK enabled GNSS-Aided Inertial Navigation Systems (GNSS/INS) at Oceanology International 2022. VectorNav's Tactical Series VN-210 and VN-310 GNSS/INS products now support external integration with several Quartz and Fiber Optic Gyroscope (FOG) based external IMUs and Gyrocompass. VectorNav has also furthered its support of the hydrography and bathymetry markets: HYPACK's 2021 Q3 update provides support for VectorNav's Tactical Series. HYPACK's support includes HYPACK Survey and HYSWEEP Survey drivers for VectorNav sensors.
Booth P251

VideoRay LLC
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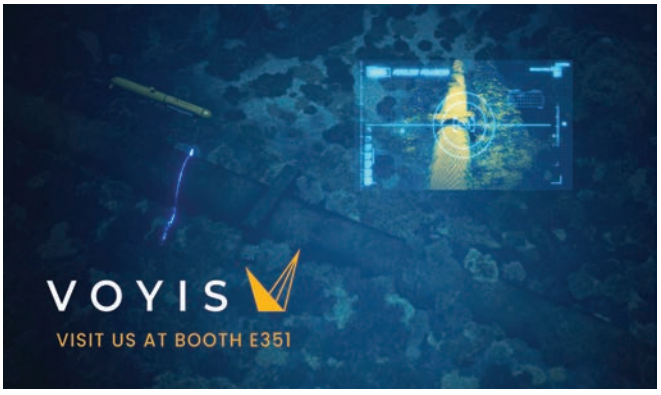

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