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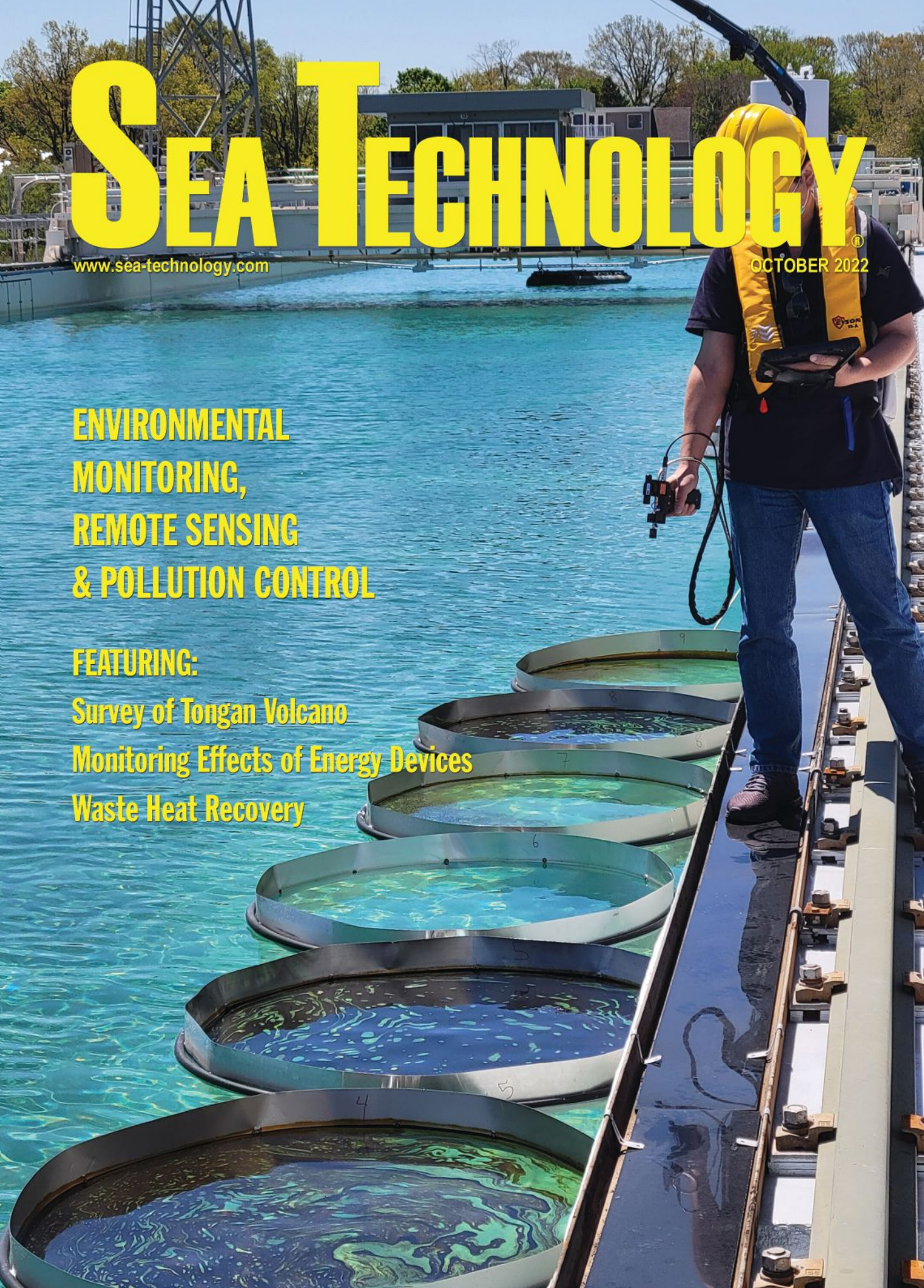
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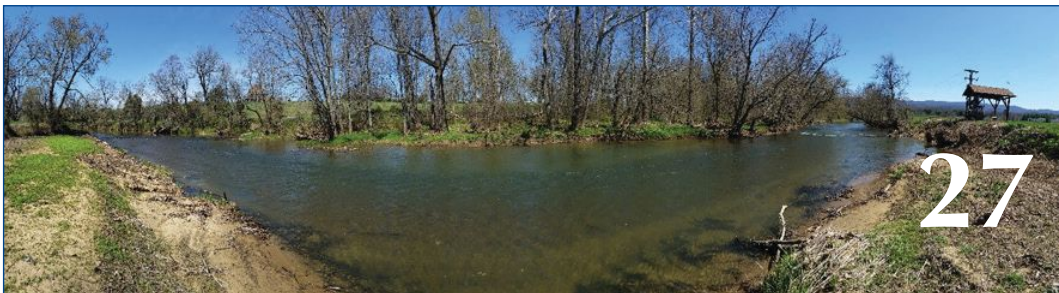
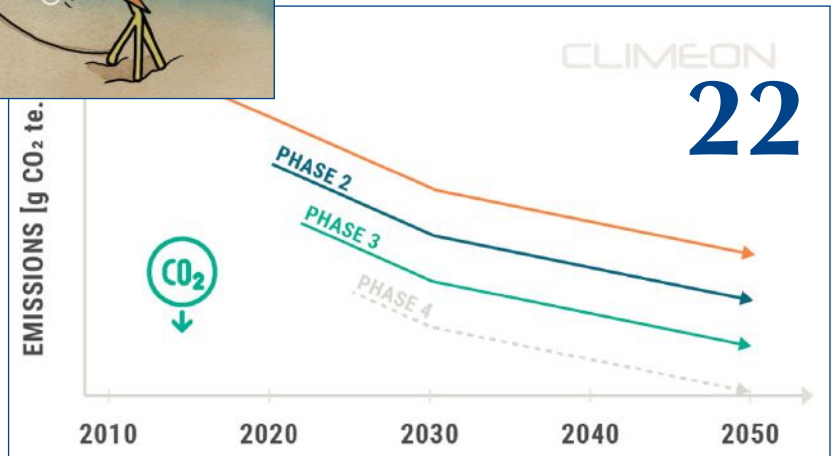
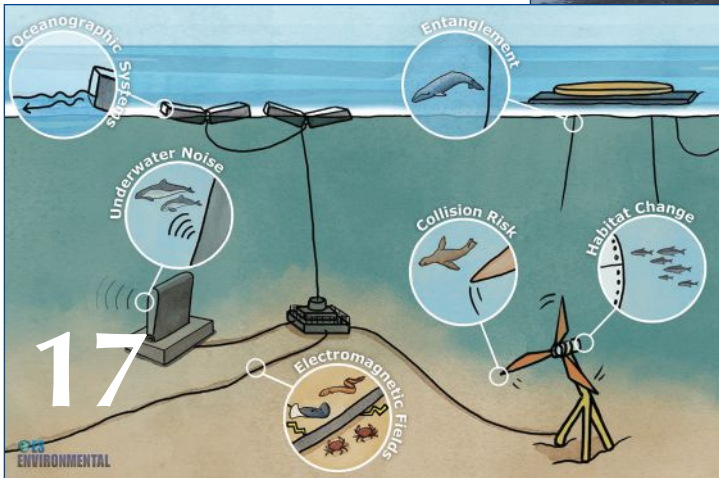
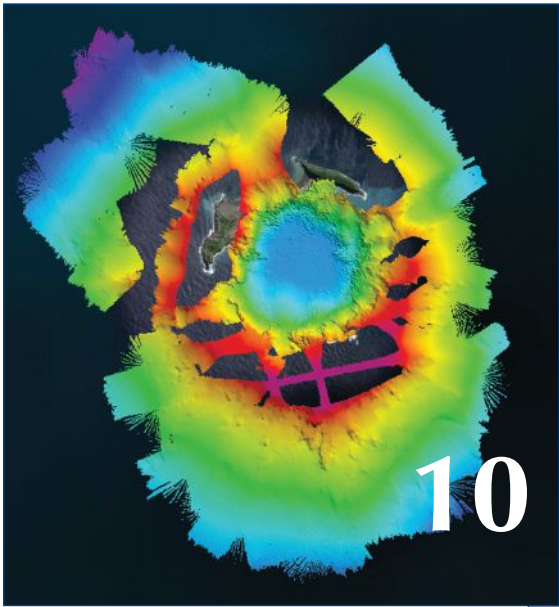
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Dr. Chuanmin Hu of the University of South Florida used sensing technology to detect, characterize and measure oil at Ohmsett – The National Oil Spill Response Research & Renewable Energy Test Facility in May 2022 during a multi-partner research initiative led by NOAA to evaluate the capabilities of various technologies for floating oil detection. (Credit: Grant Coolbaugh, Ohmsett – The National Oil Spill Response Research & Renewable Energy Test Facility)

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)) U.S. High-Tide Flooding Breaks Records. Communities in three locations along the Atlantic and Pacific coasts saw record high-tide flooding last year—a trend that is expected to continue into 2023 and beyond without improved flood defenses, according to NOAA. The newly released information documents changes in high-tide flooding patterns from May 2021 to April 2022 at 97 NOAA tide gauges along the U.S. coast. It also provides a flooding outlook for these locations through April 2023 and projections for the next several decades. High-tide flooding, often referred to as “nuisance” or “sunny day” flooding, is increasingly common due to decades of sea level rise and driven, in part, by climate change. It occurs when tides reach anywhere from 1.75 to 2 ft. above the daily average high tide and start spilling onto streets or bubbling up from storm drains. As sea level rise continues, damaging floods that, decades ago, happened only during a storm, are expected to happen more regularly, such as during a full moon or with a change in prevailing winds or currents. Coastal flood warnings for significant potential risks to life and property are projected to become much more commonplace as we approach 2050. By 2050, national-scale high-tide flooding is expected to occur an average of 45 to 70 days per year. Long-term projections are based on the ranges of expected relative sea level rise of about a foot, on average, across the United States by 2050. Specific NOAA tide gauge data can be found at: https://tidesandcurrents.noaa.gov/HighTideFlooding_AnnualOutlook.html.

)) Discovery of Deepest Known Shipwreck. The deepest shipwreck ever identified, the “Sammy B,” has been discovered by the adventurer Victor Vescovo with help from CSM Energy’s deep submersible support vessel (DSSV) *Pressure Drop*. Vescovo found the USS *Samuel B Roberts*, which went down during the Battle off Samar in the Philippine Sea in October 1944, heavily battered but largely intact. The 93-m-long ship was resting on a broken, steep slope, which made it even harder to locate by sonar because it blended in a bit with the local terrain. The hull was still intact, and the weapons were still loaded with live ammunition, while the mast was broken and the stern was shattered. The expedition took place over 10 days this summer and was the second time the team visited the Philippine Trench in search of wrecks from WWII involved in the Battle off Samar. The DSSV *Pressure Drop*, which has been used on many of Vescovo’s previous expeditions, and its crew enabled the expedition team to stay out at sea as long as it did, with the use of all its specialized equipment to search for, locate and survey the wreck. The vessel carried and supported the deep-ocean submersible *Limiting Factor*, which Vescovo helped to build and then piloted, to dive to the depth it did to discover the wreckage. The *Limiting Factor* vessel has visited the deepest points of all five of the world’s oceans.

)) Advancing Maritime Digital Engineering Tech, Skills in Japan. A group of Japanese technology leaders have established a cooperation program called “Maritime and Ocean Digital Engineering” (MODE) to promote and enhance digital engineering technology and skills for the maritime sector by building cooperative simulation platforms. Japan’s maritime industry is facing challenges, such as developing and implementing new technologies in the context of global decarbonization; maintaining shipping services by integrating autonomous ships to assist seafarers and improve safety; and ensuring high productivity among increasing complexity in ship design and manufacturing processes. MODE aims to address these challenges by using model-based development (MBD) and model-based systems engineering (MBSE), which are increasingly being introduced in the automobile industry. MBD and MBSE approach problems by examining the functions of products and components as computer models, and then checking their behaviors through simulations. MBD and MBSE enable not only the optimization of complex system designs but also the creation of a collaborative development process involving a wide range of stakeholders, including shippers and operators. The program for research and education on maritime MBD and MBSE will be established by forming a broad network between the Graduate Schools of Frontier Sciences and Engineering at the University of Tokyo and other universities and research institutes around the world that are promoting advanced engineering initiatives, plus relevant experts from other industries, such as automobile, aerospace and aviation. The program is expected to expand into maritime fields such as offshore wind power generation and subsea resource development.

)) 108th Anniversary of Panama Canal. The Panama Canal has turned 108 years old, with a legacy marked by continued contributions to international trade and record-breaking figures in recent years, such as the new record set when the containership CMA CGM *Zephyr* passed through the Neopanamax Locks and became the largest ship by cargo capacity to ever transit. Since its inauguration on August 15, 1914, and even more so with the expansion of its capacity in 2016, the Panama Canal has leveraged its geographic location to reshape world commerce, reducing the time, costs and environmental impacts associated with the transportation of finished goods and raw materials. The canal now connects 180 maritime routes that reach 1,920 ports in 170 countries. In 2021, the Panama Canal handled 2.4 percent of global maritime trade. Promoted by the Panama Canal, with the support of the Technological University of Panama, the Center for Innovation, Research and Hydro-environmental Technology was launched recently to bolster the protection of nearby water resources. Last year, the Panama Canal also pledged to become carbon neutral by 2030. As part of this commitment, it developed an annual greenhouse gas inventory, as well as an action plan with measurable objectives to reduce emissions. **ST**

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New Coming of Age For Wind Propulsion

The International Windship Association (IWSA) calls for more inclusion of wind-assisted propulsion technology in regulatory frameworks and a level playing field for all energy sources in international and regional policies and subsidies.

When launching the "Decade of Wind Propulsion" campaign last year, IWSA dubbed 2021 to 2030 as the "Decade to Deliver" on the potential of wind propulsion to help decarbonize the entire current global fleet and the vessels of the future.

In the last year, decarbonization has risen up the International Maritime Organization's (IMO) agenda, and interest in wind propulsion has intensified. The 150-plus members and supporters of IWSA have confirmed new projects, installations, pending orders and the forging of new partnerships every week during 2022 so far.

Wind propulsion has transitioned from the perception of being "blue sky" technology in the previous decade to gaining industry interest over the past few years. The conversion of that interest into investment is now quickening.

There are currently 21 large-vessel wind propulsion installations in operation, and that number will likely double over the next 12 months. A healthy R&D pipeline reported across IWSA members means that the number of test installations on the water can be expected to grow substantially in the coming year.

With the fair winds of the IMO's decarbonization demands and global events such as the COVID-19 pandemic and the conflict in Ukraine driving a growing realization of the need for efficiency and economy to be balanced more and more with energy supply security and resilience, wind propulsion technology developers are in the right place at the right time.

Wind propulsion systems can be used on virtually all types of vessels, large and small. Small wind/solar drones are also being developed for research and mapping/monitoring activities. With wind propulsion, vessels will have a lower acoustic signature and less vibration, which would be conducive to research vessels using sensitive technology.

Although the number of wind-assisted propulsion installations in use is increasing and momentum is starting to grow, critical mass is still some way off.

What's holding the mass uptake of wind propulsion technology back? Shipowners and policymakers need verified data and proven solutions. As more systems are installed and more demonstrator vessels are launched, more validated data will become available. This creates a positive cycle that leads to less uncertainty, less risk and higher uptake. Also, dependency on fossil fuels supplies is being challenged in the mid- to long-term with a marked shift toward renewable energy as decarbonization targets are put in place on a global scale. This will push more shipowners toward wind.

Furthermore, the growing tide of regulation in the shipping industry is acting as a driver, including carbon reduction targets and short-term measures such as the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII).

Wind propulsion technology is not yet sufficiently integrated into international regulatory frameworks and subsidies. IWSA was granted IMO consultative status this year, and there is work to do to position wind propulsion at the heart of IMO's regulatory framework. There also needs to be a level playing field for all energy sources in policy and subsidy.

Positive change is occurring, nonetheless. The new take on wind propulsion is coming of age as a "now" solution to an immediate problem. **ST**

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JANUARY

Annual Review & Forecast

****** *Oceanology International Americas*, February 14-16, San Diego, CA

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

****** *US Hydro*, March 13-19, Mobile, AL

MARCH

Electronic Charting/Vessel Management/ Ports & Harbors/Dredging/Homeland Security

****** *Ocean Business 23*, April 18-20, Southampton, U.K.

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

****** *Offshore Technology Conference*, May 1-4, Houston, TX

****** *XPONENTIAL 2023*, May 8-11, Denver, CO

****** *UDT 2023*, May 9-11, Rostock, Germany

MAY

Communications, Telemetry, Data Processing

****** *OCEANS 2023 Limerick*, June 5-8, Limerick, Ireland

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Survey of HT-HH Eruption's Aftermath

Maxlimer USV Reveals Undersea Impact of Tonga Volcanic Event

By Ben Simpson • Jamie McMichael-Phillips

On January 15, 2022, a South Pacific nation with over 105,000 residents witnessed the unexpected and unprecedented eruption of the Hunga Tonga-Hunga Ha'apai (HT-HH) volcano. The immediate impact had catastrophic consequences for Tonga's islands. The main island of Tongatapu was carpeted in toxic ash, and a sonic boom traveled around the world. The shape of the seabed greatly influenced the speed and size of the tsunami. Death and damage were recorded as far away as South America, and waves hit Australia, New Zealand and Japan, even touching the shores of California, Alaska and Chile. The eruption also severed the submarine fiber-optic cables connecting Tonga with the world, leaving the country in a prolonged blackout.

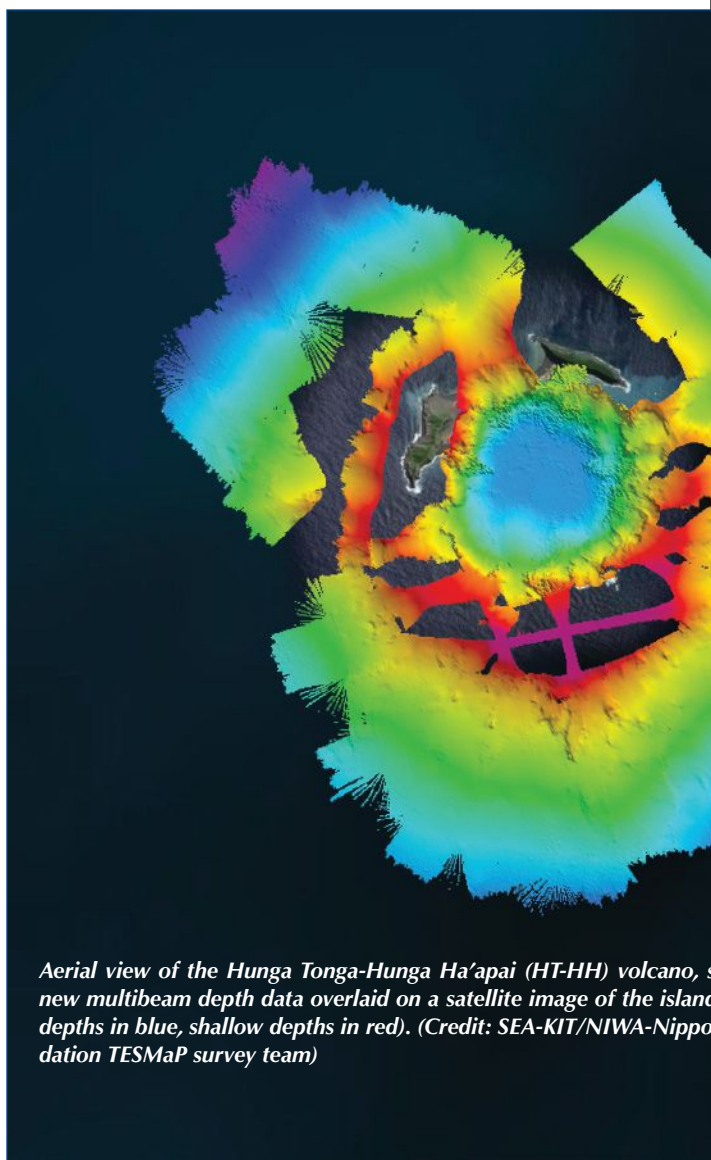
In April 2022, New Zealand's National Institute of Water and Atmospheric Research (NIWA) and The Nippon Foundation of Japan announced a collaborative mission to discover the undersea impacts of the explosion, using their collective knowledge, experience and resources to build a detailed and invaluable picture of the eruption's aftermath below the ocean's surface.

The Tonga Eruption Seabed Mapping Project (TESMaP) is funded by The Nippon Foundation and supported by The Nippon Foundation-GEBCO Seabed 2030 Project, which aims to map the world's entire ocean floor by 2030.

Modeling Future Eruptions

Today, there are around 680 million people living in coastal areas—a figure that is expected to increase to 1 billion in less than just 30 years. These coastal communities face the growing threat of storm surges and tsunamis that can wash away entire neighborhoods and endanger lives in a matter of minutes.

With similar volcanoes around the world, particularly along the Pacific Ring of Fire, the eruption of HT-HH highlights a critical risk to society, exacerbated by a lack of knowledge. Through detailed research and surveys,



Aerial view of the Hunga Tonga-Hunga Ha'apai (HT-HH) volcano, showing new multibeam depth data overlaid on a satellite image of the island. Depths are color-coded: blue for deep areas and red for shallow areas. (Credit: SEA-KIT/NIWA-Nippon Foundation TESMaP survey team)



expanding our collective knowledge of the undersea topography is vital to understanding what happened, how much material was displaced and what shape the volcano was left in. This information enables us to improve tsunami forecasting and better predict the blast effects of subsea volcanoes, which in turn helps to protect people from similar natural disasters in the future.

Phase one of TESMaP, which took place between April and May, saw NIWA scientists on board the research vessel RV *Tangaroa* survey the ocean around HT-HH, covering thousands of square kilometers and collecting video images of the eruption's impact.

Phase two, which took place between July and August this year, utilized SEA-KIT International's 12-m USV Maxlimer to conduct a month of further mapping inside the caldera. This research—conducted in an area that could not be surveyed by NIWA due to safety reasons—will prove crucial to the overall findings of the project.

Surprising Discoveries

The sheer magnitude of the explosion led researchers to expect dramatic changes to the volcano. But instead, researchers on board RV *Tangaroa* for the month-long expedition were amazed to find it largely intact.

NIWA scientists mapped a total of 22,000 sq. km of the surrounding seafloor and observed changes covering an area of 8,000 sq. km. They recorded up to 7 cubic km of displaced material—enough to fill 3 million Olympic-size swimming pools. Tonga's severed domestic internet cable was buried under 30 m of ash and sediment, and scientists found sandy mud and deep ash ripples as far as 50 km away from the volcano.

The impacts on the ecosystem were also examined. The volcano was

devoid of biology, but, remarkably, there were features as close as 15 km away that still had abundant and diverse populations of marine life. Surrounding seamounts had pockets of normal biodiversity, such as corals, sponges, starfish and mussels, indicating the resilience of such marine ecosystems and giving scientists a baseline for monitoring recovery in the future.

Preliminary water column data showed that it is still recovering, with some airborne ash yet to completely settle on the seafloor. There is also evidence to suggest the volcano may still be erupting, with a dense ash layer found in the upper water column near the site.

Mapping the Gaps with Uncrewed Technology

As part of phase two, USV Maxlimer mapped the current shape of the caldera and measured environmental conditions of the water above it, all while being controlled remotely from SEA-KIT's base in the U.K., some 16,000 km away.

This marked the first time that a USV was used for this type of mission and demonstrated how the technology is pioneering new ways of understanding our oceans.

The use of USV Maxlimer as a configurable platform for a range of sensors provided a unique opportunity to gather data safely and continuously from inside the caldera over a full month. During the mission, USV Maxlimer was expected to use just 100 liters of fuel per day, which is under 2 percent of the fuel consumption of a typical survey vessel. In addition to reducing the risk to people, deployment of a USV for survey inside the caldera ensured carbon emissions for the project remained low.

Maxlimer, the first SEA-KIT X-class USV, is the company's testing and development vessel. It was part of the winning Nippon Foundation-GEBCO alumni entry in the 2019 Shell Ocean Discovery XPRIZE and has since achieved numerous "firsts," including the first uncrewed offshore pipeline inspection and first international commercial uncrewed transit in 2019. The USV also completed 22 days of remote survey operations on Europe's continental margin in 2020, mapping over 1,000 sq. km of ocean floor.

Phase-Two Surveying

Maxlimer, together with three members of the SEA-KIT team, was based in Nuku'alofa, Tonga, for around

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40 days. Sensors on board Maxlimer collected bathymetric data, water column backscatter data, sound velocity, conductivity, temperature, turbidity, oxidation reduction, and pressure with depth and current data, all of which will enable understanding of the eruption's undersea impact and ongoing activity.

Maxlimer is equipped with a multibeam echosounder to acoustically measure depth and state of the seabed. The vessel also has new winch capability for deployment of multiple sensors down to 300 m to obtain direct water column measurements.

Data collected using a CTD instrument, deployed via the winch, provide important temperature and salinity information, as well as dissolved oxygen and turbidity readings. A miniature autonomous plume recorder (MAPR), designed to detect chemicals in the water that are common in hydrothermal plumes, recorded light-backscattering for suspended particle concentrations, oxidation reduction potential, and temperature and pressure from multiple winch dips and tows. The MAPR project is a joint initiative between NOAA in the U.S. and GNS Science in New Zealand.

This collection of oceanographic data will identify layers of geothermal activity, as well as changes in salinity and dissolved particles, and will be used for comparison studies against samples gathered outside the caldera by RV *Tangaroa*.

On this survey mission, clear signs of continuing volcanic activity were seen inside the crater, with high particle concentrations in the water that are consistent with earlier observations of ash in the water column. The water in the caldera was also found to be homogeneous between 150- and 300-m depth, suggesting strong mixing inside the caldera. The previously observed oxygen minimum was not as distinct.

"Early data shows ongoing activity within the caldera, though it is too early to tell if it is due to continuing eruption but at a reduced intensity, or hydrothermal venting driven by cooling lava, or both," Sharon Walker, oceanographer at NOAA's Pacific Marine Environmental Laboratory, said.

Maxlimer returned to the caldera in early August for a more detailed survey to fill gaps and better target volcanic plumes and hydrothermal vents with the CTD and MAPR.

"The primary objective of phase two is to map the caldera and the hydrothermal vents within it, and Maxlimer is crucial in achieving that," Dr. Mike Williams, chief ocean scientist at NIWA, said. "It is incredibly exciting to be able to look down into the caldera and see volcanic plumes. We now know that at its deepest point it is around 850 meters deep, so more than the height of two-and-a-half Eiffel Towers. The data and imagery that Maxlimer has brought back is astounding and is helping us to see how the volcano has changed since the eruption."

The 12-m USV is remotely controlled on its caldera missions from SEA-KIT's base in Essex, U.K., where a team of four operators work shifts for round-the-clock operation. A global team of surveyors and scientists based in Australia, Egypt, Ireland, Mauritius, New Zea-

land, Poland and the U.S. are collaboratively monitoring and reviewing the data collected.

USV Maxlimer is also scheduled to map areas where telecommunications cables were damaged following HT-HH's violent eruption in January 2022. During phase one of the project, the crew of NIWA's research vessel, RV *Tangaroa*, discovered that the severed domestic internet cable was buried under 30 m of ash and sediment. Project and local stakeholders hope to gain a better understanding of the extent of the damage and how it was caused—likely due to fast-moving pyroclastic flows—from phase two. SEA-KIT's USV may also be deployed to survey alternative sites suitable for replacement cables if needed before returning to the U.K. (As of the writing of this article, Maxlimer was still operational in Tonga.)

Conclusion

Maxlimer was the first SEA-KIT X-class USV to be built. There are now numerous X-class vessels working commercially around the world, but this project clearly demonstrates how crucial this technology is as a low-risk, noninvasive solution to reach, survey and understand places that are challenging or unsafe for people to access.

Maxlimer experienced 3-m seas on return from its first HT-HH mission, which proves yet again how robust the design is. Demonstrating that this kind of work can be done using less than 2 percent of the fuel of a typical survey vessel is also a significant step on the industry's path toward net-zero emissions.

Knowledge gained from the project will be invaluable to the Tongan authorities in preparing and planning for future possible eruptions.

Seabed data gathered by USV Maxlimer will also contribute to The Nippon Foundation-GEBCO Seabed 2030 Project, a United Nations Ocean Decade-endorsed program that aims to map the entire ocean floor by 2030. So far, the project has achieved 23.4% global mapping coverage.

Findings from the TESMaP project will be presented at the American Geophysical Union (AGU) Fall Meeting in Chicago this December. **ST**

Ben Simpson is the CEO of SEA-KIT International, a British company providing hi-tech USV solutions for research and industry in challenging offshore environments. Through ongoing collaboration with industry partners, SEA-KIT is sharply focused on driving down the cost of geodata collection and reducing carbon emissions. Simpson earned a B.S. with honors in maritime studies at Southampton University. He was a member of the winning Nippon Foundation-GEBCO alumni team in the 2019 Shell Ocean Discovery XPRIZE. He is a keen sailor and a fellow of the Royal Institution of Naval Architects.

Jamie McMichael-Phillips is the director of The Nippon Foundation-GEBCO Seabed 2030 Project, a collaborative initiative to inspire the complete mapping of the world's ocean by 2030 and to deliver this information via a freely available definitive map. A chartered surveyor, hydrographer and former Royal Navy officer, he has worked in a range of leadership roles, from running his own marine data-gathering missions to directing defense geospatial strategy and plans for the U.K. He previously chaired the International Hydrographic Organization's Worldwide ENC Database Working Group, responsible for monitoring the global footprint of electronic charts required for safe navigation at sea.

Ocean Greenhouse Gas Monitoring

New Autonomous Platform to Measure Spatial CO₂, Methane

By Dr. Daniel Hayes • Jöran Kemme • Dr. Claudine Hauri

To better understand the global cycles of the greenhouse gases carbon dioxide and methane, as well as the human impact on the oceans and their acidification, we need global oceanographic CO₂ and methane data. Stationary sensors can collect long-term, time-series data with suitable temporal resolution but only at a specific location. Therefore, ship-based measurements are used for spatial coverage but are inefficient in collecting data with a good temporal and vertical resolution, due to the required crew and the high cost of operating research ships. Vessels of opportunity can reduce such costs but offer no control of the route or regions to be sampled.

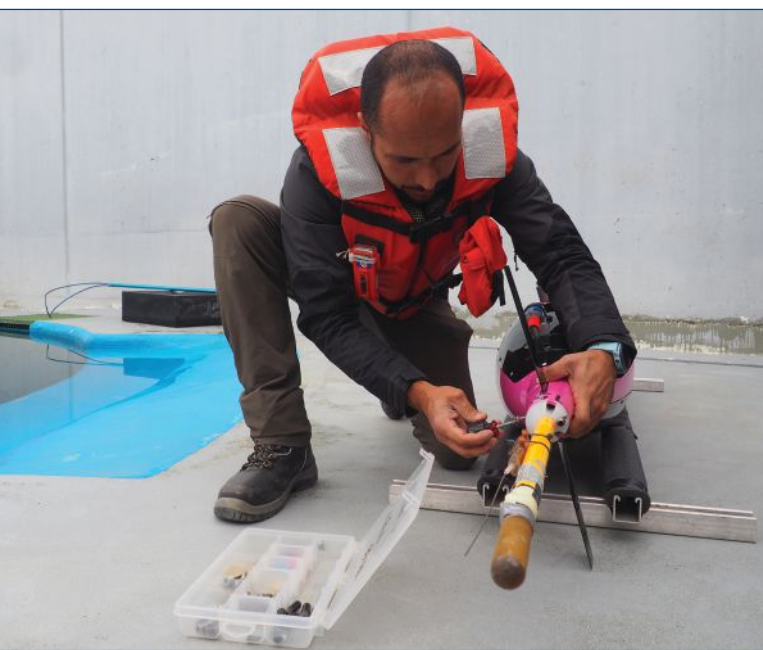
Stationary measurements can only tell us so much.

Carbon dioxide from burning fossil fuel is absorbed by the ocean and adversely affects marine life in complicated ways. Methane released from the seafloor in the rapidly changing high latitudes also presents a risk to global climate: As water conditions there change further, even more methane could be released to the ocean and, in turn, to the atmosphere. Single site sampling simply does not tell the whole story.

With the importance of carbonate chemistry to Earth system models, a new method to acquire more regular spatial and temporal CO₂ measurements is needed by researchers. One such a system—a Seaglider AUV fitted with a CONTROS HydroC sensor—was trialled in Alas-



Scientists and their industry partners take measurements of carbon dioxide and other ocean chemistry parameters from aboard the RV Nanuq during a recent project experiment. Pictured from left to right: Boat captain Brian Mullaly, sensor specialist Jöran Kemme, scientists Claudine Hauri and Andrew McDonnell. (Credit: Heather McFarland, International Arctic Research Center)



ka's Resurrection Bay, which is part of the Gulf of Alaska, by a team of oceanographers and engineers at the International Arctic Research Center at the University of Alaska Fairbanks.

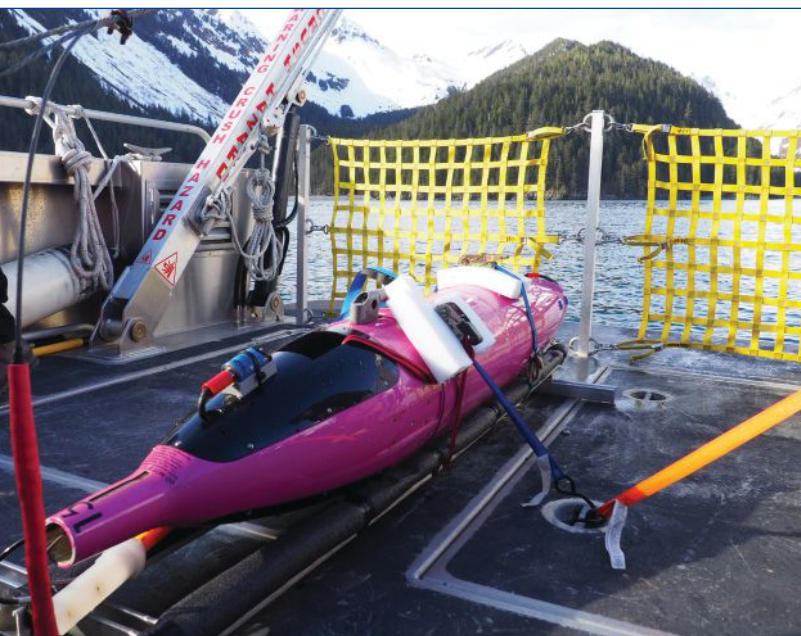
Alaska Trials

The trials, which took place in April and May 2022, were an important aspect of a project run by Dr. Claudine Hauri, the principal investigator who led the team that won funding from the U.S. National Oceanographic Partnership Program (NOPP), supported by the National Science Foundation in 2018. The trial was also attended by staff from the project's commercial partners: CONTROS sensor manufacturer -4H-JENA engineering GmbH and Cyprus Subsea Consulting and Services C.S.C.S. Ltd. (CSCS), the owner of the Seaglider adapted to carry the CO₂ sensor. The vehicle itself was remotely monitored by a team from Advanced Offshore Operations Inc.

The goal of the project is to deliver a science-ready sensor-platform pairing that can autonomously assess seawater pCO₂ levels across a wide range of temporal and spatial scales in a variety of challenging coastal environments. The trials, which consisted of 88 dives in all, were established to evaluate the combined HydroC sensor and Seaglider solution in a real coastal marine environment, from a purely operational standpoint to more technical concerns, including the mechanical aspects, electronic configuration and programming setup.

Further objectives were to: verify the glider-based measurements with discrete water samples and ship-based profiles and test the behavior of the sensor when mounted to the Seaglider and in ship-based experiments simulating the glider dives; test the flight of the glider with the sensor attached; test the ability to switch on/off and zero the sensor automatically during the dive, using the CSCS programming interface SIRMA; test the power consumption of the glider-and-sensor combination; and test the HydroC CH₄ as a drop-in sensor replacement.

While minor tweaks were made to the mechanical and electronic integration throughout the three-week testing period, the Seaglider collected high-quality data according to plan, thus verifying itself as a platform suitable for long-duration marine carbonate



(Top) Ehsan Abdi makes final adjustment before testing the carbon dioxide-measuring Seaglider in a tank in Seward, Alaska. (Credit: Heather McFarland, International Arctic Research Center) (Middle) The carbon dioxide-measuring Seaglider sits on the deck of the RV Nanuq on the way to test dive in the Gulf of Alaska. (Credit: Heather McFarland, International Arctic Research Center) (Bottom) The tail of the carbon dioxide-measuring Seaglider at the surface of the water between dives in the Gulf of Alaska. (Credit: Heather McFarland, International Arctic Research Center)

chemistry monitoring. And while this is an incredibly positive result because it means the availability of up-to-date oceanic CO₂ data can increase exponentially, integrating the CONTROS sensor—which is designed for stationary or ship-board deployment—with the Seaglider was a challenging task.

Shrinking Sensors

Gliders can contribute data on climate variables, such as temperature, salinity and oxygen, in near real time via satellite, but until now, reliably measuring CO₂ levels in seawater has been practically impossible due to the size, weight and power requirements of the sensors. Smaller, more efficient sensors have not been accurate or stable enough for long-term autonomous deployments, hence the need to adapt the HydroC CO₂, which is already proven to provide the accuracy and stability required in stationary and ship-borne applications.

Preliminary theoretical and bench work started on this in 2018. In November 2020, the International Arctic Research Center team started working with Advanced Off-shore Operations Inc., an underwater glider operations specialist, -4H-JENA engineering, the owner of the CONTROS sensor brand, and CSCS, a Seaglider specialist and owner of a four-vehicle fleet. It was clear to the entire team that the biggest problem to overcome was that the HydroC sensor was never going to fit into a Seaglider, so its form factor had to change for the project to ever take off.

There were several challenges related to the rationale behind the HydroC sensors' standard design. The CONTROS HydroC's optical CO₂ measurement principle requires an internal headspace and a defined optical-path length. To regularly check the zero point of the detector, the sensors require a separate gas cycle with pumps and valves to remove the CO₂. This allows for correction of detector drift, but requires space inside the unit.

The weight in water of the sensors had to be reduced to allow for optimal balancing of the Seaglider's buoyancy. Furthermore, the laser detector within the original HydroC CH₄ was too big to fit in a smaller housing—this was an important aspect as the team was aiming to allow the HydroC CO₂ sensor to be swapped for CH₄ (methane) to improve sampling capabilities of the platform even further. Lastly, it was important to verify if the repeated profiling and, therefore, changes in hydrostatic pressure and water temperature would put excessive stress on a membrane-based sensor.

The standard HydroC is already a high-performance sensor, so no component changes were needed; however, it was necessary to rearrange them to fit the system into a shorter but wider housing. The HydroC CH₄ laser detector was replaced with a newer, more compact laser detector to fit this shorter housing, which was made from machined POM instead of titanium and pressure tested up to 300 m depth. Following testing, it was verified that the HydroC TOUGH membranes, which are now standard for every HydroC sensor, are already highly resistant to pressure and temperature changes, so these were not changed for the Seaglider system.

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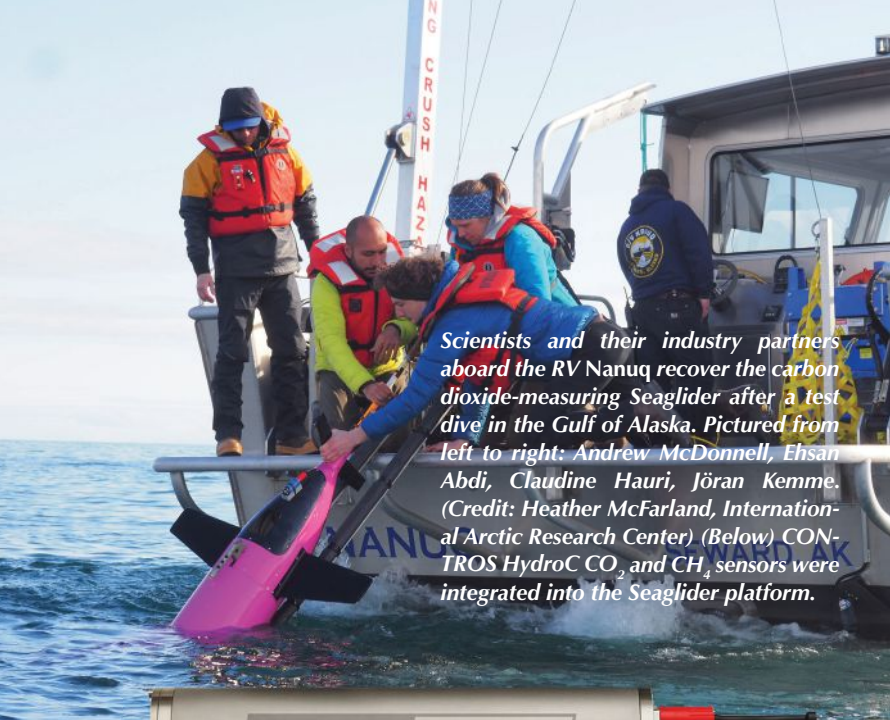
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Scientists and their industry partners aboard the RV Nanuq recover the carbon dioxide-measuring Seaglider after a test dive in the Gulf of Alaska. Pictured from left to right: Andrew McDonnell, Ehsan Abdi, Claudine Hauri, Jöran Kemme. (Credit: Heather McFarland, International Arctic Research Center) (Below) CONTROS HydroC CO₂ and CH₄ sensors were integrated into the Seaglider platform.



higher after this adjustment.

Contribution to Ocean Observing

The entire project, including this year's trials in Alaska, aims to use ocean gliders to measure carbon dioxide and methane. Gliders have a unique ability to measure over extended periods in three dimensions and at high spatial and temporal resolution, so they can quickly and cost-effectively deliver more data to researchers when compared to existing temporal or spatial methods.

While the project team is most familiar with the Seaglider family of gliders, the adapted sensor solution can easily adapt to other AUVs, which could enable even more data to be acquired globally. Additionally, the fact that gliders are normally recovered for sensor calibration post-mission, when data are corrected (unlike profiling floats), means that, with proper care, gliders can be one of the major contributors to the Global Ocean Observing System and the Global Carbon Observing System.

A new generation of HydroC sensors will add more value in this context. The team at -4H-JENA is working on integrating the HydroC-specific post-processing of the data into the sensor itself, which would allow for transmission of already processed data during a running mission, so databases and platforms can be updated in near real time. The new generation also opens the opportunity to integrate both the CO₂ and CH₄ measurement in a single sensor, doubling the amount of useful data that can be collected in a single, long-duration mission. **ST**

Dr. Daniel Hayes is the managing director of Cyprus Subsea Consulting and Services C.S.C.S. Ltd. (CSCS).

Jöran Kemme is a project engineer at -4H-JENA engineering GmbH.

Dr. Claudine Hauri works at the International Arctic Research Center at the University of Alaska Fairbanks.

Extending Gliders

Like all gliders, Seaglider's payload space is limited as a result of its optimal hydrodynamic design. In its favor, it has a powerful programming interface that allows users to add their own sensors, and with SIRMA it is possible to pre-program almost anything that can be done in the lab without additional power-hungry processors. It is also well-suited for dissolved gas measurements because it descends slowly and predictably through the water column.

Despite -4H-JENA's work on adapting the CONTROS sensors, form factor changes were also needed on the glider itself. The HydroC CO₂ and CH₄ sensors are the largest sensors to be installed in any Seaglidors to date, and in addition to accommodating the size of these sensors, the system needed space for the sensors' required external pump, intake/outtake plumbing and cabling. Another key challenge was to get the glider to "talk" the language of the sensor, which was done using the Seaglider programming interface and CSCS's SIRMA device.

A major change was the addition of a ring of fiberglass, which extended the normal forward fairing by 40 cm. Combined with a removal of the tip of this forward fairing, this allowed the placement of the sensor, pump and plumbing at the front of the vehicle. A cable to the aft section of the vehicle was threaded between the fair-

Clean Energy from the Ocean

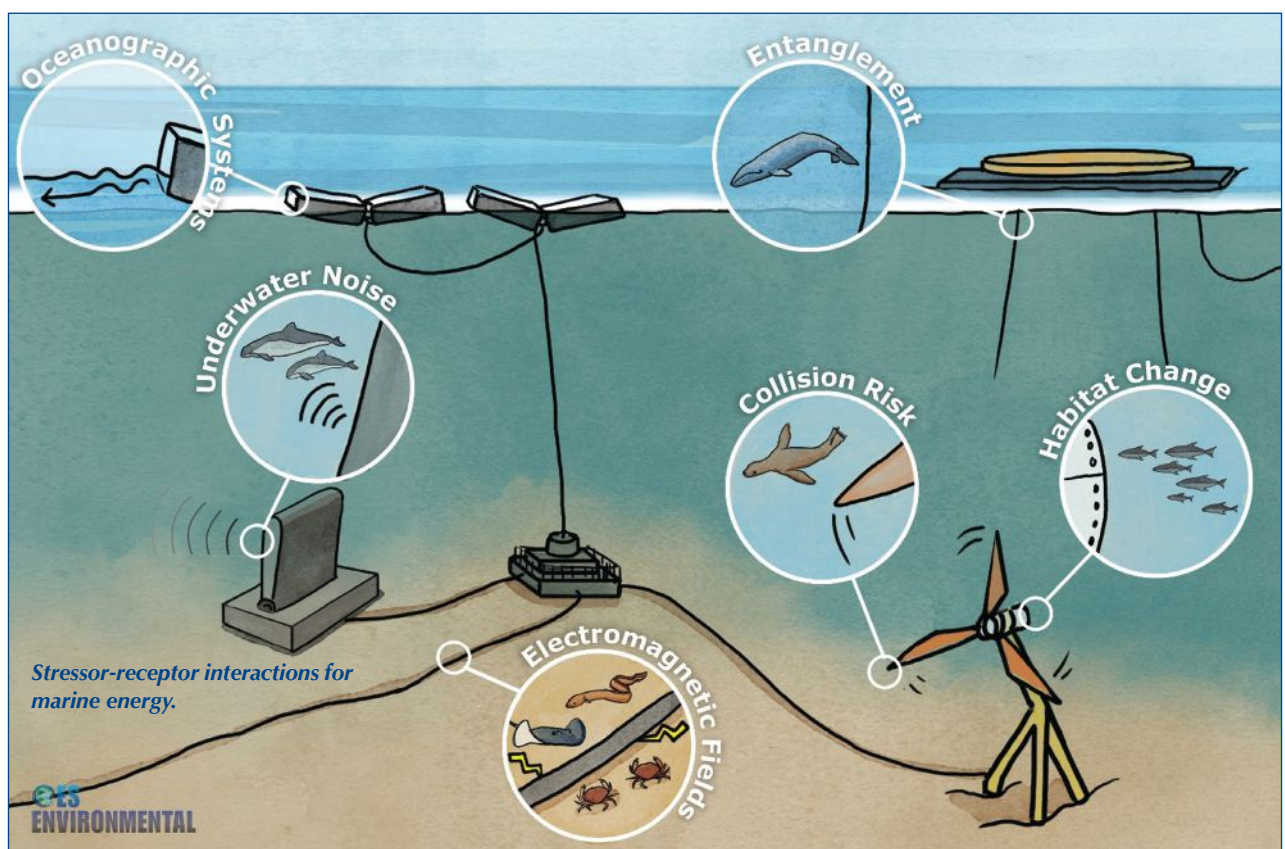
Measuring the Environmental Footprint of Devices

By Deborah Rose • Cailene Gunn • Lenaïg Hemery

Marine energy, also referred to as marine renewable energy or marine and hydrokinetic energy, is energy harvested from the movement of water in the oceans or large rivers, and ocean gradients. This includes tides, currents, waves, river flows, temperature gradients and salinity gradients. Offshore wind is excluded, as the source of power is not ocean water. Most marine energy devices use rotating or moving parts to harness energy. The energy may then be used at sea, exported to land

via electric power cables, or used to generate stable fuels or products such as ammonia or hydrogen that can be transported for use.

According to research from the National Renewable Energy Laboratory, there is an estimated 2,300 terawatt-hours per year of marine energy available in the U.S., which is enough energy to power 220 million homes and provide up to 57 percent of all U.S. electricity generation. The majority of this is from potential wave





Triton fieldwork in Sequim Bay. (Credit: Andrea Starr, PNNL)

and tidal energy in Alaska, though each coastal state has access to marine energy resources. Ocean thermal energy conversion in the Gulf of Mexico and around tropical U.S. island territories also provides significant contribution to the total energy potential.

Numerous potential benefits exist from marine energy development. Projects can stimulate local economies and create high-paying jobs in installation and maintenance. Once installed and operational, marine energy provides a secure energy source to reduce vulnerabilities from natural disasters and oil dependence (including eliminating possible oil spills and poor air quality from burning petroleum), as well as the potential for mitigation of climate change with reduced fossil fuel consumption. Marine energy can also provide power for unique areas and applications where other renewables such as solar are not feasible, such as in the Arctic or far offshore. Furthermore, marine energy is more consistently available and predictable than many other renewable energy resources, taking advantage of cyclical and perpetual natural phenomena such as waves and tides. Additional benefits to ecosystem functions with the creation of habitat and marine reserves are also possible.

US Marine Energy Capacity

Despite the magnitude of the resource and the potential benefits, the marine energy industry in the U.S. and internationally is still in the early stage of development. According to data from the International Renewable Energy Agency, there was approximately 530 MW of installed marine energy capacity in 2021.

In the U.S., there are currently only a few operational devices and test centers for marine energy. The Iguigig Hydrokinetic Project has been harnessing the power of the Kvichak River in Alaska off and on since initial demonstrations in 2014 and provides electricity to the village grid, reducing the reliance on burning diesel to power the community. The Roosevelt Island Tidal Energy Project was the first commercially licensed tidal power project in the U.S. and tested several iterations of turbines in the East River of New York from 2002 to 2022. The Cobscook Bay Tidal Energy Project in Maine was the

first revenue-generating, grid-connected tidal project in North America, testing devices intermittently from 2012 until decommissioning in 2022. There are also two test sites for wave energy converters in the U.S.—PacWave in Oregon and the U.S. Navy's Wave Energy Test Site in Hawaii. There are several other marine energy projects in various stages of development across the U.S., as well as planned projects that were never deployed for a variety of reasons.

Environmental Effects

One of the reasons for these deployment issues is environmental concerns that have stalled the industry both in the U.S. and internationally. The oceans are an important resource for both humans and other species, and many of these species and traditional uses are protected by regulations. These laws are critical to protecting the ocean environment from harmful activities, but they also create barriers to innovative and research-oriented marine energy projects that may, in reality, present very low risks. To advance the marine energy industry in an environmentally conscious manner and to mitigate risks from possible deployments, data are needed to quantify potential risks and interactions between energy devices, marine animals and the ocean environment during project development.

Interactions between marine energy devices and the marine environment can be described in terms of stressors and receptors. Stressors are the parts of a device or system that may cause harm or stress to a marine animal or the environment. Receptors include the marine animals living in and traversing the vicinity of a marine energy development area, the habitats into which devices are deployed, and the oceanographic and ecosystem processes affected by a device or an array of devices.

There are six key stressor-receptor interactions that have been investigated for marine energy. None of these interactions are expected to pose significant risk to marine animals and habitats, particularly with only small numbers of devices in the water.

Collision Risk. This is the possibility of direct contact between an animal and a device component or turbine

blade. Collision of an animal with moving device parts (e.g., turbine blades) or a moving device (e.g., tidal kite) could cause permanent injury or death.

Underwater Noise. This is the sound generated during the operation of a device. Sound is an integral sensory modality for most marine animals. Humans and terrestrial animals often rely primarily on sight to communicate, navigate, interact, forage and avoid predation. In contrast, underwater sound is essential for marine species, particularly marine mammals. Depending on the intensity and characteristics, additional noise from human sources may cause stress, behavioral changes (e.g., avoidance), physical injuries and temporary or permanent reductions in hearing ability, as well as masking other important sound cues in the marine environment.

Electromagnetic Fields. EMFs are physical fields generated by electrically charged objects. Marine species with specialized sensory capabilities, such as some species of sharks, skates, rays, fish, turtles and crustaceans, may detect and react to EMFs. Artificial EMFs from underwater marine energy or other electricity transmission cables could cause changes in the behavior and movement of susceptible animals and may potentially cause long-term changes in their growth or reproductive success.

Changes in Habitat. These are caused by introducing any new structure to the marine environment, which has the potential to alter where animals live, how common

they are at a particular location, and their foraging or reproductive success. Changes in habitat can be caused by the installation, operation and/or decommissioning of marine energy systems, and can have both positive and negative effects.

Changes in Oceanographic Systems. The operation of large numbers of marine energy devices could cause changes in oceanographic systems, such as alteration of water circulation, wave heights or current speeds, as well as removal of energy from the system. These changes, in turn, could affect sediment transport, water quality and/or marine food webs. Wave and tidal devices have the potential to affect oceanographic systems in unique ways, based on how devices are designed to harvest energy.

Entanglement. Entanglement or mooring-line encounter is unlikely to be dangerous to marine animals because mooring lines or underwater cables used for marine energy devices have no loose ends or slack to create loops that cause entanglement. However, entrapment may occur with large arrays of devices if an animal were to enter an array and become unable to navigate out due to the presence of multiple cables and devices.

Not all of these environmental interactions are well understood for marine energy. Ocean monitoring in the high-energy conditions ideal for marine energy harvesting is a difficult task, considering the technical challenges presented by corrosive seawater, biofouling, low light, turbid conditions, debris, access for maintenance and



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*TFIT changes-in-habitat research.
(Credit: Cailene Gunn, PNNL)*

potential for interference with device operations. Additionally, the lack of standard practices and tools for environmental monitoring around existing devices makes data-sharing difficult, intensifying requirements for expensive, site-specific monitoring. However, in addition to ongoing research projects, information can be gained from other comparable industries, such as offshore wind or oil and gas platforms, to make predictions for marine energy. The complex relationships between stressors and receptors can be examined through observations, laboratory and field experiments, modeling studies or a combination of these.

Understanding Stressor-Receptor Interactions

The U.S. Department of Energy Water Power Technologies Office and National Laboratories are working on closing some of the gaps in understanding of these stressor-receptor interactions through experiments, data collection and observations during marine energy testing, data syntheses, application of data from other industries, and collaboration with regulators. The two core projects in this effort are the Ocean Energy Systems (OES)-Environmental Initiative and the Triton Initiative, both led by teams of researchers at Pacific Northwest National Laboratory (PNNL).

OES-Environmental. OES-Environmental is an international collaboration of 16 countries, led by the U.S. through PNNL, that aims to mobilize information and practitioners to coordinate research and progress the marine energy industry in an environmentally respon-

sible manner. OES-Environmental synthesizes scientific research about marine energy and the environment into reports for various audiences, including a comprehensive State of the Science Report produced every four years. The State of the Science, most recently released in 2020 and scheduled again for 2024, summarizes and synthesizes current research knowledge around the environmental effects of marine energy. Each of the six stressor-receptor interactions is assessed in the report, with additional chapters on socioeconomic data collection, environmental monitoring, marine spatial planning and adaptive management.

In addition to this synthesis work, OES-Environmental curates a database on marine energy publications through the Tethys website (<https://tethys.pnnl.gov>) and has also been developing outreach tools for regulators to translate the science into permitting and management decisions. These tools include an informational brochure for new regulators, ongoing webinars and guidance documents for each of the stressor-receptor interactions and specific country contexts. Learning and collaborating internationally allows each participating country to gain knowledge from projects in various stages around the world, as well as how other countries address permitting challenges within their particular context.

Triton. The Triton team is based out of PNNL-Sequim in Sequim, Washington, and leverages the capabilities of the Marine and Coastal Research Laboratory. This team researches and develops technologies and methods for environmental monitoring around marine energy devic-

es to understand and quantify the stressor-receptor interactions identified through OES-Environmental's research. Triton projects range from monitoring animal behavior, assessing underwater noise, characterizing EMF, modeling collision risk, and leveraging open-water facilities to validate emerging research technologies. Part of Triton's efforts include communication, outreach and engagement with the environmental monitoring research community and marine energy end-users to best address industry needs and bolster impact.

The Triton Field Trials project (TFiT) was a four-year effort to evaluate and test existing monitoring technologies for applications with marine energy, emphasizing changes in habitat, collision risk, EMF and underwater noise. Two of the significant challenges TFiT aimed to address were environmental monitoring costs and lack of standardization of methodology and analyses. The custom nature of new marine energy technologies makes it difficult for marine energy developers to both create a functionally viable device and conduct the necessary environmental monitoring to satisfy permitting requirements for their deployment. Ultimately, the TFiT project developed recommendations for instrumentation and monitoring methods from tests at open-ocean, riverine and tidal project sites in California, Alaska, New Hampshire and Washington, and published these recommendations in a special issue of a journal.

Synergy. For an example of the synergy between the two PNNL projects, habitat change was one of the six stressor-receptor interactions identified in the OES-Environmental 2020 State of the Science and was addressed by the Triton team with targeted research. Marine energy devices must be attached to the seafloor (e.g., using gravity foundations, pilings or anchors), with mooring lines and devices themselves in the water column and transmission cables running along the bottom.

The physical presence of these elements has the potential to disrupt or create new benthic and pelagic habitats, or alter the behavior of organisms in the area of a project. Through its work with the international marine energy community, OES-Environmental has summarized the current scientific knowledge on these potential effects, as well as identified remaining knowledge gaps and uncertainties around these effects.

In addition, the project team has listed guidance and recommendations to help increase the understanding of the various possible changes to marine habitats at short- and long-term scales. A major caveat highlighted in the process was the inconsistency in the data collection methods used at different project sites, and sometimes between project phases within a site, which could make challenging the identification of changes in habitats or the transfer of data between project sites.

The role of TFiT in advancing knowledge of this stressor was to identify the technologies that would bring the most consistent results for monitoring changes in habitats through in-depth reviews and field testing. The recommendations from these studies are intended to be used by all in the marine energy community to help figure out what technologies to use, when and why.

Conclusion

Collaboration between the OES-Environmental and Triton Initiatives as described for research on changes in habitat, as well as multiple other stressors of concern, has allowed for synergistic outcomes for the marine energy industry, and is expected to make research and outreach engagements even more efficient as the industry progresses in the U.S. as well as internationally. These iterative processes and feedbacks between the two research teams allow for refinement of the research process to become more efficient and support broad learning and sharing of information around the world.

As the industry grows with the support of the U.S. Department of Energy and the National Laboratories as a research backbone, the U.S. can expect to see an increase in community-scale marine energy projects, new devices demonstrated at existing test centers and evolution of markets for marine energy, in particular, low-power applications such as providing energy for aquaculture, ocean observations, remote communities and more.

Funding marine energy projects takes myriad forms. Private investments, community-backed cooperatives, research competitions with prizes and government support are all pieces of developing marine energy devices that meet real-world needs at reasonable costs and with minimal environmental impact.

Energy from the ocean will play a key role in the coming decades in efforts to combat climate change while supplying cities and small communities with clean, reliable power that people can feel good about using.

Acknowledgments

This work would not be possible without funding support from the U.S. Department of Energy Water Power Technologies Office. We also thank the members of the Triton and OES-Environmental teams at PNNL for their contributions to the work of understanding environmental effects of marine energy broadly, as well as to this article in particular.

References

For a list of references, contact Deborah Rose at: deborah.rose@pnnl.gov. **ST**

Deborah Rose is a research scientist with the OES-Environmental team at PNNL, based in Seattle, Washington. Her work aims to understand opportunities for marine energy within the blue economy and environmental and socioeconomic risks using interdisciplinary approaches.

Cailene Gunn is a researcher and lead science communicator with the Triton team at PNNL, based out of Sequim, Washington. Her background is in restoration ecology and biogeochemical cycling in coastal environments, and her current work is focused on marine energy environmental monitoring and improving technical project communications and outreach.

Lenaïg Hemery is a benthic ecologist at PNNL based out of Sequim, Washington, working extensively with both the Triton and OES-Environmental teams. Her research uses an integrative approach to characterize and understand the patterns and processes of marine benthic biodiversity, particularly in relation to human activities at sea.

EEDI Phase Three

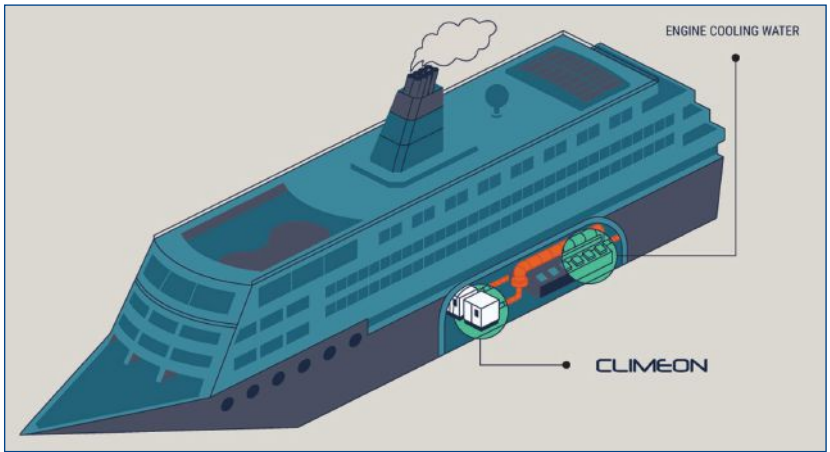
How to Improve Ratings, Achieve Compliance and Future-Proof Fleets

By Alexandra Widelund

Commissioning a new vessel allows operators to expand their fleet and increase profitability with additional resources, but the design of a ship has a major impact on its subsequent performance and revenue-making capabilities. With increasing environmental regulations, such as the Energy Efficiency Design Index (EEDI), newbuild ships must be designed with their environmental impact in mind.

First introduced alongside Ship Energy Efficiency Management Plans (SEEMPs) in 2011, the EEDI regulations require newbuild vessels to achieve a “minimum energy efficiency level per capacity mile” (Resolution MEPC 203 (62), MARPOL Annex VI).

The EEDI measures design efficiency, as opposed to operational efficiency, and is the most important technical measure for newbuild vessels, according to the International Maritime Organization (IMO). To comply with the EEDI, a ship must meet the requisite standard for its

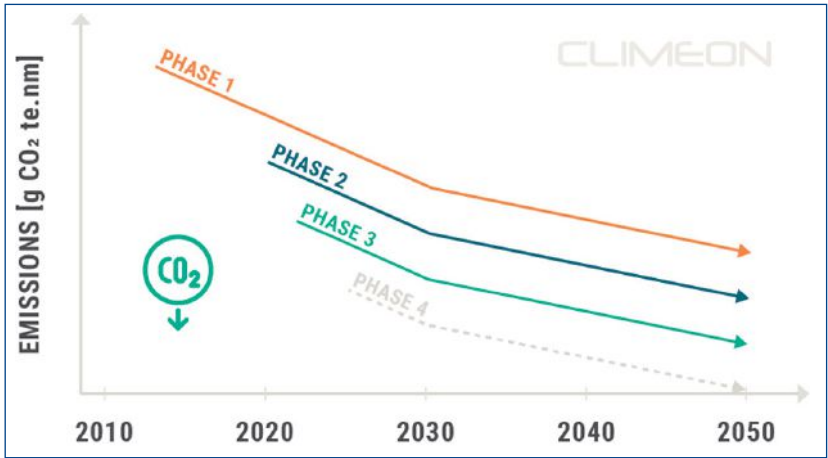


type and size, expressed in grams of CO₂ per capacity mile (sometimes referred to as “transport work” or “tonne mile”).

Therefore, each ship has a required EEDI (the EEDI standard they must meet) and an attained EEDI (the actual EEDI rating the vessel is given).

Providing a ship’s attained EEDI is equal to or better than its required EEDI, it will be deemed compliant with the Energy Efficiency Design Index.

A complex formula is used to calculate a ship’s required EEDI and attained EEDI, but in simple terms it can be expressed as follows:



(Left) The phased implementation of increasing emissions reductions aims to decarbonize the shipping industry and achieve the IMO’s net-zero ambitions. (Above) The Climeon HeatPower module enables on-board waste heat recovery and clean energy production.

Vessel Type	Vessel Size	Phase 3 Reduction – April 2022
Gas Carrier	20,000 DWT +	30%
Container Ship	200,000 DWT +	50%
	120,000 – 200,000 DWT	45%
	80,000 – 120,000 DWT	40%
	40,000 – 80,000 DWT	35%
	15,000 – 40,000 DWT	30%
	10,000 – 15,000 DWT	15 – 30%
LNG Carrier	100,000 DWT +	30%
Cruise Passenger Ship (non-conventional propulsion)	85,000 GT +	30%
	25,000 – 85,000 GT	0 – 30%
General Cargo Ship	15,000 DWT +	30%
	3,000 – 15,000 DWT	0 – 30%

(Top left) Following the latest IMO resolution, many vessels will need to meet enhanced emissions reductions. While there are various exclusions that may apply to specific vessels, the regulations broadly require the following reductions in this table. Source: 2021 Revised Marpol Annex VI, Resolution MEPC 328 (76). (Bottom left) Set to come into force in 2025, a second iteration of EEDI phase three demands the following reductions in this table. Source: 2021 Revised Marpol Annex VI, Resolution MEPC 328 (76).

by 10 percent compared to the relevant segment baseline under phase one of the EEDI. When phase two of the EEDI was introduced, the requisite reduction percentage was 20 percent, and now, under phase three, gas carriers above 15,000 DWT must reduce CO₂ emissions by 30 percent in comparison with the relevant baseline.

Although the EEDI has been in force for some time, its requirements have been strengthened incrementally, with new phases being introduced every few years. With more vessels now subject to the Energy Efficiency Design Index and ships facing lower emissions output standards, it's more important than ever for shipowners, shipyards and design houses to use the latest maritime technology to increase energy efficiency and reduce CO₂ emissions.

Originally, phase three of the EEDI was scheduled to come into force in 2025. In a bid to accelerate the decarbonization

of the shipping industry, however, the IMO brought the implementation of phase three forward to April 2022 and strengthened the regulations even further [Resolution MEPC 324 (75); 2021 Revised Marpol Annex VI, Resolution MEPC 328 (76)].

Meeting EEDI Requirements

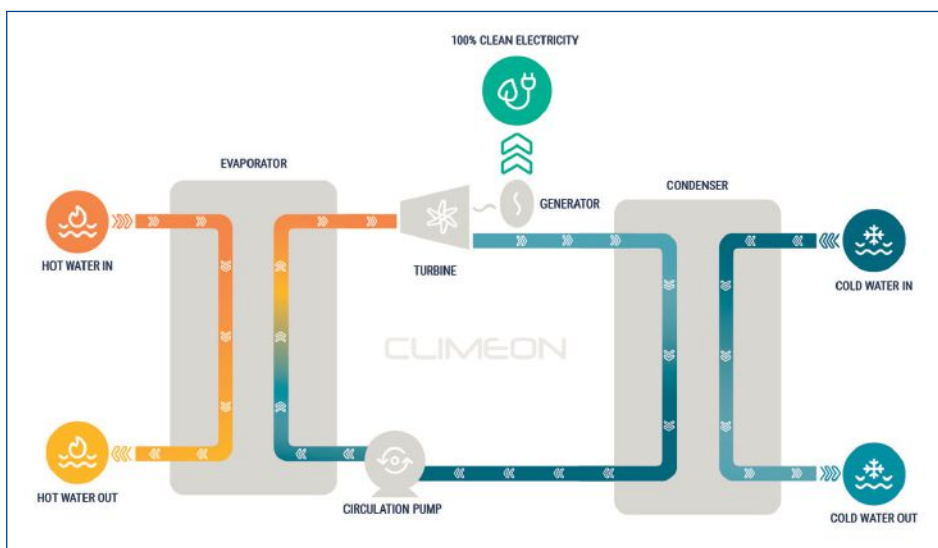
As environmental regulations tighten across the board, it's vital that shipowners use the latest innovations to achieve the requisite EEDI rating for their vessels. To date, various methods have been used to optimize vessel

EEDI = CO₂ emissions/transport work.

How Are EEDI Regulations Implemented?

The EEDI increases the energy efficiency of the industry by setting required technical efficiency standards for new vessels based on an established reference line (baseline). Historical emissions data have been used to set this baseline, and, according to EEDI regulations, new vessels must achieve a reduction in terms of percentage.

For example, gas carriers above 15,000 deadweight tonnage (DWT) were required to reduce CO₂ emissions



(Top left) Converting onboard waste heat into clean electricity increases the energy efficiency of vessels and, therefore, enhances EEDI ratings. (Bottom left) The Climeon HeatPower unit is a modular and scalable method of utilizing waste heat recovery to increase a vessel's energy efficiency.



Waste Heat Recovery for EEDI Compliance

Although shipowners are using new forms of tech to improve the energy efficiency of newbuild vessels, there is one type of technology that is often overlooked: waste heat recovery (WHR). Marine WHR can be used to successfully increase energy efficiency and, therefore, enable shipowners, shipyards and design houses to achieve required EEDI ratings.

Marine waste heat recovery essentially means that onboard waste heat is captured, repurposed and used to generate clean, carbon-free electricity. This power is then used by the ship's grid, which means it is less reliant on diesel-powered generators. As a result, less fuel is used and fewer CO₂ emissions are released, which helps to enhance the EEDI rating of the vessel.

Low-Temp vs. High-Temp WHR

Onboard waste heat is produced at varying temperatures, and it is the temperature of the heat that determines how it can be used. To date, many energy-saving WHR solutions, such as economizers and boilers, have focused on utilizing high-temp onboard waste heat.

However, the majority of onboard waste heat is actually low temperature (80 to 100° C), and few solutions are aimed at repurposing this potentially valuable by-product. By using low-temp WHR solutions based upon Organic Rankine Cycle (ORC) technology on board newbuild ships, the vessel's overlooked low-temp waste heat can successfully be transformed into a sustainable asset.

While low-temp ORC waste heat recovery offers numerous benefits, there are specific advantages in relation to newbuild vessels and EEDI shipping regulations. Different types of vessels have varying needs, which means that one energy-efficient solution may not be suitable for all ships. Furthermore, a vessel's operational pattern and profile can affect the efficacy of onboard energy-efficient technology.

All vessels produce waste heat, which means that marine WHR can be used on virtually all ships to increase energy efficiency. From cruise ships and Ro-Ro ships to cargo ships and container ships, the universal and ubiq-

energy efficiency and, therefore, improve EEDI ratings, including: reducing hull resistance; increasing propeller efficiency; slow steaming; low-carbon fuels; and optimizing routes and operating patterns.

As you can see, there are many ways to increase a ship's energy efficiency, and shipowners have been forced to steadily embrace more sustainable shipping methods in order to achieve EEDI compliance thus far. However, the acceleration of phase three and the drive toward the decarbonization of the shipping industry means that additional solutions will need to be implemented.

As the EEDI is concerned with the energy efficiency of a ship's technical design, rather than its operation, which is assessed via other measures, such as the Energy Efficiency Operational Indicator (EEOI) and Carbon Intensity Indicator (CII), it follows that technical efficiency can be improved by using onboard technologies.

Furthermore, integrating new technologies into newbuild ships can actually be far easier than retrofitting them onto existing vessels, which gives shipowners striving to achieve optimal EEDI ratings an advantage over those who are battling to achieve requisite Energy Efficiency Existing Ship Index (EEXI) ratings.

Selecting the right onboard technologies is critical to improving energy efficiency, maintaining crew and passenger safety and achieving optimal vessel performance.

uitous nature of onboard waste heat makes ORC marine WHR a viable solution across segments and sizes. If solutions for low-temp ORC waste heat recovery, such as Climeon HeatPower 300 Marine, are included, even more energy can be produced from the available heat.

At Climeon, we're committed to increasing sustainability in shipping, which is why our ORC technology is designed with larger vessels in mind. For ships with an engine size exceeding 15 MW and an available thermal energy of more than 1,000 kW, the Climeon HeatPower 300 Marine system can deliver meaningful emissions reduction and optimal efficiency.

Compatible with Other Solutions

As EEDI requirements and other environmental regulations become increasingly stringent, vessels typically need to use a combination of solutions to reduce emissions and increase energy efficiency. To achieve optimal performance, onboard energy efficient solutions must, therefore, be compatible with one another and provide enhanced energy saving when used in conjunction. Further, the energy-saving solutions should not interfere with other necessary onboard equipment that utilizes low-temperature waste heat, such as feedwater preheating, freshwater generators and the vessel's HVAC systems.

As ORC waste heat recovery technology, such as Climeon HeatPower 300 Marine, can be used as a stand-alone solution or in addition to other waste heat recovery technology, it is an effective component of a newbuild vessel's technical design.

Modular and Scalable

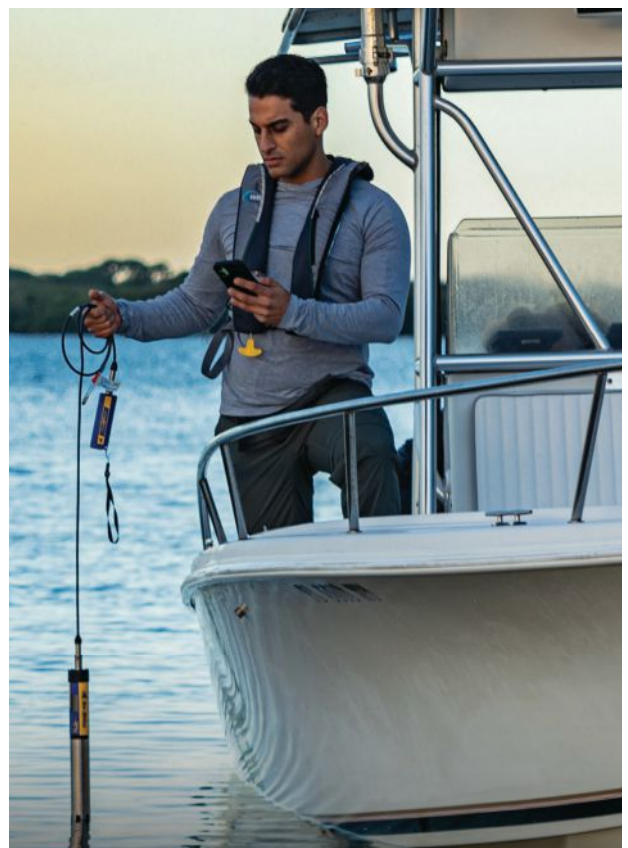
Effective maritime energy-efficient solutions must provide shipowners, shipyards and design houses with maximum flexibility, both in terms of integration and performance. While the acceleration of phase three of the EEDI has strengthened regulations in the short term, we can expect maritime emissions rules to become stricter over time (see, for example, possible phase four requirements from the IMO).

As vessels have an average lifespan of 25 to 30 years, the ships being built today will need to adhere to increasingly demanding regulations throughout their lifetime, and energy-saving and emission-lowering technology must, therefore, be capable of future performance optimization. When shipowners choose low-temp ORC waste heat recovery to achieve their required EEDI rating, they retain the flexibility to enhance and increase their energy savings in the future.

As a scalable solution, the Climeon HeatPower 300 Marine system can be extended with additional modules, for example. This effectively increases the output of clean energy and significantly reduces both fuel consumption and carbon emissions.

Compact and Easy to Install

Onboard space is inevitably limited, regardless of how efficient or progressive a vessel's design is. For energy-saving technology to be viable within the shipping industry, it must, therefore, take up a minimal amount of



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Installation of a Climeon HeatPower waste heat recovery unit.

space. Similarly, the installation and integration process must be streamlined to ensure swift setups and uninterrupted commissioning.

Delivered as a single unit, the Climeon HeatPower 300 Marine system requires just five integration interfaces: a cold-water source, a hot-water source (waste heat), compressed air, control signals and electrical power. With a simple installation process, HeatPower modules can be integrated into a newbuild vessel quickly and in accordance with the shipyard's manufacturing schedule.

Minimal Maintenance

While the initial integration of energy-efficient technology must be simple and straightforward, maintenance requirements must also be kept to a minimum. If any on-board tech requires extensive or excessive maintenance, it can negatively affect the performance of the vessel, increase costs and disrupt established routes.

With this in mind, Climeon's team of marine engineers has developed maritime ORC WHR technology that requires nominal onboard maintenance. Furthermore, a simple module design ensures that existing crewmembers can conduct onboard maintenance.

The Climeon HeatPower Control and optional cloud-based Climeon Live system for automated monitoring and management enable the onboard Climeon ORC WHR system to be remotely monitored by Climeon personnel, thus providing remote support to the crew should it be required.

Safe and Proven Application

The shipping industry has a number of regulations designed to enhance and maintain safety at sea, and all onboard technology, equipment and materials must adhere to these sector-specific requirements. While there are many potential innovations that could reduce shipping emissions, their safety and efficacy are yet to be proven.

In contrast, Climeon's HeatPower 300 Marine sys-

tem is fully compliant with industry regulations, including SOLAS requirements. Project certified by ABS, DNV and Lloyd's Register, shipowners can be confident that Climeon technology can be used to increase the energy efficiency of their vessels while meeting environmental and safety requirements.

Already being used on board Maersk, Virgin Voyages and Viking Line, our maritime waste heat recovery technology is safe, proven and effective.

Future-Proofing Your Fleet

Although the EEDI applies to most newbuild ships, some vessels remain exempt from the Energy Efficiency Design Index due to their type, engine power, etc. Despite this, many shipowners are opting to comply with the EEDI and obtain an EEDI rating even when it isn't mandated.

By doing so, shipowners can obtain a competitive advantage, as charterers are more likely to contract a vessel that has a requisite attained EEDI in place. The increased energy efficiency associated with these ships can reduce operating costs, which offers charterers financial incentives to select EEDI-compliant ships.

In addition to this, voluntarily complying with the EEDI ensures vessels will have the required certification if the Energy Efficiency Design Index is expanded again in the future. While a minority of vessels remains exempt from the EEDI, it is arguably a matter of time before the scope of the index widens, thus mandating compliance across a wider spectrum of vessels.

Furthermore, the publication of technical efficiency in EU ports [Regulation (EU) 2015/757] places additional pressure on shipowners to enhance the design efficiency of vessels, regardless of whether a ship is subject to the EEDI regulations.

Climeon's ORC waste heat recovery technology is helping to decarbonize the shipping industry and providing shipowners, shipyards and design houses with easy-to-integrate, energy-efficient solutions. With the potential to decrease fuel consumption and reduce CO₂ emissions, maritime waste heat recovery is a key method of decarbonizing the industry, increasing energy efficiency and meeting environmental regulations, such as the EEDI.

References

For a list of references, contact: info@climeon.com. **ST**

Alexandra Widelund is IP and product manager at the energy technology company Climeon. She has over 20 years of experience managing intellectual property rights, innovation and ideas. Prior to joining Climeon, Widelund was a patent attorney at Bergenstråhle & Partners. She obtained an M.S. in automotive engineering from the KTH Royal Institute of Technology.



Monitoring Chemical Contaminants

OPTICS: An Innovative Tool to Assess Aquatic Systems

By Dr. Grace Chang • Todd Martin • Frank Spada



The South River in Crimora, Virginia.

Integral Consulting Inc. has created OPTICS (OPTically based In-situ Characterization System), which works on the principle that chemical contaminants in water are often associated with specific substances also present in the water, such as organic matter and fine-grained particles, and that these substances respond in unique ways to light stimulation.

Commercially available underwater sensors, such as those used by OPTICS, can measure unique optical signatures, thereby affording investigators the ability to effectively characterize the substances associated with chemical contaminants, as well as the contaminants themselves. Because the optical sensors can operate continuously and record data at high frequency (once every few minutes or so), Integral's OPTICS tool provides an innovative method for continuous monitoring and quantification of complex contaminant dynamics in water bodies.

South River Monitoring

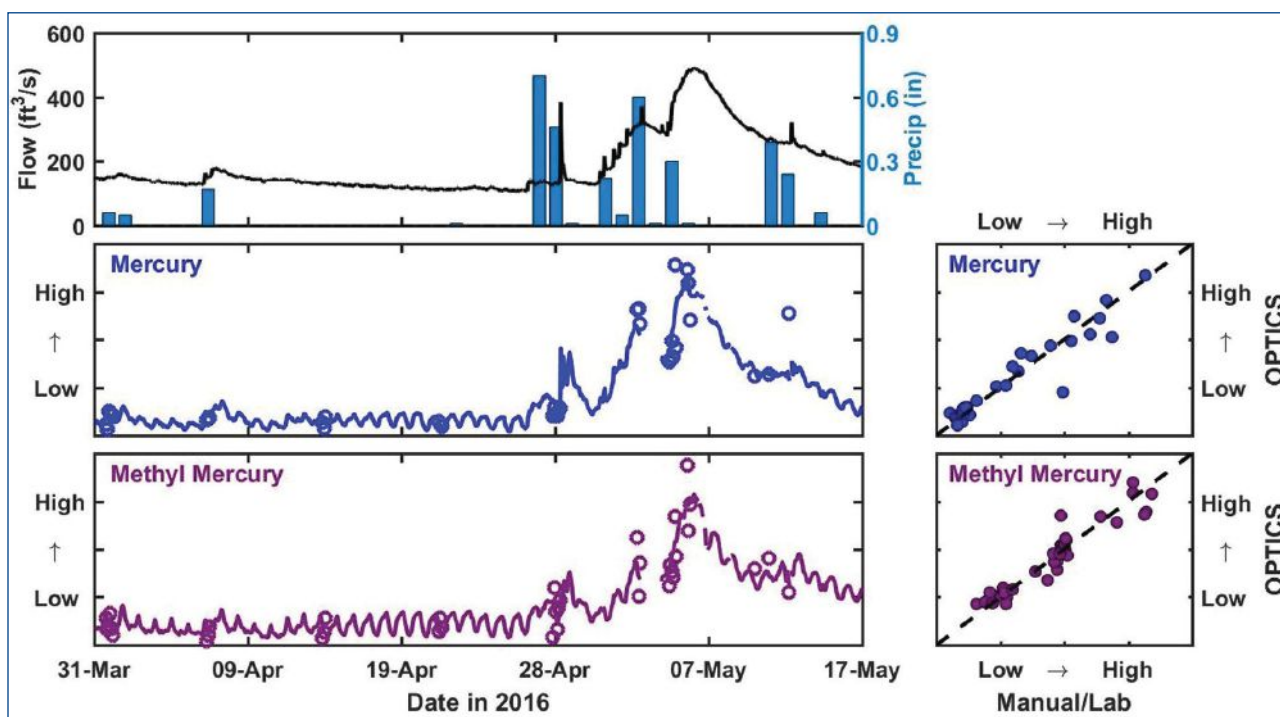
The South River in Crimora, Virginia, is affected by historical releases of mercury from a former rayon manufacturing plant in Waynesboro, Virginia. Mobilization of legacy mercury from secondary sources (e.g., riverbed and riverbank sediments) has been contributing to the redistribution of mercury to surface waters. To effectively

remediate the system, it is necessary to understand the mechanisms for mercury contamination and transport in the South River. Therefore, Integral implemented an OPTICS monitoring program in 2016 to investigate the movement of mercury and methylmercury in the water at a site 11 mi. downstream of the former rayon manufacturing plant.

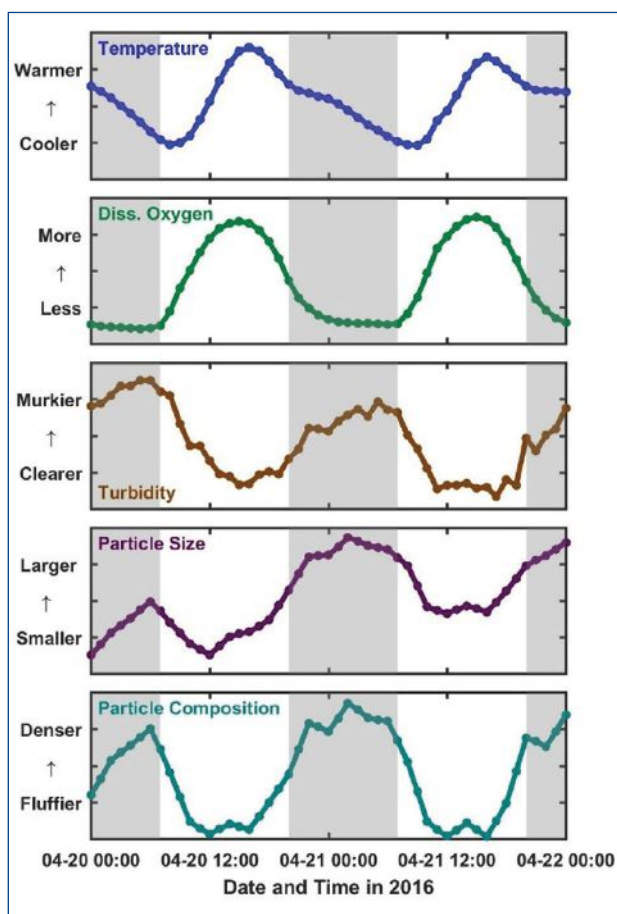
Integral deployed its OPTICS tool in late March 2016 over a six-week period as part of a monitoring study, during which water samples were periodically collected. The water samples were analyzed in a laboratory for chemical concentrations to calibrate and validate the performance of OPTICS.

Results indicate that mercury and methylmercury concentrations were correctly derived from optically based methods, with OPTICS-derived concentrations describing more than 90 percent of the variance in the laboratory-based data set; the regression model's "goodness of fit" was excellent. Thus, continuous records of accurate contaminant concentrations, as well as optical and water quality properties measured by OPTICS sensors, were available for evaluation of the mechanisms affecting the movement of mercury and methylmercury in the South River.

The six-week time-series data records show two noticeable signals: daily periodicity during low-flow (dry)



(Top) Time-series data records of South River flow and precipitation and validated mercury and methylmercury concentrations over the six-week monitoring period. OPTICS-derived chemical concentrations compare well with concentrations derived from the laboratory analysis of manually collected water samples. (Left) Daily oscillations in water quality parameters and optical properties. Night-time signals, from 7:00 p.m. to 7:00 a.m., are highlighted in gray.



conditions (most prominent between April 11 and 26, 2016) and increases in contaminant concentrations during high-flow conditions resulting from precipitation events.

The increase in chemical concentrations during rain and high flow was not unexpected—it is well known that

sediments, and contaminants associated with sediments, are mobilized during high-flow conditions. This is the primary reason why rivers, estuaries, bays and even the coastal ocean appear murkier during and just following high-river-flow events. The increase in concentrations of mercury and methylmercury observed in the South River toward the end of April and into the middle of May 2016 can therefore be attributed to resuspension of contaminated sediments and mobilization of bank sediments during high flow associated with a storm.

The daily oscillations in mercury and methylmercury concentrations, however, were unexpected and had not been previously observed at the South River. The OPTICS data were more closely evaluated to provide insight into the cause of the daily oscillation. It was clear that chemical concentrations increased by up to a factor of 2 at night and decreased by the same amount during the day. Peak concentrations occurred at 7:00 a.m. and lowest concentrations at 7:00 p.m.

Measured water quality parameters and optical properties describing particles also exhibit daily oscillations. The signals in temperature are expected, with water warming during the day and cooling at night. The variability in the amount of dissolved oxygen in the water is also typical of aquatic systems and indicates biological processes: photosynthesis by algae during periods

“The South River in Crimora, Virginia, is affected by historical releases of mercury from a former rayon manufacturing plant in Waynesboro, Virginia.”

of increased sunlight. However, the patterns in turbidity, particle size and particle density are generally contrary to photosynthetic processes. Signals indicative of biological growth should show increased turbidity and generally larger and less-dense particles during the daytime relative to night-time.

Although less dense particles were observed in the daytime in the South River data set, the data show that the water is more turbid at night and particles in the water are larger than during the day.

Analysis of Nighttime Turbidity, Contaminants

Research by scientists at other sites suggests that the churning up of riverbed sediments during the night by bottom-feeding crawfish, fishes or other animals, termed nocturnal bioturbation, could have been the cause of the observed daily oscillations in contaminant concentration and suspended particulate properties in the South River.

Using high-powered microscopes on water samples collected during the day and night, scientists have been able to take a closer look at resuspended material in streams where increased nighttime turbidity has been observed. The sediment images show that nighttime particles in these streams were larger and denser in nature compared to daytime particles, which is similar to what was observed in the South River.

Researchers in the United Kingdom performed laboratory experiments to investigate the potential effects of nocturnal bioturbation. They placed crawfish in darkened aquaria with clear water and bottom material typical of rivers. After just a few minutes, the crawfish began to stir up the bottom sediments. After less than 10 min., the water became so murky that the crawfish were no longer visible to the observer; turbidity signals increased by more than 200 percent.

Conclusion

In summary, Integral used OPTICS to continuously monitor mercury and methylmercury concentrations, together with other water quality and optical properties in the South River. The excellent data quality and high data quantity generated by OPTICS made it possible to investigate the movement of chemical contaminants.

Results show mobilization of riverbed and bank sediments, and associated mercury and methylmercury, during a weeklong storm flow event that began at the end of April 2016. Sediment and sediment contaminants were resuspended daily from the riverbed under base-flow conditions during the nighttime, which appears to be attributable to nocturnal feeding by crawfish or other animals. This daily pattern of chemical contaminant re-

suspension had not been previously observed in more than 30 years of South River monitoring, highlighting the power of OPTICS monitoring.

This study shows that Integral's OPTICS tool provides a marked advancement over traditional manual water sampling and analysis by extending the time periods and sampling frequencies over which chemical contaminants can be measured. OPTICS provides a new and innovative technique for continuous monitoring and analysis of complex contaminant transport in aquatic systems, including pollutant source characterization and transport direction, plume identification and tracking, and monitoring of remediation effectiveness.

Acknowledgments

This work was previously published in *River Research and Applications*.

References

For a list of references, contact Dr. Grace Chang at: gchang@integral-corp.com. **ST**

Dr. Grace Chang has more than 25 years of experience in limnology and oceanography, with more than 40 peer-reviewed publications. She has managed an assortment of research programs and is widely recognized for her advancement of analytical methods in hydrodynamics and particle characterization, as well as environmental research and monitoring.



Todd Martin is an engineer and hydrogeochemist with 26 years of experience in the environmental field. With substantial experience conducting remedial investigation and feasibility studies, he emphasizes implementing innovative empirical and modeling strategies to understand processes driving site risks and finding cost-effective alternatives for remediation to optimize for long-term site management.



Frank Spada is a developmental engineer and ocean engineering technician who oversees technical activities and field operations for oceanographic research. Well-versed in oceanographic sensor systems and monitoring platforms from design to implementation, he has deployed research platforms in lake, river, surf zone, coastal and deep-ocean environments.



international

IMCA Guidance on Environmental Sustainability

The International Marine Contractors Association (IMCA) has published its Code of Practice for Environmental Sustainability. Created by the global experts on IMCA's Environmental Sustainability Committee, the code sets expectations for the marine contracting industry in managing key environmental and climate topics.

Following research among members, working groups are being established to speedily drive forward preparation of guidance on key elements, such as the circular economy, supply chain engagement, life below water and environmental performance factors, to enable members to move forward with their organization's environmental sustainability performance goals.

OVI Continues Ocean Plastics Cleanup

Ocean Voyages Institute (OVI) has been continuing its record-setting plastics cleanup mission from the North Pacific Gyre. OVI's mission is to remove discarded ghost nets (derelict fishing gear) and consumer plastics from the ocean. OVI's sailing cargo ship *Kwai* unloaded in Sausalito, California, this summer after 45 days in the North Pacific Subtropical Convergence Zone, more commonly known as the North Pacific Gyre/Great Pacific Garbage Patch.

In 2020, OVI completed the largest open-ocean cleanup in history, totaling 340,000 lb. It has recovered more than 500,000 lb. of nets and consumer plastics from the Pacific Ocean prior to its latest expedition.

In 2022, OVI transected the North Pacific Gyre from Honolulu to San Francisco covering over 4,600 nautical mi. The debris patch extends over 500,000 sq. mi., an area greater than California to Texas.

Swedish Club Expands in Asia

The Swedish Club, an international marine insurance company owned and controlled by its members, has opened a new office in Singapore. Following 150 years in business and more than 50 years of international development, this move acknowledges the importance of the growing markets in Asia and the club's commitment to serving its members locally.

The new full-service office is responsible for members in Singapore, India, Japan and Thailand.

New Office in Europe for ClassNK

ClassNK has opened a new surveyor office in Rome in response to the recent increase in the number of surveys and audits required in the southern part of Italy and Malta. ClassNK's newest office is located at the center of the Italian Peninsula to provide more efficient local service.

JIP on Bio-Influenced Corrosion

DNV has joined ExxonMobil Upstream Research Co. and Microbial Insights Inc. in a joint industry project (JIP) to develop the next generation of microbiologically influenced corrosion (MIC) detection, monitoring and

mitigation technology. The cost of corrosion is estimated at \$2.5 trillion globally. Difficult to detect and monitor, MIC poses a significant problem in numerous industries, and taking early action to mitigate its effects can protect the environment and safe operations by reducing the risk of costly pipeline failures.

Assembling MIC experts from across the industry, the project plans to create up to 1,200 data points of corrosion-to-biomarker correlations, generated on simulated pipelines with actual field waters and participant-selected service conditions.

The team aims to develop methods, tools and workflows (biomarker technology) to improve reliable detection of MIC in oil field operations, heavily leveraging advanced laboratory (bio)reactors and molecular analytical platforms that have been specifically developed for MIC biomarker discovery.

Dualog Moves into Krakow

Maritime software provider Dualog has made a move to expand its software research and development capability by setting up a new operation in Krakow, Poland. Morten Lind-Olsen, CEO of Dualog, has set his sights on Poland to increase research and development capacity. The new Krakow office comprises six staff, who are working on expanding software solutions for integrated ships.

New Danica Hub in Cyprus

Danica Crewing Specialists has opened a new operational center in Limassol, Cyprus. The new Cyprus regional hub will offer the company's one-contact-point service policy.

Danica's crew-supply network also covers Ukraine, Georgia, the Baltic States (Latvia, Estonia, Lithuania), Romania, Bulgaria, Turkey and the Philippines.

Phoenix: New Test Tank and 25-Year Anniversary

Phoenix International Holdings Inc. has a new, modern test tank at its Bayou Vista, Louisiana, facility. This tank can be used for multiple subsea applications, such as underwater weld testing (both wet- and dry-habitat conditions); underwater nondestructive testing; and performance trials, including underwater welding certifications and underwater tooling calibration and testing. It can be rented to perform equipment or material trials in a controlled underwater environment prior to project execution.

This new test tank comes as Phoenix celebrates its 25th anniversary. The company was founded in 1997 by six underwater operations specialists as a diving company dedicated to the waterborne repair of U.S. Navy ships. Over the past 2.5 decades, Phoenix International Holdings Inc. has evolved into a full-service provider of underwater solutions, from the surface to 6,000-m depth.

E-marine PJSC Relies on MakaiLay Software

In the last year, Makai Ocean Engineering Inc. has started commissioning the cable installation software MakaiLay on E-marine PJSC's cable installation and re-

pair vessels. MakaiLay was recently added to the cable ships *Maram*, *Umm Al Anber* and *Niwa*, with other ships to follow.

E-marine PJSC will also use MakaiPlan Pro for pre-installation planning. The E-marine team has completed trainings on both software products and plans to conduct more trainings as Makai's software becomes fully adopted and integrated into their workflow.

MakaiLay will allow for more precise control throughout the cable installation, with specific improvements in deepwater areas. MakaiPlan Pro enables powerful and precise 3D dynamic simulations of submarine cable installations. Cable operators can quickly simulate an entire cable lay in advance at up to 50 times faster than real time.

Aqua Survey Adds Sediment-Sampling Vessels

Aqua Survey has added three new sediment-sampling vessels to its fleet: the *Manasquan*, *Sandusky* and *Packanack*. Each one was designed by a marine architect to vibracore efficiently and handle the rigors of electrovibracoring.

The *Manasquan* was recently deployed on its inaugural job, collecting vibracore samples along the Schuylkill River.

MarineMax Acquisition

MarineMax, a boat retailer that also offers related marine products and services, has expanded its presence in Texas by acquiring Endeavour Marina in Seabrook. Endeavour Marina is an established full-service marina serving the greater Seabrook market and is located on Clear Lake. The MarineMax team is now running marina operations while the Endeavour team remains in place.

TowBoatUS Now Serves Upper Rappahannock

TowBoatUS Upper Rappahannock has opened to serve this portion of the Rappahannock River with professional 24/7 on-water towing and assistance coverage.

There is a nationwide network of more than 300 TowBoatUS "ports" providing routine on-water assistance, including towing, battery jumps, fuel drop-offs and soft ungroundings. The towing service responds to about 90,000 requests for assistance each year.

TDI-Brooks Adds to Shallow Geotechnical Kit

TDI-Brooks' has brought online a shallow-water (less than 75 m) pneumatic vibracore (pVC) to supplement its other electric VC options (Feritech FT550 and Rossfelder P-5). The pVC is a lightweight (4,600 lb. in air), high-power vibracorer. The pVC can be used for cores up to 6 m in length (and down to 9 or 12 m with frame extension). The topside display informs the winchman of the exact penetration of the barrel into the soil at any point during the vibrating insertion.

Additionally, TDI-Brooks has added a second Datem Neptune Seabed CTP to its inventory, which now includes both N3K and N5K units.

In early 2023, TDI-Brooks will bring online a Manta-200 CPT for its shallow-water geotechnical kit. **ST**

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Subsea Digital Display



C-Level is an ROV- or diver-deployed digital level that may be used to measure and display the inclination angle of underwater structures or mooring lines. The measured angle is shown in real time on a high-visibility LED matrix display. It has a 300-m-depth-rated acetal housing with anodized aluminum front plate and acrylic window. The unit has an integral 3.6-Ah rechargeable battery pack, which is ample to power it for a full working day. OceanTools Ltd.

Ultrasonic Thickness Gauge

Cygnus 2+ is a hands-free device updated with a new front display for easy gauge setup. It has an end display for thickness readings, ideal for rope access or climbing work. There are three versatile measuring modes to suit levels of corrosion and different materials. Cygnus 2+ measures remaining metal thickness easily and accurately without removing protective coatings. Cygnus Instruments.

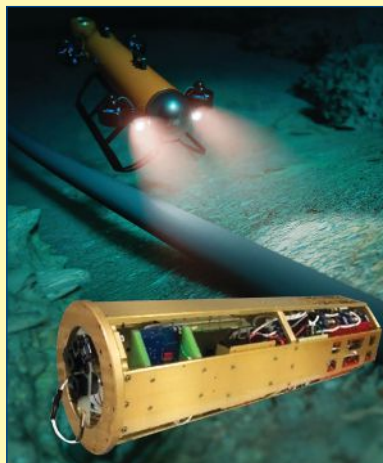
Distress Signal Light

C-1004 SOS eVDS is a next-generation electronic visual distress signaling device (eVDS) featuring infrared and white light. It is a legal replacement for pyrotechnic flares. C-1004's anti-corrosion protection can withstand the rigors at sea, and its lithium batteries have a shelf life of 10 years. The new model is the smallest and lightest choice accepted for legal U.S. Coast Guard (USCG) carriage. Sirius Signal LLC.

3D CAD Library for Ship Design

Design engineers can use this library to select and integrate Roxtec sealing solutions for cable and pipe penetrations in their designs without leaving the FORAN user interface. This integration provides cable and piping penetration items for use on board a wide variety of ships. Solutions are available from simple designs to advanced naval vessels. Roxtec International AB.

Subsea Power Distribution



PowerMod Subsea MVDC converts directly at the ocean floor from 1 to 20 kV and can down convert at a charging station to 48 V or other required voltages. It is bi-directional for grid or loop configuration. Permitting the establishment of multiple charging stations located anywhere along a cable at any depth, the system eliminates the need to surface underwater drones (ROVs) for charging. These pressurized power conversion modules can operate at depths down to 3,500 m. Diversified Technologies Inc.

VSAT for Smaller Vessels

Sealink 60 is a new Ku-band VSAT service designed to meet the needs of smaller merchant, offshore and fishing vessels. Created in response to the growing demand for regional VSAT coverage requiring a smaller antenna, Sealink 60 provides flexi-

ble, regional connectivity to vessels seeking to upgrade from L-band services. The service is offered with unlimited usage and data speeds up to 5 Mbps. Marlink.

Robotic Manipulator Design

Movelt Studio Developer Platform and Movelt Studio SDK (software development kit) help robotics and software engineers to create, debug and ship complex manipulation projects faster. The developer platform has a set of pre-built tools that make it easy to build and debug behavior trees, inspect trajectories, diagnose failures and provide robot recovery. SDK is a runtime framework that is highly extendable through a plugin-based behavior architecture that allows a robot to make its own decisions. It includes a library of behaviors for the most common robot manipulation tasks and enables companies to develop their own for application-specific needs. PickNik Robotics.

Accelerometer

Model 622B01 has been upgraded into a new product that includes added temperature output and high-temperature capabilities. With a sensitivity of 100 mV/g and frequency range of 0.2 to 15 kHz, the HTTO622B01 is ideal for predictive maintenance applications in environments up to 325° F. It has a rugged, noncorrosive stainless steel enclosure and case-isolated electronics to eliminate noise issues. PCB Piezotronics Inc.

Corrosion Detection

With advanced Multiple-Echo technology, the Portagauge 5 enables the user to find corrosion under paints and coatings up to 20-mm thick and measure true material thickness. You can customize with various frequency sensors and input sound velocity to test custom materials. The LCD display has a built-in backlight. Coltraco Ltd.

Fish-Cage Cleaning Robot System

M16 is a modem that enables the Watbot to communicate natively with the base station without signal interference. With up to 12 robots

working in a fish farm at any given time, M16 ensures that there is no interference created by multiple robots communicating simultaneously. Water Linked AS and Watbots AS.

Containerized BWMS

A containerized version of the EcoOne filterless ballast water management system (BWMS), the EcoOne Container Unit is well suited for semisubmersible rigs, jack-up rigs, drillships, FPSOs, FSRUs and other vessels with infrequent ballasting operations at medium to high flow rates. Ecochlor Inc.

Remote Temperature Monitoring



WebDAQ 316 is a stand-alone, temperature logger designed for remote monitoring and control of thermocouple data. It can log 16 thermocouple channels and has a built-in web server that allows access from any device with a web browser. Wi-Fi support enables wireless operation, and data can be viewed in real time or post-acquisition. The logger allows for export of .csv data for Excel and MATLAB. Measurement Computing Corp.

Voyage Management

Navigation charts and voyage planning is the latest service addition to the SperrySphere platform, leveraging NAVTOR's service to reduce fuel costs, support compliance with environmental regulations and reduce workload for navigators by providing all critical voyage information in one integrated application. Northrop Grumman Sperry Marine and NAVTOR AS.

Digitized Training

An online eShop offers seafarers a host of courses, from compliance

to soft skills courses and more. The courses, approved by the Bahamas Maritime Authority, are self-paced and designed to give seafarers flexibility to train and learn on their own terms. OneLearn Global.

Fuel Oil Sensor

SMART VISCO measures the viscosity and temperature of fuel oil before injection into the main engines of large ships. The monitor

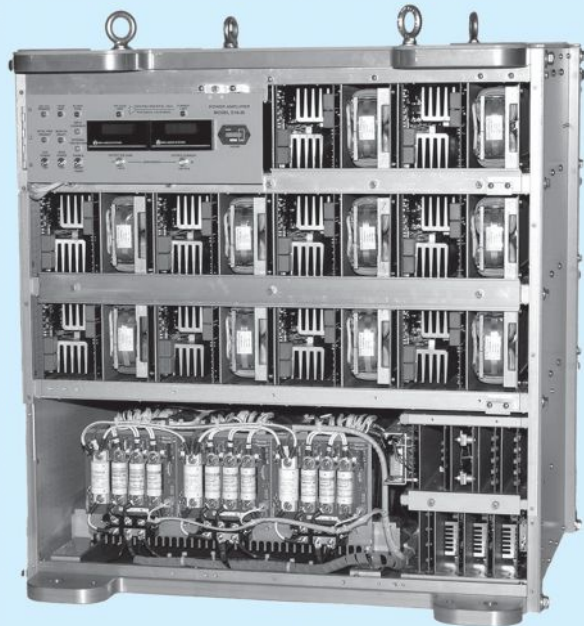
reports the data via analog and digital outputs. The sensor measures all grades of heavy fuel oil using ultrasonic guided wave technology. Rivertrace.

Offshore Seismic System

SeisWind 3D ultra ultra high resolution (UUHR) offers efficient data acquisition for detailed ground modeling and interpretation of near-surface geology. Fugro N.V. **ST**

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RightShip Acquisition

RightShip has acquired Thynk Software's maritime tech business. Thynk's founder and CEO, Marlon Grech, and around 30 of his colleagues have joined RightShip with the acquisition. Grech will also become RightShip's first chief technology officer.

RightShip launched its digital maritime platform after close collaboration with Thynk. The company has an environmental, social and governance focus for its technology.

All-Electric Harbor Tug

Damen's first all-electric harbor tug, the RSD-E Tug 2513, was officially delivered to its new owner, Ports of Auckland (POAL). The revolutionary tug was named *Sparky* and received its Maori name, *Tiaki*, in a special blessing ceremony held in Auckland.

This powerful new tug, which has a 70-tonne bollard pull, is capable of maneuvering even the largest vessels and can undertake two or more assignments before being recharged, which takes just 2 hr.

In 2016, Ports of Auckland set the goal of becoming a zero-emissions port by 2040, and, in light of the impetus to tackle climate change, the port authority challenged Damen to develop a fully electric tug. Over the course of the next six years, the two organizations worked closely to develop this pioneering, sustainable vessel type.

OKEE Maritime Chooses StormGeo Digital Tools

German shipowner OKEE Maritime, which manages a fleet of 10 container vessels in regional feeder services worldwide, has adopted StormGeo's digitalization tools to improve environmental performance, including StormGeo's route optimization and fleet performance management solutions. In addition to onboard weather-based route optimization software and an advanced data-reporting tool from StormGeo, Hamburg-based OKEE Maritime has added fleet performance management services. This gives them access to StormGeo's s-Insight platform for environmental performance, which includes the newly released Carbon Intensity Indicator (CII) Simulator. With this simulator, OKEE Maritime can face the impending industry challenges associated with the International Maritime Organization's upcoming regulations and develop a competitive advantage in the market.

Greensea, SeeByte Collaborate

In response to the growing demand for true ROV autonomy within the field of maritime explosive ordnance disposal (EOD) robotics, Greensea Systems Inc., creator of the open-architecture robotics platform OPENSEA, and autonomy and automatic target recognition (ATR) specialist SeeByte are collaborating.

The two companies have previously operated as competitors, both fielding software for ROVs, but they

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recently recognized that to satisfy the emerging needs of key maritime robotics consumers, such as the U.S. Navy, pooling intellect and experience through collaboration is the only way forward. As a result, for the first time, they are working together under a Department of Defense other-transaction agreement led by the Defense Innovation Unit.

"True ROV autonomy for EOD robotics requiring advanced technology—over-the-horizon control, intervention autonomy and automatic target recognition—will only happen at the pace customers demand through collaboration," said Ben Kinnaman, Greensea CEO, who initially asked SeeByte if they'd be interested in this collaboration.

Prototype High-Resolution Data Available in Beta

NOAA has released prototype high-resolution data for use by navigation systems in the Ports of New York/New Jersey and Los Angeles/Long Beach. The data are meant for testing purposes and should not be used for navigation operations. The bathymetry represented in the prototype data are not necessarily representative of the current condition of the channels.

The prototype data leverage the International Hydrographic Organizations S-102 Bathymetric Surface Product Specification – Edition 2.1.0. This specification has been optimized for use in navigation systems and is a digital elevation model that represents the seafloor in a regular grid structure. In addition to creating product files, these data sets also maintain compliant discovery metadata that allow for machine-to-machine discovery and dissemination.

The S-102 prototype data for these two ports are generated from Coast Survey's National Bathymetric Source (NBS), a continuously updated compilation of the best available bathymetry. As NBS continues to expand its operational area, NOAA will release additional S-102 prototype data for ports within that region.

As the S-102 standard continues to evolve toward the operational edition (3.0.0), NOAA will continue to develop prototype products and services for testing and evaluation until it can release operational products for navigation.

Falcon for Expedition Yacht

A Saab Seaeye 1,000-m-rated Falcon robot has been chosen as a standby rescue resource for emergency recovery of the expedition yacht *Dapple's* manned submersible. The Falcon also comes fully equipped for undertaking scientific research and survey operations.

For *Dapple*, the Falcon is specifically equipped with HDTV cameras, a multifrequency scanning sonar, multibeam sonar, laser system and an eventing suite. It also comes with both a three-jaw and a five-function manipulator, each with rope cutters, along with hydraulic cable cutter and a rotary cleaning brush.

Although the Falcon's key role is recovery of *Dapple's* submersible, for general diving safety, the Falcon can survey a dive site first, then watch over a diver below and transport items back and forth during a dive. **ST**

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Joint Venture for Offshore Wind Vessels in US

Crowley and ESVAGT have executed additional joint venture agreements that further strengthen their commitment to support purpose-built, Jones Act vessel development and availability for U.S. offshore wind production.

The new agreements, which follow the original agreement between the companies in 2021, will support their joint efforts for service operation vessels (SOVs). The latest additions focus on the financial and development efficiencies in the vessel development process between the companies.

The venture was created to develop a best-in-class design and deliver wind-dedicated, U.S.-flag SOV vessels. Crowley will own and operate the vessels crewed with U.S. mariners, and Crowley and ESVAGT will share in the financials of the venture.

Collaboration for South Korea Offshore Wind Power

Korean Register (KR) has signed a memorandum of understanding (MOU) agreeing to technical cooperation in the development and construction of offshore wind power projects with Korea Electric Power Corp. (KEPCO).

KEPCO plans to build a 2.7-GW offshore wind power plant by 2029 near the southwest coast of South Korea to increase the distribution rate of renewable energy in the country.

Under the MOU, KR will provide technical advice on safety, adequacy of construction, production and maintenance during the building of the offshore wind power plant. KR will also provide detailed survey and engineering services.

URI Now Part of DOE Marine Energy Program

The University of Rhode Island (URI) has been accepted into the U.S. Department of Energy's Testing Expertise and Access for Marine Energy Research (TEAMER)

program. TEAMER funding enables technology developers to conduct tests at URI's Ocean Engineering Department facilities, including its wave tank, wave-current flume and acoustic tank. There is no charge for clients to use URI facilities. TEAMER reimburses URI's fees directly.

In addition to increasing collaborative R&D projects with experts and faculty members, URI students will have opportunities to work directly with technology developers and gain valuable experience that can be applied when they are ready to join the rapidly growing marine renewable energy workforce.

In other TEAMER news, the Marine Renewable Energy Collaborative of New England's (MRECo) Bourne Tidal Test Site (BTTS) located at the southern end of the Cape Cod Canal has been recommended for TEAMER acceptance, pending National Environmental Policy Act (NEPA) review. Once the NEPA review has been completed, BTTS will provide an open-water yet close-to-shore prototype testing facility for tidal and current energy devices and many types of marine sensors and underwater communication devices. The BTTS will provide clients with the infrastructure and support needed for Technology Readiness Level (TRL) gated development for mid-scale prototype testing in a relevant open-water environment.

Biggest Renewable Hydrogen Plant in Europe

Shell Nederland B.V. and Shell Overseas Investments B.V., subsidiaries of Shell plc, have taken the final investment decision to build Holland Hydrogen I, which will be Europe's largest renewable hydrogen plant once operational in 2025.

The 200-MW electrolyzer will be constructed on the Tweede Maasvlakte in the port of Rotterdam and will produce up to 60,000 kg of renewable hydrogen per day.

The renewable power for the electrolyzer will come from the offshore wind farm Hollandse Kust (noord), which is partly owned by

Shell. The renewable hydrogen produced will supply the Shell Energy and Chemicals Park Rotterdam, by way of the HyTransPort pipeline, where it will replace some of the gray hydrogen usage in the refinery. This will partially decarbonize the facility's production of energy products, such as petrol, diesel and jet fuel. As heavy-duty trucks are coming to market and refueling networks grow, renewable hydrogen supply can also be directed toward these to help in decarbonizing commercial road transport.

MPS Wave Energy Array Demo

Marine Power Systems (MPS) has signed up to demonstrate a multi-megawatt wave energy array at the European Marine Energy Centre (EMEC) in Orkney, Scotland. The Swansea-based marine energy developer will bring its first commercial-scale-array demonstration to two berths at EMEC's Billia Croo wave test site, off the west coast of Orkney, in 2025 to 2026.

MPS's PelaGen wave energy converter (WEC) design has a unique wave energy capture mechanism enabling energy to be harnessed during the heave and surge of a wave. Each device is designed to capture over a megawatt of power.

The PelaGen WECs will be deployed on MPS's modular floating platform, PelaFlex, based on a tetrahedral design for enhanced stability.

Cable Protection for Two Taiwan Offshore Wind Farms

CRP Subsea was awarded a contract by Seaway 7, the renewables business unit of Subsea 7, to provide 140 NjordGuard cable protection systems and bellmouths for the Changfang and Xidao offshore wind farms off the west coast of Taiwan. The cable protection systems and bellmouths will protect the interarray and export power cables for 62 wind turbines and horizontal directional drilling conduit cables from fatigue damage due to wave and current forces.

Project commissioning should be complete by 2023. The farms will comprise 62 turbines with total capacity of 589 MW. **ST**

Ammonia, LNG Comparison

Bureau Veritas (BV) has carried out a study aimed at de-risking the use of ammonia as a marine fuel, with a specific focus on leak mitigation and treatment, in collaboration with TotalEnergies. The joint preliminary study has evaluated the health and safety risks from ammonia leaks for crew and passengers and pinpointed key safety criteria.

The study examined different leak scenarios for single-wall and double-wall containment, as well as during bunkering operations, also providing key insights on the efficiency of ventilation and vapor-processing systems, the size of safety zones needed and the health risks to people exposed to leaks.

Ammonia is one of the main zero-carbon fuel options currently envisioned by shipping as the industry seeks to decarbonize. Because it burns without emitting CO₂ and is zero-carbon “well-to-wake” when produced from renewable energy, it is a top contender among potential alternative fuels.

However, ammonia presents several safety challenges, which must be addressed before it can be used on board ships. Ammonia is toxic to humans, and exposure beyond certain levels and durations can have serious health consequences for crew and other people on board. For shipowners and designers, a key challenge is to prevent accidental ammonia leaks during ship operations and bunkering.

To help de-risk ammonia as fuel, BV is building on a tried-and-tested approach that was used in the last decade to propel the development of LNG as fuel. BV’s Rule Note NR 671 was also used as a guideline, given its focus on preventing ammonia leaks and requirements for onboard vapor-processing systems.

As ammonia-powered engines and propulsion systems are still being developed, BV and TotalEnergies began by assessing what concentrations of ammonia in the air would be problematic, then compared those levels to LNG. An LNG-fueled

tanker served as the model for comparison.

LNG becomes dangerous at around 50,000 parts per million (ppm), while ammonia starts to have health effects above 30 ppm when permanently exposed, or around 300 ppm when exposed for 1 hr. Based on this, Bureau Veritas noted that unless modifications are made to design, safety distances should be much greater for ammonia than LNG.

New Milestone for Global Seafloor Mapping

The Nippon Foundation-GEBCO Seabed 2030 Project, an international effort to chart the world’s entire ocean floor, has announced an increase in ocean data equating to the size of Europe.

The latest GEBCO Grid figure now stands at 23.4 percent, reflecting an increase of 10.1 million sq. km of new bathymetric data from last year’s figure. This increase is equivalent to an area around the size of Europe, and slightly larger than the Sahara, Earth’s largest hot desert.

Seabed 2030 is a collaborative project between The Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO) to inspire the complete mapping of the world’s ocean by 2030 and to compile all bathymetric data into the freely available GEBCO Ocean Map.

Red Hind Recovery

A more than 30-year marine conservation effort in the U.S. Virgin Islands helped the recovery of a fish species important in commercial, recreational and subsistence fisheries, a new Oregon State University study found.

Red hind, a species of grouper in the Caribbean, historically experienced intense fishing pressure, which led managers to implement progressively restrictive fishing closures in the U.S. Virgin Islands.

In a study published in *Frontiers in Marine Science*, researchers at

Oregon State and the University of the Virgin Islands found that the fishing restrictions at the location they studied helped lead to a more than 35 percent increase in average fish size and the recovery of the population to a benchmark considered sustainable for many fish species. By a measure known as spawning potential ratio, the red hind are now at a benchmark considered sustainable for many fisheries, but that does not mean that continued recovery is guaranteed, the researchers noted.

The recovery of the red hind population at the spawning aggregation site is due in part to management decisions, fishers adhering to closures and long-term monitoring.

Proposed Speed Regulations To Protect Endangered Whales

NOAA Fisheries has proposed changes to vessel speed regulations to further protect North Atlantic right whales from death and serious injuries resulting from collisions as part of a multifaceted approach to stabilize and recover this endangered population.

The changes would expand the current mandatory seasonal speed restrictions of 10 kt. or less in designated areas of the ocean and extend to most vessels measuring 35 to 65 ft. in length.

In addition, the agency is releasing a draft “roadmap” for public comment about on-demand, or “ropeless,” fishing gear (*Sea Technology*, September 2022) that outlines possible ways to increase the use of this technology in commercial fisheries off the U.S. East Coast. The draft roadmap leverages lessons from fisheries using on-demand gear around the world. It identifies the status and remaining research and technology needs for on-demand fishing gear and includes considerations of the economic, safety, operational, regulatory and enforcement challenges and opportunities related to implementing on-demand fishing.

The North Atlantic right whale is one of the world’s most endangered large whale species, with the latest estimate numbering the population at less than 350. **ST**

Analysis of Method to Store CO₂ Long Term in Ocean

Ocean Alkalinity Enhancement (OAE) may be a relatively safe way of storing CO₂ in the ocean, potentially for thousands of years. This technique mimics natural weathering processes and accelerates them by adding low doses of alkalinity to the ocean's surface, slightly increasing its pH and enhancing its ability to absorb CO₂ from the atmosphere.

In 2021, scientists from Dalhousie University and Planetary Technologies, working in Halifax, Canada, started a joint industry-academic project to investigate the efficacy and safety of OAE.

The team chose Bedford Basin, located in Halifax Harbour, as a site for future experimental alkalinity additions. This basin is small and relatively enclosed, making it easy to characterize in both time and space, and it has been monitored weekly for almost 30 years by researchers at the Bedford Institute of Oceanography and, more recently, Dalhousie. This makes it ideal for a controlled experiment.

Before adding alkalinity to the basin, the team needs to complete considerable foundational work, including measuring baseline characteristics of the basin. The physical processes in the basin need to be studied to predict where alkalinity additions could end up and over what time scales. Anything added to the ocean's surface will move horizontally and diffuse downward. This rate of mixing downward is particularly important for determining OAE feasibility.

Increasing alkalinity at the ocean surface creates a region of relatively low CO₂ concentration, commonly characterized as pCO₂ (partial pressure of CO₂). For OAE to be effective, this region of low-pCO₂ water needs to maintain contact with the atmosphere to facilitate further exchange and take up CO₂ from the atmosphere. This exchange is relatively slow (on the order of months). However, vertical mixing could occur much faster. Fast rates of vertical

mixing would move this high-alkalinity, low-pCO₂ water downward too soon, essentially making the alkalinity addition ineffective at drawing down atmospheric CO₂ on the short time scales (weeks to months) necessary for this process to be commercially viable.

To characterize these processes in the Bedford Basin, researchers are developing a high-resolution, 3D numerical model of the basin. They have also been sampling the 3D variability of the basin since December 2021 to establish a baseline and provide data to evaluate the model's performance.

A research scientist at RBR developed a fast underway profiler called the EcoCTD that allows the team to capture extremely high-resolution temperature and salinity observations of the entire basin over short time scales. At the heart of the EcoCTD is an RBR*concerto*³ CTD with a fast-response thermistor and additional bio-optical sensors, including a fluorometer.

Once the physical model is validated, the researchers will add a biogeochemical modeling component and conduct further comparison with observations.

Arctic Shark Found in Belize

A Greenland shark was found in a coral reef off Belize. This marks the first time a shark of its kind has been seen in western Caribbean waters off the world's second longest barrier reef.

Little is known about Greenland sharks. They tend to be seen in the frigid waters of the Arctic and North Atlantic oceans. The slow-moving species is also slow growing. A life in the slow lane may benefit them because they have been estimated to live upward of 400 years. They are the longest-living vertebrate known to science.

Because little is known about them, that means nothing can be definitively ruled out about the species. Greenland sharks could possibly be trolling the depths of the ocean all around the world. Experts

speculate that they could be found worldwide, living in tropics at greater depths, where they can find their preferred low temperatures.

Glover's Reef Atoll, where the shark was found, has a steep slope along its edges that drops from 1,600 to 9,500 ft. deep, which means there is cold water needed for a Greenland shark to thrive.

Disability Education Programs

Thanks to a grant from the Community Foundation of Sarasota County, Mote Marine Laboratory & Aquarium is partnering with The Haven, a local nonprofit offering programs and services for children and adults with disabilities. The partnership uses informal science education to create interactive, engaging and accessible lessons.

Participants engage directly with Mote's educators and educational content monthly during programs, experiencing specialized marine STEM lessons to inspire interest in STEM, awareness for the environment and inclusive access to marine science and learning.

Hydrology Impacts on West Florida's Continental Shelf

A new study by Florida Atlantic University's Harbor Branch Oceanographic Institute, in collaboration with Florida International University, suggests that increased freshwater discharge could mitigate the effect of climate warming on the West Florida Shelf by reducing shelf waters' stratification.

The current river discharge in South Florida is the product of a historical effort to drain water from the Everglades region. The Central and Southern Florida Project water-drainage system has altered the regional hydrology, reducing the total amount of freshwater reaching the coastline.

Changes in salinity and/or nutrient patterns have had significant direct and indirect impacts on the water column and ecology, with documented micro- and macroalgal blooms, mass mortality of seagrasses, fragmentation of seascapes, sponge die-offs, and declines in pink-shrimp catches. **ST**

contracts

Reygar, Stoke Gifford, U.K., has partnered to provide an integrated service for monitoring and reducing fuel, energy use and carbon emissions across vessels and business operations of firms in the marine industry. Cedar Marine.

Bureau Veritas (BV), Paris, France, has signed a cooperation agreement to study the feasibility of installing carbon capture and storage (CCS) units on existing ships to meet 2030 Carbon Intensity Indicator targets. Wah Kwong and Shanghai Qiyao Environmental Technology Co. Ltd.

BMT, London, U.K., has signed a memorandum of understanding to jointly research ship design and cybersecurity in the maritime sector. University of Plymouth.

BIO-UV Group, Lunel, France, has received an order to supply a low-flow BIO-SEA L-Series ballast water treatment system for retrofit installation to the 1,268-gt expedition vessel *Quest*. TECO2030.

Crowley, Jacksonville, Florida, specializing in global supply chain solutions, has chosen a provider to assess its value chain for environmental, social and governance (ESG) impacts. Crowley has committed to reach net-zero carbon emissions by 2050. EcoVadis.

Reventec Ltd., Downton, U.K., has supplied Alpha 900 with its LS200 capacitive fuel level sensor. The Alpha 900 is an uncrewed, fuel-powered helicopter for maritime security and surveillance that can launch from moving vessels. Alpha Unmanned Systems.

Miros Group, Asker, Norway, has secured a trio of three-year agreements to install its Internet of Things (IoT) dry-sensor WaveSystem. As part of project requirements for the monitoring of wave and current to a water depth of 10 m, WaveSystem will be installed on three pipelay support vessels, alongside access to

Miros Cloud services delivering real-time sea state data. Subsea 7.

Ashtead Technology, Aberdeen, Scotland, a subsea rental equipment and solutions specialist, has signed a rental agreement with an international provider of electronic engineering equipment for the underwater industry. RTS. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

NOVEMBER

November 2-4—MAST Med 2022, Athens, Greece. <https://mastconfex.com>.

November 8-9—Institute of Fisheries Management Annual Conference, Guildford, U.K. info@ifm.org.uk or <https://ifm.org.uk/events/ifm-53rd-annual-conference>.

November 8-10—CLEAN GULF, New Orleans, Louisiana. www.cleangulf.org.

November 8-10—Deepwater Operations and Topsides, Platforms & Hulls Conference & Exhibition, Galveston, Texas. www.offshore-event.com.

November 8-10—International Naval Engineering Conference and Exhibition, Delft, Netherlands. www.imarest.org/events/category/categories/imarest-event/international-naval-engineering-conference-and-exhibition-2022.

November 9-10—Sustainable Innovation Forum, Sharm El-Sheikh, Egypt. <https://sustainableinnovationforum.org>.

November 14-18—BlueTech Week, San Diego, California. <https://tmabluetech.org/bluetech-week>.

November 17—Deepwater Executive Summit, Houston, Texas. <https://deepwaterexecsummit.com>.

November 17-19—Pacific Marine Expo, Seattle, Washington. www.PacificMarineExpo.com.

November 22-24—Marine Renewables Canada Conference, Halifax, Canada. <https://marinerenewables.ca/event/marine-renewables-canada-2022-annual-conference>.

DECEMBER

December 12-16—AGU Fall Meeting, Chicago, Illinois, and virtual. www.agu.org/Fall-Meeting.

2023

JANUARY

January 25-26—Coastal Futures, London, U.K. <http://coastal-futures.net>.

January 30-February 1—Floating Wind Solutions, Houston, Texas. <https://floatingwindsolutions.com>.

FEBRUARY

February 13-15—Geo Week, Denver, Colorado. www.geo-week.com.

February 14-16—Oceanology International Americas, San Diego, California. www.oceanologyinternationalamericas.com.

February 27-March 1—World Ocean Summit, Lisbon, Portugal. <https://events.economist.com/world-ocean-summit>.

MARCH

March 12-16—US Hydro, Mobile, Alabama. www.thsoa.org/us-hydro.

March 26-28—Canadian Underwater Conference & Exhibition (CUCE), Halifax, Canada. www.cuce.ca.

March 28-30—MCE Deepwater Development, London, U.K. <https://tinyurl.com/456e9yjb>.

APRIL

April 18-20—Ocean Business 23, Southampton, U.K. www.oceanbusiness.com.

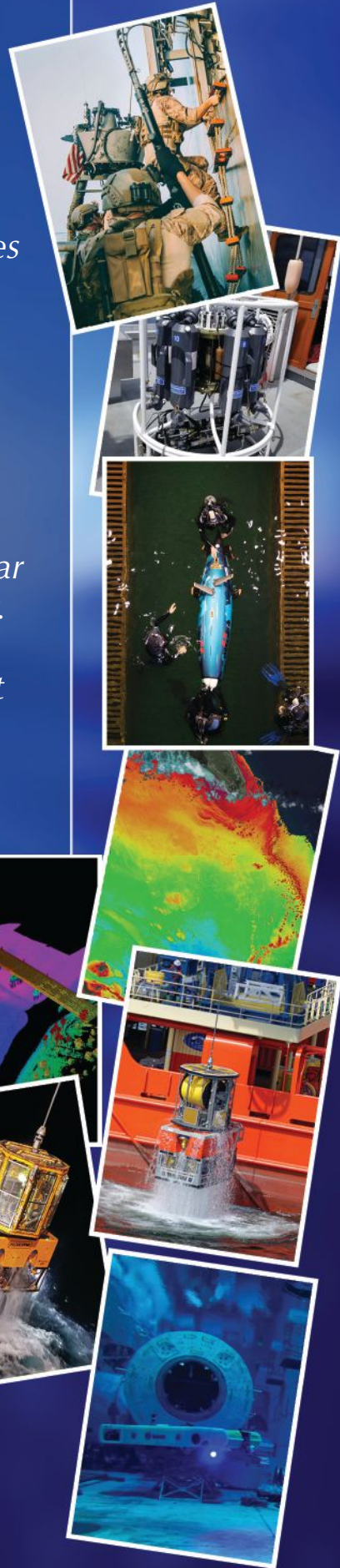
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people

Shahrom Bin Ali has joined BMT Singapore as a marine engineer surveyor. After obtaining his diploma in maritime engineering at Singapore Polytechnic, Bin Ali started his sea-going career at A.P. Moller as a marine engineer on a wide range of vessels. He obtained his Class 1 certificate of competence in 2006 and switched to the offshore industry in 2008 to work with AHTS vessels and anchor-handling, towing, supply and survey operations.



Van Ameyde Marine, a Netherlands-headquartered marine surveying, consultancy and loss prevention group, has appointed **Rob Chesters** as its new global business development manager. Based in the U.K., Chesters will work with teams across the group to develop a global strategy and service offering, with

the aim of expanding the company's international reach geographically and by market sector. Chesters has more than 20 years of business development experience in the maritime services sector.

The International Marine Contractors Association (IMCA) has appointed **Dustin Varnell** to its business development team. Based in Rhode Island, he will focus on the U.S. offshore wind energy market.

Captain **Andre LeGoubin** has been elected as the Nautical Institute's new president. He is an STS mooring master and maritime expert witness and consultant with 40 years of maritime experience.

Jason Barfield has joined Teledyne Marine as technical sales manager for the instruments and imaging technology verticals. Based out of Texas, he will serve customers in the offshore energy sector throughout North America, South America and Canada.

The U.S. Coast Guard Cutter *Polar Star* (WAGB-10) has changed command from **Captain William Woityra** to **Captain Keith Ropella**. During Woityra's two-year tenure, *Polar Star* broke ice at both ends of the Earth. In 2021, the ship set a record for the highest winter Arctic latitude by any U.S. surface ship. In Antarctica in 2022, the crew navigated into uncharted waters and broke the world record for southernmost navigation by any vessel.

VideoRay has named **Brad Clause** as account manager for the offshore wind renewable energy, aquaculture and shipping markets. He has more than 20 years of experience with subsea ROV missions. VideoRay has also established a defense and government business unit, with

Mark Fleming in the lead as vice president. Fleming served in the U.S. Navy, specializing in explosive ordnance disposal, and he joined VideoRay 10 years ago. VideoRay has also promoted **Andy Goldstein** to chief operating officer. He joined VideoRay in 2009 and most recently served as vice president of engineering and operations.

Old Dominion University has selected **Elspeth McMahon** as associate vice president for maritime initiatives. This new position was created as a result of a task force identifying areas where the university could help catalyze economic development in Hampton Roads, Virginia.

CSignum Ltd. has appointed **Gordon Nelson** as application engineer to lead the application development and commercial deployments of the HydroFi modem (Sea Technology, July 2022). Reporting to Chief Commercial Officer Molly Reyes and based out of the company's headquarters in Scotland, he will serve as the key technical resource in coordination with sales, engineering, partners and customers.

Crowley has appointed **Charles "Charlie" Jors** as chief naval architect for the company's engineering services. He will lead Crowley's vessel design and marine engineering teams and has nearly 20 years of naval architecture and marine engineering experience. **ST**

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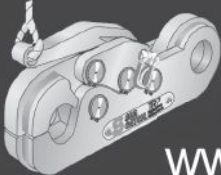
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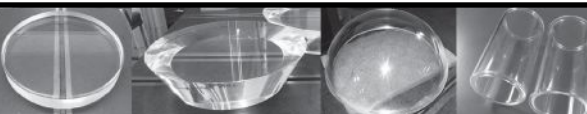
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Pandemic Sees Rise in Maritime Distress Signals—Peter Broadhurst

Peter Broadhurst is senior vice president of safety and security at Inmarsat. He joined the company in 2014 as vice president of maritime service delivery, responsible for leading the development of products and services from conception and implementation through to launch and life cycle management. He was instrumental in launching Inmarsat's high-speed broadband service Fleet Xpress in 2016.



While the impact of the COVID-19 pandemic on seafarer welfare has been well documented, the secondary effect of overworked and dispirited crew on vessel safety has been less widely acknowledged. Findings from a new report by Inmarsat, the world leader in global, mobile satellite communications, imply a correlation between COVID and a rising number of ships in distress.

Aiming to establish the main safety concerns facing the industry, “The Future of Maritime Safety Report 2022” examines data from Global Maritime Distress and Safety System (GMDSS) calls logged between 2018 and 2021. Although this period saw a steady decrease in total vessel losses across the industry, GMDSS calls rose sharply, from 597 in pre-COVID 2018 to a peak of 834 at the height of the pandemic in 2020.

Logic suggests that COVID-19 played a considerable role in this spike, with the crew-change crisis, rapid turnaround in ports and fatigue on board affecting ship safety and the ability of seafarers to perform their duties. Since the pandemic affected access to seafarer training, it is also reasonable to connect COVID-19 to shortages in trained personnel, inadequate oversight on board and significantly extended crew contracts—all of which might have affected operational safety. A

specific case concerns a tanker—the vessel type from which Inmarsat recorded the highest number of GMDSS calls (134) in 2021—that struck an oil and gas production platform in the Gulf of Mexico in October 2020. According to a report by the National Transportation Safety Board Marine Accident Brief, the incident occurred because the master was experiencing fatigue because of having not slept in more than two days. The report also noted an improper handover between masters.

Similar cases have befallen tugboats, which saw a small increase in overall incidents between 2018 and 2021. For example, in December 2021, a tug collided with an LNG vessel it was attempting to assist, with official reports indicating this was one of several incidents in the Panama Canal region in which seafarer fatigue had compromised vessel safety.

In 2021, many parts of the world had begun to recover from the effects of pandemic-related regional lockdowns and port restrictions, and Inmarsat's report reveals a stabilization in GMDSS numbers during that year.

But despite this ongoing recovery, the industry continues to face challenges associated with the pandemic, while other threats—namely, escalating geopolitical tensions, piracy and more frequent extreme weather events—have contributed to the overall increase in vessel incidents.

Perhaps overshadowed by the pandemic in recent years, geopolitical tensions are a constant threat to maritime safety. In April 2021, car carrier *Helios Ray* suffered onboard explosions while off the coast of Oman. The following July, Liberian-flagged tanker *Mercer Street* was attacked by an explosive drone in the same location. Both incidents were attributed to rising tensions between Iran and Israel.

Piracy, too, is an ever-present concern. Data from the International Maritime Bureau (IMB) reveal that despite 2021 seeing the fewest cases of piracy and armed robbery since 1994 at a total of 132, incidents in the Singapore Straits climbed 50 percent, indicating that some regions still pose a piracy threat to vessels and their crew.

In one of the report's expert opinion pieces, Cyrus Mody, IMB's deputy director, calls for “open and honest communication” in addition to “greater international collaboration” to help tackle piracy.

Another perennial threat is extreme weather. Several ships succumbed to storm conditions in the study period, including offshore vessel *Seacor Power*, which, in April 2021, was flipped by hurricane winds in the Gulf of Mexico, leading to significant loss of life and property. A total of 86 lives were lost when the *Varaprada* tug and Afcons' *Barge P305* sank after being caught in Cyclone Tauktae in the Arabian Sea in May 2021.

According to Trond Ski, senior advisor to the Norwegian Coastal Administration, to prevent such incidents, the industry should “take advantage of the benefits new technology brings into the trusted safety services we use” and deploy “quality data” from “reliable sources.”

The drastic rise in distress calls over the last three years is a clear indicator that shipping has not emerged from the pandemic unscathed. As the industry continues to navigate COVID-19 outbreaks and resultant lockdown measures, we could see further peaks in safety incidents. The pandemic, however, is but one of several factors contributing to maritime safety concerns. To reduce the frequency and severity of all kinds of vessel incidents and thereby save lives, shipping must put safety at the core of its operations and use every solution available to it. **ST**

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