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HELIX Neptune, Copperstone Technologies' newest amphibious robot, conducting a bathymetric survey in Alberta, Canada, August 2021. (Credit: Rijesh Augustine)

NEXT MONTH
Wireless platforms, marine radar in naval defense … Merging acoustic communication features in a single device … The role of underwater autonomous tech in NATO maritime strategy … NAVSEA's latest projects … Development of flying ship technology.

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)) Survey on European Firms and Climate Investments. The European Investment Bank's (EIB) new climate report, "European firms and climate change 2020/2021: Evidence from the EIB Investment Survey," looks at how prepared EU businesses are to meet the challenges of climate change and the energy transition. The report's findings are based on the EIB Investment Survey (EIBIS 2020), a survey of firms primarily in the European Union. The new climate report provides a brief overview of firms' perceptions of climate risks, investment to address those risks and the main factors influencing their decisions. Nearly 60 percent of European firms said that they felt exposed to the physical risks of climate change, compared with 50 percent in the U.S. Firms that are thinking about the energy transition tend to see it more positively, equating the transition with increased demand for their products or a boon to their reputation. Nonetheless, roughly one-quarter of EU firms expect the transition to cause disruptions in their supply chain. EU firms' investment in climate change measures is rising steadily. More EU firms (45 percent) are actively investing to address climate change than U.S. firms (32 percent). Firms that view the transition negatively are not investing as heavily, even though they say they are vulnerable to climate change's impact. When they do spend on climate change, firms often invest in energy efficiency. Despite the pandemic, the share of EU firms investing in energy efficiency increased substantially to 47 percent in 2020, from 38 percent the year before. The figure also rose significantly in the U.S., to 50 percent of firms. Barriers to climate investments are hindering Europe's progress in meeting its 2030 climate change goals, such as reducing carbon emissions by 55 percent. A majority of firms say that uncertainty over regulations and taxation, along with high upfront investment costs, limit their ability to invest in climate measures. EU firms consistently report higher barriers to climate investment than their U.S. counterparts. View the report at: www.eib.org/en/publications/european-firms-and-climate-change-2020-2021.

)) Industry Report on Sustainability. Trelleborg's marine and infrastructure operation has launched a new research report titled "Serious About Sustainability," which reveals where sustainability sits on the maritime sector's priority list, the key business drivers for sustainability and what actions are having the most immediate impact. The report also details the pivotal role partnerships are playing in creating a more sustainable value chain. Comprising quantitative and qualitative research across more than 90 organizations around the world, respondents ranged from various maritime roles and businesses, including port owners and operators, engineers, tug operators, maritime pilots, and consultants. Guided by the UN's Sustainable Development Goals (SDGs) and sustainability as a top priority, Trelleborg Group has pledged a long-term commitment to enhancing sustainability by design, a commitment to create more sustainable products, technology and operational processes. In support of SDGs, Trelleborg's marine and infrastructure operation spans three key focus areas: responsible supply chains from sourcing to end-of-life, decarbonizing the maritime and infrastructure sector through the development of clean tech, and engineering sustainability through premium product design. To download the report, visit: https://bit.ly/3jK8iuH.

)) Applications Open for Washington Maritime Blue Innovation Accelerator. Washington Maritime Blue has opened applications for the Third Wave of its Innovation Accelerator. Maritime Blue (in partnership with the Port of Seattle and Washington State Department of Commerce) has been running a program focused on helping early-stage companies in the maritime and ocean space learn how to scale. With the help of its mentor network, the Innovation Accelerator has worked with more than 20 companies over the past couple of years that have gone on to raise millions in venture funding, acquire strategic customers who have helped grow their business, and have connected with each other in unique ways. The following specialties are of particular interest in the Third Wave of the Innovation Accelerator: maritime decarbonization and digitalization; port operations, shipping and logistics; sustainable fishing, aquaculture and mariculture; ocean data and marine energy; noise reduction and acoustics; technology for conservation; and all things blue economy related. Deadline is November 19, 2021. Learn more at: https://maritimeblue.org/blue-accelerator.

)) New Inclusive Energy Innovation Prize. The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and the Office of Economic Impact and Diversity (ED) have introduced the Inclusive Energy Innovation Prize. The new prize will provide cash prizes of up to $250,000 each ($2.5 million total) to groups and organizations to support entrepreneurship and innovation in communities historically under-represented and underserved in the energy sector. To achieve these ambitious goals, the U.S. must equitably invest in climate change mitigation and clean energy solutions and support those leading the innovation and deployment efforts equally. The Biden Administration's Justice40 initiative has set a parallel goal: to deliver 40 percent of the overall benefits of relevant federal investments in climate and clean energy to underserved communities. Community-centric organizations and educational institutions with experience engaging with and promoting under-represented and underserved communities are encouraged to apply. Such organizations will support environmental, climate, and energy justice and use their experience and institutional knowledge to serve as bridges between DOE and innovators. Learn more at: www.herox.com/InclusiveEnergyInnovationPrize. ST

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editorial

***Dan Jackson**, Founding Director, Cerulean Winds*

The UK Can Accelerate Offshore Decarbonization

Green infrastructure developer Cerulean Winds has an ambitious plan to accelerate decarbonization of oil and gas assets through an integrated 200-turbine floating wind and hydrogen development that would shift the dial on emissions targets and create significant jobs. The £10 billion proposed green infrastructure play would have the capacity to abate 20 million tonnes of CO_2 through simultaneous North Sea projects West of Shetland and in the Central North Sea. Cerulean estimates that the current 160,000 oil and gas jobs can be safeguarded, and 200,000 new roles within the floating wind and hydrogen sectors will be created within the next five years.

A formal request for seabed leases has been submitted to Marine Scotland. The venture is now calling on the U.K. and Scottish governments to make an exceptional case to streamline the regulatory process in order to deliver an extraordinary outcome for the economy and the environment.

Cerulean Winds is led by serial entrepreneurs—myself and Mark Dixon—who have more than 25 years of experience working together on large-scale offshore infrastructure developments in the oil and gas industry. We believe the risk of not moving quickly on basin-wide decarbonization would wholly undermine the objectives set out in the North Sea Transition Deal, which targets a net-zero basin by 2050.

The U.K. is progressing the energy transition, but a sense of urgency and collaborative approach is required to enable rapid decarbonization of oil and gas assets, or there is a risk of earlier decommissioning and significant job losses. Emissions are quite rightly no longer acceptable, but with emissions penalties and taxes coming, the U.K. oil and gas industry's role in homegrown energy security during the transition could be threatened unless current decarbonization efforts can be greatly speeded up. Not moving quickly enough will be catastrophic for the economy and the environment.

Cerulean has Tier One contractors in place to deliver the U.K. Continental Shelf (UKCS) backbone development and has engaged the financial markets for a fully funded infrastructure construct. Project advisers include Société Générale, a leading European financial services group, and Piper Sandler, corporate finance adviser to the energy industry.

The proposed development involves over 200 of the largest floating turbines at sites West of Shetland and in the Central North Sea with 3 GW of capacity feeding power to the offshore facilities, plus 1.5-GW power to onshore green hydrogen plants. It will have the ability to electrify the majority of current UKCS assets and future production potential from 2024 to reduce emissions well ahead of abatement targets. Green power will be fully available to offshore platforms at a price below current gas turbine generation via a self-sustained scheme with no upfront cost to operators. Green hydrogen can be developed at scale, with £1 billion hydrogen revenue potential.

Cerulean has undertaken the necessary infrastructure planning to ensure the required level of project readiness, targeting financial close in the first quarter of 2022. Construction would start soon after, with energization commencing in 2024. An infrastructure project finance model, commonly used for major capital projects, is being adopted.

We have a transformative development that will enable the U.K. to rapidly decarbonize oil and gas assets, safeguard many thousands of jobs, and support a new green hydrogen supply chain. We call on the Scottish government and Marine Scotland to support an exceptional streamlined regulatory approach to enable this development that will decarbonize the UKCS and be the single biggest emissions abatement project to date. **ST**

Environmental Force Multipliers

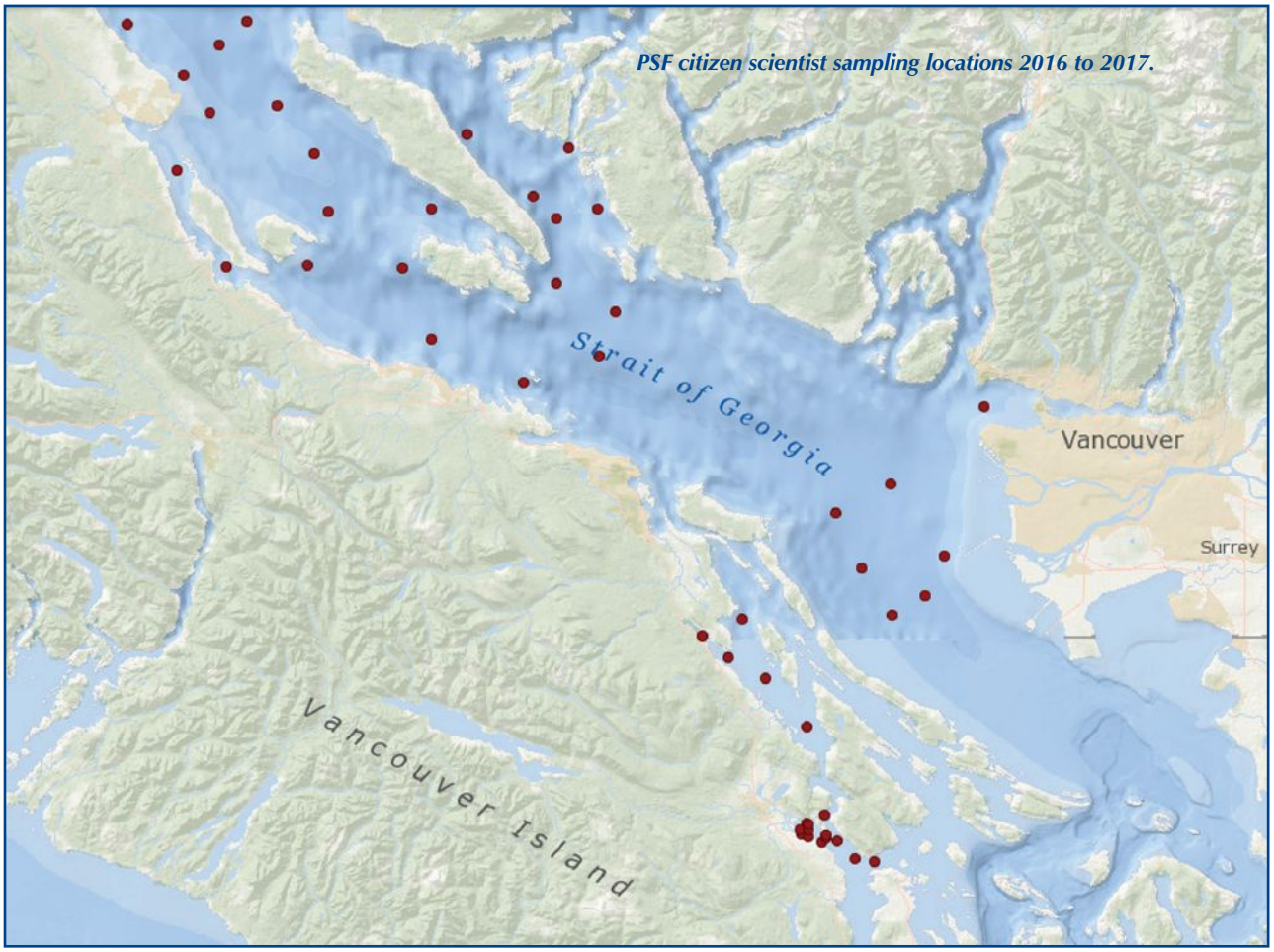
Expanding Oceanography via Citizen Science and Flexible Technology

By Chris Malzone • Nicole Frederickson • Dr. Isobel Pearsall

Increased focus on our oceans is resulting in greater awareness of our shortcomings and the challenges we face to expand our knowledge. At the forefront of our knowledge base are robust data collection efforts that cover the entire breadths of relevant spatial and temporal scales.

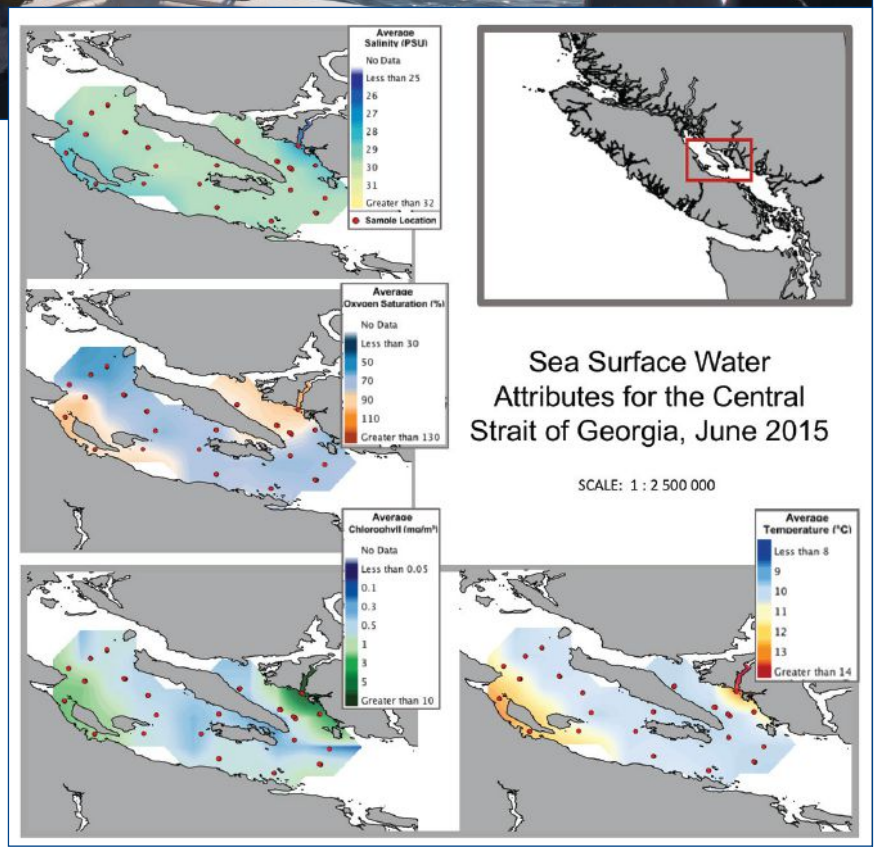
The challenges we face are: the need for vast distribution of high-quality data collection and having enough adequately trained personnel to fully execute data collection. These intertwined obstacles may be overcome through innovative solutions.

The quality of any data collection effort begins with



PSF citizen scientist sampling locations 2016 to 2017.

Citizen scientist preparing a Niskin bottle for water sampling. (Below) Oceanographic attributes, maps, animations and data are available at the Strait of Georgia Data Centre (https://sogdatacentre.ca).



reliable and accurate technologies that are deployed over long enough time scales and large enough spatial scales such that the data analysis provides meaningful results. Remote sensing solutions (satellite, aerial surveys, etc.) provide such scales; however, the data must be ground-truthed to ensure accuracy. In-situ measurements using oceanographic instrumentation are required to validate and expand upon remote sensing measurements, and, in turn, collection of these data require personnel trained in the use of marine technology. Shortages of qualified field personnel is a challenge. A solution lies with citizen scientists and instruments that are so simple in their design that any nonoceanographer can quickly execute a data collection effort.

One prime example of such a project takes place in the Strait of Georgia (SoG) in British Columbia, Canada, where researchers are collaborating with citizen scientists to obtain data that will provide knowledge into the decline of Pacific salmon stocks, particularly Coho and Chinook salmon, over the past two decades. Spearheading this effort is the Pacific Salmon Foundation (PSF), which is coordinating, training, and managing a loyal and vested team of citizen scientists to perform high-quality data collection at spatial and temporal scales never before accomplished.

Citizen Science in the Strait of Georgia

What Is It? Citizen science centers on collaboration with local communities to address research questions through the collection and analysis of data, whereby new discoveries are made and new technologies are developed to improve our understanding of environmental problems. In the Strait of Georgia, members of the public collect important oceanographic data to help understand the decline of Pacific Salmon stocks. The project is a partnership between PSF, Department of Fisheries and Oceans Canada (DFO), and Ocean Networks Canada (ONC). Through this program, data have been collected at a spatial and temporal level never achieved before; the entire strait can be sampled within one day.

How It Works. PSF's Citizen Science Oceanography Program in the Strait of Georgia is the brainchild of Dr. Eddy Carmack, a retired scientist from the Institute of Ocean Sciences, DFO. It involves volunteers using a "mosquito fleet" of their own fishing vessels to do oceanographic surveys in seven overlapping areas of the Strait of Georgia every two weeks.

Projects involve the use of oceanographic instruments that are lowered through the water to collect and store measurements of conductivity, temperature and depth (CTD) to calculate salinity, and two auxiliary sensors to measure fluorescence (an indicator of plankton productivity and algal growth) and dissolved oxygen content (to quantify ocean mixing). Once the instrument is back on board the vessel, data are automatically transmitted to ONC's data management system using a custom-designed app. Quality checks are then performed on the data, and once verified, the data are archived and made freely available to the public via the Strait of Georgia Data Centre (https://sogdatacentre.ca).

In addition to the water profiling, physical water samples are collected for plankton and nutrient analysis. A Secchi disk is used to measure and record water clarity.

Why It's Important. Collecting oceanographic measurements in this manner is a force multiplier for research. In a single day, dense data sets can be obtained simultaneously, allowing researchers to increase the accuracy and validity of data comparisons. In an era of over-commitments and shrinking budgets, dedicated and trained local citizens have never been more significant.

This collaborative program is now continuing for a seventh year, providing oceanographic information that addresses multiple research project requirements at temporal and spatial scales not achievable with large traditional research vessels. The data collected are allowing researchers to assess annual variation in physical/chemical oceanography, develop ecosystem models, validate satellite imagery, and understand spatial and temporal changes in productivity of the Strait of Georgia.

AML Oceanographic's AML-6 can accommodate up to six exchangeable X2Change sensors on the end-cap and two external cabled sensors, plus UV biofouling prevention.

Keeping It Simple: The Technology

Following experience gleaned in the early days of PSF's Citizen Oceanography Program, some key technological improvements were identified. The first is reliability: Technology must be designed to withstand harsh conditions that may be experienced during small boat operations and not be prone to failure. The second is simplicity: The equipment must be easily configured by citizen science members and simple enough in its design that maintenance requirements are minimal and field repairs are limited. The third is optimal size: The CTDs must be small in both size and weight such that they can be deployed and retrieved manually by hand. The fourth is flexibility: The architecture must be flexible enough such that the data can be integrated into ONC's existing infrastructure. The fifth is cross-compatibility: Data must be compatible to allow for comparison with existing data sets in the region.

In addition, prompt instrument service and maintenance and timely and accessible customer support are required from the instrument manufacturer to ensure no scheduled data collection events are missed.

Following a recommendation from ONC, PSF contacted AML Oceanographic to explore its AML-6 LGR multiparameter instrument. Located in Victoria, British Columbia, AML Oceanographic supplies instruments and moving vessel profilers for mission-critical oceanographic and hydrographic projects. AML is unique in its approach to technology. It implements exchangeable technology onto the end-caps of all instruments so that sensors can be removed for calibration, exchanged with those measuring different parameters, and added to increase application scope.

AML recently released its second generation of this technology, referred to as the X2Change product line. In addition to over 20 parameters available as X2Change sensors, the end-user may also incorporate any external (clamped to the instrument body) non-X2Change sensor through a SubConn bulkhead connector. AML also incorporates its innovative biofouling prevention technology utilizing UV-C underwater lamps that protect both the external and X2Change sensors. UV radiation is noncontact, nontoxic and can operate indefinitely given a continuous power supply, making it an appealing form of biofouling prevention. Regardless of configuration, AML instruments have a long history of reliability, performance and flexibility such that users can focus on the data and not the technology. Being in the same city provides an added benefit to PSF in that it drastically reduces annual maintenance times by simplifying logistics.

The Pacific Salmon Foundation selected the AML-6 LGR configured with a high-accuracy conductivity and temperature sensor, Turner chlorophyll a/b sensor and a Rinko III dissolved oxygen sensor. The numerical designation in the product name refers to the number of X2Change ports available to the end-user, while the LGR refers to the instrument being configured with onboard battery and memory storage. The AML-6 LGR comes configured with an onboard GPS to record the position of every cast and onboard hotspot Wi-Fi for rapid data transfer.

The Wi-Fi and GPS from the AML-6 are also critical to PSF's field operations. Through their partnership with ONC, the AML-6 API was used to integrate into the Community Fishers mobile app designed and built by ONC. The app allows fishers and volunteer citizens to upload the georeferenced oceanographic data to ONC's world-leading data management system, Oceans 2.0.

"Citizen science efforts such as those being conducted through the Pacific Salmon Foundation ... are proven to be force multipliers."

From there, the data are archived, processed, and visualized for scientists and the public around the world. All the data are ultimately stored in the PSF-UBC Strait of Georgia Data Centre, where they are freely available to the public.

The Data Centre also creates outreach products from these data. Some examples include: a story map (https://arcg.is/0KXDjq); maps of harmful algae distribution (https://arcg.is/enDKG); a digital Atlas, developed by Dr. Rich Pawlowicz and UBC (University of British Columbia) students (https://sogdatacentre.ca/atlas); and newsletters.

Supporting Research

To ensure credibility and robustness of these data collection efforts, PSF provides their volunteers regular training on the technology and best field practices. This dedication to quality by both the staff and the volunteers has led to these data being used in DFO's annual "State of the Physical, Biological and Selected Fishery Resources of Pacific Canadian Marine Ecosystems." The PSF Citizen Science Program was also endorsed by the GlobalHAB international science program supported by the Intergovernmental Oceanographic Commission of UNESCO. Currently, it is the only HAB (harmful algal blooms) endorsed project involving citizen science.

Some of the outcomes of the program's harmful algae analysis include reports on *Alexandrium* spp. and *Heterosigma akashiwo*. *Alexandrium* is an algae that causes frequent shellfish harvesting closures in BC due to high Paralytic Shellfish Poisoning toxins, while *Heterosigma* is a fish killing algae. These reports contribute to better understanding of these taxa ecology.

The first peer-reviewed study based on the PSF's Citizen Science data,"Harmful algae and oceanographic conditions in the Strait of Georgia, Canada based on citizen science monitoring," was accepted for publication in 2021. This study reveals spatiotemporal distributions, ecological niches, and statistically significant relationships between environmental drivers and several HABs-forming taxa. Data collected during this study have the potential to be combined with higher trophic level data (e.g., zooplankton and fish) to further analyze interactions among physical oceanographic parameters, food web dynamics and potential outcomes for fish stocks. Together, this information can aid in understanding the relationships between SoG conditions and the survival and growth of fish species such as Pacific salmon, which are of cultural and economic importance in the region.

The Citizen Science Program supported by PSF is continuing the collection and analysis of samples that will be highly beneficial in understanding the local ecology of HABs-causing taxa, which may lead to the development of predictive models.

A Community of Environmental Force Multipliers

From species distribution to processes governed by physics, scientists have followed the same basic scientific principles for conducting their research. The process has historically relied on personnel specially educated in a discipline and trained to perform both the collection and analysis of the data. There are some logistical issues with this type of model, including: availability of trained field personnel in terms of headcount and scheduling, utilizing highly educated personnel to conduct lower-level tasks, and coordinated collection of time-critical data sets over large spatial extents. In the end, results from such studies are often published many years beyond the original collection efforts and do not reflect the current status.

Citizen science efforts such as those being conducted through the Pacific Salmon Foundation not only alleviate many of the logistic challenges but also, when managed properly, are proven to be force multipliers. Temporal and spatial scales are quickly expanded, adding more relevance to the overall study. PSF implements a framework incorporating technology that is reliable and easy to use, training that maintains quality, and citizen scientists that are inherently loyal to the cause through their willingness to be a volunteer. PSF and the citizen scientists have not only contributed to credible research but have also built a community that has a vested interest in the outcome.

Acknowledgments

Svetlana Esenkulova of the Pacific Salmon Foundation contributed to this article.

References

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Chris Malzone is the vice president of marketing and sales at AML Oceanographic. He holds a M.S. in oceanography from Moss Landing Marine Labs. Over his 30 years in marine science, Malzone has worked in positions ranging from lead scientist to general manager for academic and commercial organizations. His project focuses have been in fluid dynamics, seafloor and habit mapping, and fisheries.

Nicole Frederickson holds a B.S. in natural resource protection from Vancouver Island University. Prior to becoming the manager of the Pacific Salmon Foundation's Citizen Science Oceanography Program in 2019, she volunteered as a citizen scientist for four years. In addition to her work with PSF, she also works with Vancouver Island First Nations on fisheries-related issues.

Dr. Isobel Pearsall is the director of the Marine Science Program at the Pacific Salmon Foundation. She oversees a number of large-scale citizen science programs and a broad range of research initiatives. She is also project lead for the Strait of Georgia Data Centre.

Sailing into the Eye of the Storm

Ocean Drones Collect Critical Hurricane Data

By Richard Jenkins • Christian Meinig • Gregory R. Foltz

Saildrone's "hurricane wing" is a shorter, ruggedized wing optimized for hurricane storm wind events Category 1 (74 to 95 mph/118 to 151 km/h) and above.

As hurricane season approaches each summer, coastal communities in the Caribbean and on the U.S. Atlantic seaboard brace for impact. These intense and often deadly storms aren't only a persistent threat to human safety, they also present a significant economic impact—hurricane damage in the U.S. is estimated at around $54 billion annually. NOAA has predicted a 65 percent chance that the 2021 Atlantic hurricane season will be above normal, with 15 to 21 named storms. Half of those are expected to become hurricanes, and three to five are expected to be major hurricanes, Category 3 or higher.

The biggest challenge in hurricane forecasting is predicting how quickly a storm might intensify, as either an underestimate or overestimate of intensification can have severe consequences just before landfall. The exchange of heat between the ocean and atmosphere is one of the key physical processes providing energy to a storm. To improve understanding of this process, scientists need to collect in-situ observations before and during storms.

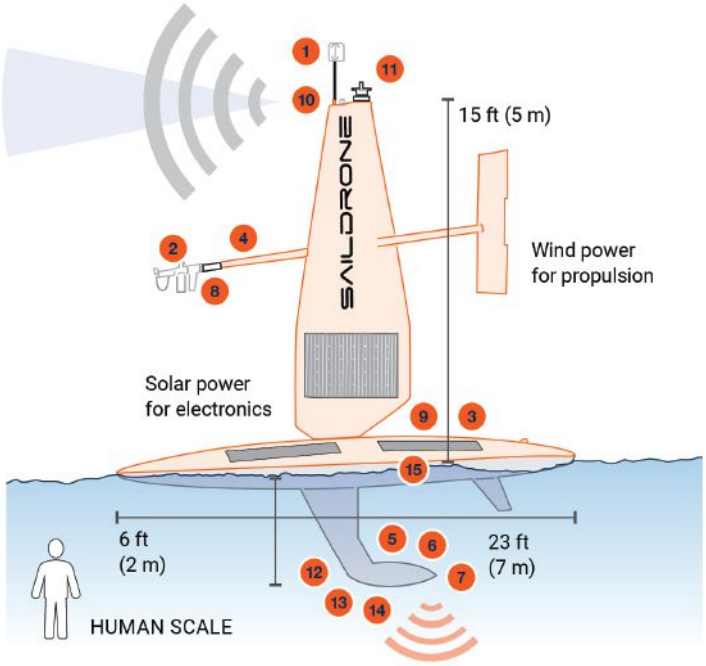
USV Deployment

This summer, Saildrone partnered with NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) and Pacific Marine Environmental Laboratory (PMEL) to sail five uncrewed surface vehicles (USVs) into tropical storm and hurricane events in the Atlantic Ocean.

Saildrone USVs are highly maneuverable, wind- and solar-powered vehicles designed for long-range data collection missions. The 23-ft. Saildrone Explorer is typically equipped with a 16.5-ft. (5-m) rigid wing sail for forward propulsion. This wing is optimized for a wide range of sailing conditions, from very light to moderately heavy wind speeds. Standard Saildrone Explorers are rated to operate in winds up to 60 mph, but hurricane winds routinely exceed 115 mph.

To withstand hurricane-strength winds and severe waves, Saildrone has developed a shorter, ruggedized "hurricane wing," which gives the vehicles the same maneuverability as the standard wing but is less susceptible to damage from large breaking waves. Saildrone USVs are the only autonomous vehicle that can collect meteorological and environmental data above and below the sea surface and withstand the extreme winds and sea state present during a hurricane.

Saildrone has been working with PMEL since 2015 to refine the platform for specific ocean conditions and integrate a wide variety of surface and subsurface instru-



PAYLOAD OPTIONS

No.	Variable	Sensor	
1	Wind speed & direction	Gill Windmaster 3D Ultrasonic 20Hz @ + 5.2 m	ATMOSPHERIC
2	Air temp & humidity	Rotronic HC2 - S3 with rad shield @ + 2.3 m	ATMOSPHERIC
3	Barometric pressure	Vaisala Barocap PTB210 @ +0.2 m	ATMOSPHERIC
4	Photosynthetically active radiation	LI-COR LI-192SA @ +2.6 m	ATMOSPHERIC
5	Salinity & temperature	Seabird SBE 37 @ -1.5 m	OCEAN
6	Dissolved oxygen	Seabird SBE 37 ODO @ -1.5 m	OCEAN
7	Chlorophyll-a	Wetlabs ECO-FL-S G4 @ -0.5 m	OCEAN
8	Skin temperature	Heitronics CT 15.2 @ +2.3	OCEAN
9	Wave height & period	Dual GPS aided IMU	OCEAN
15	Carbon	NOAA PMEL ASVCO2 (pCO2) Atmospheric & dissolved pCO2	OCEAN
10	AIS transceiver		MDA
11	Smart camera array	360° High-resolution optical cameras with ML target detection	MDA
12	Ocean currents	Teledyne RDI Workhorse ADCP 300 kHz @ -1.9 m	ACOUSTIC
13	Fish biomass	Simrad WBT Mini (EK80) @ -1.9 m	ACOUSTIC
14	Bathymetry	Shallow single-beam: Airmar DT800	ACOUSTIC
		Deep single-beam: Teledyne Echotrac E20	ACOUSTIC
		Deep single-beam: Simrad WBT Mini	ACOUSTIC

(Above) The Saildrone Explorer standard sensor suite. (Right) Three Saildrone Explorers equipped with hurricane wings wait for deployment in the U.S. Virgin Islands.

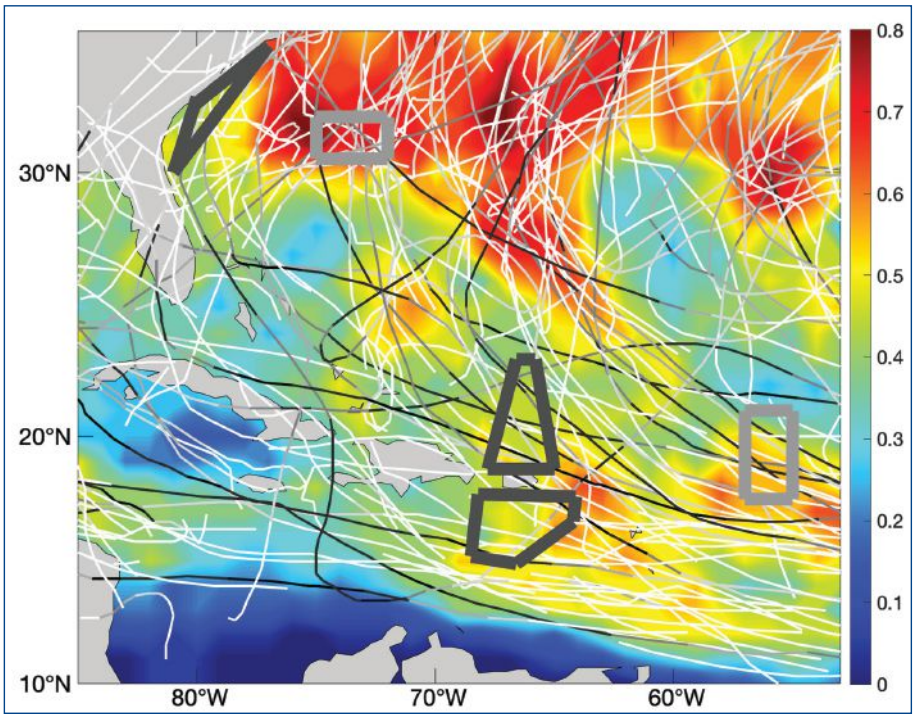
mentation, focusing on climate quality observations. In November 2020, Saildrone began a three-month test of the first hurricane wing in an area of the North Pacific where winter storms are frequent. The vehicle experienced several storms, and the mission demonstrated its durability and maneuverability at all points of sail.

In July 2021, three Saildrones were deployed from the U.S. Virgin Islands, and two Saildrones were deployed from Jacksonville, Florida. Each vehicle was stationed in one of five operating areas in the Tropical Atlantic Ocean, creating a web of coverage in Hurricane Alley for the height of hurricane season.

Very few observations have ever been collected from inside hurricanes. NOAA and the U.S. Air Force's Hurricane Hunter airplanes measure the winds and temperature near the surface of the ocean remotely and drop sensors that give instantaneous measurements, but they cannot capture the exchange of heat between the ocean and the atmosphere that fuels a storm's intensification. The Saildrones will work continuously, before, during and between hurricane events, collecting data about normal ocean conditions including sea surface temperature, salinity, wind speed and direction, barometric pressure, dissolved oxygen, wave height and period, and ocean current speed and direction. The measurements of winds, air temperature, humidity and ocean surface temperature from the Saildrones will enable the accurate estimation of the total transfer of heat from the ocean to a hurricane. The high-frequency (20 Hz) air temperature and 3D wind measurements will also allow direct quantification of the turbulent momentum and sensible heat exchanges between the ocean and atmosphere and their dependence on surface wave conditions.

Scientists from AOML and PMEL are working together to pilot the vehicles into a series of hurricanes for testing and sampling. Regions were chosen to preposition the Saildrones in areas with the highest probabilities of sampling hurricane conditions, based on a statistical analysis of past hurricane tracks. As a hurricane develops, the vehicles will be tasked to sail toward the storm.

Saildrones transmit collected data in real time. The change in these data values is expected to provide clues as to why certain storms intensify faster than others and how strong they might become. The Saildrones are also



Historical tropical cyclone activity and Saildrone operating regions. Thick gray lines enclose the areas where Saildrones are operating August to October 2021. Light gray indicates only Saildrones; dark gray indicates Saildrones that will coordinate with ocean gliders. Thin lines are tracks of past Category 5 hurricanes (black), other hurricanes (gray), and tropical storms (white). The background colors represent the probability of tropical storm-force winds during August to October 2021, based on data from 2000 to 2019.

equipped with high-resolution 360° cameras, providing a visual account of the building storm.

Game-Changer

Saildrone's new hurricane wing is a game-changer for the collection of in-situ data in the most extreme weather conditions on Earth and will be field-tested under hurricane conditions for the first time. While crewed vessels typically steer clear of approaching storms for the safety and security of passengers on board, an autonomous vehicle will be able to go where no scientific vessel has ever ventured: right into the eye of the hurricane to gather data that could make communities around the world safer from these destructive storms.

Data collected during the 2021 Atlantic hurricane mission will also be sent to the World Meteorological Organization's Global Telecommunication System and disseminated to all of the major forecast centers—some 20 agencies worldwide, including NOAA's National Weather Service (NWS) and the National Environmental Satellite, Data and Information Service (NESDIS). NWS will use the Saildrone data to improve forecasting. NESDIS will align findings resulting from the Saildrone data with that of other observing platforms, such as underwater gliders, which measure conditions in the upper several hundred meters of the ocean. Three of the Saildrones will track ocean gliders throughout the mission. Together the Saildrones and gliders will obtain nearly collocated and simultaneous measurements of the upper ocean and near-surface atmosphere, the first time that this will be done using autonomous vehicles.

Saildrone has a proven history of operating successful missions in the world's harshest environments, with over 13,000 days at sea and 500,000 nautical miles sailed from the Arctic to the Southern Ocean. This year, Saildrone will launch several novel missions, including the first freshwater mission in the Great Lakes with the U.S. Geological Survey and a year-round mission to study air-sea carbon dioxide exchange in the Gulf Stream.

Acknowledgments

The 2021 hurricane Saildrone mission work is supported by funding from several NOAA sources: the Office of Marine and Aviation Operations Uncrewed Systems Program, Oceanic and Atmospheric Research Ocean Portfolio, Weather Program Office, Pacific Marine Environmental Laboratory, and Atlantic Oceanographic and Meteorological Laboratory. **ST**

Saildrone founder and CEO Richard Jenkins developed Saildrone's core technology during a 10-year campaign to break the world speed record for wind-powered vehicles, which he achieved in 2009. He then began to apply his now-patented wing technology to uncrewed vehicles capable of collecting high-resolution data in the most remote areas of the ocean.

Christian Meinig is the director of engineering at the NOAA Pacific Marine Environmental Lab in Seattle, Washington. His interests include the research, development, deployment, and transition of ocean and atmospheric observing systems and working through partnerships to deploy them at scale to better observe the ocean.

Gregory R. Foltz is a physical oceanographer at NOAA's Atlantic Oceanographic and Meteorological Laboratory. His research focuses on gaining an improved understanding of the upper ocean and its impact on the atmosphere, including tropical cyclone-ocean interaction. Foltz is closely involved with several in-situ ocean observing programs in the tropical Atlantic.

Wave Sensor on Buoy

Partnership Offers Small, Easily Deployed Buoy for Real-Time Data

By Marla Isenstein

Data about sea-state conditions, water quality and offshore weather are invaluable for a range of applications, including meteorological, recreational, shipping, cruise and military vessel decision making, as well as for safeguarding shore and maritime-based assets and infrastructure. Data buoys, typically used to produce these data, have been in existence in one form or another since 1939, when U.S. Coast Guard vessels were used as "weather ships." Since then, the use of buoys to collect physical data has progressed with numerous networks and individual buoys operated by a variety of local, regional and even worldwide agencies, as well as private stakeholders.

Although the 6-m NOMAD design (Navy Oceanographic Meteorological Automatic Device) first developed in the1940s for the U.S. Navy's offshore data collection program is still being used today, the trend, as with most technological advances, has been toward

CB-25-SVS buoy being deployed by a single crew member. (Credit: David Ruck, Great Lakes Outreach Media)

smaller and more efficient systems with increasingly accessible data streams available in real time.

NexSens CB-25-SVS: Small Buoy, Big Possibilities

Ohio-based NexSens Technology, specialists in the design and manufacture of real-time environmental measurement systems, has had a longstanding partnership with SeaView Systems, centered on the industry-leading SVS-603 wave sensor, which has been deployed for a number of projects on NexSens buoys.

Prior to 2021, the smallest self-powered data buoy hull manufactured by NexSens was 24 in. (61 cm) in diameter and weighed 100 lb. (45.4 kg). The two companies recognized an opportunity to push into new applications with a wave buoy that exploits the latest sensor advances in a small package.

"More than the compactness of sensors, the reduction in power consumption is what's driving the shrinking size of the newest buoys," said Paul Nieberding of NexSens. "Lower power consumption means smaller solar panels, which really opens up the constraints of buoy design."

To get perspective, they enlisted Ed Verhamme of LimnoTech, a veteran of many buoy deployments, to help spec the new design. The result was a top-level requirement for a buoy that could be deployed by a single person from a small craft but still offer the possibility of supporting a flexible palette of sensors.

"Smaller is better, but there's a point of diminishing returns where you lose flexibility and you end up with a single-purpose product," said Verhamme. "To be really useful, we wanted enough payload capacity to add more sensors and meet regulations for beacon lights or other requirements."

SeaView Systems also saw a chance to leverage the experience it had gained in deployments on a broad range of buoy hulls and other platforms, such as ASVs and AUVs. "Our latest sensor design includes a rich set of algorithms and the analytical tools to characterize and correct for non-idealities in buoy behavior as wave followers," said SeaView's Timothy Crandle, Ph.D. "This enables us to draft a basic hull model based on past experience with similar buoys or, when available, based on qualification tests, ideally with a collocated reference of some kind." In either case, the basic model can be easily included as part of the sensor configuration.

The result is the NexSens CB-25-SVS, built around SeaView's SVS-603HR, the latest version of the wave sensor model. With an 18-in. (46-cm.) hull diameter and weighing less than 30 lb. (13.6 kg), it can be used for drifting, tethering or mooring applications.

Buoy Hull Verification, Testing Considerations

No two buoy deployments are exactly alike, and there are a host of considerations that factor into the behavior of a buoy (and, crucially for many cases, the mooring) as a wave-following platform. These include response of the buoy and mooring combination to wave stimulus across the spectrum, including possible resonance and "large-signal" effects that result from a nonlinear wave response; noise sources within the buoy/mooring combination; sensor noise; mounting position of the sensor with respect to buoy center of gravity; pitch and roll characteristics of the buoy; and many more.

A typical sequence for creating a hull model for a buoy such as the NexSens CB-25-SVS might be to eliminate sources of error based on system noise (which can occur based on sensor noise, mooring effects, hull motion behavior, etc.) using various filtering techniques (including SeaView's proprietary Mean Noise Filter) and then to address hull wave response (based on the non-ideal response of the hull to wave motion) in the form of a response amplitude operator (RAO).

For most cases, it is more practical to derive details of a noise model and response function (RAO) from empirical observations rather than a first-principles calculation. The advantage of using empirical observations is

CB-25-SVS deployed in Lake Erie with the Toledo Water Intake Crib in the background. (Credit: David Ruck, Great Lakes Outreach Media)

that these encompass the effects of the buoy and mooring system as a whole, rather than applying a model based on an idealized representation of the buoy alone.

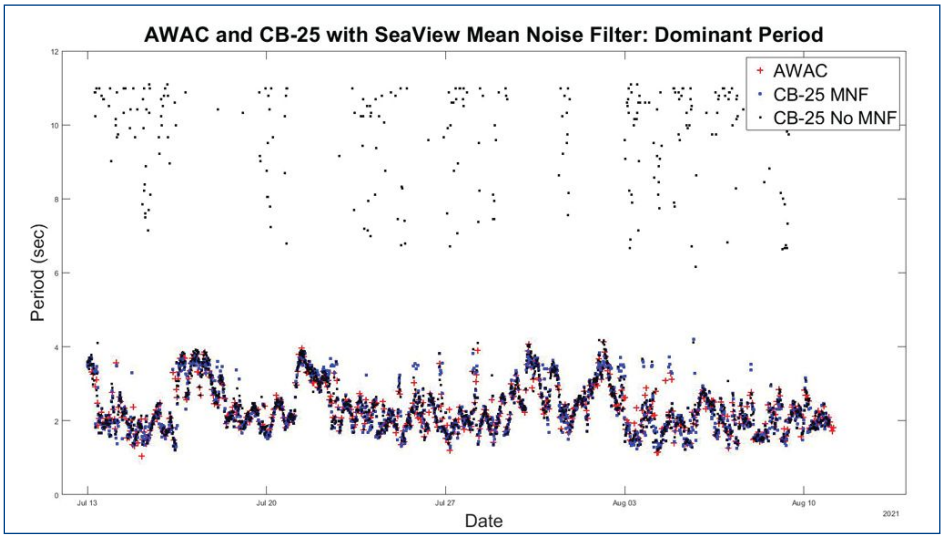
"The challenge in characterizing buoys is to ensure they are following the waves properly—difficult for all but the most idealized circumstances—or to successfully compensate where they are not," said SeaView's Crandle.

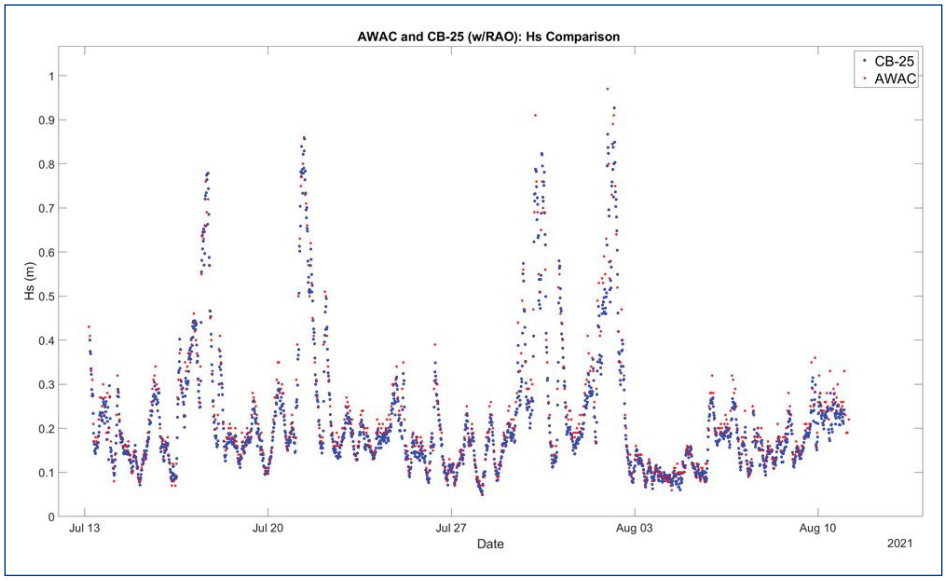
But even recognizing these shortcomings is itself a challenge, often best addressed by reference data, even if they are not for precisely the same buoy hull. To address this need, SeaView has been accumulating data (both raw and qualitative figures of merit) from its growing customer base for use in characterizing the behavior of a library of buoy hulls that can be used as a benchmark reference for any new buoy that comes into play. The data form the basis for an educated starting point for most any buoy hull.

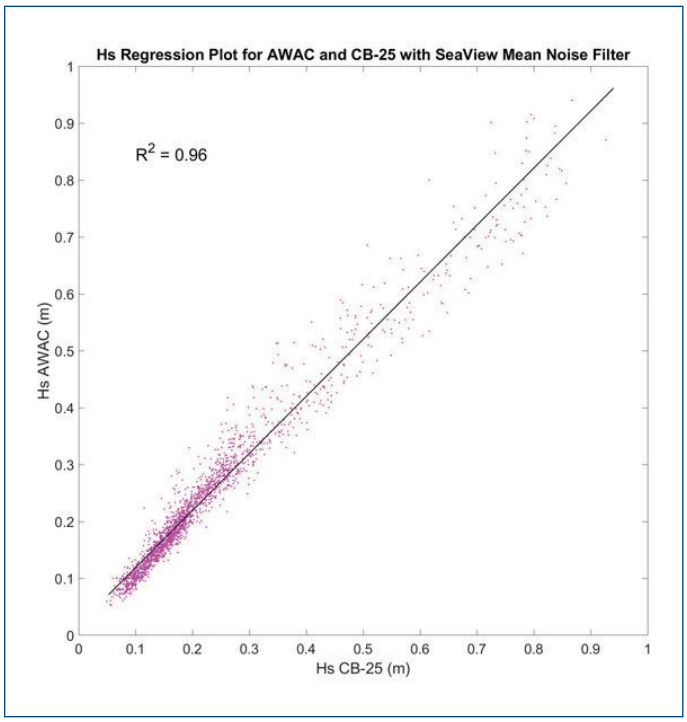
However, the best way to characterize a new hull fully is still to compare it against a "trusted" reference measurement. ("Trusted" is a relative term as waves are notoriously difficult to measure precisely in ocean settings without highly specialized techniques or equipment.) In the ideal case, which is rarely available in a typical deployment, the results of an unqualified buoy/mooring system might be compared with a reference from another nearby buoy with a trusted measurement system, or a collocated measurement system such as a bottom-mounted acoustic wave and current profiler (AWAC).

CB-25-SVS Test Deployment and Hull Model Results

Thanks to Verhamme and LimnoTech, longstanding experts in Great Lakes metrology buoy technology, the







(From top to bottom) Period comparison between AWAC and CB-25-SVS before and after application of SeaView's Mean Noise Filter. AWAC and CB-25-SVS significant wave height comparison after filtering and RAO. AWAC and CB-25-SVS significant wave height regression plot.

CB-25-SVS was deployed for verification testing July and August 2021 in Lake Erie near the Toledo Water Intake crib, the site of a bottom-mounted AWAC that provided a reference measurement for direct wave parameter comparisons.

Following an initial deployment, complete data (including both spectral and time-series data) from the SVS-603HR sensor on board the CB-25-SVS and AWAC data were retrieved for analysis.

An initial comparison between the dominant period data produced by the CB-25-SVS and AWAC (desirable for comparison because it does not rely on wave-following behavior for its measurements) revealed a common artifact of system noise in the CB-25-SVS results in the form of period values that appear to be spurious. (These data are often removed using QARTOD, change percentage limits or similar data qualification techniques but are shown here in the interest of examining the unvarnished quality of the buoy platform.)

Among the tools available on the SVS-603HR is SeaView's proprietary Mean Noise Filter (MNF). This filter uses a proprietary noise measure and associated algorithm to qualify buoy motion characteristics and filter the energy spectrum, and can often bring spurious measurements into alignment. Applying this eliminates the spurious period values and brings all of the data points for this sample set into the range as measured by the AWAC.

Observation of the comparison of the significant wave height produced by the CB-25-SVS in comparison with the AWAC shows the need for a modest RAO correction to adjust for some resonance effects. Applying a modest RAO correction brings the AWAC and the CB-25-SVS Hs time-line values into alignment. A correlation plot for the MNF and RAO-adjusted Hs values yields a correlation R^2 value of 0.96.

While a better correlation could be expected with

"'More than the compactness of sensors, the reduction in power consumption is what's driving the shrinking size of the newest buoys'"

further optimization of the RAO, the data appear to match within a rough confidence band for the AWAC data. Further refinement of the RAO is probably of diminishing incremental value.

Buoy Design Features and Capabilities

Similar to many larger NexSens buoy hulls, the CB-25-SVS is constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A rechargeable battery with integrated solar panels powers the buoy, and all electronics are housed in a quick-removable waterproof package with wet-mate connectors. Three 1.5-in. pass-through holes facilitate cable routing for underwater sensors. The system includes battery management capabilities to trigger power conservation steps in the event of dwindling reserves.

Available with integrated 4G cellular or Iridium satellite communications, the CB-25-SVS wave buoy sends data in real time to NexSens' cloud-based WQData LIVE data center. In a basic configuration, this free service allows users to securely access and analyze data, as well as share data through an API or auto-report.

"We are excited about the CB-25-SVS buoy," said NexSens' Nieberding, "the next in a line of smaller, smarter buoys that brings together the strengths of NexSens and SeaView to fill an exciting market niche. The CB-25-SVS combines ease of deployment, versatile, configurable sensor selection, support for a variety of telemetry options, and out-of-the-box web hosting support for simple MET data accessibility."

"There will always be many applications that require larger solar panels and a larger buoy to support a bigger, power-hungry set of instruments," said Verhamme. "But the CB-25-SVS sits in a sweet spot that's small enough to be deployed single-handedly but still has flexibility to include the sensors demanded by a range of applications."

Acknowledgments

NexSens would like to gratefully acknowledge the support of the Cleveland Water Alliance Testbed Program for enabling NexSens to expedite deployment, validation and data collection of the performance of our technology under real-world conditions. **ST**

Marla Isenstein received her B.S. in environmental engineering from the University of Michigan. At SeaView Systems Inc., she performs algorithm and system development and testing for the SVS-603 wave sensor, as well as performing other data-driven analyses, such as tunnel ovality investigations and tunnel inspection sonar data analyses.

Science-Industry Cooperation

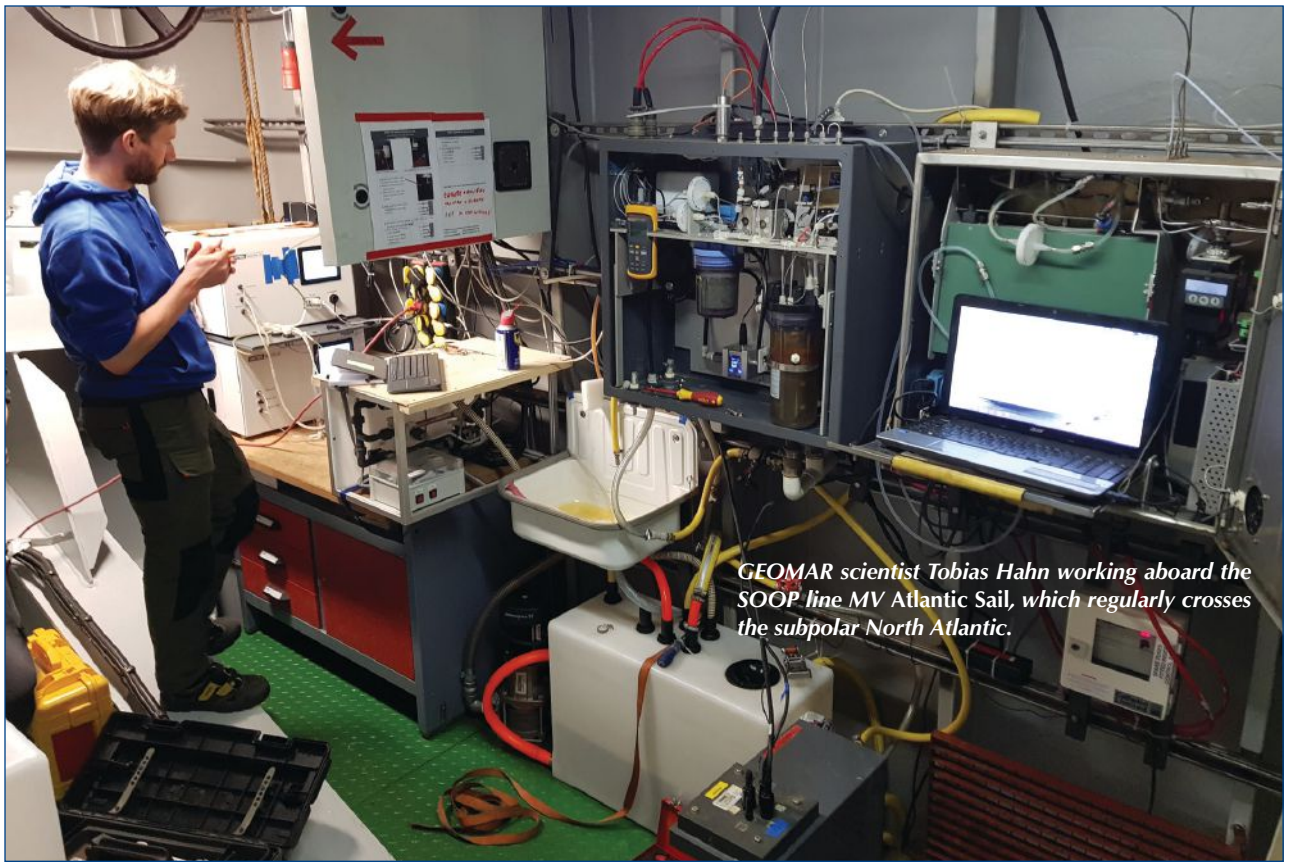
Delivering Innovations for Marine Carbon Monitoring

By Tobias Hahn • Nadja Kinski

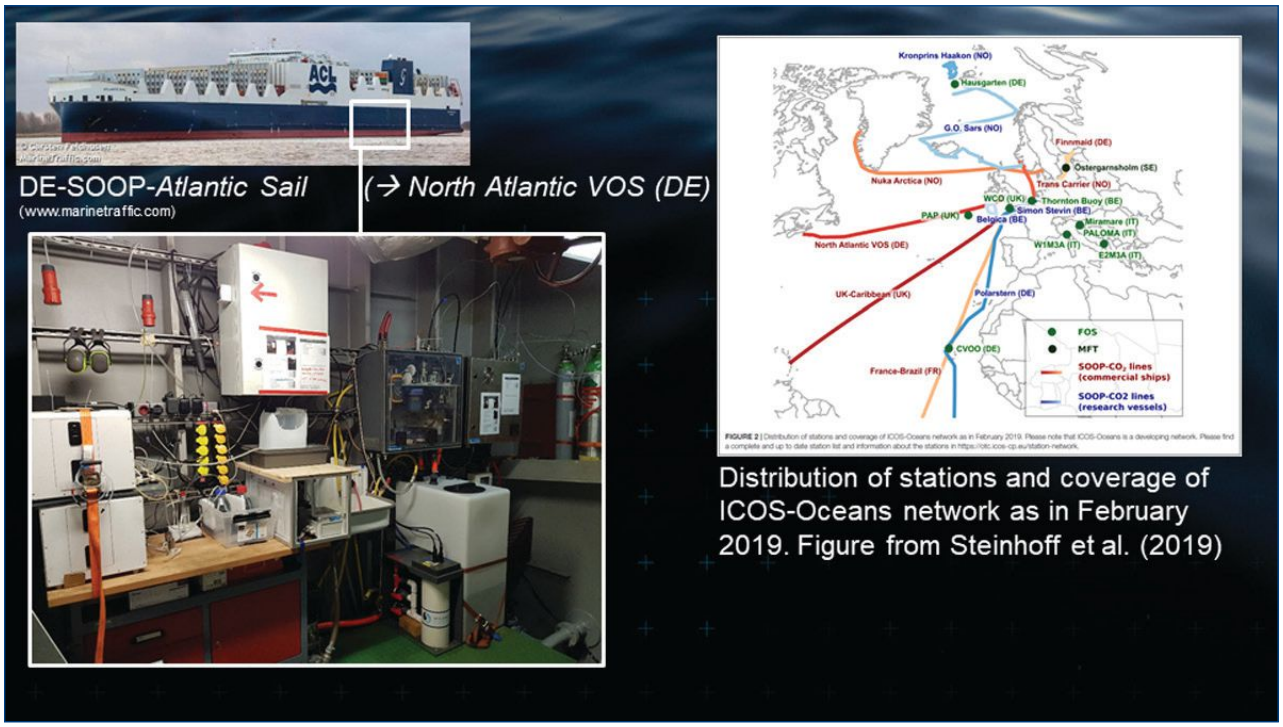
Analytical chemistry is powerful. What human senses can't ascertain can usually be determined by physicochemical measuring techniques. The prerequisite, though, is full comprehension of the method itself under controlled conditions. Yet, this isn't ultimately what marine scientists are interested in.

Marine research aims to characterize and comprehend natural and anthropogenic processes and phenomena by complete understanding of the carbon cycle resulting in actionable climate science. This takes place in a complex global environment: the vast, remote and dynamic ocean.

CO_2 is undoubtedly a prominent chemical compound of human interest. Full understanding of the carbon cycle can only be achieved by detecting and quantifying the impact of changing CO_2 levels in atmosphere, ocean and terrestrial areas, as well as their interactions. It is scientifically proven that CO_2 levels in the atmosphere are



GEOMAR scientist Tobias Hahn working aboard the SOOP line MV Atlantic Sail*, which regularly crosses the subpolar North Atlantic.*



The systems aboard the MV* Atlantic Sail*—the ship is also known as North Atlantic VOS (DE)—and a snapshot of the ICOS-Oceans network as of February 2019 (from Steinhoff et al, 2019).

rising due to anthropogenic activity such as fossil fuel burning. The ocean currently absorbs about one-third of all anthropogenically produced CO_2, causing ocean acidification, which affects marine biodiversity. Land incorporates a further one-third, mainly through enhanced biomass production of the biosphere. The rest remains in the atmosphere, causing, among other things, global warming, evidence of which we experience through the increase in heat waves, wildfires and floods in 2021.

What may look like a rule of thumb estimate is actually a result of decade-long, meticulous, collaborative and international scientific research. Global, coordinated efforts are undertaken to establish a sustainable ocean observation network—with marine carbon chemistry playing a pivotal role. We, therefore, need sustained observations with solid, reliable and community-accepted instrumentation in order to track and predict future trends, as well as autonomous measurements to augment substantial coverage of the ocean.

At least two of four variables must be known to fully characterize the marine carbonate system. Measuring more than two in situ simultaneously and with high accuracy produces even more precise and quality controlled data. One is pCO_2: partial pressure of CO_2. The second is DIC: dissolved inorganic carbon, the sum of all dissolved chemical species. The third is TA: total alkalinity, the buffer capacity. A fourth variable is pH: a chemical indicator of how acidic or alkaline a liquid is.

There are about a dozen measurement systems and sensors on the market for CO_2 partial pressure. Unfortunately, not all meet scientific requirements of accuracy, but efforts to improve the situation are made within the science community by ICOS (Integrated Carbon Observation System) intercomparison exercises. Additionally, pCO_2 shows high spatial and temporal variability both naturally and with the anthropogenic trend. Looking deeper into the causes of pCO_2 change, however, requires a second marine carbonate system variable to be measured.

Comprehensive Measurement

For many years DIC, TA and pH could only be measured from discrete samples requiring much effort in laboratory setups and well-trained staff due to limitations in existing instrumentation for continuous mode.

It was CONTROS Systems & Solutions GmbH based in Kiel, Germany, that came up with a commercially available measurement system for TA in 2015, the HydroFIA TA. The team behind CONTROS sensors, now a division of -4H-Jena engineering, have continued to develop analyzers in close collaboration with partners such as GEOMAR and Leibniz Institute for Baltic Sea Research Warnemünde (IOW), fulfilling the needs of marine carbonate system measurement since introducing its first TA analyzer to the scientific community.

The original HydroC CO_2 sensor for the measurement of pCO_2 was complemented well by the further development of analyzers for TA and pH. The determination of these three variables with the specifications reached by HydroC sensors and HydroFIAs enables characterization of the marine carbonate system to the level of accuracy required by marine scientists. Furthermore, -4H-Jena engineering will launch a system for the quantification of atmosphere/sea flux processes soon, which is important

-4H-Jena engineering HydroFIA systems for TA and pH are designed for continuous field monitoring and can provide a stream of accurate, important data for marine researchers.

in order to completely understand the carbon cycle.

The motivation behind this development is to deliver a single comprehensive solution available for the whole oceanographic community to enable scientists to gather comparable data sets internationally.

CONTROS HydroFIA systems are designed for continuous in-situ field monitoring of TA and pH in seawater and brackish water, as well as the measurement of discrete samples in the laboratory to cover all relevant scenarios. The flow injection analyzers (FIAs) evaluate absorption spectra of indicator dyes using a CCD (charge coupled device) spectrometer. This method is principally drift free and allows the generation of long-term data series with low maintenance effort.

For the determination of TA, bromocresol green and hydrochloric acid are added to the sample. The evolved CO_2 is removed using membrane technology from the HydroC (TOUGH membrane) during a degassing sequence at approximately pH=3. This procedure can be considered as open-cell titration that allows a one-point calibration. It can be referenced automatically during field deployments against certified reference material provided by Andrew Dickson, Scripps Institution of Oceanography of the University of California, San Diego, thereby assuring highest research data quality. For the determination of pH, the reagent m-cresol purple is added to the sample, and the absorption spectra are measured at 25° C, from which pH is calculated using the approach of Mueller and Rehder (2018). A paper by Steinhoff et al (2019) provides a detailed overview of the marine observation domain and coverage (ICOS-Oceans).

The development of the HydroFIA pH was part of the BONUS PINBAL project in close cooperation with IOW, the University of Gothenburg and the Institute Oceanology of the Polish Academy of Sciences. The traceability and outstanding reliability of the measurements qualifies the HydroFIA pH for use as a reference system and for the verification of submersible pH electrodes in the field.

TA and pH are already common variables to complement marine carbonate system observations by established and emerging observing networks, such as Biogeochemical-Argo (BGC-Argo), which features floats as robotic platforms fitted with diverse submersible sensors. BGC-Argo aims to be a global observation network. Another example is the global Ship-Of-Opportunity (SOOP) network that is partly operated in ICOS and is the backbone of the surface ocean CO_2 network. It features autonomous measuring systems on commercial ships that can be operated easily by nonscientists (seafarers).

A German-led extension of the BGC-Argo program, the DArgo2025 project, aims to integrate the work of the project partners—GEOMAR, IOW, Carl von Ossietzky Universität Oldenburg, Institute for Chemistry and Biology of the Marine Environment (ICBM), and the Fed-

"Full understanding of the carbon cycle can only be achieved by detecting and quantifying the impact of changing CO_2 levels in atmosphere, ocean and terrestrial areas, as well as their interactions."

eral Maritime and Hydrographic Agency (BSH)—into the BGC-Argo context. Coordination provides tangible advantages in terms of quality control, operational approach and interoperability in relation to the floats and the data they produce. Here, the contribution of GEOMAR is comparing and referencing float pH measurements with the HydroFIA pH, ultimately to ensure maximum impact of the research on an international level.

Partnerships with commercial shipping companies are contributing to improving the amount and quality of ocean CO_2 data. The SOOP network provides continuous measurements, as well as calibration of the BGC-Argo floats, using equipment installed on ships sailing established commercial routes.

A SOOP line across the subpolar North Atlantic (DE-SOOP-*Atlantic Sail*) is operated by GEOMAR and currently augmented with unattended measurements of TA and pH (both HydroFIAs), in addition to pCO_2 and O_2.

These are just a few examples of successful collaborative projects generating significant data sets to determine marine carbon chemistry. Marine scientists using instrumentation provided by trusted manufacturers such as -4H-Jena engineering make an important contribution to the complete understanding of the global carbon cycle, resulting in actionable climate science. Ocean observation is crucial for reaching the United Nations Sustainable Development Goals (SDGs), especially SDG 13 (climate action) and 14 (sustainable ocean development).

Conclusion

It is clear that analytical methods aren't the only way to notice and detect increases in atmospheric CO_2 levels anymore. The climate system is already responding to increased global temperatures and causing challenges for millions of people globally. There is still time to slow the effects as stated in the IPCC AR6 report of 2021, and perhaps begin to mitigate or reverse them in the future. To reach this goal, it is essential that the community beyond scientists is equipped with ocean measurement technologies, which need to be available on a wide basis.

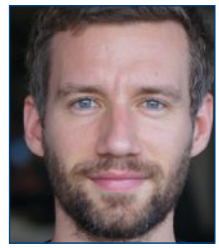
Securing data with accuracy, precision, flexibility and scale is impossible if only the scientific community is engaged, so it's encouraging that companies such as -4H-Jena engineering continue to collaborate with researchers. Through this "pull" approach from climate researchers, measurement technologies can serve the purposes of research and enable us to understand the marine carbon cycle and close knowledge gaps faster and better than previously possible.

GEOMAR, partly through its experience with -4H-Jena engineering as a commercial partner, recommends intensifying user-manufacturer collaboration in order to maximize outcomes, scientific research and monitoring efforts.

Ultimately, climate change severely impacts humankind, and we as young researchers and manufacturers prefer to apply the most advanced measurement technologies of today, so we have a chance to keep monitoring the ocean environment decades in the future. We never forget that the data we generate will help to derive meaningful actions to mitigate the effects of climate change and environmental pollution—hopefully, in time.

References

For a list of references, contact: thahn@geomar.de. **ST**



Tobias Hahn has an M.S. in chemistry and is a doctoral researcher of chemical observational chemistry at GEOMAR Helmholtz Centre for Ocean Research Kiel. He studied chemistry at the University of Bremen and Kiel University. He is currently completing his Ph.D. thesis on oxygen optodes and has been working on the DArgo2025 project since September 2020 to enhance marine carbonate chemistry observation from the container vessel MV Atlantic Sail*, an official ICOS SOOP line. He is keen to highlight the knowledge exchange and lessons learned of -4H-Jena engineering instrumentation within the manufacturer, scientific community and for all users.*

Nadja Kinski has a B.S. in chemistry and environmental technologies from the University of Applied Sciences in Lübeck, Germany. She was a chemistry laboratory technician at Dräger Safety AG & Co. KGaA and has been working with CONTROS sensors and analyzers since 2012. She now leads the -4H-Jena engineering team in Kiel. The core competence within CONTROS sensors by -4H-Jena engineering is in providing comprehensive solutions for oceanographic and limnologic measurement campaigns. The company provides expert advice from planning through deployment and the entire operational life cycle of diverse and complex ocean monitoring campaigns.

Energy Storage Solutions

Advancing Safety in Power Systems

By Ian Robinson

As battery technology evolves rapidly, every newbuild commercial vessel can, and should, benefit from energy storage systems (ESS). Even if ESS are not installed at commissioning, it's likely that they will be during the lifespan of a vessel, as they will be essential in unlocking a zero-carbon future.

While most vessels won't be able to rely on pure battery propulsion, in combination with zero-carbon fuels, wind-assisted propulsion and other various optimization solutions, ESS will form a ubiquitous part of shipping's zero-carbon future. From peak shaving to managing a hotel load to supplying emergency power, ESS can improve performance, save fuel and contribute to a safer voyage.

However, it is imperative that safety isn't compromised for the pursuit of innovation, and more so that the safety of the vessel, its passengers and crew remains a priority. Recent events, however, indicate that this core component may be falling behind, suggesting that the battery industry has a pressing need to fight against a race to the bottom when it comes to safety in pursuit of affordability.

Sterling PlanB A60 test cell stack, post-testing.

The State of Play

In March of this year, a Norwegian passenger vessel was evacuated after the energy storage solution in use caught fire. Initial reports indicated that the batteries may have been exposed to heat, which could have produced explosive and flammable gases in enclosed spaces on board the vessel, in turn resulting in a complete evacuation not only of the vessel but also of the surrounding areas.

This follows a similar event in October 2019 in which a battery-hybrid ferry caught fire and

A60 module in oven testing.

exploded while in dock, injuring some 12 firefighters and first responders, damaging equipment beyond repair, and sparking an investigation into the incident, the official report of which has not been issued yet.

Let's not mince words: In 2021, there is simply no excuse for an uncontrolled fire on a vessel. Battery manufacturers need to join all other maritime suppliers and up their game regarding safety, and be more transparent about how we protect passengers and crew from these risks.

Fortunately, the technological solutions to mitigate these risks already exist. Owners need to understand—and manufacturers need to explain clearly—what the risks are and what elements are needed to mitigate them. As with any other new technology, there is a learning curve, but it is one that we cannot afford to ignore.

Understanding ESS Risk

When it comes to battery safety 101, the most significant risk is thermal runaway. Thermal runaway can occur when battery cells are subjected to mechanical damage, operating over or under the correct voltage, or a high internal temperature. In these situations, heat may be generated within the lithium-ion cells, which results in the temperature increasing until the cells vent toxic and flammable gases. If ignition should occur, these toxic gases can lead to fires that are notoriously difficult to extinguish. Furthermore, if the fire spreads from one cell to another and gases become concentrated without efficient ventilation, it can result in an explosive atmosphere.

This effect may be comparatively uncommon among reliable ESS systems, but, when it does occur, thermal runaway can result in serious injury and/or damage to a vessel.

So, what precisely does the technology to prevent this hazard look like? And how can the industry, in the pursuit of fully decarbonized operations, ensure that safety does not go ignored?

Mitigating Risk: How to Enhance Safety

There are numerous ways that the risk of thermal runaway risk can be mitigated. One of the most important of these is integrated water cooling which is, arguably, the most effective way of stopping a damaged cell from entering thermal runaway because it cools the cell faster than it can feasibly heat up. Unlike air-cooling technology—which has been in place in many ESS fire situations—liquid cooling is integrated into the system, with cooling channels surrounding each individual cell to support the temperature control within an individual cell or bank of cells.

The ability to vent flammable gases in the event of an emergency is also important. Sterling PlanB batteries, for instance, use the E-Vent system, which vents flammable gases away from the battery area using a one-way valve that opens at low pressure. This not only minimizes the risk of fires that result in explosions; it also reduces crew exposure to harmful and toxic gases.

A third risk mitigation factor is the ability to physically prevent fire from overheated, overcharged or damaged cells from propagating the next cell. Meaning that should one cell catch fire, the likelihood of the bank suffering the consequences is significantly lower.

Monitoring the ongoing safety and performance of a cell is another key element that should be present in any system. While many systems monitor performance on a whole-system basis, the fact that it only takes one cell to fail means that we would recommend cell-level moni-

ESS cells 12 and 16 after exposure at 950° C.

toring. The "always-on" electronic control systems from Sterling PlanB collect vital telemetry data from a battery system on a cell-by-cell level and connect to onboard safety systems, preventing human error or technical challenges that could turn monitoring or safety systems off inadvertently.

Ultimately, safety systems in marine batteries must be designed holistically, rather than as separate components. This ensures that every aspect of the battery is as safe as possible, and every safety system is designed into the core of the system rather than as an add on or an extra; battery safety is maximized if all the systems on board are designed to work together from inception.

Independent Standards in Safety

The pursuit of battery safety is helped by the introduction of new standards, such as DNV's 2020 rules for commercial vessel batteries. As an early adopter of the certification, Sterling PlanB has become one of the first energy storage solutions providers to adhere to the new testing standard, which substantially mitigates the risk of the spread of fire by eliminating the cell-to-cell propagation of thermal runaway within a battery module.

Securing the type approval certification required extreme testing conditions. Across nine separate tests—conducted for Sterling PlanB and observed by DNV—all standards were met.

Additionally, we at Sterling PlanB have recently designed and tested the world's first A60 fire-rated battery, capable of withstanding temperatures that would simply vaporize the plastic and composite materials of lesser offerings, the formal results of which are expected soon. Put into plain numbers, many lithium-ion cells can reach temperatures in excess of 900° C during thermal runaway events. Sterling PlanB's ESS can withstand temperatures of up to 950° C for 60 min. without the need for battery room fire protection.

Conclusion

It's clear that battery technology is set to play a major role in the efforts toward decarbonization, such as the International Maritime Organization's target of at least 40 percent CO_2 emissions reduction in shipping by 2030. Indeed, it is already helping to shape how the industry perceives fuel technologies. As this evolution occurs, as with most new technologies, prioritizing the ongoing safety of engineering and upkeep is the only way in which we will achieve a more sustainable future in marine energy.

Given the current state of play within shipping, and the pressure to remain commercially viable well beyond 2030, there is already an indication that some operators and owners are compromising the safety of their vessel and crew in order to pursue greater affordability. Yet the two are not mutually exclusive—and neither are they negotiable. **ST**

Ian Robinson is the director of engineering at Sterling PlanB.

international

Fresh Funding for DeepSea Technologies

DeepSea Technologies, specializing in vessel performance monitoring and optimization, has secured €5 million in fresh funding from existing and new investors. The round was led by Nabtesco Technology Ventures, with participation from The Signal Group and existing investor ETF Partners.

As shipping faces the challenge and opportunity of having to decarbonize and digitalize simultaneously, DeepSea's technology enables its clients to make data-driven decisions to lead the industry forward. The investment reinforces DeepSea's strong financial position and will enable further technological and product research, design and development. The new funding will also accelerate the company's international commercial expansion, which will focus on Asian markets.

CGG Agrees to Sell Part of Business

CGG S.A. has entered into an agreement with Topicus and Vela Software for the sale of CGG's GeoSoftware business. The GeoSoftware business will be owned jointly by Topicus and Vela, with Topicus owning 60 percent and Vela 40 percent.

Accreditation for Diving System Inspector

The International Marine Contractors Association (IMCA) is developing its Accredited Diving System Inspector (ADSI) scheme, which will introduce an industry-recognized professional accreditation for this important group of skilled workers. ADSIs will be accredited to conduct IMCA Diving Equipment Systems Inspection Guidance Note (DESIGN) audits.

IMCA is seeking known, respected and experienced DESIGN auditors to be put forward for early ADSI certification, so they can act as field training supervisors when the scheme is launched in 2022.

Hanwha Invests More in LEO Satcom

Hanwha Systems, the South Korean Fortune 500 global technology and manufacturing company, has made a $300 million equity investment in OneWeb, a low Earth orbit (LEO) satellite communications company. Hanwha brings further defense capabilities and the latest antenna technologies to OneWeb, alongside relationships with new government customers and expanded geographical reach. This investment brings OneWeb's total equity investment since November 2020 to $2.7 billion.

OneWeb's first-generation fleet of 648 satellites that will deliver global coverage in 2022 is fully funded. To date, the company has launched 254 satellites into orbit.

Danish CCS Project

The UN Climate Panel has published its report that paints a bleak forecast for the climate and signals a "code red for humanity." There is an immediate need for measures to effectively reduce CO_2 emissions, and CO_2 capture and storage (CCS) has a critical role to play. Proj-

ect Greensand is one such groundbreaking initiative. It comprises a consortium of 29 companies led by INEOS Energy and Wintershall Dea that aim to develop a full CCS value chain in Denmark. The ambition is safe CO_2 storage in Danish North Sea fields by 2025 and addressing 25 to 40 percent of remnant emissions that must be managed in order to reach Denmark's ambitious 70 percent reduction target by 2030.

UK Blue Planet Fund

This first amount of funding from the U.K.'s £500 million Blue Planet Fund will be used for five programs to tackle climate change, enable marine recovery and reduce poverty in developing countries. These programs will increase marine protection, reduce plastic pollution, tackle the decline of coral reefs around the world, and use the U.K.'s expertise and knowledge to help respond to marine pollution disasters.

The U.K. has a new global "30by30" target to protect 30 percent of land and 30 percent of the ocean by 2030, which will be supported by the Blue Planet Fund.

Water Quality Monitoring for UNESCO Site

MacArtney Germany has supplied multiparameter sondes, including a measurement and service concept, for water quality monitoring related to a renovation project for a UNESCO World Heritage site, the world's largest complex of warehouses, Speicherstadt Hamburg. The site represents the value of trade in Hamburg during its foundation.

The Speicherstadt, built between 1885 and 1927, rests on thousands of oak poles that have deteriorated due to bacterial decomposition and indentation of the fleet bed as a result of an expanded tide difference. Renovation was necessary to prevent the poles from sinking, including reconstruction arrangements raising the fleet bed by 0.5 to 1.5 m and supply of bearing sand and cement.

Guidelines for Maritime 3D Printing

ClassNK released its "Guidelines for Additive Manufacturing (3D Printing)" that summarize the approval requirements for metallic marine equipment by additive manufacturing technology as part of its effort to meet the industry's demand for a third-party certification for marine equipment manufactured with an advanced technology. Additive manufacturing technology is a method for manufacturing by laminating and combining materials such as resin and metal based on 3D model data. It can mold complex and high-precision shapes.

SES, Teledyne Milestone

Survey Equipment Services (SES) in Houston has placed an order for its 100th Teledyne ODOM ECHOTRAC E20 single-beam hydrographic echosounder. SES is a major distributor of Teledyne Marine's products.

USCG Fast Response Cutters in Guam

Representatives from Bollinger Shipyards LLC were on hand in Apra Harbor Guam for the commissioning ceremony of three U.S. Coast Guard Fast Response Cutters (FRCs): USCGC *Myrtle Hazard*, USCGC *Oliver Henry* and USCGC *Frederick Hatch*. The three FRCs build out and strengthen the U.S. strategic presence in the Indo-Pacific and are there "as a response to coercive and antagonistic behaviors from China" in the region, according to U.S. Coast Guard Commandant Adm. Karl Schultz, who was also present at the ceremony.

UUV Communication Test under Arctic Ice

During the U.S. Navy's recent biennial Ice Exercise (ICEX 2020), General Dynamics partnered with MIT to put the Bluefin-21 Macrura UUV to the test under the ice in the Arctic Circle.

Arctic ice makes it more difficult for a UUV to relay its precise location via GPS. The team designed an experiment to test a new communication framework. The ICEX tracking range, also known as ICEX-tracker, utilized a series of four surface buoys outfitted with acoustic modems below the ice and connected to base camp via radio. Depending on the depth of MIT's Macrura UUV, it alternated between the modems to optimize communication.

Recommendations on Renewables for Canada

Marine Renewables Canada has provided input to the government of Nova Scotia's consultation on the Sustainable Development Goals Act (SDGA) and new Climate Change Plan for Clean Growth.

Nova Scotia has taken important strides to increase its share of renewable electricity and meet greenhouse gas (GHG) reduction targets. Marine renewable energy from tides, waves, offshore winds and river currents can play a role in supporting the province's goals and ambitions.

Greensea Adds Office Space

Greensea Systems, creator of OPENSEA, a universal open-architecture software platform for the marine industry, recently expanded its Vermont operations by leasing 4,200 ft^2 of additional commercial space in Richmond, Vermont. This will provide additional office space and an engineering laboratory space for research and development.

DOE Funds OPT WEC

Ocean Power Technologies Inc. (OPT) has been selected by the U.S. Department of Energy (DOE) to further the development of a next-generation wave energy converter. In DOE's recent awards for clean energy Small Business Innovation Research (SBIR) projects, OPT will receive up to $197,203 to perform a preliminary conceptual design and feasibility study of a modular and scalable, small-scale, mass-on-spring wave energy converter (MOSWEC) PowerBuoy for powering autonomous ocean monitoring systems.

New Office for Trelleborg in Houston

Trelleborg's marine and infrastructure operation in North America has moved into a new sales office in Houston. This will enable the operation to meet growing demands across the region's markets and provide more localized and coordinated customer support. **ST**

Metocean Measurements For Floating Wind Farms

Nortek is supporting metocean survey and consulting company Partrac Ltd. to provide floating wind farm developers with detailed and accurate data on metocean conditions at potential development sites. Using acoustic Doppler current profilers (ADCPs), Partrac can extend its capabilities and adapt to increasingly complex offshore environments as interest rises in floating offshore wind farms. The company is increasingly being asked to obtain data that developers can use for site characterization and modeling in deeper waters.

Nortek has been working with Partrac for many years. Historically, shallow-water wind farm feasibility studies have been carried out using Nortek's higher-frequency, shorter-range Signature and AWAC instruments. Moving to deeper water requires a longer-range ADCP solution, so Nortek has recently provided Partrac with its Signature250 ADCP and accompanying subsurface buoy to measure currents and directional waves up to 200 m for current profiling, and 150 m for wave height and direction.

Olympic Subsea Chooses Vessel Insight

Olympic Subsea, an operator in the subsea and renewable energy markets, will install Kongsberg Digital's Vessel Insight across its entire fleet as a means of accessing, collecting and consolidating a full range of mission-critical data.

Olympic Subsea's fleet-wide upgrade to the data infrastructure service will enable the company to continue the digitalization journey that began with its implementation of KDI's Vessel Performance solution for energy usage and operational monitoring.

Agreement to Progress Japan Offshore Wind

ClassNK and the Carbon Trust, a global climate change consultancy, have signed a memorandum of understanding to support the progress of offshore wind power generation in Japan. ClassNK and the Carbon Trust will collaborate on assisting national initiatives to improve progress in areas critical to the successful implementation of offshore wind projects, including acceleration of industrial development and technical innovation, regulatory and policy reform, standardization, and increasing skills in the industry.

In December 2020, Japan's Ministry of Economy, Trade and Industry published its Green Growth Strategy, which includes the offshore wind industry as one of 14 sectors expected to grow. In addition, the Public-Private Council has established the Vision for Offshore Wind Power Industry to enhance the competitiveness of the offshore wind sector, accelerate efforts to promote effective and efficient R&D, and strengthen the supply chain to reach the target of 10 GW by 2030 and 30 to 45 GW by 2040.

Floating Wind, Hydrogen Development in North Sea

Green infrastructure developer Cerulean Winds has signed an agreement with px Group, a U.K. operator of large-scale industrial facilities, as it moves to progress its plans for an integrated 200-turbine floating wind and hydrogen development in the North Sea.

The Cerulean proposal has capacity to generate 3 GWh of power, enough to electrify the majority of offshore facilities, reducing CO_2 emissions by more than half from 2025. An excess of 1.5 GWh of power would be diverted to onshore green hydrogen plants.

The three onshore hydrogen sites would be located in north England, northeast Scotland and on Shetland. Under the agreement, px Group would be responsible for lease and ownership arrangements for the sites and for obtaining planning permissions and permitting. This new agreement would see px Group operate the hydrogen generation facilities and the associated onshore infrastructure, including the onshore substations and grid connections.

BP's UK Hydrogen Facility To Be Complete by 2030

BP's clean hydrogen facility in Teesside, U.K., (H2Teesside) will be completed by 2030. The project plans to produce up to 1 GW of blue hydrogen, 20 percent of the U.K.'s hydrogen target, making this blue hydrogen production facility the largest in the U.K. H2Teesside will make the region the U.K.'s first hydrogen transport hub.

The project will capture and send for storage of 2 million tonnes of CO_2 per year, equivalent to capturing the emissions from the heating of 1 million U.K. households.

Teesside accounts for over 5 percent of the U.K.'s industrial emissions. The U.K. aims to be the world's first major economy to be net zero, by 2050.

Cable Survey for Coastal Virginia Offshore Wind

Acteon, a marine energy and infrastructure services company, has supported Siemens Gamesa, an offshore wind turbine manufacturer and operations and maintenance provider, with a cable survey for the Coastal Virginia Offshore Wind (CVOW) pilot project.

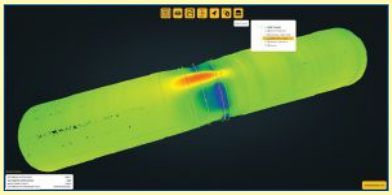
The CVOW export cables are about 45 km (28 mi.) long, and the array cables are 1 km (0.62 mi.) long. The survey was performed by Terrasond, a product and service line brand within Acteon's geo-services segment, from the *Atlantic Endeavor*, the CVOW project's dedicated crew transfer vessel.

Acteon has an agreement with Siemens Gamesa to jointly provide a fully integrated offshore wind turbine operations and maintenance (O&M) package for the CVOW pilot project, which is the first offshore wind project installed in U.S. federal waters. Siemens Gamesa and Acteon have since been working together to fully optimize the wind turbine service and balance of plant O&M workscopes to provide cost-effective and integrated asset management services at the 12-MW, two-turbine installation. **ST**

productdevelopment

For more information on any of these products, visit our website at **www.sea-technology.com/products**

3D Online Viewer Platform



Viewport View has been designed to offer simple, user-friendly access to 3D data files, without requiring any specialist hardware, training or installation. It brings 3D data to life, even for nontechnical personnel. It's intended for use across organizations, facilitating cross-discipline collaboration. Viewport3 Ltd.

Data Platform Updates

GTReplicate has been substantially upgraded to provide more file synchronization capabilities across satellite networks. New features include email integration, ability to invoke third-party applications and flexible file transfer options. GT-Maritime.

Drysuit

Divemaster Commercial is reliable and durable even in the harshest of conditions. Its specially formulated 5.5-mm hypercompressed neoprene allows for complete freedom of movement. It comes with durable hard sole boots. Northern Diver International Ltd.

Ship-to-Ship Transfers

Transfer via Buoy Terminal (TVB) is designed to enable export tankers to load or discharge at a single-point mooring (SPM) type terminal, with the dynamic positioning (DP) shuttle tankers discharging in DP mode while keeping at a pre-determined distance of circa 150 m from the export tanker. The DP shuttle tanker independently holds station in relation to the export tanker. SafeSTS Ltd.

Running Line Monitors

The standard range of these RLMs (15, 60, 200-t capacity) is designed for harsh marine environments. They are typically used in cable laying, towing, mooring and other winch operations to measure and record line tension, pay-out, and speed. Available in cabled or wireless configurations, they can be integrated into existing vessel systems, or supplied as standalone systems. Dynamic Load Monitoring (UK) Ltd.

Vessel Monitoring System

S-Tracking VMS is a dual cellular and Iridium satellite system that allows users to track and monitor activities of vessels remotely. With Iridium satellite connectivity, S-Tracking ensures communication between fishermen on board with management agencies onshore, even in the most remote waters. Viettel Group and Iridium Communications Inc.

Acoustical Volume Meter

An easy, fast and precise way to measure volume of an object or capacity of a cylinder or vessel is to use the RION VM-240. The time required for a single measurement is extremely short (about 2 sec.). RION Co. Ltd.

UV Sanitation

Disinfection solutions that can ward off the new delta variant of COVID include: UV sanitation carts; handheld UV sanitizers; UV air sanitation systems; HVAC UV disinfection lights; mobile UV air sanitation

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CHESAPEAKE TECHNOLOGY

equipment; Far-UV linear and high bay fixtures; and UV ball cleaners. Larson Electronics LLC.

Aquaculture Monitoring Buoy

The development of this new buoy has been driven by a significant increase in seaweed farming globally. It offers a full suite of standard metocean and water quality parameters, plus a pan tilt zoom (PTZ) camera. OSIL.

High-Temperature DC Motor

DCX22S HT works with the GPX22 and GPX26 gearbox ranges, including the high-efficiency GPX22UP. These can have extended temperature lubrication to match motor ambient temperature capability. maxon motor ag.

Subsea Simulator for Training

EOD Workspace Simulator incorporates a physics engine based on actual subsea vehicle models, which provides the realism needed to prepare operators, technicians and other subject matter experts to be successful in critical real-world subsea environments when using EOD Workspace in the field. More operators can train in more locations, independent of vehicle availability. Greensea Systems Inc. and GRi Simulations Inc.

Integrated Connectivity Platform

The combination of the Orange secured and digital network infrastructure and SES Networks' Skala Global Platform, which provides worldwide coverage through multiple geostationary satellites and gateways interconnected by a global terrestrial network, will deliver reliable, high-performance broadband services everywhere. These services will be available from developed markets to the hardest-to-reach places on Earth. Orange S.A. and SES Networks.

Condition-Monitoring System

Mimic 5 is the latest version of a CM system developed to accommodate big data. It is cloud-based, compatible with a wide range of data collection methods and fully fleet enabled. Through automated, online and wireless data collection from vibration sensors, process sensors and vessel control systems, Mimic 5 enables condition and performance monitoring of machinery, vessels and fleets. James Fisher Marine Services Ltd.

Debris Removal Platform

This automated platform safely removes debris that falls onto the deck after recovering the draghead of a trailing suction hopper dredger. A bulldozer blade pushes the debris overboard. RUD Ketten Rieger & Dietz GmbH u. Co. KG.

Airborne LiDAR Bathymetry

Fugro RAMMS, the world's smallest and lightest deepwater airborne LiDAR bathymetry (ALB) system, can now be deployed from vessels of opportunity using a Schiebel CAMCOPTER S-100 uncrewed aerial system (UAS). The UAS incorporates vertical takeoff and landing (VTOL) technology, making it an ideal nearshore and coastal mapping solution in areas that lack aviation infrastructure. Fugro, Areté Associates and Schiebel Corp.

Anti-Fouling Paint

SEAFLO NEO M1 PLUS incorporates the anti-fouling agent Selektope to protect ocean-going vessels with varying trading patterns and activity levels against soft and hard fouling. It is a low volatile organic compound sustainable coating. CMP (Chugoku Marine Paints Ltd.) Group and I-Tech AB.

Upgraded Dual-Fuel Engine

20DF's power per cylinder has increased from 185 to 195 kW, while the methane slip was lowered by as much as 40 percent, thereby drastically reducing CO_2 emissions. The existing control system was replaced by the latest UNIC all-inclusive automation system. Wärtsilä Marine Power. **ST**

Green Hydrogen Production From Offshore Wind

EDP, TechnipFMC and other research partners are joining forces to develop a conceptual engineering and economic feasibility study for a new offshore system for green hydrogen production from offshore wind power, called the BEHYOND project. The study will include innovative integration of equipment for the production and conditioning of green hydrogen and infrastructure that allows for its transportation to the coast. The goal is to create a unique concept that can be standardized and implemented worldwide, allowing for large-scale hydrogen production.

BEHYOND brings together EDP and TechnipFMC with the CEiiA research center - Center for Engineering and Development, WavEC Offshore Renewables, and the University of South-Eastern Norway. The joint development will allow the consortium partners to position themselves in the hydrogen value chain, developing new business models and creating engineering solutions, new products and services for the hydrogen sector worldwide.

This consortium will strengthen cooperation between Portugal and Norway and increase Portugal's competitiveness in the growth of the blue economy. The BEHYOND project was selected for support by the Blue Growth Programme of the European Economic Area Financial Mechanism (EEA Grants).

Hydrogen, Ammonia Fuels

Wärtsilä is pioneering the adoption of hydrogen and ammonia as viable engine fuels through advanced testing in Wärtsilä's fuel-flexible combustion engines. Hydrogen and ammonia contain no carbon, meaning the combustion releases no CO_2 emissions. Full-scale engine tests have been recently carried out in Wärtsilä's engine laboratory in Vaasa, Finland, to assess the optimum engine parameters for running on these fuels.

The test results are very encouraging, with one test engine performing very well when running on a fuel with 70 percent ammonia content at a typical marine load range. Tests were also completed successfully on another engine in pure hydrogen operation.

Testing will continue throughout the coming years with the aim of defining the most feasible internal combustion engine-based solutions for power plant and marine applications, thereby enabling the transition to a decarbonized future with green fuels.

For the energy market, Wärtsilä expects to have an engine and plant concept for pure hydrogen operation ready by 2025. For the marine market, the company expects to have an engine running on an am-

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monia blend this year. Wärtsilä anticipates having an engine concept with pure ammonia fuel in 2023. In the energy sector, it is anticipated that green hydrogen will deliver 7 percent of the global energy demand by 2050.

IUCN Calls for Urgent Action For Great Barrier Reef

The International Union for Conservation of Nature's (IUCN) call for urgent action to address impacts from climate change and poor water quality affecting the Great Barrier Reef has been adopted by the World Heritage Committee, despite the reef not being included on the List of World Heritage in Danger.

The World Heritage Committee has requested Australia to invite a mission by IUCN and UNESCO's World Heritage Centre to the Great Barrier Reef. The mission will aim to ensure that Australia's revised Reef 2050 Plan delivers the action needed on all the threats to the reef, particularly climate change and water quality. Its findings and recommendations will be reviewed at the next session of the World Heritage Committee in 2022.

According to IUCN, both the current condition and the long-term outlook of the Great Barrier Reef have further deteriorated, despite major efforts by Australia to implement its Reef 2050 Plan. There is an unprecedented speed and scale of damage caused by coral bleaching events in 2016, 2017 and 2020 that have affected two-thirds of the site. Other threats, particularly poor water quality, have further impaired the reef's ability to recover.

The Great Barrier Reef was inscribed on the World Heritage List in 1981. As the largest reef on Earth, its vast and diverse ecosystems support thousands of marine and terrestrial species.

'Rules of Thumb' for MPAs

As ocean habitats face threats such as climate change, overfishing and pollution, marine protected areas (MPAs) can provide sanctuary to threatened populations and vital ecosystem services. Using the best available science, Mote Marine Laboratory and Aquarium and IUCN's World Commission on Protected Areas, Marine Connectivity Working Group (MCWG), have published the new Marine Connectivity Conservation "Rules of Thumb" for MPA and MPA Network Design. This is the first guidance from the MCWG for advancing connectivity conservation practices in marine environments. The "Rules of Thumb" include: identifying the role of marine connectivity in the face of climate change, and identifying climate change resilience as an objective in MPA management; including multiple types of ecosystems and habitats in MPAs to account for various levels of ecological connectivity; and recognizing the relationship between MPAs and areas that may be used for commercial fishing, offshore mining/drilling, etc. as species traverse these places. **ST**

Fossil Shark Scales Indicate Declining Populations

Scientists recently made news by using fossil shark scales to reconstruct shark communities from millions of years ago. At the same time, an international team of researchers led by UC Santa Barbara ecologist Erin Dillon applied the technique to the more recent past.

Human activities have caused shark populations to plummet worldwide since records began in the mid-20th century. The scientists were concerned that these baseline data may reflect shark communities that had already experienced significant declines. Dillon compared the abundance and variety of shark scales from a Panamanian coral reef 7,000 years ago to those in reef sediments today to discern how reef-associated shark communities have changed since humans began using marine resources in the area.

The results, published in the *Proceedings of the National Academy of Sciences*, indicate that shark abundance in the region declined roughly three-fold since prehistoric times, with swifter-swimming species taking a harder hit. Much of this decrease is echoed in historical records, suggesting that sharks in Caribbean Panama were most heavily impacted within the past century.

Live Streaming from the Deep

The world's deepest-diving, acrylic-hulled manned submersible will be equipped with Sonardyne's BlueComm optical communications link to allow live streaming of deep-ocean expeditions anywhere in the world.

The Triton 7500/3 series submersible will operate from REV *Ocean*, one of the world's most advanced research vessels, currently under construction for the Norwegian nonprofit of the same name.

BlueComm will allow the occupants of the Triton submersible to live stream high-definition video and audio to the surface, including to those on board the vessel's 35-person auditorium, and even website and television audiences worldwide to share first-hand in their experience.

The Triton 7500/3 is the only acrylic-hulled submersible able to carry up to three people down to 2,286-m water depth. BlueComm will support its missions by transmitting data using high-power light-emitting diodes (LEDs) that are rapidly modulated.

Most underwater data transmission is done using acoustic signals because of the ability of sound to travel long distances, measuring many kilometers, through water. But the bandwidth available using acoustics is not wide enough for high-definition video. By using light, BlueComm is able to stream up to 10 Mbps through 150 m.

The Triton submersible will work

alongside a 6,000-m-rated Kystdesign ROV, which will also be fitted with BlueComm. The Triton submersible will stream its video to the ROV, which will then feed the data up to the REV *Ocean* research vessel via a cable.

Warming Climate Negatively Affects Antarctic Krill

Climate conditions play a significant role in the reproductive success of mature female Antarctic krill and are a factor in fluctuations of the population that occur every five to seven years, a new study from Oregon State University has found.

Environmental factors, including large-scale climate patterns that affect availability of food, influence the females' overall health during the spawning season. While those climate patterns are natural, they are trending warmer and more intense due to climate change, which is likely to have a negative impact on the krill population.

Krill serves as the base of the food web in the Antarctic Peninsula, supporting everything from whales to penguins to seabirds. Understanding the connection between the environment and population health is critical for predicting future demographic patterns and responses to climate change in the krill population.

The western Antarctic Peninsula is home to a significant portion of Antarctic krill biomass. It is also where the bulk of the krill fishery occurs; it is the largest fishery in the Southern Ocean, with an estimated 313,000 tons harvested in 2018. Krill are used as feed for fish farms and as a source of supplements, such as omega-3 oil.

Citizen Science App

Ocean Networks Canada's (ONC) Community Fishers app offers vessel operators, mariners and fishers an opportunity to collect water column data by using a CTD connected to a mobile device. The app simplifies the collection and transfer of oceanographic data to ONC's data management portal, Oceans 2.0, for evidence-based decision making.

In 2020, ONC launched a geospatial mapping tool that further enhances the Community Fishers experience. This interactive visual interface displays high-resolution water column profiles, enabling clear visual representations of complex underwater environments. The geospatial map helps users identify problems, track changes, set priorities, perform forecasting and respond to events.

Searching for Wrecks

"The Wreckless Divers" dive club in South Africa uses JW Fishers' Proton 5 magnetometer to search for wrecks around 120-m depth.

Cape Point (the Cape of Storms) has become home to many shipwrecks dating back to the 1700s, mostly with their exact locations unknown. The dive club aims to confirm the identity, location and condition of wrecks. **ST**

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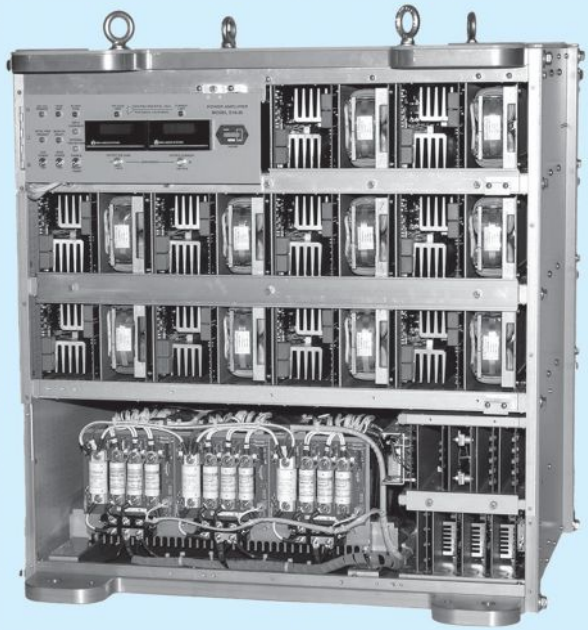

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Canadian Coast Guard Uses Iridium Certus

The Canadian Coast Guard has adopted Iridium Certus connectivity with support from Iridium partner MetOcean Telematics. Iridium Certus delivers weather-resilient and completely global coverage, ensuring dependable connectivity in the high Arctic, where the Coast Guard serves.

The Coast Guard deployed dozens of Iridium Certus Thales VesseLINK 700 terminals on its vessels, including icebreakers, to contribute to reliable internet connectivity as crew members ensure the safety of mariners in Canada's waters and protect the marine environment.

Hull Survey with Mini-ROV

Bureau Veritas (BV) and service provider MaDfly (Marine Drone Services) have successfully completed the first full in-water ship's hull survey with a mini-ROV on Brittany Ferries' ship *Bretagne*.

Efficient underwater inspections of shipping vessels are playing an increasingly important role for the industry as a substitute for docking surveys at agreed intervals or occasional surveys of hull damage.

This inspection was the first of its kind, with the test survey performed twice. A remotely operated drone performed an in-water survey with a BV surveyor on board the vessel. In parallel, Bureau Veritas also tested the capability with its own remote inspection solutions using full HD live video footage from MaDfly. This enabled BV to carry out the survey remotely without any attended surveyor on board, with live streaming, video and audio recording, and photo options.

Iver AUV Demo

L3Harris Technologies, in collaboration with Marine Tech Systems (MTS), has demonstrated live underwater autonomy capabilities of its Iver AUV during the 2021 Winterfest at Lake Saint Clair in Tasmania, Australia. The Iver's modular open systems architecture (MOSA) flexibility allows rapid configuration to leverage the newest sensor and communications payloads. The MOSA approach enables future initiatives such as the integrated undersea surveillance system where capabilities must be introduced into operations at the speed of relevance.

AMC Search, the training and consultancy division of the Australian Maritime College, hosted the annual autonomous maritime system (AMS) event to conduct individual and collaborative capabilities and foster and develop relationships among Australian AMS users in academia, defense and industry.

Satcom for Azure Network Cloud Services

SES has announced Microsoft as the first cloud provider customer for its next-generation medium Earth orbit (MEO) system, O3b mPOWER. Microsoft plans to leverage the MEO high-performance connectivity services to showcase its Azure Orbital solutions that integrate satellite connectivity with Azure services. Microsoft will use SES's current MEO to provide connectivity before migrating to O3b mPOWER next year.

SES's current O3b and upcoming O3b mPOWER systems operate in the medium Earth orbit, around 8,000 km above Earth's surface. When fully operational in 2022, O3b mPOWER will deliver an unprecedented increase of flexibility and throughput speed and capacity to any Azure Network locations on the planet. O3b mPOWER will introduce new levels of cloud-scale satellite connectivity, intelligent automation and managed services.

Updated NMEA Installation Standard

The National Marine Electronics Association (NMEA) has released an extensively updated and expanded version of the NMEA 0400 Installation Standard. This standard is the basis for the popular NMEA Marine Electronics Installer training certification courses that are taught virtually and in person. Version 5.0, Edition 2021 is a major revision to the world's most extensive Installation Standard for marine electronics.

Sections have been added for installation best practices of Wi-Fi, AIS Class B+, NMEA 2000 testing, NMEA OneNet cabling, cell phone boosters, EPIRBs, and general installation best practices.

Digital Twins for Power Grids

The research project KogniGrid, investigating the potential for digital twin assistance and operation of power grids, has been finalized. The result is Kongsberg Digital's newly commercialized digital twin for power grids, Kognitwin Grid. Tensio has now signed up for a six-month trial of the new SaaS product.

With the increasing use of green energy sources, the rising prevalence of electric transportation and continued electrification of our energy systems, society is moving forward, but the current infrastructures are under pressure. Our grids are not built to handle the new complexity, and if we experience blackouts, technologies people rely on, such as electric ferries will not run.

There is a pressing need for new tools that enable precise, data-driven and always-on insight into how much energy is needed and when. Tools are also needed to alert operators when there are threats to the grid. Digital twins allow operators to forecast grid condition, balance grids and prevent blackouts.

Wärtsilä Engines, Fuel Supply For Two Ferries

Wärtsilä will supply the engines and fuel gas supply systems for two new Ro-Pax ferries being built at the Rauma Marine Constructions yard in Finland for TT-Line Company Pty Ltd., an Australian ferry fleet owner and operator. The scope of supply per ship includes: four 46DF dual-fuel main engines; three 20DF dual-fuel auxiliary engines; and two LNGPac fuel storage, supply and control systems. The engines are future-proofed to operate on alternative green fuels. **ST**

contracts

Kawasaki Heavy Industries Ltd., Tokyo, Japan, has jointly established a new company, HyEng Corp., to pursue joint development of marine hydrogen-fueled engines. This will accelerate the drive to develop new markets for decarbonization in the marine domain. Yanmar Power Technology Co. Ltd. and Japan Engine Corp.

Xodus, Perth, Australia, has been awarded the conceptual engineering design contract for a carbon capture and storage (CCS) project offshore Malaysia. The Kasawari CCS project, off the coast of Sarawak, will comprise the capture and processing of CO_2 from the sour gas field development, which will then be injected in a depleted gas field. PETRONAS.

SMD, Wallsend, U.K., has signed a manufacturing partnership with a build-to-order controlled flow excavation (CFE) solutions provider. SMD will exclusively build, test and commission an advanced fleet of subsea excavation and trenching equipment. SEAJET Systems.

Forum Energy Technologies Inc., Houston, Texas, has been awarded a contract to provide a life extension upgrade on one of its Perry ST200 Trenchers for a Western Hemisphere telecommunications equipment company. This will support the installation and maintenance of subsea cables vital to an international communications network. Undisclosed.

Petrobras, Rio de Janeiro, Brazil, has been awarded a three-year contract for subsea inspection, repair and maintenance services in Brazil from the *Fugro Aquarius* using two Fugro-built 3,000-m, work-class ROVs. Fugro.

Greensea Systems, Richmond, Vermont, was awarded a three-year contract to support development and launch of the next-generation PowerBuoy-based Maritime Domain Awareness Solution (MDAS) on the OPENSEA platform. Ocean Power Technologies.

Columbia Shipmanagement (CSM), Riyadh, Saudi Arabia, has entered into a joint venture and will manage 35 offshore units and jack-up rigs, with more to follow, drawing on an expert team of between 70 and 80 staff taken from both companies. It will focus heavily on local talent, training, and the optimization of people and processes. The venture aims to place Saudi Arabia at the forefront of developments in the shipping and energy sectors. Spectrum Group.

Unique Group, Pinkenba, Australia, has signed a memorandum of understanding to jointly develop an industry-accredited USV Coxswain's course to be delivered globally, using Unique Group's fleet of USVs as training platforms and base stations as training simulators. Australian Maritime College.

Strohm, IJmuiden, Netherlands, has entered a joint industry program with its Thermoplastic Composite Pipe (TCP) Flowline and Riser technology. This has the potential to revolutionize the deepwater flowline and riser market in Brazil and beyond with a corrosion-free solution that has a 30-year design life. Petrobras and Shell.

Corvus Energy, Seattle, Washington, has been selected to supply the energy storage system for the all-electric tug *eWolf* by Crowley Maritime Corp. The vessel will be installed with a 6.2-MWh Corvus Orca Energy battery, which will be part of the complete integrated electrical propulsion system delivered by ABB. ABB Marine & Ports.

Valeport, Totnes, U.K., sensor technology has been chosen to provide sound velocity and bathymetric data for the pioneering Armada fleet of ocean-going robotic vessels. Ocean Infinity.

AYRO, Paris, France, will locate its production facility for its Oceanwings, a wind propulsion system for maritime transport, in Caen, France. The Chamber of Commerce and Industry of Caen in Normandy. **ST**

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meetings

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

NOVEMBER

November 2-5—Aquatech Amsterdam, Amsterdam, Netherlands. +31 (0)6 51815306 or a.koomen@rai.nl.

November 2-5—Europort, Rotterdam, Netherlands. www.europort.nl.

November 15-19—BlueTech Week, Virtual. www.tmablue-tech.org/bluetech-week.

November 16-17—Subsea Asia, Kuala Lumpur, Malaysia. www.subseauk.com/11668/subsea-asia-2021.

November 16-18—CLEAN GULF, San Antonio, Texas. cdavie@accessintel.com or www.cleangulf.org.

November 24-25—Marine Renewables Canada, Halifax, Canada. https://marinerenewables.ca/marine-renewables-canada-2021-annual-conference-november-24-25-2021.

DECEMBER

December 6-10—World Ocean Summit Asia-Pacific, Virtual. oceansummit@economist.com or https://events.economist.com/world-ocean-summit-asia-pacific.

December 15-17—UDT, Rostock, Germany. www.udt-global.com.

2022

JANUARY

January 10-13—Nor-Shipping, Oslo, Norway. www.nor-shipping.com.

January 26-27—ACIs Ship Recycling Congress, Rotterdam, Netherlands. +91 9921 81 9902 or skanwar@acieu.net.

FEBRUARY

February 1-3—Euromaritime, Marseilles, France. www.euromaritime.fr.

February 21-24—OCEANS 2022 Chennai, India and Virtual. https://chennai22.oceansconference.org.

February 22-24—Blue Innovation Symposium, Newport, Rhode Island. info@blueinnovationsymposium.com or https://blueinnovationsymposium.com.

February 22-24—Subsea Expo, Aberdeen, Scotland. www.subseauk.com.

MARCH

March 1-3—Floating Wind Solutions, Houston, Texas. https://floatingwindsolutions.com/fws-22.

March 27-29—Canadian Underwate Conference and Exhibition, Halifax, Canada. www.cuce.ca.

For more industry meetings, visit sea-technology.com/meetings. **ST**

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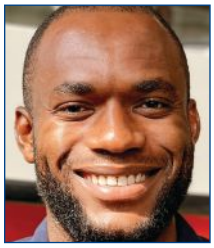
people

Molly Reyes, CSignum's former director of strategy and business development, has assumed responsibility for external engagement as chief commercial officer of CSignum Ltd., a specialist in wireless subsea communications, asset digitization and actionable insights for ocean industries. She manages commercial strategy and business development via marketing, sales and customer service activities.



Ezekiel David has joined Subsea Europe Services GmbH as a marine surveyor. He holds an M.S. with distinction in surveying and geoinformatics, with specialization in hydrography and geodesy, from the University of Lagos in Nigeria. He will complete his second master's at Hamburg Hafencity University in tandem with his position at Subsea Europe Services.

Dominique Philibert has become president and COO of CR Ocean Engineering LLC (CROE), replacing **Nick Confuorto**, who has retired and remains with the firm in an advisory capacity. Philibert was previously CROE's technology director.

North Star Renewables has created a new senior leadership role to oversee its service offshore vessel (SOV) fleet. **Steve Myers** has been appointed as SOV operations director. He has worked in the energy sector for almost two decades, including 10 years in renewables.

The U.K. Hydrographic Office (UKHO) has announced that **RAdm. Rhett Hatcher** has been appointed as the U.K.'s national hydrographer and as UKHO's deputy chief executive. He is the U.K. government's representative at the International Hydrographic Organization (IHO).

KPI OceanConnect has launched its Alternative Fuels and Special Projects division to achieve net-zero sustainability ambitions. **Bill Wakeling**, an expert in marine fuels, will lead the new offering.

SMD has modified its senior leadership team. **Mike Jones**, who was CEO, has been made chairman. **Julian Zhu** is now CEO, having been a director at SMD. **Dr. Paul Davison**, who was managing director for equipment and service, is now deputy CEO of sales and marketing. **Sarah Lawson** has become COO; she was previously operations director. **Richard Howarth** has stepped down as CFO but remains an adviser while SMD recruits a new CFO. **Chris Wilkinson** is stepping down as CTO and remains an adviser during the transition to a new CTO. **ST**

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Europe's Future Depends on the Atlantic Ocean—*Tor Eldevik and Michael Norton*

Tor Eldevik (pictured) is head of the Geophysical Institute and professor/researcher of large-scale oceanography and decadal climate dynamics at the University of Bergen/Bjerknes Centre for Climate Research. He studies climate predictability, variability and change, with a focus on the North Atlantic and Arctic Oceans. Michael Norton is a professor and Environment Programme director of EASAC.

The European Academies' Science Advisory Council (EASAC) has released the results of its two-year expert study of the state of the North Atlantic and its implications for Europe. The study assesses the latest knowledge on ocean issues that are critical for humanity's fate on the planet.

Its release coincided with the UN's World Oceans day and adds weight and detail to the UN's emphasis that the health of the oceans is intimately tied to our health. The UN's Sustainable Development Goal 14: Life Below Water aims to conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Europe's future in the Atlantic realm is one of great concern but also one of great promise. The EASAC report is very clear about future climatic risks to the region, but the report equally focuses on the future benefits we can harvest from better understanding of the relations between the state of the Atlantic and climatic conditions over Europe. These relationships affect everything from the supply of renewable energy to fisheries.

One of the study's key findings is that, looking at the most recent evidence on melting glaciers and ice sheets in Greenland and the Antarctic, the trend is that sea level rise is accelerating. European nations would be well advised to plan for a rise of 1 m or more between 2000 and 2100 and to closely monitor future trends to adjust as new data come in.

The loss of mass in the Antarctic is sufficient to affect the gravitational pull on the Earth's oceans so that they move away. This means that as the Antarctic melts, oceans shift to the North, and sea level rises even faster around Europe as a consequence of this shift.

The study finds there are dramatic consequences on weather and marine ecosystems from climate change. One example is the Atlantic Meridional Overturning Circulation (AMOC), which includes the Gulf Stream circulation. It acts as a conveyor of massive amounts of heat from the subtropics to the Arctic, shapes weather patterns, and influences life on more than one continent. As recently as 12,000 years ago, the AMOC "switched off" and drove destructive cooling; the possibility of this recurring as the planet warms has inspired Hollywood movies.

Indeed, as the climate warms, models do suggest that the AMOC will weaken, but EASAC's study finds that the latest measurements show that periodic weakening and recoveries do not yet reveal trends that can be separated from natural variability.

While the media image of a little ice age for Northwest Europe is not on the immediate horizon, the report does confirm how important this fundamental circulation in the Atlantic is—not just to Europe but to the climate thousands of kilometers away. When the ocean currents change and the delicate balance between hot and warm is disturbed, the consequences can be dramatic, potentially affecting hundreds of millions of people. We need an early-warning system to address this challenge.

Another finding of the study is that the effects of acidification on marine ecosystems are not yet understood. One of the results of increasing carbon dioxide levels in the atmosphere is that the oceans around Europe are acidifying, along with the rest of the world's oceans. Warming oceans are already reducing fishery yields, and changing marine ecosystems make fisheries management more difficult and complex, so the objective of sustainable fisheries depends on a much better understanding of how marine ecosystems respond to climate change. Marine protected areas may need to move as the sea warms and circulation patterns change. Europe needs a more comprehensive monitoring network for acidity, and we need to understand much more how ocean acidification will affect marine ecosystems and fisheries around our shores.

The study finds that a large untapped potential remains for predicting the natural fluctuations of European climatic conditions that persist in the background of global warming; fluctuations that are tightly linked with the state of the ocean. Substantiating this predictability offers potential benefits for societal and commercial planning purposes and preparedness, and should be developed to allow application in a range of fields, including tourism, renewable energy production, agriculture, aquaculture and fisheries.

According to the study, there is only one possible remedy to the climate problem: slashing emissions and increasing carbon uptake by the world's forests and other carbon sinks. The study also recommends that we should only support low-carbon energy technologies to reduce CO_2 levels, such as wind and solar renewable energies, instead of biomass, which continues to add CO_2 to the atmosphere. These renewable energies, which are recommended in the findings of previous EASAC studies, should be a focus worldwide. **ST**

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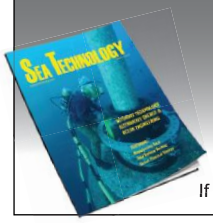

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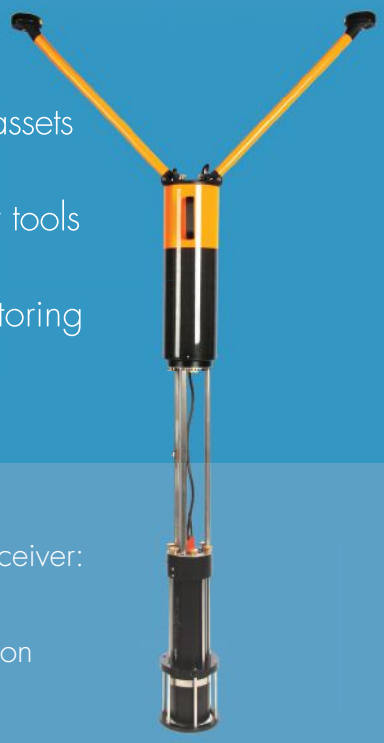

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