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JUNE 2024

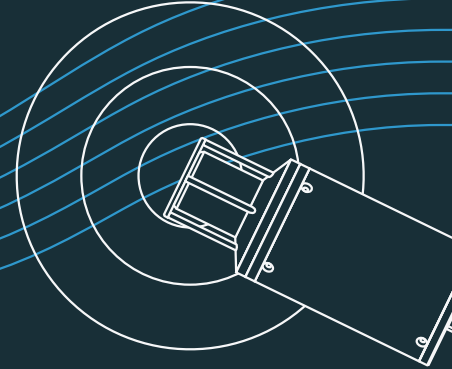
**SEAFLOOR MAPPING
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FEATURING:

Ultrahigh-Resolution Surveys

Global Satellite-Derived Bathymetry

The Ocean Enterprise

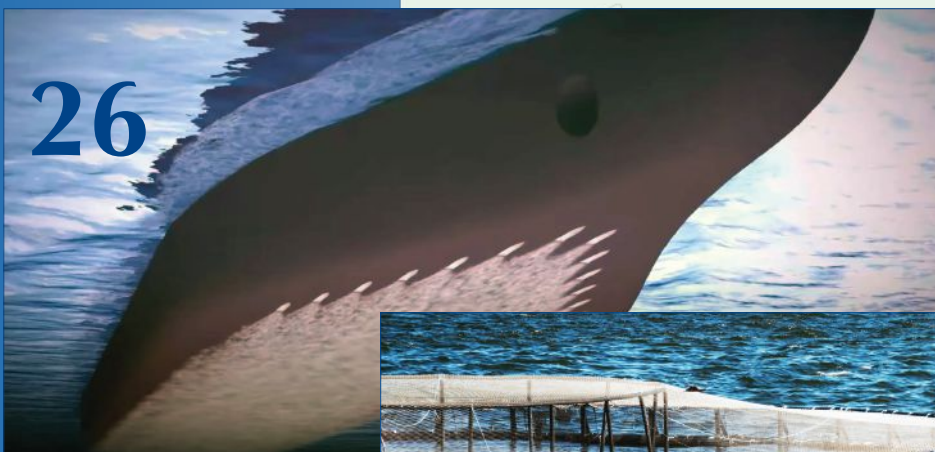
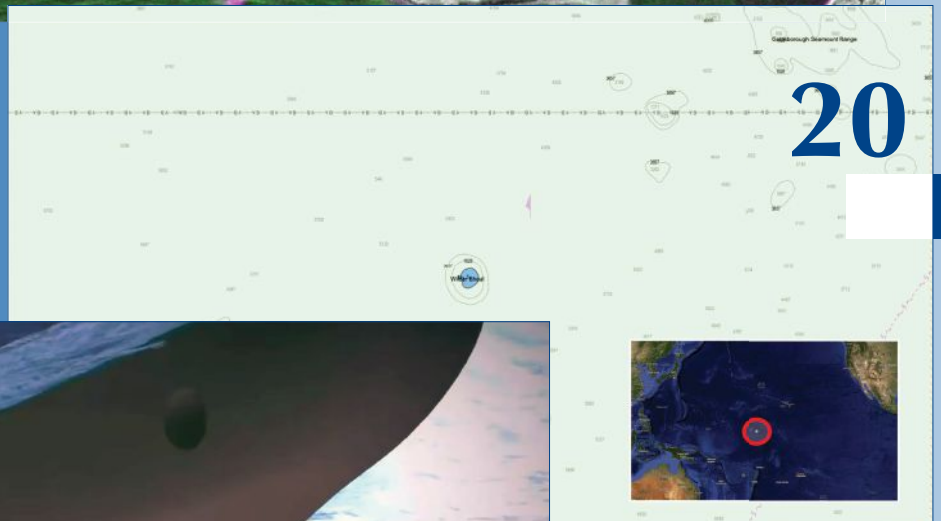
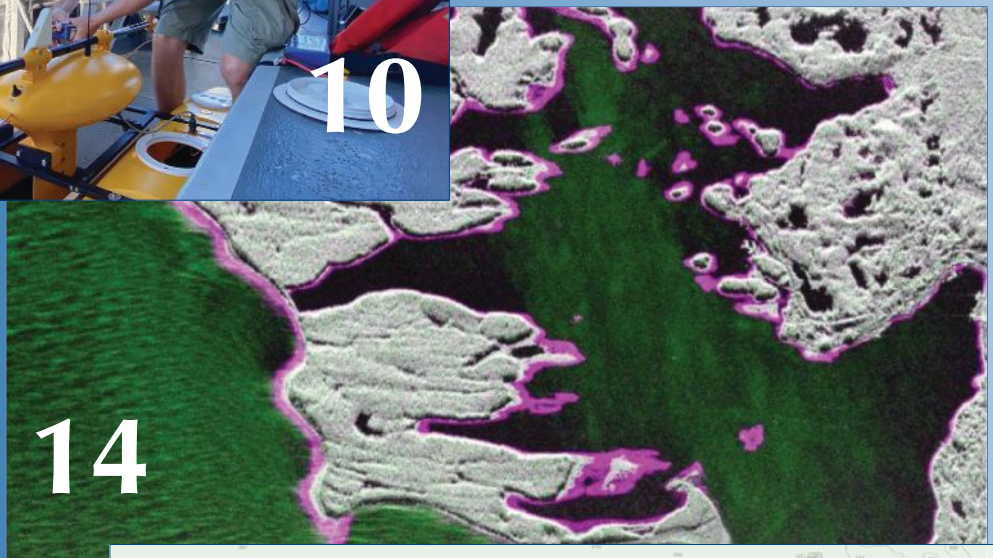


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Volume 65, No. 6

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The Cascade Locks Marine Park, located in the Columbia River near Portland, Oregon, was surveyed in March 2023 using Ping DSP's 3DSS sonar system. The image includes the lock itself, which is partially opened, as well as other related structures, including stairs. (Credit: Ping DSP)

NEXT MONTH

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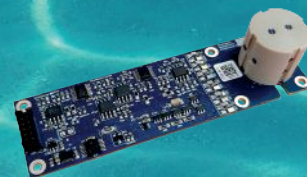
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)) Singapore Ranked Best Maritime City. Singapore remains the leading maritime city in the world, followed by Rotterdam and London, according to the 2024 Leading Maritime Cities (LMC) report from DNV and Menon Economics. The city-state, with its large owned and managed vessel fleets, strategic geographic advantages, pro-business policies, and its position as a leader in the maritime energy transition, is expected to hold this position for the next five years. The LMC report offers new insights into the maritime cities that offer the best policy measures, initiatives and support. These cities excel in both soft and hard infrastructure, and boast elite talent enabling maritime companies and individuals to connect and prosper. Similar to previous iterations, the study benchmarks each maritime city on five pillars: Shipping Centers, Maritime Finance and Law, Maritime Technology, Ports and Logistics, and Attractiveness and Competitiveness. Fourth and fifth place overall went to Shanghai and Oslo. Shanghai is predicted to grow in importance across the next half-decade and become the second most prominent maritime city. Singapore, Oslo, Shanghai and Rotterdam are considered as the cities best prepared for digital transformation.

)) NOIA Safety in Seas Award Winners. The National Ocean Industries Association (NOIA) has announced LLOG and SLB as the winners of the 2024 NOIA Safety in Seas Award Competition. LLOG is the Culture of Safety winner, while SLB won the Safety Practice Award. At the awards ceremony in Washington, DC, NOIA President Erik Milito emphasized that success is a collective effort. LLOG COO Eric Zimmermann and CFO Philip Cossich and SLB Managing Director North America Offshore Anna Guichard and President Offshore Atlantic Wallace Pescarini accepted the awards in front of NOIA membership. Compass Publications Inc., the publisher of *Sea Technology* magazine, established the NOIA Safety in Seas Award in 1978. Since 2014, NOIA has conferred two distinct safety awards annually to recognize excellence among those who, by their actions, design or influence, have contributed to improving the safety of life offshore. Leaders at LLOG have cultivated a supportive and transparent environment that encourages the sharing of concerns, mistakes, and observations. LLOG's Subsea Integrity Management Program represents a risk-based safety approach to managing critical subsea components and is integrated throughout the design process, resulting in LLOG consistently surpassing industry averages in safety metrics. SLB's safety practices include the Live Well Program to address mental health and emotional well-being and the Unlock Your Power program to provide employees with tools and strategies to bolster self-awareness and resilience to stress, integrating neuroscience, attention training and emotional intelligence. Additionally, a fit-for-purpose safety methodology resulted in a 30 percent reduction in total recordable injury frequency over the past five years, accompanied by a 115 percent increase in the report rate per employee per year.

)) Funding for Argo Fleet. NOAA and the U.S. Department of Commerce have announced that \$2.7 million from the Bipartisan Infrastructure Law will be used to replenish and expand an important array of robotic floats in the Argo program that measure ocean and climate data. The Argo array is a fleet of robotic instruments that measure temperature and salinity in the global ocean, drifting freely with the currents. Every 10 days, an Argo float dives 1.2 mi. below the surface to collect data, which it then transmits via satellite after it returns to the surface for use in weather forecasts and climate research. This funding will support the development of "OneArgo," a new and improved design for the instrument array, including floats that can measure biogeochemical conditions in two key regions that are ecologically and economically important to the U.S.—the Gulf of Mexico and the California Current Ecosystem. The funding will also support efforts to increase our knowledge of the Arctic and the Tropical Pacific Ocean, where data collection has been sparse. The Argo program includes 26 countries. The data from the Argo array plays a major role in ocean and climate assessments, such as assessments by the Intergovernmental Panel on Climate Change. When OneArgo is fully implemented, it will benefit fisheries modeling and management, sea level rise predictions, advanced seasonal weather forecasting and the emerging industry associated with marine carbon dioxide removal. Argo currently includes 4,000 floats and ultimately aims to add 700 more to the array.

)) Deep Exploration of the Arctic. The Ocean Census Arctic Deep Expedition, led by The Nippon Foundation-Nekton Ocean Census Alliance, UiT (The Arctic University of Norway) and REV Ocean, brings together a multidisciplinary team of 36 scientists and media experts from 15 leading academic institutions to discover, research, and document this underexplored region. Departing from Tromsø, Norway, aboard the Institute of Marine Research's RV *Kronprins Haakon*, the expedition is the first leg of UiT's EXTREME24 mission. Equipped with REV Ocean's 6,000-m-rated ROV Aurora, the expedition will sample and film the remote and enigmatic marine environment of the Fram Strait passage between Greenland and Svalbard. The research area encompasses a wide range of deep-sea habitats, including the Knipovich Ridge, Dumshaff Abyssal Plain, Jøtul vent field, Svyatogor Ridge, Alta Seamount, and Molløy Deep (the deepest point in the Arctic Sea at 5,550 m). Some of these unique habitats are being targeted for deep-sea mining. In October 2024, a taxonomic workshop will be hosted by Ocean Census and UiT at university labs in Tromsø. The resulting curated collection will be housed at the Arctic University Museum of Tromsø, providing a valuable resource for future research endeavors and contributing to the global understanding of marine biodiversity in the region. **ST**

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For other geographical areas,
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How to Encourage Low Emissions in US Workboats

To prime the U.S. workboat market for the transition to low-carbon powertrains, workboat operators must be given further support in the selection of new vessel designs and new low-emission propulsion systems. Current U.S. emissions legislation for workboats and diesel engine marine craft is geared toward EPA Tier 4, but some states, such as California, are proposing local legislation that goes further in reducing diesel emissions from harbor craft and ferries operating near coastal communities to improve public health.

Workboat operators have some hesitancy in adopting new powertrains as they look to long-term fleet needs and vessel operability. This hesitancy means missing early opportunities to explore new powertrain developments, such as methanol combustion or fully electric systems. The consequence is higher costs as operators have to rapidly adapt to new regulatory time tables.

To facilitate the adoption of low-emission powertrains in workboat operations, there are three actions that the industry can take. One is for naval architects to build collaborative relationships with powertrain manufacturers to give broad propulsion options to U.S. workboat operators. In responding to tenders for vessels or working directly with boat yards, designers need to be able to demonstrate that new low-emission powertrains can deliver the same resilience and flexibility in operations to which workboat operators have become accustomed. This requires a full understanding of workboat operator needs and the willingness to embrace innovative designs that provide the optimum combination of efficient and low-emission power without compromising on performance. Naval architects should move beyond off-the-shelf designs by working closely with powertrain technology firms to provide workboat operators with the best combination for their needs.

Another step is for workboat tenders from public authorities to reward low-emission vessel designs. In the competitive environment of workboat operations, tenders from public authorities, such as ports and harbors, should incentivize proposals that include new hybrid vessels ahead of forthcoming regulation. Tenders should also encourage proposals that clearly define the reduced environmental impacts of new low-emission powertrains, such as demonstrated reduction of noise and potential for fuel spills.

A third step is to prove the investment case to workboat operators, with the cost savings of hybrid and electric powertrains made clear in the design stage. The operating data from early adopters of low-emission powertrains demonstrate that vessel operators can save considerable fuel costs. Similarly, reduced overhead costs in maintenance have also been demonstrated for hybrid and electric powertrains.

For example, the University of Vermont has received a hybrid 19-m survey vessel that drove a huge reduction in diesel engine use. The vessel operates fully electric for at least 60 percent of its operations, including winches and A-frame deck equipment, delivering significant value for the vessel owner without compromising on performance. Panning out in the market, local patrol and pilot vessels designed with hybrid propulsion will anticipate the future needs of the U.S. workboat market.

A new workboat vessel must be able to operate in the long term. Naval architects, powertrain engineers, and end-customers in ports, harbors, and public authorities must collaborate to create powertrain options that offer low emissions and robust design. We also need competitive contracts that reward low-emissions innovation and adoption. New designs must meet both evolving regulations and the needs of workboat operations. **ST**

SEA TECHNOLOGY® 2024

JANUARY

Annual Review & Forecast

****EUROMARITIME 2024**, January 30-February 1, Marseille, France

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

****Oceanology International 2024**, March 12-14, ExCel, London, U.K.

MARCH

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

****UDT 2024**, April 9-11, ExCel, London, U.K.

****OCEANS 2024 Singapore**, April 14-18, Singapore

****XPONENTIAL 2024**, April 22-25, San Diego, CA

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

****Offshore Technology Conference**, May 6-9, Houston, TX

MAY

Communications, Telemetry, Data Processing

JUNE

Seafloor Mapping/Sonar Systems/Vessels

****Sea Technology supports these shows**

BONUS INFORMATION

- | | | |
|----------------------------|---------------------|-----------------------|
| • Capital Report | • Marine Renewables | • Ocean Engineering |
| • Company Profiles | • Marine Resources | • Ocean Research |
| • Contracts | • Meetings | • People |
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EDITORIAL CONTACT: Aileen Torres-Bennett, oceanbiz@sea-technology.com

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4 EDITORIAL CALENDAR

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JULY

Deck Gear, Cable, Connectors, Power Systems & Salvage

****IMAGE 2024**, August 25-30, Houston, TX

AUGUST

Ocean Resources Development & Coastal Zone Management

****OCEANS 2024 Halifax**, September 23-26, Halifax, Canada

SEPTEMBER

Geophysical Exploration/Seafloor Engineering

OCTOBER

Environmental Monitoring, Remote Sensing & Pollution Control

****EURONAVAL 2024**, November 4-7, Paris, France

****CLEAN GULF**, November 18-20, San Antonio, TX

****MAST Australia 2024**, November 19-21, Adelaide, Australia

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Ultrahigh-Resolution Surveys

Multibeam Echosounders on Man-Portable USVs, Small Survey Vessels

By Melanie Tibbs • JP Cheminade

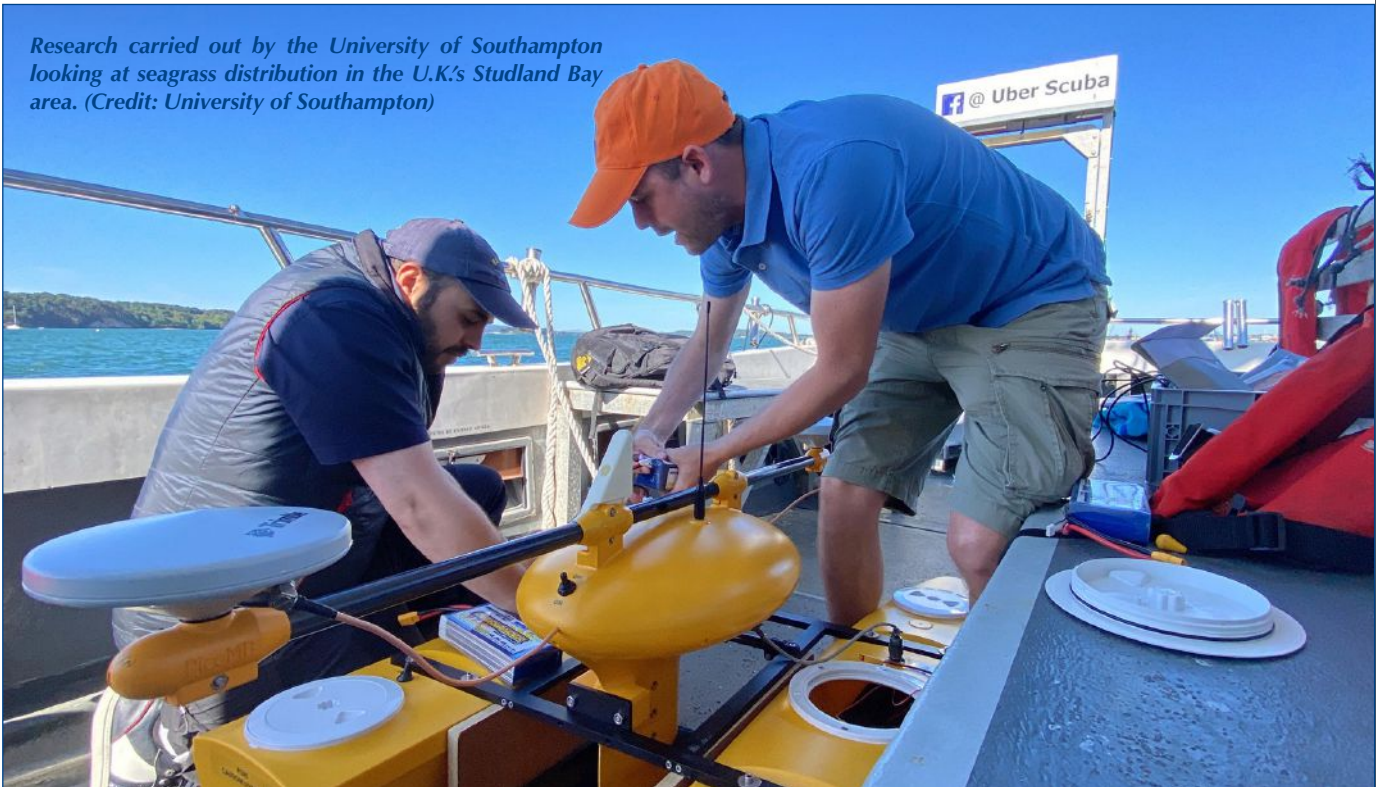
In the realm of shallow-water hydrographic and bathymetric surveying, the quest for high-resolution imaging and accurate mapping has led to the development of sophisticated sonar technologies. Among these, Picotech multibeam sonars stand out for their capabilities in underwater surveying, imaging and mapping.

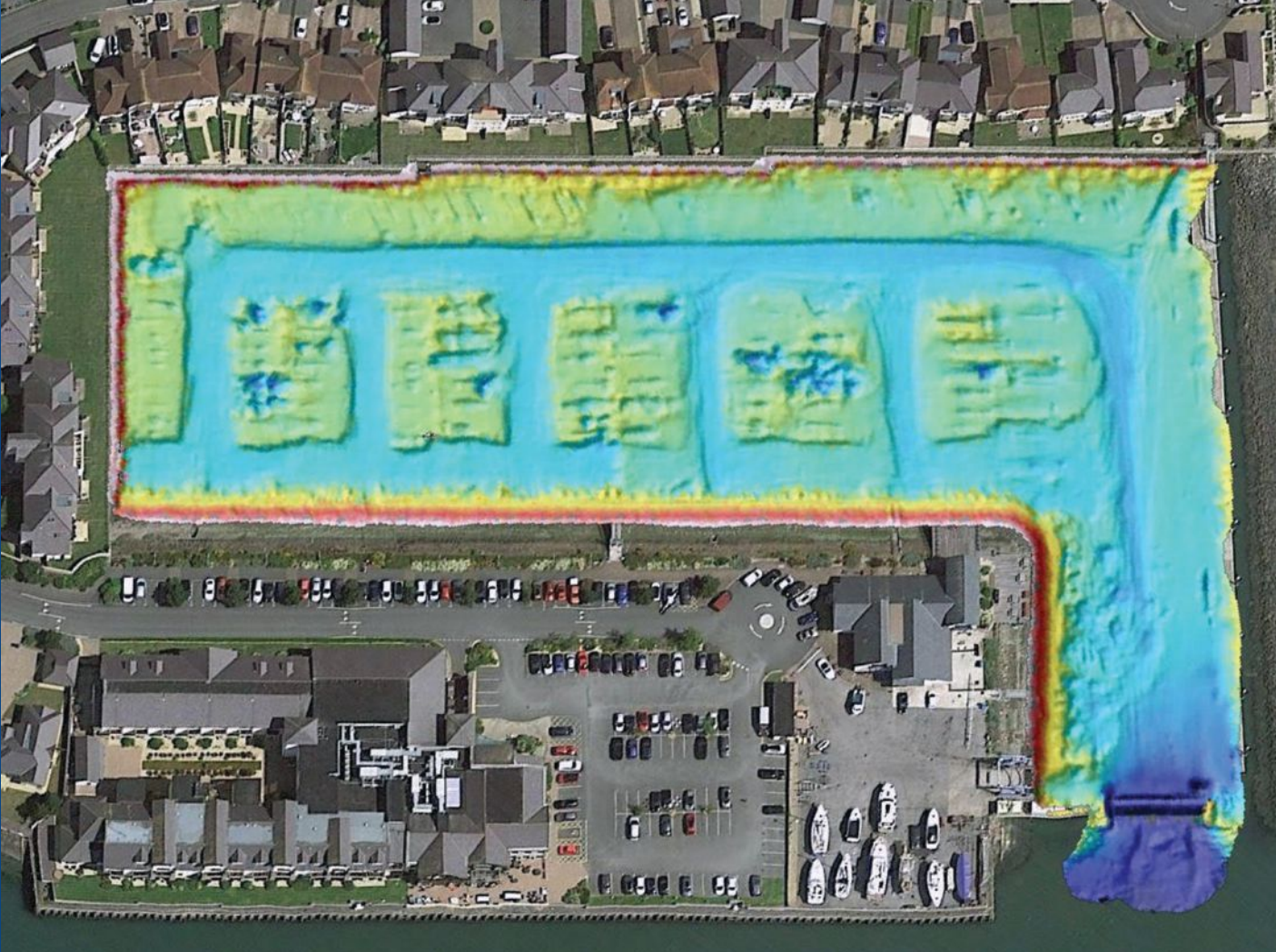
Traditional sonar systems emit a single beam of sound waves and receive echoes to generate spot depths of the underwater environment. However, the images produced from these soundings lack detail, accuracy and resolution, particularly when used in complex terrains.

Multibeam sonars revolutionize underwater imaging by focusing and processing multiple beams of sound waves simultaneously. By covering a wider area and capturing more data points, multibeam sonars produce highly detailed three-dimensional maps of the seafloor with much greater accuracy. This capability makes them indispensable tools in various fields, including marine research, underwater archaeology, offshore exploration and hydrographic surveying.

Picotech has long been at the forefront of sonar technology, continually pushing the boundaries of innova-

Research carried out by the University of Southampton looking at seagrass distribution in the U.K.'s Studland Bay area. (Credit: University of Southampton)





(Above) Picotech sonars offer high-resolution survey of harbor areas. (Right) The small size of the PicoMB13X series, when used on a portable USV, enables access to tight spots.

tion to deliver state-of-the-art solutions. Picotech multibeam sonars represent the culmination of years of research, development and engineering excellence. Their advantages are: small size, low weight, and class-leading power consumption to allow for rapid mobilization, simple launch and recovery, and long endurance. The option of an integrated Applanix POS MV SurfMaster inertial navigation system means that mobilization is quick and easy and no longer an esoteric task, opening up the world of hydrography to many traditionally land-based geomatics companies.

The bathymetry and snippets/backscatter outputs of Picotech multibeam sonars make them indispensable tools across a wide range of industries and applications.

Marine Research and Exploration

In the field of marine research, Picotech sonars play a crucial role in studying underwater ecosystems and mapping underwater topography and ecology. Researchers rely on Picotech's high-resolution im-



“The bathymetry and snippets/backscatter outputs of Picotech multibeam sonars make them indispensable tools across a wide range of industries and applications.”

aging capabilities to study coral reefs and underwater habitats and to unravel the mysteries of what lies on the bottom of any reservoir, river, harbor, or sea. For example, the PicoMB130 has been used by the University of Southampton for the study of seagrass distribution and Newcastle University for the study of geomorphology in the Mekong Delta.

Snippets (backscatter) data outputs come as standard and provide additional information on bottom type (hardness) as an invaluable addition to the bathymetric data. This combination means images show the same

geographical extents, though each provides a different insight into the same environment.

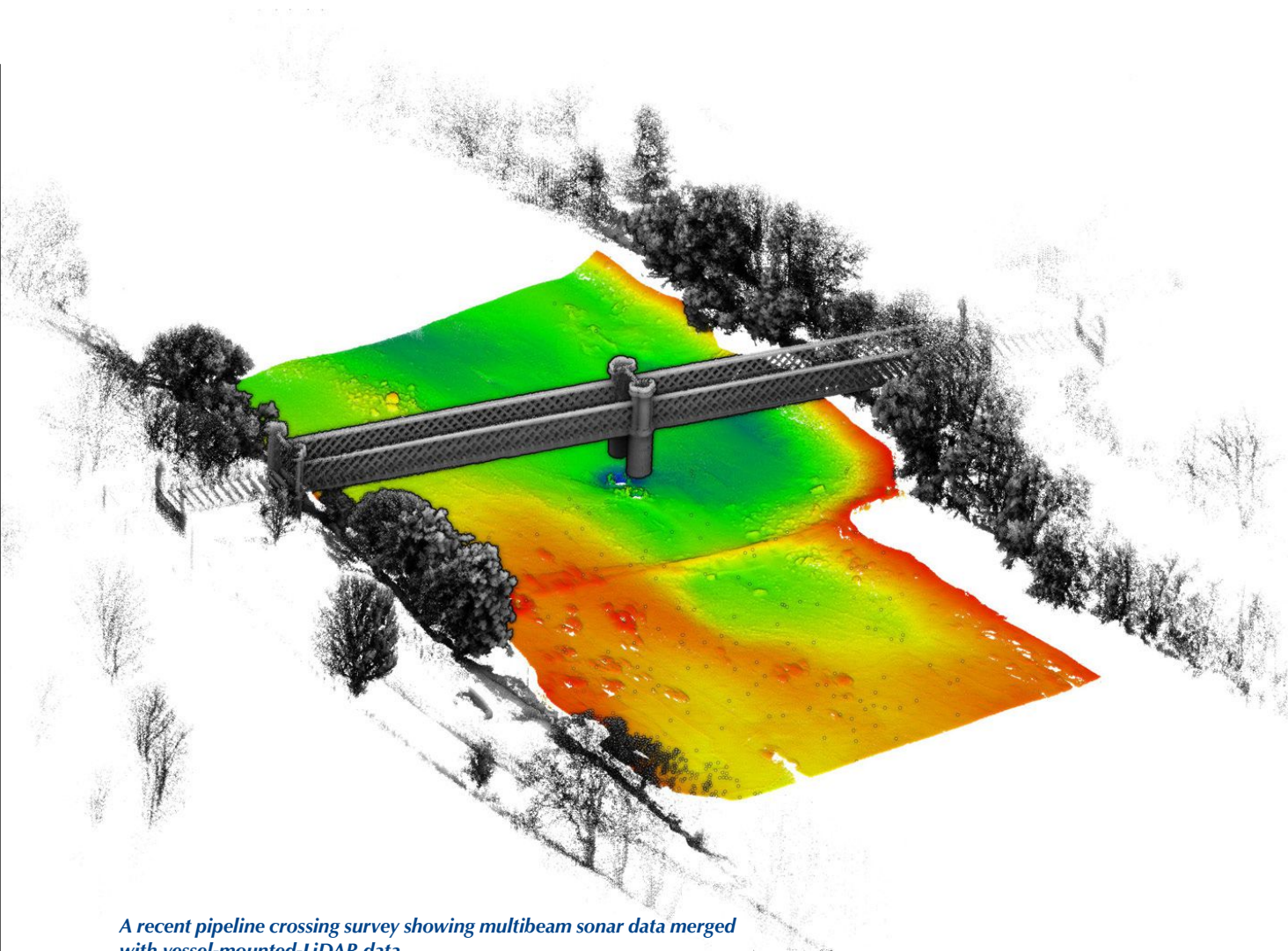
Hydrographic Surveying

Hydrographic surveyors depend on Picotech multibeam sonars (PicoMB) for accurate mapping of navigable waterways, harbors and coastal areas. By generating detailed bathymetric data, Picotech sonars provide data for safe and efficient maritime navigation, as well as aiding the planning and construction of marine infrastructure projects. International Hydrographic Organization special order surveys are achievable and routinely carried out around the world with PicoMB.

Picotech can be pole mounted on larger vessels or on any one of the numerous USVs/ASVs now available on

Recent survey work on the U.K.'s River Mersey.





A recent pipeline crossing survey showing multibeam sonar data merged with vessel-mounted-LiDAR data.

the market (e.g., PicoCAT, Seafloor Systems' HyDrone, Maritime Robotics' Otter, Blue Robotics' BlueBoat, etc.). PicoMB have even been successfully mounted on personal watercraft, such as jet skis and water bikes.

Dredge Support

In the ports, harbors and marinas sector, PicoMB sonars play a vital role in bathymetric surveying in support of both hydrography and dredge support. Due to their small form factor, PicoMB can be mounted on very small vessels, capable of accessing areas that larger systems cannot, causing less disruption to ongoing port/marina operations.

Scour and Accretion Monitoring

PicoMB are very suited to scour and accretion surveys for monitoring spatial and temporal changes in bathymetry following the installation or removal of civil engineering works, such as dams, quay walls, flood defenses, tunnels and bridges. These kinds of surveys are used to provide engineers with current depth data and models to show the differences in comparison to previous surveys.

Utilities Surveying

PicoMB have a niche for utilities surveying in aquatic

areas, especially where depth, access, or flow rates limit the options for larger sonar systems and/or traditional crewed survey craft. Examples include reservoirs, rivers and pipeline crossings.

Conclusion

Picotech multibeam sonars represent a paradigm shift in underwater imaging and mapping technology, offering unparalleled size to power consumption to data resolution ratios. There is always one system available on the market best suited to one particular application, but very rarely do you find one system suited to so many applications, such as the PicoMB.

Picotech sonars empower surveyors, researchers, engineers and explorers to unlock the secrets of the underwater world in areas never before accessible, with unprecedented clarity and precision. As technology continues to advance, Picotech remains at the forefront of innovation, driving new discoveries and insights into subsurface survey and inspection: www.picotech-ltd.com. **ST**

Melanie Tibbs is a director of Picotech Ltd.

JP Cheminade is the director of Geodesea Ltd.

Global Satellite-Derived Bathymetry

New Satellite Sensors Continue to Improve Technique

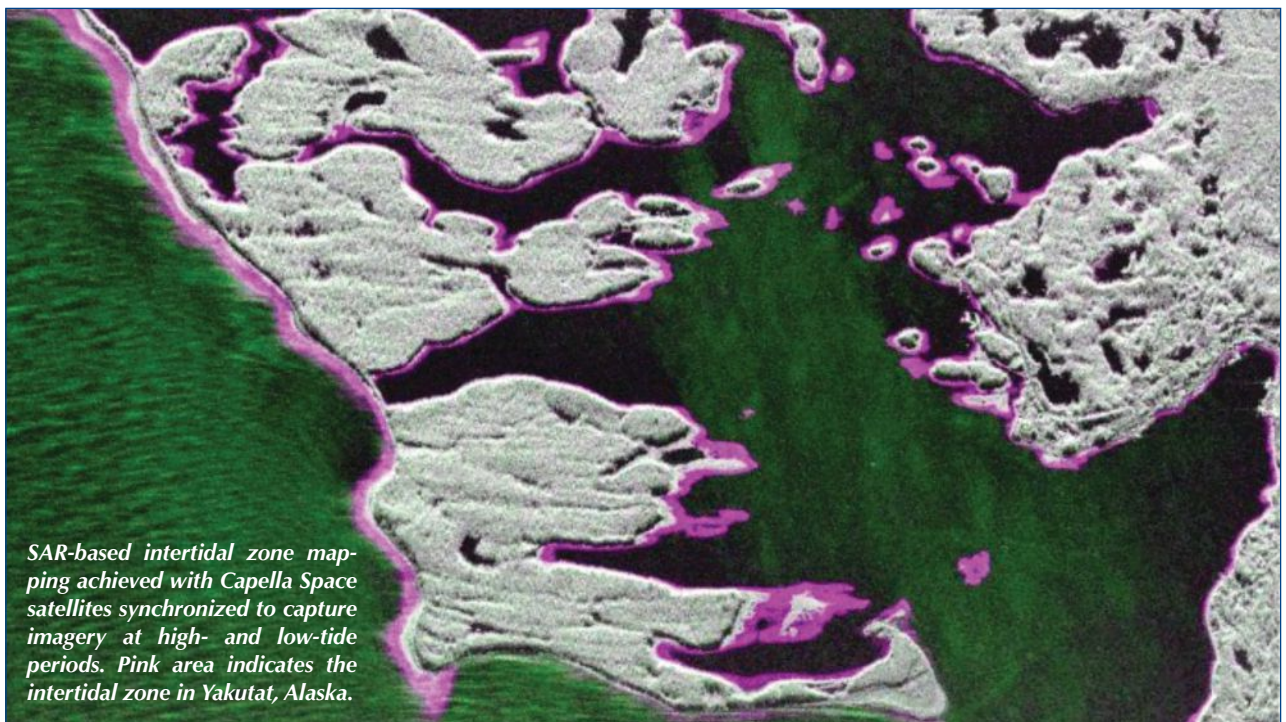
By Kyle Goodrich

In less than a decade, satellite-derived bathymetry (SDB) has evolved from a shallow-water mapping technology that could be applied only in clear, calm waters to one that can now be used cost-effectively and reliably in a wide variety of coastal environments around the globe. A 2023 project conducted in the challenging waters of Alaska was one of several that highlighted the arrival of SDB as a commercially viable, globally applicable sea-floor mapping technique.

TCarta Marine of Denver, Colorado, successfully completed the Alaska project despite the presence of nearly every environmental condition that traditionally thwarted SDB production. The results were impressive: Seafloor

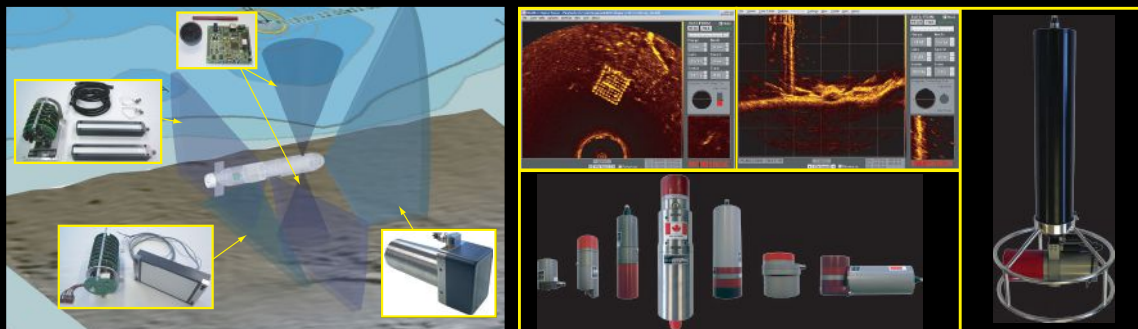
depths were measured down to 26 m in Kachemak Bay and to 3 m in the murky and turbulent Arctic waters of Point Hope. Additionally, the data sets were delivered on time and within budget to the customer, NOAA's Office of Coastal Management, and the data were made freely available to the public via the NOAA Digital Coast website: <https://coast.noaa.gov/dataviewer/#/>.

Fully appreciating the significance of this effort requires an understanding of SDB technology. It involves the analytical processing of the red, green, blue and infrared bands in optical multispectral satellite imagery. These spectral signatures captured by space-based sensors result from light energy penetrating the water col-

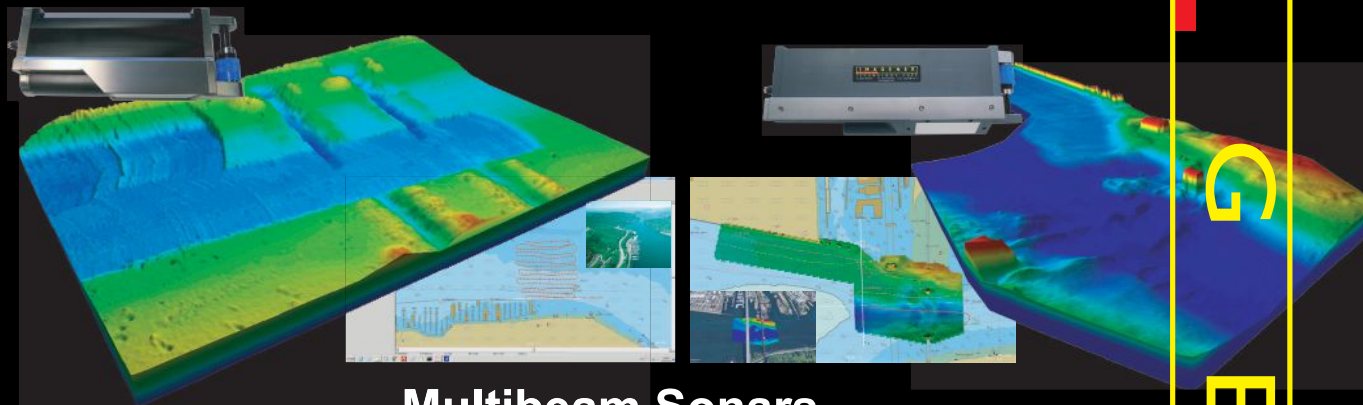


SAR-based intertidal zone mapping achieved with Capella Space satellites synchronized to capture imagery at high- and low-tide periods. Pink area indicates the intertidal zone in Yakutat, Alaska.

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umn and reflecting off the seafloor. Processing these spectral reflectance values with specialized SDB algorithms calculates the depth of the water.

Numerous factors, however, can foil the SDB methodology. Darkness and cloud cover entirely prevent image collection by optical satellites, while the presence of sea ice and high levels of sediment or chlorophyll in coastal waters hinders light penetration, thereby eliminating seafloor reflectance and SDB derivation. The polar regions experience excessive cloudiness and six months or more without adequate sunlight for SDB. During summer months, glacial runoff creates highly turbid waters in addition to large-scale phytoplankton growth due to 24 hr. per day of light. Overall, the conditions for SDB in Alaskan waters are among the most challenging in the world.

Despite these drawbacks, SDB is a popular mapping technique that has been applied reliably in many parts of the world and is a vital component to comprehensive coastal mapping programs. The primary benefit is that it can be used in shallow coastal zones that are too dangerous for shipborne methods, such as sonar, or too remote for deployment of airborne LiDAR.

Optical satellites, on the other hand, capture imagery globally across political boundaries and without risk to personnel, equipment, or the environment. The reduction in use of carbon-fuel-burning survey platforms is also a considerable benefit of satellite-based survey methods, and carbon costs are now becoming a consideration in international tenders for ocean mapping.

Geographic areas most amenable to SDB have traditionally included the Caribbean, Red Sea, Pacific atolls and the Arabian Gulf. Historically, SDB extraction from multispectral imagery was performed with one of two algorithms: Radiative Transfer or Band Ratio. The first is extremely computer intensive, sometimes taking days to process one image and requires extensive expertise. Band Ratio, on the other hand, is faster but requires calibration data, such as sonar or other direct depth measurement, which often aren't available in remote or dynamic coastal zones, and high accuracy is limited due to areas of homogeneous seafloor.

The expansion of commercial SDB to parts of the world once thought impossible or impractical for it has resulted from a convergence of critical factors in just the past several years. These include dramatic improvements in satellite remote sensing capabilities, refinements in machine learning technologies to select images and derived water depths, and global availability of a secondary satellite-based bathymetric derivation method: space-based LiDAR.

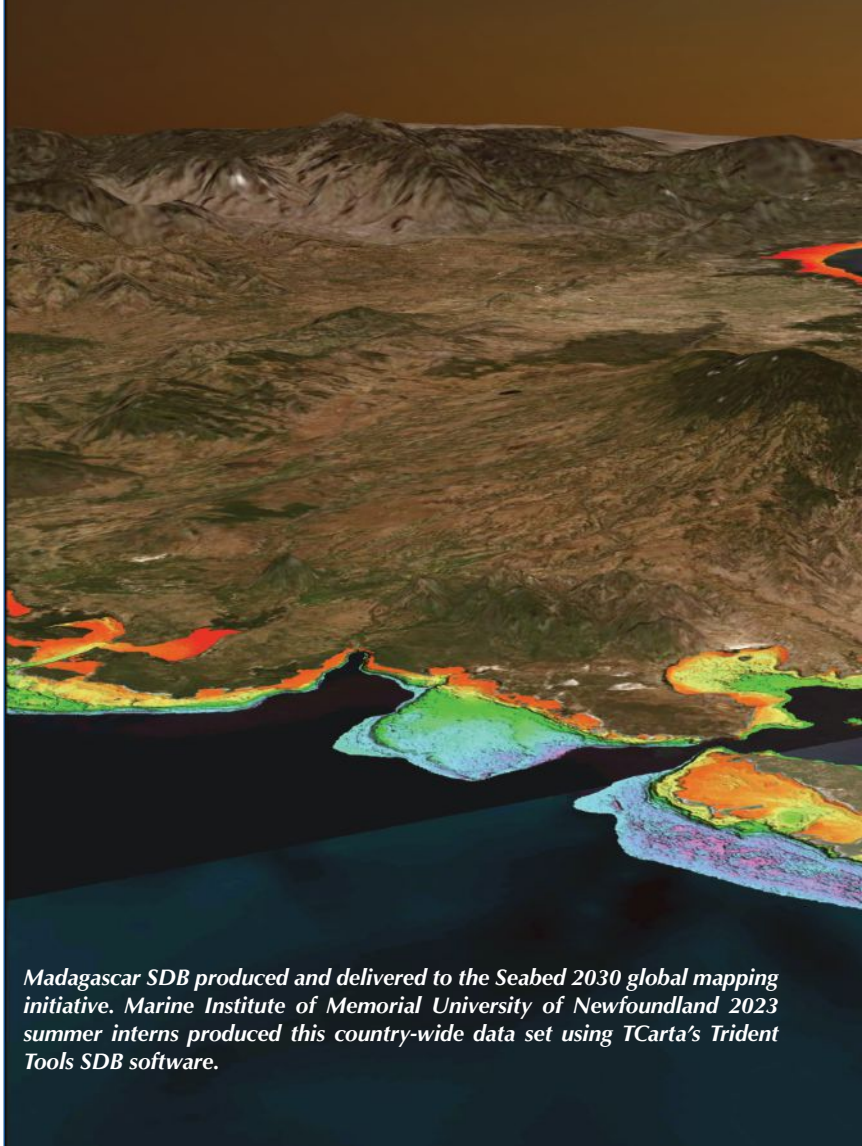
The simultaneous emergence of these innovations has enhanced the quality and reliability of SDB mea-

surements in places where it has always been applicable and expanded its technical viability to almost all environmental conditions and geographic locations. Just as importantly, the method can now be affordably applied in massive project areas, even if time and budgets are limited.

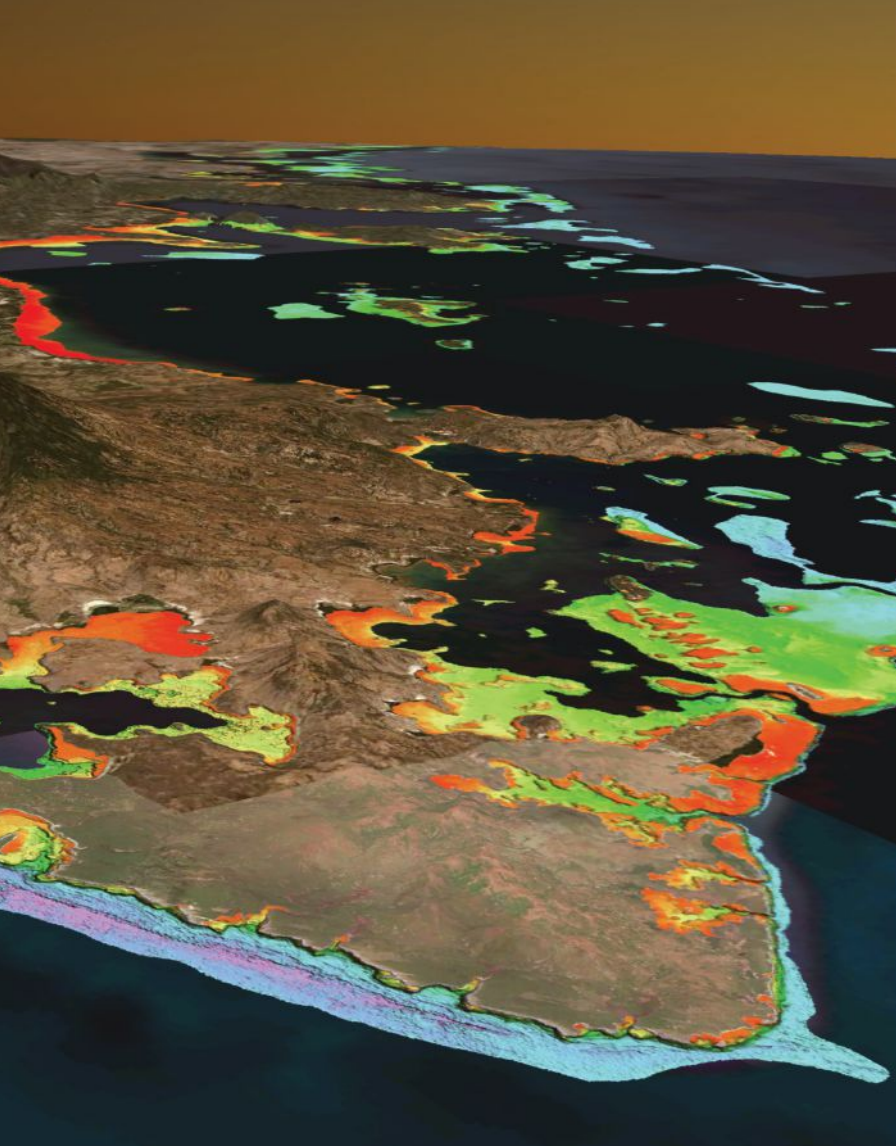
This is just the start of a paradigm shift in SDB methodology and applicability. There are additional advancements now being researched—mainly in the form of new satellite imaging technology—that will continue to enhance satellite-derived bathymetry.

Mapping the Alaskan Coastline

The success of the Alaska project would likely not have been possible if it weren't for the research and development conducted under two Small Business Innovation Research (SBIR) grants awarded to TCarta by the National Science Foundation and NOAA between 2018 and 2022 with the goal of modernizing SDB techniques and expanding the pool of usable sensors. The research focused on overhauling the entire SDB workflow, devising tweaks to the algorithms themselves, as well as experimenting with new and better data imagery selection,



Madagascar SDB produced and delivered to the Seabed 2030 global mapping initiative. Marine Institute of Memorial University of Newfoundland 2023 summer interns produced this country-wide data set using TCarta's Trident Tools SDB software.



data cleaning techniques and accuracy assessment.

The NOAA grant sought to specifically improve SDB outcomes in high-latitude areas such as Alaska and the Arctic. TCarta worked on the theory that notoriously turbulent coastal zones in this region experienced some calm days suitable for SDB. But pinpointing such ideal conditions that also coincided with periods of daylight dramatically narrowed the potential acquisition window of optical satellite image collection.

Fortunately, the availability of SDB-suitable imagery has exploded over the past 25 years with the launches of numerous optical imaging constellations. Gone are the days when the U.S. Landsat and French SPOT satellites were the only image sources, with imagery collected once a week at best. Today, there are numerous Earth observation systems in orbit operated by Maxar, Airbus, European Space Agency (ESA), Pixxel, Planet, Satellogic, and several others that provide a plethora of images to select from.

These satellites have been capturing imagery for years and amassing enormous archives of data covering the entire Earth. In many cases, these archives contain deep stacks of numerous images for each spot on the globe,

some with hundreds of images to select from. In addition to more frequent acquisitions, some of these sensors capture reflectance data in different segments of the optical and infrared spectra, which enhance SDB by penetrating deeper into the water column, providing additional seafloor information and enabling more robust corrections for atmospheric distortions.

TCarta had been modifying the original SDB derivation algorithms with the addition of these new spectral bands and ratios of multiple bands and then applying machine learning to recognize the best results from the seafloor extraction process. It was a natural step to then apply machine learning to stacks of archived satellite images and find the ones with the clearest, calmest water conditions for SDB processing. From there, the process was refined to use machine learning to isolate and combine the best pixels from multiple overlapping images for derivation of water depths. Searching the archives manually to find images with the right characteristics would be impossible or too time consuming for practical application. Machine learning makes this possible.

For Alaska, TCarta processed high-resolution multispectral imagery from the Maxar and Planet archives to complete the project. These data sets were chosen for their high spatial resolution and frequency of imagery collection, which were required to meet the bathymetric accuracy

requested by NOAA's Office of Coastal Management. TCarta used a custom process to assimilate the radiometric measurements of the two different sensor systems for consistent SDB extraction.

Incorporation of machine learning into the SDB processing workflow has substantially reduced production time. TCarta routinely processes dozens to hundreds of images in the same time it would have taken for one just a few years ago. This has substantially improved the overall economics and viability of SDB as a commercial service.

Adding Satellite LiDAR for Validation

The other major addition to the SDB workflow has been space-based LiDAR, or laser altimeter, data from NASA's ICESat-2 satellite. Launched with the intent of measuring the thickness of sea ice, glaciers and tree canopies, the satellite also directly measures seafloor depth down to about 30 m under the right conditions. The LiDAR's green laser emissions penetrate shallow water, reflect off the bottom, and return a signal to the sensor. The data can be processed to determine depth to high levels of accuracy.

The ICESat-2 measurements are made in single-point



Seabed 2030 and Marine Institute of Memorial University of Newfoundland 2023 summer interns and facilitators. Plans for a 2024 (year two) intern program and data contribution to Seabed 2030 are underway.

survey measurements with approximately 1 m between points along the track and with several kilometers between each track, which means the data cannot be used as a standalone bathymetric mapping tool for broad areas, but its value is still considerable.

ICESat-2 has proved to be the ideal validation and calibration data set that extends SDB utility to remote parts of the world where no control points can be collected or are otherwise unavailable from on-site methods. The ICESat-2 data are applied in two aspects of the modernized SDB workflow. The laser measurements are first employed as training data to train the machine learning algorithms to recognize water depths in optical imagery. The ICESat-2 points are also used to validate the accuracy of SDB calculations derived from the Radiative Transfer SDB method, enhancing the confidence in derived water depth values. By combining both methods and information from two satellites using independent methods for water depth derivation, greater confidence in the results is achieved.

Although TCarta uses the NASA data in all SDB projects now, the value of the data set was demonstrated most vividly in another 2023 project where TCarta performed bathymetric mapping of the entire Madagascar coastline. Mapping the coastal zone of the fourth largest island on Earth was noteworthy for several reasons, aside from its

sheer size and remoteness. First, the project was supported by the Seabed 2030 program, which was also the recipient of the final products. Second, TCarta completed the SDB mapping in cooperation with students during a summer work term program at the Marine Institute (MI) of Memorial University in St. John's, Newfoundland, Canada.

Due to a limited budget and grand ambitions to make large contributions to Seabed 2030, free imagery from the 10-m-resolution ESA Sentinel-2 satellite was used. Thousands of satellite images, many stacked over the same areas of interest, were obtained for the entire Madagascar coast. Without machine learning and ICESat-2, the SDB mapping project would have taken 12 months or more just a few years ago, but the student-involved teams completed it in a few weeks, achieving 24-m-deep measurements along the majority of the Madagascar coastline.

The technology and techniques developed under TCarta's research grants have not only gone on to benefit the commercial and government projects, but also it has proven to be a tremendous instructional tool for future hydrographers and contributed significant data coverage to the global effort to map the entirety of the seafloor.

The Future of SDB

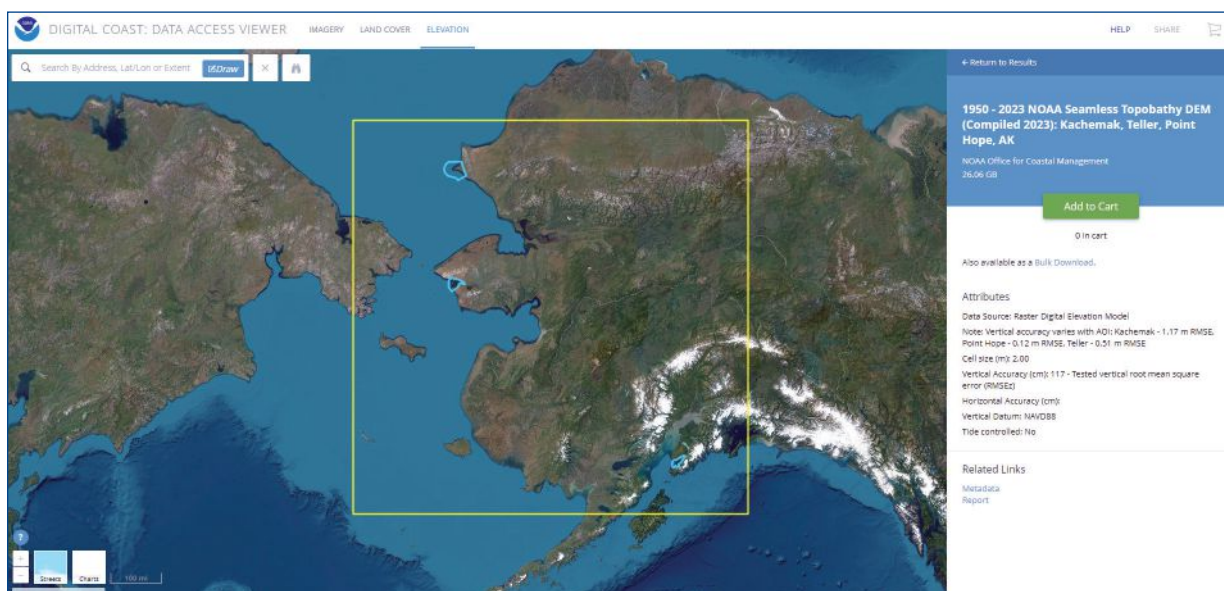
The revolution in commercial imaging satellites has included two types of data collection systems that hold significant potential for SDB applications and supplemental coastal products.

These are synthetic aperture radar (SAR) and hyperspectral satellite constellations.

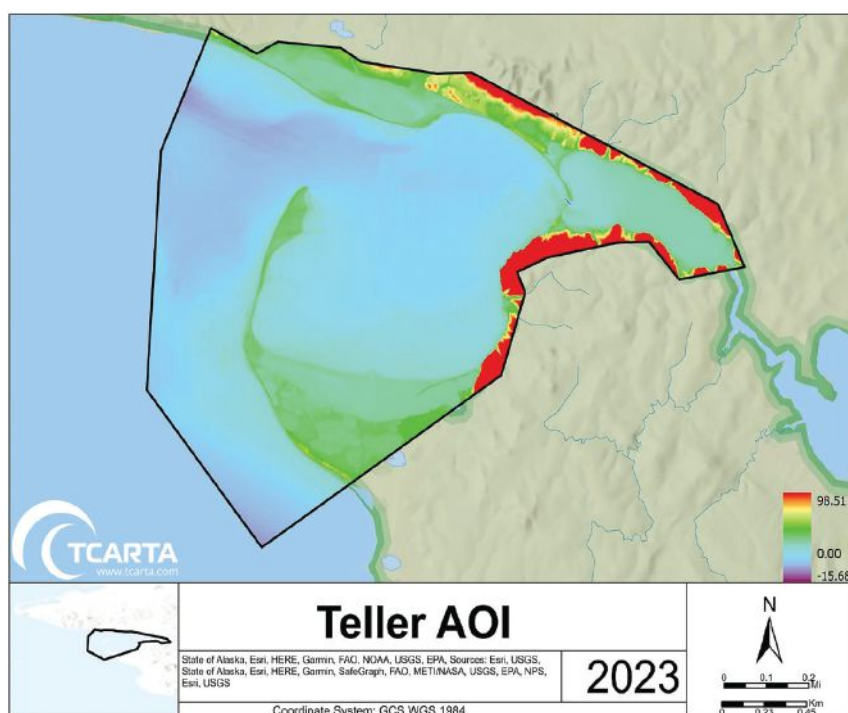
The primary advantage to SAR is that, unlike passive optical systems that capture reflected sunlight, radar sensors actively emit signals that can pass through darkness and clouds to bounce off the Earth's surface and return data. This means they can collect data 24/7 anywhere on the globe. The key difference in recent SAR missions is their spatial resolution supports practical coastal mapping. Commercial SAR operators include Capella Space and Umbra in the U.S., ICEYE of Finland, and Synspec of Japan.

While SAR does not provide seafloor depth information due to lack of water column penetration, it does add important shoreline location data that can enhance SDB accuracy. TCarta has used the radar data collected at both day and night in some high-latitude projects to precisely map high- and low-tide water levels to determine the extent and characterization of the intertidal area. These shoreline features can be applied as a complement to the SDB products, but it is often requested by some commercial clients as a standalone coastal map product.

TCarta has teamed with Capella on joint research projects to determine other ways high-resolution SAR can be incorporated into marine mapping and possibly SDB projects. As an analytic partner, TCarta has been



(Above) TCarta results in Teller, Point Hope and Kachemak, Alaska, under sub-contract to Axim Geospatial and contracted by NOAA's Office of Coastal Management, are available in NOAA's Digital Coast Data Access Viewer. (Right) TCarta produced SDB in Teller, Alaska, which was integrated with multiple freely available data sources into a seamless topobathy digital elevation model.



developing coastal products and tools for ready use by customers around the globe.

The potential for hyperspectral satellite data to directly impact SDB by facilitating deeper and more accurate seafloor measurements is even more significant. Generally referring to sensors that acquire reflected data in more than 10 spectral bands, hyperspectral systems have recently been launched by several companies: Pixxel in India, Wyvern in Canada, Orbital Sidekick of the U.S. and others.

The excitement for SDB analysis is that these sensors capture reflected energy in very narrow bands across the visible and infrared portion of the spectrum. Initial research by TCarta in cooperation with Pixxel indicates these narrow bands, especially in visible green and blue, will detect reflected energy that has passed more cleanly through the atmosphere without distortion and penetrate deeper into the water column. This will potentially extend the useful range of SDB into deeper, and possibly less clear, water.

While more advanced satellite imaging platforms will continue to play key roles in SDB progress, the SBIR

grants from the U.S. government have most directly impacted shallow-water mapping capabilities for the hydrographic and hydrospatial communities. These investments are paying off in terms of safer coastal navigation, more responsible shoreline development, and more diligent environmental protection in the littoral zone. **ST**

Kyle Goodrich is the president and founder of TCarta Marine and has a 22-year career in geospatial services. Since founding TCarta in 2008, he has led numerous geospatial product research and development plans, including the development and commercialization of satellite-derived bathymetry, stereo photogrammetric bathymetry, a global aggregation and assimilation of multi-source bathymetry data and global vector shoreline. As principal investigator in TCarta's National Science Foundation and NOAA Small Business Innovation Research Phase Two projects and as an active industry member in international hydrographic commissions, Goodrich is a persistent and passionate leader in the commercialization of satellite-based marine remote sensing technologies.

Mitigating Malicious GPS Disruptions

3D Forward-Looking Sonar Can Guard Against Spoofing

By Matthew Zimmerman • Heath Henley

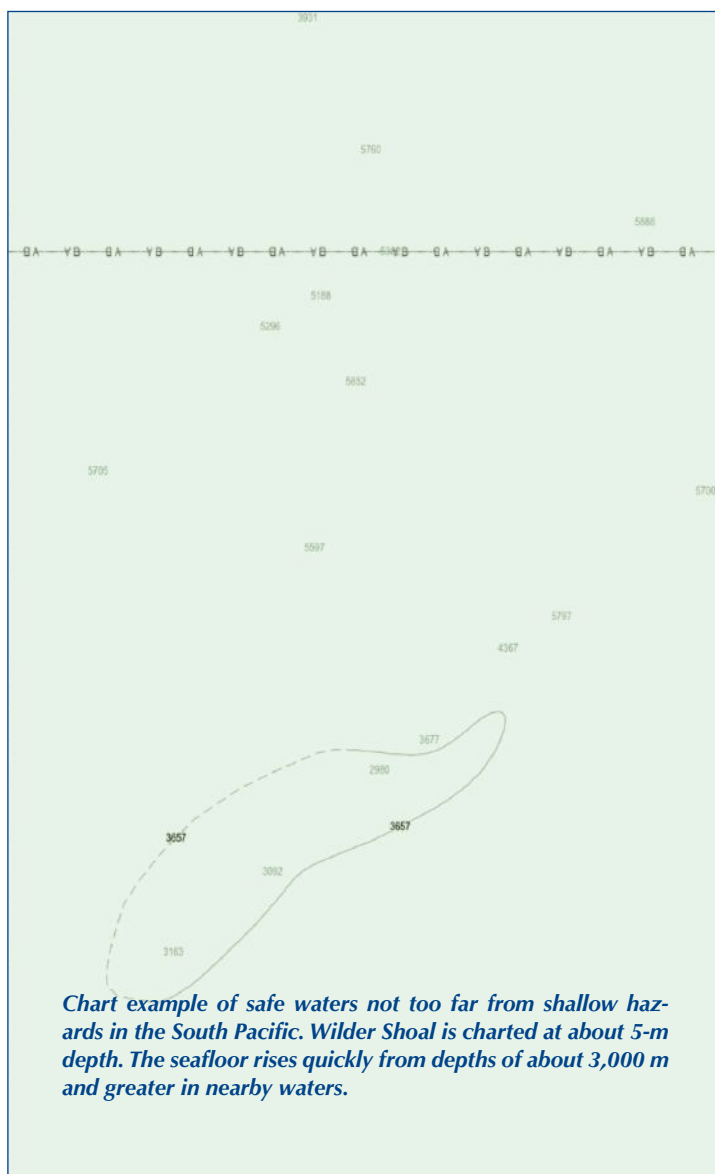
Over the last 20 years, the integration of GPS technology into all aspects of modern life has expanded dramatically. Though originally developed for vehicle (and soldier) navigation applications, GPS is now found in a wide range of products, from smartphones to drones and even precision computer numerical control (CNC) machines. The war in Ukraine has brought the topic of GPS disruption to the general public, and various websites now offer regularly updated maps of GPS-disrupted areas.

With the widespread adoption of electronic chart display and information systems (ECDIS) and global availability of electronic nautical charts (ENCs), many navigation tasks aboard ships have been simplified dramatically as compared to older methods of calculating position and plotting atop a paper chart. However, a critical component in the safety and efficacy of these systems is the reliability of the vessel's GPS-derived position. Though the topic of GPS disruption in the media has mostly been focused on its impact to aviation and its use in defending against drone attacks, such disruptions can also have a great impact on marine navigation.

GPS Jamming v. GPS Spoofing

Disruptions to GPS generally fall into two categories: jamming and spoofing. Jamming is a relatively unsophisticated attack consisting of simply flooding the radio-frequency bands in which GPS signals operate with "noise." Because GPS signals are very weak, it is relatively easy to transmit another signal that can overwhelm the intended GPS signal. Other than transmitting power and targeting the correct spectrum, there is nothing particularly special about the signals needed for jamming. In fact, solar flares are known to cause occasional jamming disruptions, though these are usually brief.

Spoofing, on the other hand, is a much more sophisticated attack where impostor signals are transmitted with



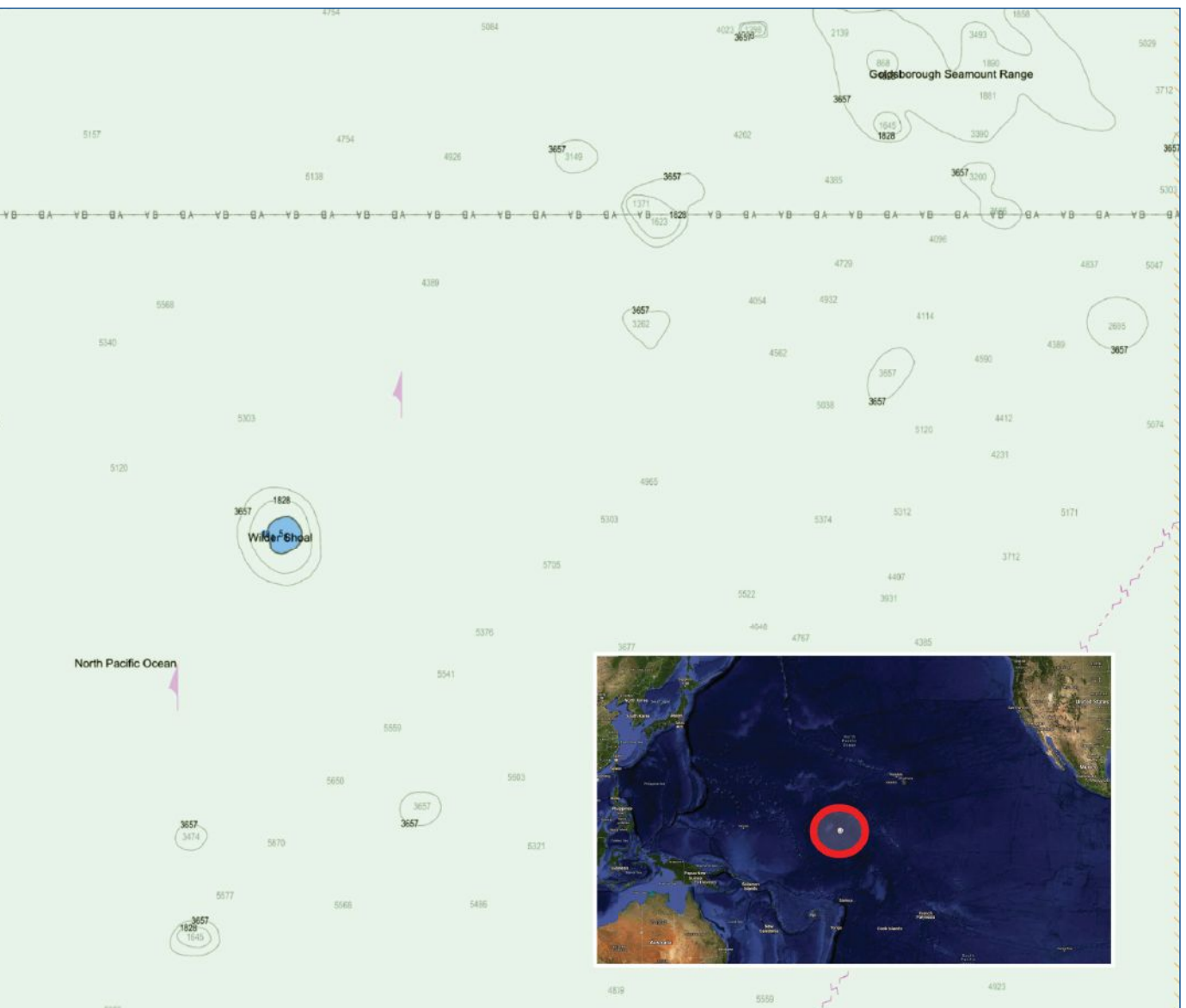
the intent of “fooling” the GPS receiver into believing that it is in a different location. By mimicking the format of actual GPS signals, a malicious attacker can inject incorrect position and timing information simply by transmitting at a higher power level than the actual, weak GPS signals. In the most basic cases, the attacker is not trying to be subtle and simply transmits locations that are obviously fake. For example, in April of this year, more than 100 cargo ships appeared to be located at the Beirut Airport due to a GPS spoofing attack. In these cases, vessel operators can easily notice the obvious error and disregard GPS information when operating.

However, more deceptive and dangerous spoofing attacks attempting to maliciously misdirect vessels are possible. In these scenarios, correct positions are initially transmitted to the vessel via the spoofed GPS signals. Then, slowly over time, the spoofed signals send incorrect information in an attempt to drag the vessel off course without being noticed by the crew. The nefarious course corrections could be used to lead the vessel into hostile waters or run them aground on rocks or sandbars.

In 2013, the *MY White Rose of Drachs* participated in an experiment to evaluate the difficulty of carrying out a spoofing attack at sea and to determine how easily sensors in the ship’s command room could identify the threat. As part of this project, researchers from the University of Texas at Austin were invited on board to purposefully implement a spoofing attack designed to surreptitiously adjust the vessel’s track while transiting. The test resulted in “tricking” the vessel onto a parallel track hundreds of meters from its intended route. Throughout the experiment, the crew was aware of the testing and monitored the vessel’s safety through other means. However, had they not been involved with the experiment, they likely would not have noticed the spoofing attack. A similar attack could be performed on an unsuspecting vessel, leading it off course and into a navigation hazard.

Threats to Ship Navigation

The first step in mitigating GPS jamming and spoofing attacks is to detect the attack. Detecting GPS jamming is fairly trivial since it results simply in the GPS receiver





Aerial view of a large private yacht navigating the gap between submerged hazards.

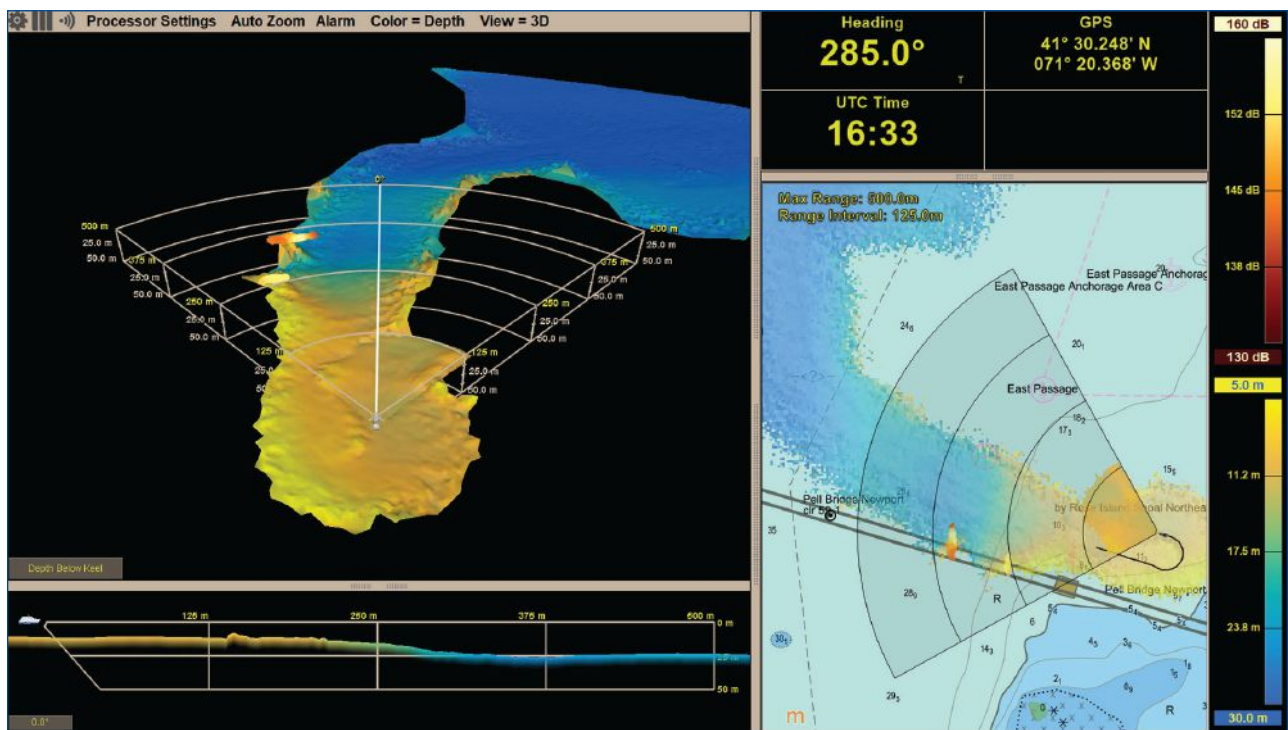
being unable to produce steady position and timing outputs. Even the most basic GPS receivers are able to recognize when they are not able to produce an accurate fix. In these cases, the vessel's crew will need to operate using other positioning techniques and will generally need to set their ECDIS to use manual position fixes rather than those automatically generated by GPS. The crew may employ dead reckoning, visual sightings to known objects, or even celestial navigation. However, many of these techniques are not well practiced or understood by a modern crew.

Though the attack method is quite different than with GPS jamming, obvious spoofing attacks where the falsified position is clearly false are also easily noticed and can be mitigated similarly. However, defense against surreptitious GPS spoofing is far more difficult; without being able to recognize these attacks, a vessel operator won't know that they are being led astray.

Well-known techniques such as receiver autonomous integrity monitoring (RAIM) can be used to detect some spoofing scenarios. However, RAIM has been shown to have limitations. This has resulted in attempts by numerous GPS receiver manufacturers to develop even more sophisticated monitoring techniques. At the same time, new spoofing attack techniques are also being realized. One newer technique example is utilizing distributed spoofing sources, which, combined with the latest UAV drone advances, has the potential to greatly complicate the detection of GPS spoofing. Of course, even newer spoofing detection capabilities are under development, with threats and countermeasures developing in an infinite cycle of cat and mouse.

This is a current concern for the U.S. military, which is actively exploring better solutions for navigation in GPS-denied environments, including using inertial navigation systems (INS) and automated celestial navigation sensors.

Improved position, navigation



Screenshot of FarSounder's SonaSoft with chart overlay and 3D viewer. The vessel is navigating along the James-town Bridge in Narragansett Bay, Rhode Island, with an Argos 3D FLS.

and timing (PNT) redundancies are also a current concern for marine autonomous surface ships (MASS). With limited or no crew on board, these vessels cannot rely on bridge crews to notice and react to GPS attacks.

Limitations of Alternate PNT Technologies

Though GPS is the most well-known PNT technology, other alternatives do exist. Though generally more robust to external jamming and spoofing, most other PNTs suffer from one or more of the following limitations: losing accuracy over time without frequent corrections from fixes to known positions; requiring clear night skies for celestial navigation; requiring skills and training no longer common among vessel operators; installation of expensive, fixed beacons; installation of additional vessel board equipment; and physically larger and more expensive than GPS.

Before the widespread adoption of GPS, an alternate positioning system called Loran-C was readily available to and used by many vessels operating nearshore. Loran-C utilized a series of shore-based transmitters that functioned somewhat similarly to GPS. Though not without its limitations, Loran-C offered positioning capability that was more robust against spoofing as compared to GPS signals. However, as of 2010, operation of Loran-C was ended in the U.S. and Canada. Operation in most of Europe ended in 2015.

Similarly, differential GPS (DGPS) is an enhancement to the original GPS architecture that utilizes both satellite

and ground-based stations to yield higher accuracies as compared to the GPS capabilities originally offered by the U.S. Department of Defense's intentional limitation of performance via selective availability for civilian applications. Ironically, it was the U.S. Coast Guard that led the development of DGPS, primarily to overcome the U.S. Department of Defense's selective availability performance limitations. In 2000, selective availability was turned off, bringing civilian GPS capabilities on par with DGPS capabilities, and in 2020, U.S. DGPS stations were shut down. Many other countries followed suit, with U.K. and Ireland ending their DGPS services in 2022. Various DGPS spoofing detection techniques have been developed previously, including those that operate by monitoring the position of a ground station.

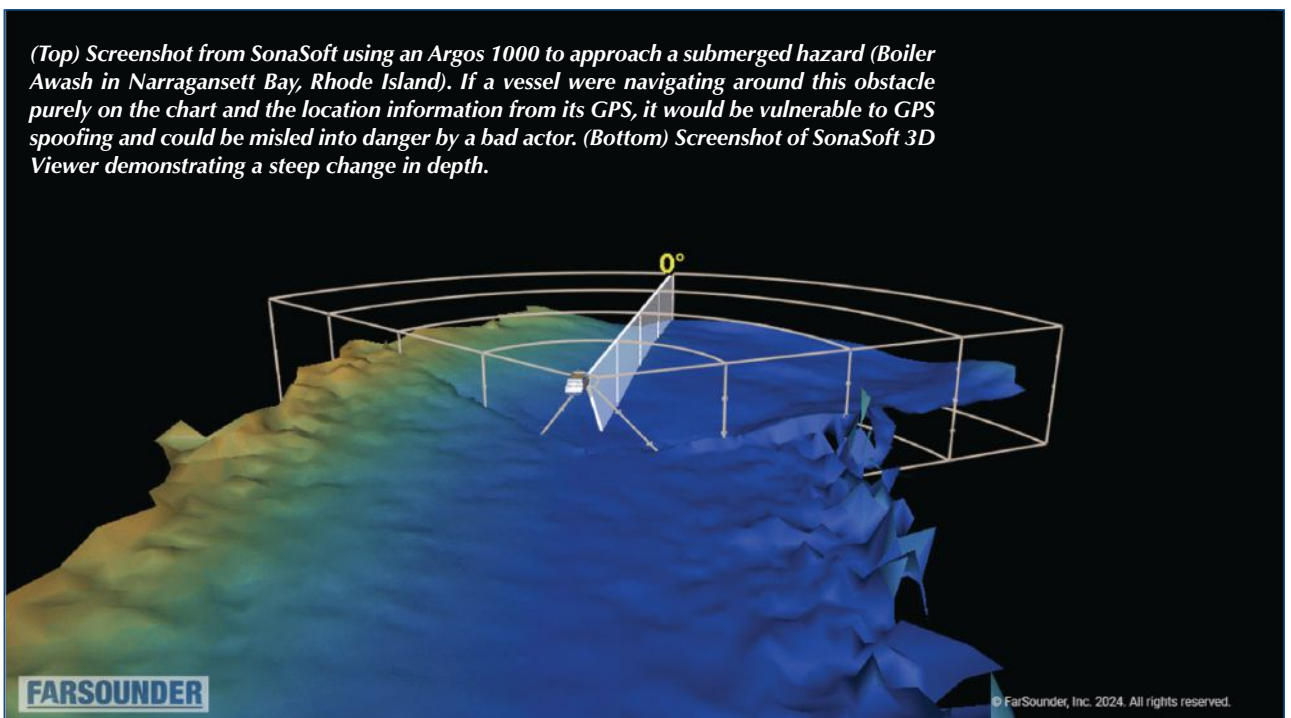
With both Loran-C and DGPS architectures, having a fixed ground station can yield simplifications in techniques for detecting spoofing. However, given the discontinuation of the infrastructure for those systems, these advantages cannot be leveraged by the civilian community. The U.S. Department of Defense relies heavily on reliable PNT information and is actively working on technologies and processes to improve operational readiness in GPS-denied environments. The U.S. Government Accountability Office has also studied the problem and has made a number of policy recommendations that could help accelerate the implementation and adoption of new approaches to PNT. A robust solution will likely consist of a combination of technologies, including the coupling of both absolute positioning and relative positioning sensors.

3D Forward-Looking Sonar as Failsafe

When transiting known waters, vessel operators utilize nautical charts to plot a safe passage and nominally rely on these charts while underway. However, simply



(Top) Screenshot from SonaSoft using an Argos 1000 to approach a submerged hazard (Boiler Awash in Narragansett Bay, Rhode Island). If a vessel were navigating around this obstacle purely on the chart and the location information from its GPS, it would be vulnerable to GPS spoofing and could be misled into danger by a bad actor. (Bottom) Screenshot of SonaSoft 3D Viewer demonstrating a steep change in depth.



navigating by chart position does not guarantee safely avoiding underwater obstacles since less than 25 percent of the world's oceans have been mapped, and only about 50 percent of coastal areas have been surveyed. Even the U.S. is lacking complete surveys. As of January 2024, 52 percent of U.S. waters have been mapped at 100-m resolution or better. The remaining half is considered unmapped.

Therefore, when navigating even through charted waters, it is valuable to be able to quickly identify areas where the chart data are not reliable. Existing 3D forward-looking sonar (3D FLS) products are able to provide this type of information and are in use aboard a wide range of vessels operating all over the world. FarSounder's Argos sonars include a chart overlay display that allows users to quickly see where the historical chart

data and real-time 3D FLS data correlate and, more importantly, don't correlate. In places where the 3D FLS information matches the chart, the operator can have strong confidence in the chart data. In places where they don't match, the operator should reduce confidence in the chart data.

As discussed earlier, one of the immediate threats from GPS spoofing to vessels is leading them astray from their intended route, causing them to run aground or collide with a subsurface obstacle. The use of currently available 3D FLS can help mitigate navigation safety threats of this type. Even if GPS spoofing is not detected, a mismatch between what the sonar detects versus what the chart shows should alert the user to the navigation threat. This means that 3D FLS is a valuable navigation tool even in waters that seem to have reliable chart data.

“... defense against surreptitious GPS spoofing is far more difficult; without being able to recognize these attacks, a vessel operator won’t know that they are being led astray.”

Separate from the currently in use application of real-time navigation and obstacle avoidance, 3D FLS has the potential to be used as a tool for confirming/updating a vessel’s actual position. Both the FLS data and local history mapping data from Argos sonars could be used to match the bathymetric shape of the sonar’s measurements to the shape of previously mapped bathymetry. Similar to a known visual or radar fix to a land-based object, contours between historical and real-time surveys could be matched to produce a “bathymetric position fix.” This concept has been previously explored using traditional down-looking multibeam sonars and is sometimes employed by submarines. This approach works best when operating in conjunction with INS and where there are strong bathymetric trends available for matching.

It is clear from current military conflicts that GPS disruptions are an actual hazard, not to be taken lightly. Given the increased use of UAVs and USVs, one can anticipate that GPS disruptions will continue to become an even greater threat in the future, and adapting operations for GPS-denied environments is quickly becoming a concern not only for military applications but also for civilian applications. **ST**

Since the founding of FarSounder in 2001, Matthew Zimmerman has driven the company’s technical development of its 3D forward-looking sonar technology. FarSounder’s products are motivated by decreasing the environmental impact of all types of ships and providing increased navigation safety to surface vessels. Zimmerman currently serves as CEO of FarSounder and is a member of the International Hydrographic Organization’s Crowd-Sourced Bathymetry Working Group.



Heath Henley holds a Ph.D. in chemical engineering from the University of Rhode Island. His research was focused on the development and testing of thermodynamic models for fluid mixtures. His research has given him a strong background in algorithm development and implementation, and he focuses his skills on acoustics, signal processing and bathymetry at FarSounder.



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Digitalization and Decarbonization

How Data Are Evolving Clean Technology for Vessels

By Nick Chrissos

When it comes to data and digitalization, the shipping industry is following the well-established path of other sectors that have successfully incorporated digital technology and harnessed its potential for business and industry development.

Shipowners and operators now widely acknowledge the significance of the digital journey that the shipping industry is on and recognize the powerful potential of data. The surge of digital solutions in shipping in recent years indicates a shift from viewing data as a “nice to have” to recognizing it as a vital catalyst for driving industry transformation.

It is no longer a matter of whether the vast majority of shipping companies will embrace digitalization and data but rather when and how rapidly they will do so. Those companies that are already on the digital journey stand to gain competitive advantage, while those that do not embrace data and digitalization may well be left behind as the industry changes and progresses.

The shipping industry is transitioning from an era where data were collected and stored passively, often leading to valuable insights being forgotten or overlooked, to a phase where data are being actively leveraged to inform key business decisions and sustainability strategies. The actionable data are propelling the industry's digitalization and decarbonization transformations in parallel.

Digitalization and Clean Technology

There are countless applications for digitalization in the shipping industry, but I'd like to focus on just one at the moment: clean technologies. Data and digitalization are having a significant impact on physical clean technologies, such as air lubrication systems.

While these technologies have historically, and rightly, been more recognized for their physical aspects rather than their digital ones, the reality is that these two aspects are increasingly becoming intertwined. Digitaliza-

tion is opening up new opportunities for traditional clean technology providers, as well as for shipowners and operators.

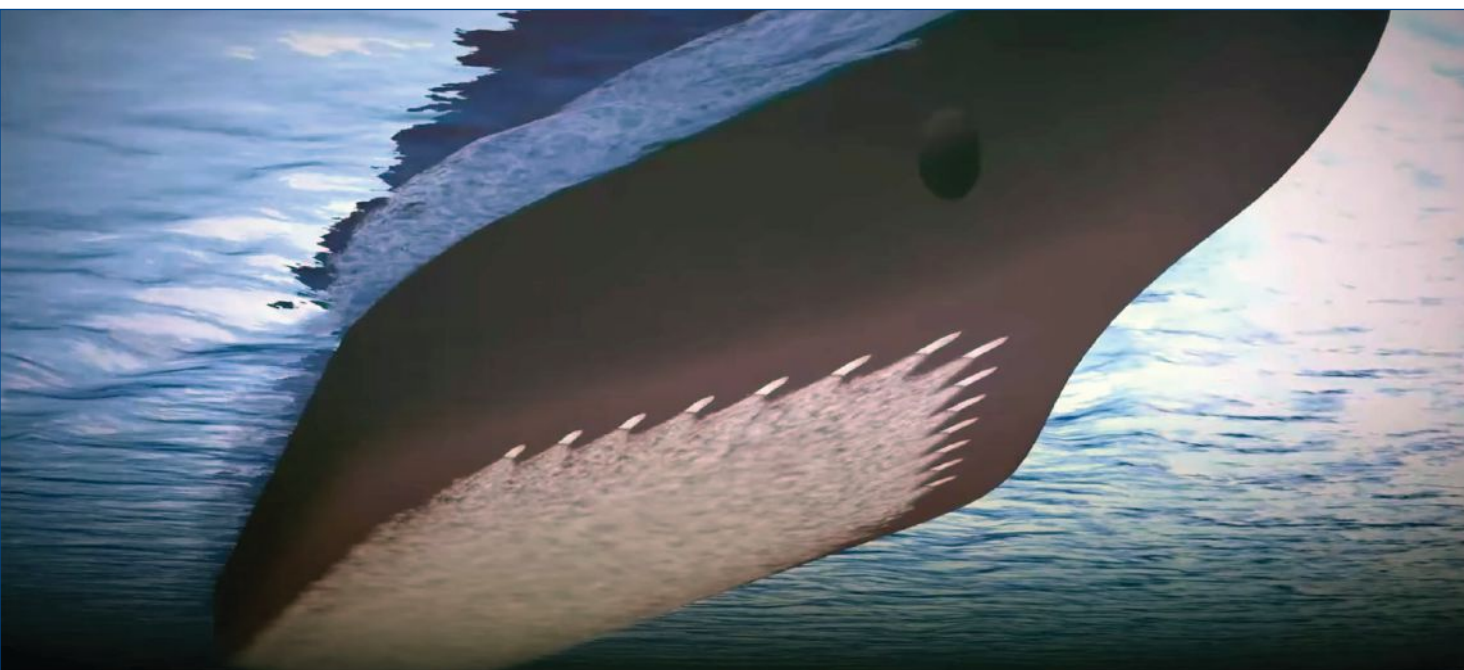
In simple terms, data are being used by clean technology manufacturers to raise both the floor and ceiling of fuel-saving potential. Like the intelligent systems within modern cars that tune the vehicle's engine as it drives, maritime clean technologies will soon learn and respond to their environment and operate in a way that ensures maximum efficiencies.

With these clean technologies deeply integrated into a vessel, there is the potential for them to identify and unlock efficiencies that shipowners and operators may not even know exist. In other words, these technologies can become active and intelligent solutions to maximize the performance of a ship.

Take Silverstream Technologies' air lubrication system for example: It releases a carpet of air under the ship to reduce the frictional resistance between the hull and the water, cutting average net fuel consumption and greenhouse gas (GHG) emissions by 5 to 10 percent. The integration of the Silverstream system within the vessel's ecosystem provides in-depth insights into a ship's hydrodynamic performance. The team then harnesses data from the system, as well as multiple sensors around the vessel, to gain a detailed understanding of how the air lubrication technology is working and to identify factors that could influence the ship's overall performance.

Additionally, with Silverstream's air lubrication technology delivering fuel efficiency and GHG emissions reductions on vessels, it is important to accurately calculate, measure, and report the precise efficiency level and decarbonization impact it is having on each ship. Consequently, monitoring and measuring performance data, as well as system health, are an integral digital component of the system.

In 2021, Silverstream secured the largest ever order of a maritime propulsion clean technology when MSC



Silverstream is an air lubrication technology that improves a ship's hydrodynamic performance. Data from the system can be combined with sensors around the vessel to attain insights on a ship's overall performance.

ordered the system for more than 30 cargo vessels. This deal is expected to save MSC an estimated 1.6 million tonnes of emitted CO₂ and over €250 million in fuel costs, and MSC has since ordered more systems to improve the efficiency of its vessels.

A proven track record of in-depth emissions data is not only vital for monitoring and improving existing users' systems but also for reassuring prospective customers that the clean technology will work for their ship and their unique operations.

Verified Performance Data

Adopting a proven clean technology is one of the most effective ways to improve vessel efficiency, cut fuel use, and thus reduce fuel expenditure and emissions. However, the clean technology market sometimes lacks transparency on performance, with prospective customers asked to make decisions in the near term that will impact the vessel's entire remaining life span. As a result, shipowners have rightly been wary of clean technology providers that don't openly provide detailed performance data for their technology.

Shipowners and operators should also look for emissions savings that have been verified by a third party. This is most often done when a technology goes through systematic and independent testing phases in collaboration with class societies and similar reputable institutions. Vessel performance data that can easily be compared when the technology is switched on versus switched off

in similar test conditions or operations are especially important.

It is also key to consider whether performance data apply to the entire operational range of the vessel or a single point of optimization, as well as whether that voyage is typical of how the ship is usually operated. Examining how the new technology will interact with other equipment and clean technology already on board the vessel, and supporting this with data and simulations where possible, is also worth considering. Contextualizing performance data with all of these variables will make it more accurate and realistic.

Changing Perceptions

While more in-depth data and widespread digitalization are already opening up new opportunities for clean technology providers, many in the broader shipping industry still need to change their perceptions of clean technologies. With this in mind, there are two key shifts in sentiment required as clean technologies evolve.

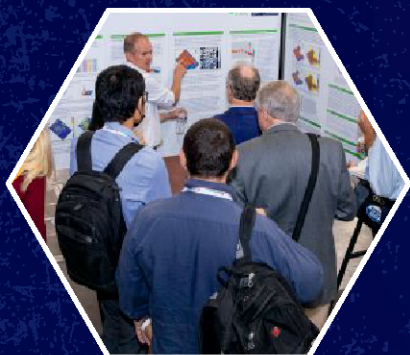
First, the industry will have to become acquainted with humans being more distanced from active decision making on some tactical elements of ship operation. The systems and algorithms that will drive vessel efficiency (and, indeed, routing, navigation, berthing and more) are already at the point where they use more information, often in real time, than a human can process. Optimizing clean technologies even further will require trust in the machine learning (and soon to be artificial intelligence) systems that underpin them, with humans moving to aggregation and actioning the insights provided by smart technologies.

Second, and more significantly, shipping will have to change its technology outlook. Currently, technology—whether physical or digital, traditional or innovative—is generally seen as a means to fulfill the requirements of today, not to anticipate the future.

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“In simple terms, data are being used by clean technology manufacturers to raise both the floor and ceiling of fuel-saving potential ... maritime clean technologies will soon learn and respond to their environment and operate in a way that ensures maximum efficiencies.”

While it's true that proven efficiency technologies can cut GHG emissions today, they should not be viewed as static solutions. The shipping industry should more widely recognize that leading clean technologies will be digitally enhanced and iterated upon throughout the life cycle of a vessel. As a result, these technologies represent a future-proof investment that can meet shipowners' and operators' needs, as well as regulatory requirements.

Just as many clean technologies should not be viewed as static, neither should the shipping industry's regulatory environment. The European Union's Emissions Trading System (EU ETS) was applied to the maritime industry from January 1, 2024 and has added a progressive cost on emissions—only enhancing the value proposition for clean technologies. Meanwhile, the International Maritime Organization's Energy Efficiency Existing Ship Index (EEXI), Energy Efficiency Design Index (EEDI), and Carbon Intensity Indicator (CII) are likely to become more impactful as they mature and become more stringent.

While the specifics may still need to be ironed out, the regulatory, commercial and environmental “direction of travel” is clear for shipping. And investing in intelligent clean technologies for vessel efficiency not only aligns with environmental objectives but also constitutes a good business strategy—today and in the future. **ST**

Nick Chrissos joined Silverstream Technologies in 2022 as the company's first chief digital and information officer. He is passionate about the value of data and investing in the research and implementation of new solutions and services for Silverstream's customers. Chrissos previously held a number of roles at Cisco, including serving as the company's chief technology officer for small and mid-size business; director of innovation in Europe, the Middle East, Africa and Russia; CTO of collaboration in the U.K.; and head of unified communications technology in Europe. His background is in software engineering, with a bachelor's in electronics systems engineering from the University of Essex and an M.S. in software engineering from the Southampton Institute.



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The Ocean Enterprise

Toward the Development of an Integrated Global Industry

By Brendal Townsend • Zdenka Willis • Chelsea Bladow

The process of observing the ocean and disseminating data, information, and knowledge to address critical societal and environmental issues—such as climate change mitigation and ocean health restoration—requires a robust and sustained infrastructure. Simultaneously, as we seek to harness the ocean’s potential for economic growth and food security, we recognize the indispensable role of ocean data in informing and supporting investments. These data empower communities, cities, regions, and nations to adapt and thrive in the face of climate change challenges.

At the heart of this endeavor lies the “Ocean Enterprise.” Comprising public, private, nonprofit, research and academic sectors, the Ocean Enterprise generates essential knowledge to tackle pressing societal challenges. These include climate adaptation, hazard resilience, ecosystem preservation and sustainable blue economic growth. Notably, the growing marine technology and service sector plays a pivotal role within the Enterprise. Despite its critical importance, the Ocean Enterprise remains fragmented, underfunded and undervalued across the ocean information value chain—the pathway from observing raw data to delivering actionable intelligence that meets end-users’ needs.

While great progress has been made by the Global Ocean Observing System (GOOS) led by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the Regional Alliances (e.g., the United States Integrated Ocean Observing System, Australia’s Integrated Marine Observing System, the European Global Ocean Observing System, etc.), the different components of the Ocean Enterprise could be better coordinated to lower barriers and enhance opportunities in terms of system and market growth for the private sector.

The growth and maturation of oceanic observing networks plays a crucial role in our collective future.

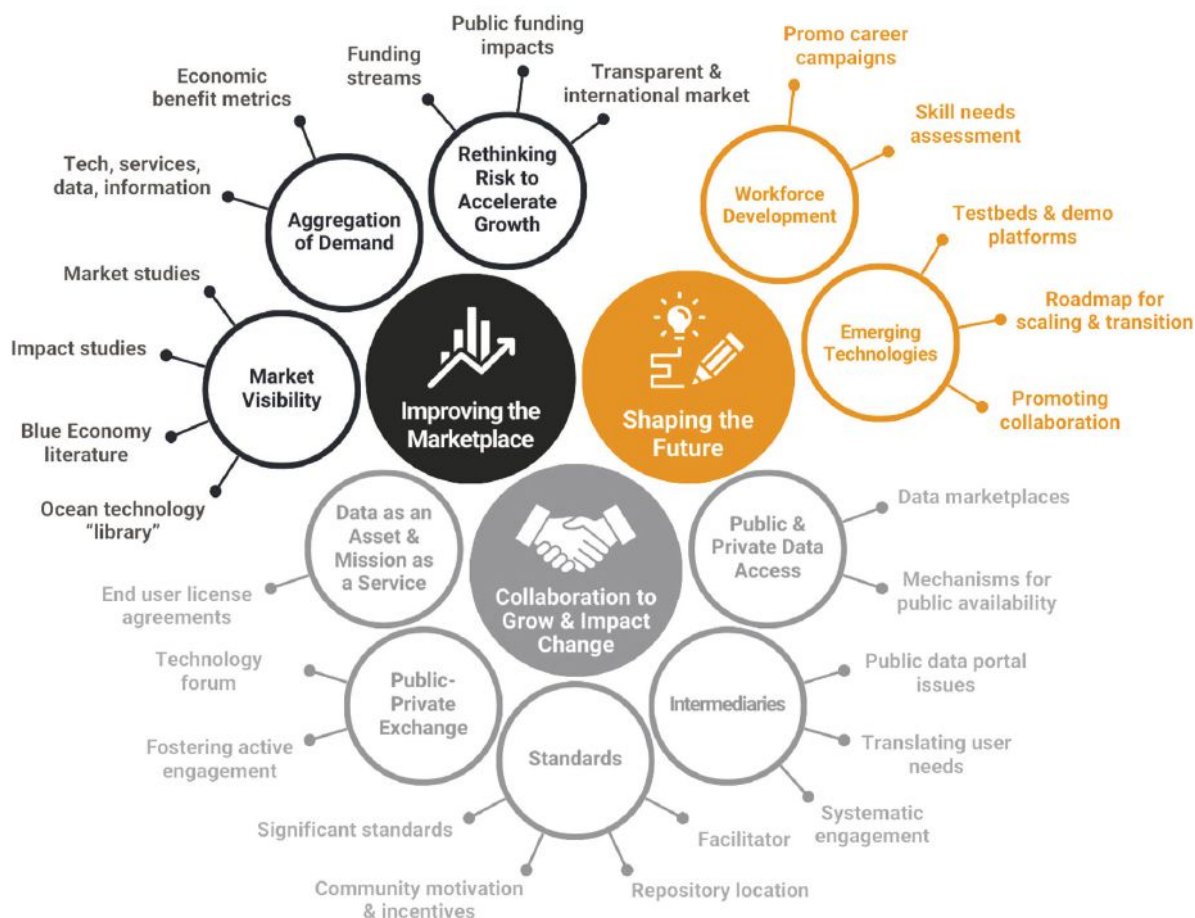
Despite being predominantly funded by public and academic sectors, these systems face recurring challenges. Interconnected components form the backbone of infrastructure for ocean observation, measurement and forecasting. By catalyzing the maturation of the Ocean Enterprise, we seek to unlock transformative solutions that safeguard life on Earth.

The private sector component of the Ocean Enterprise is increasingly seeking to engage with intergovernmental networks, such as GOOS, and regional and national networks, necessitating closer collaboration. Although blue investment has increased overall, the Ocean Enterprise remains overlooked due to its perceived invisibility and riskiness.

The Marine Technology Society (MTS) and its partners’ ultimate goal is to accelerate the maturation of the Enterprise by highlighting the critical enabling role its components play in enhancing oceanic system knowledge and predictive capacity, building resilience against climate-related disasters, and enabling sustainable blue economy development.

In working toward this goal, MTS, in partnership with GOOS, NOAA, Kongsberg Discovery and L3Harris, launched the “Dialogues with Industry” program in 2021 to uncover and understand the barriers and opportunities facing the Ocean Enterprise. This multi-year collaborative process engaged the Ocean Enterprise’s stakeholders through the dialogues, and consultations provided insights that were sobering yet galvanizing.

The program yielded the following insights: ocean data and services are still viewed as nonessential luxuries rather than mission-critical assets; ocean observing is not recognized as a distinct market sector meriting investment; the economic value and job creation potential remain largely invisible; sustained funding sources are fragmented and elusive; the lack of standards obstructs integration and scalability; and lack of aggregated demand dilutes market forces and development potential.



The graphic highlights the 26 high-priority action pathways in the border area. These high-priority action pathways are identified with the challenges they address and associated with the three priority areas: Improving the Marketplace, Collaboration to Grow and Impact Change, and Shaping the Future. (Credit: Ocean Enterprise Roadmap)

Priority Areas

In our quest to propel the Ocean Enterprise forward, three priority areas have emerged: improving the marketplace; collaboration for growth and impact; and shaping the future. These priority areas highlight challenges and associated action pathways that, when addressed, will be critical to our collective success.

Improving the Marketplace

The ocean's vast expanse holds untapped potential, but a fundamental roadblock is the lack of a vibrant marketplace for ocean data, information and knowledge. While public funding has traditionally sustained ocean observations, both private and public sector investment in the Ocean Enterprise have increased. However, much of this funding is funneled into research, with only a fraction dedicated to maintaining or expanding ongoing observation operations or discovering innovative solutions for collaboration.

As new ocean-based markets emerge, the private sector must be primed and ready to engage in the identified high-priority actions. To address this challenge, we must take stock of the market size and increasing value of ocean technologies, data, knowledge and services. For new industries to be able to meet rising demand, emerging markets must be studied to attract venture capital.

Priority actions pathways highlighted include, but are not limited to: authoritative targeted market studies; a centralized repository for blue economy literature; aggre-

Goals

In January 2024, MTS published the Dialogues with Industry landmark roadmap. This roadmap outlines three priority areas, 10 challenges and 26 prioritized action pathways, all organized under three interdependent goals. Our intention was to create goals that are easily comprehensible and that unite the Ocean Enterprise community.

The first goal is a robust ocean enterprise: We aim for the Ocean Enterprise to be universally recognized as essential to lives and livelihoods.

The second goal is visibility and recognition: The Ocean Enterprise must step into the spotlight. It should be visible, identifiable and acknowledged as a significant contributor to national and global gross domestic product (GDP). Stakeholders must understand their roles within the Ocean Enterprise and identify with them.

The third goal is a distinct market sector: Within the ocean observing, products and services sector, we seek to carve out a distinct market identity—one that attracts investment and fosters growth.



(Top left) Aquacultural practices in Nova Scotia in a fish farming barge. Private companies are essential to collaboration in the Ocean Enterprise. (Middle) A fully integrated ocean observing system can deliver ocean information across three key application areas: operational services, climate and ocean health. (Credit: Global Ocean Observing System, GOOS) (Top right) Woods Hole Oceanographic Institution (WHOI) deploys an Environmental Sample Processor (ESP) in the Gulf of Maine. Ocean observing sensors and systems are critical to the Ocean Enterprise. (Credit: WHOI, McLane Research Labs and NOAA)



gation of demand of existing ocean observing technologies; and transparent and international product development marketplace communication.

Cultivating a flourishing ocean technology sector hinges on identifying commercialization pathways, fostering testbeds and accelerators, and identifying validated value propositions to secure venture funding and corporate buy-in.

Collaboration to Grow and Impact Change

A core challenge is bridging the differing motivations, timelines and expectations across the Ocean Enterprise's diverse components. The public component prioritizes societal needs and public goods. Private companies emphasize profitability, competitiveness and stakeholder value. Academia focuses on foundational research to expand our understanding. These divergences can create chasms obstructing collaboration, innovation and an integrated, cross-sector approach.

Fostering enhanced collaboration that respects each component's distinct drivers while aligning toward common sustainability goals is paramount. Shifting from traditional platform/sensor acquisition models to "data-as-a-service" and "mission-as-a service" provisioning can optimize efficiency, spur new markets, enhance impacts, and increase customer value. However, this paradigm shift requires addressing trade-offs around data quality, intellectual property, commercial viability and user needs.

Priority actions pathways highlighted include, but are not limited to: identifying challenges and opportunities of existing ocean observing network business models; identifying community motivation and incentives for incorporating standards; and developing and adopting end-user licensing agreements.

Shaping the Future

Realizing the full economic promise of our oceans



demands a two-pronged investment: a pipeline of diverse, skilled professionals and the modern infrastructure to translate ocean data into sustainable growth. The ocean economy demands talents ranging from technical skills, such as ocean sensing and data analysis, to business acumen in marketing, management, and teamwork. Developing this human capital is imperative for public and private sectors.

But human capital alone is not enough. We also need to focus on research, tech transfer, innovation hubs, market access, standards and regulations, and platforms for sharing ocean data. While emerging technologies could upgrade existing infrastructure, realizing those gains will take major efforts to enhance agility and adaptability. Unlocking the ocean's economic potential hinges

on this dual commitment to people and infrastructure.

Priority action pathways highlighted include, but are not limited to: developing an Ocean Enterprise skills needs assessment; developing roadmaps for efficient scaling and support of the transition of private ocean observing platforms/sensors; and promoting the growth of and collaboration among blue tech clusters, incubators and accelerators.

With concerted investments on human and physical capital fronts, we can cultivate a thriving, future-oriented ocean economy that creates jobs while expanding scientific understanding of our oceans. The oceans are a frontier of economic opportunity—if we equip ourselves to seize it responsibly.

The Journey Ahead

This roadmap is not destined to languish in obscurity. Rather, it marks the commencement of practical and collective efforts in the interest of all Ocean Enterprise

stakeholders. Our mission? To forge a more cohesive, inclusive and mature global Ocean Enterprise—one that transcends boundaries and fosters collaboration among private entities, government bodies and scientific communities.

As we move ahead, several critical steps will unfold. One is collaboration across borders as MTS and GOOS continue to work side by side. Together, we will track progress made against the success indicators provided in the roadmap and recommend solutions for change with a global focus. Funding and expertise from IOOS and NOAA will fuel this collaborative endeavor.

Another step is to create a broader advisory network. MTS's existing Government-Industry-Science Organizing Committee will evolve into the Dialogues Industry Steering Committee. This transformation ensures a diverse range of advice, fostering innovation and inclusivity.

A further step is public engagement. Your involvement matters: We invite you to be an active participant. You can join our Dialogues with Industry Fora, engage in meaningful discussions, and contribute to the evolution of our shared vision. Visit www.oceanenterprise.com to get involved.

Acknowledgments

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Brendal Townsend is the senior director of the Ocean Enterprise Initiative at MTS.

Zdenka Willis is the past president of MTS.

Chelsea Bladow is the communications manager at MTS.

international

Decarbonization Network in Korea

Ulsan Port, a key maritime hub for Asia, has reaffirmed its pledge to environmentally friendly shipping practices by becoming a member of DNV Korea's Decarbonization Network. The network unites technical executives and managers from various stakeholders in Korea's maritime industry. It comprises two groups: major Korean yards (nine in total) and an amalgamation of shipowners, managers, charterers, banks and research institutions (17 in total). Ulsan Port Authority, one of the world's four largest tank terminal clusters, has joined both groups.

Recently, the network members visited Jeongil Stolthaven, the largest tank terminal in Ulsan, and looked at major storage facilities and fuel-handling processes for eco-friendly fuel, such as methanol and biofuels.

Collaboration for Energy Transition

Eni, a global energy company; Fincantieri, one of the world's largest shipbuilding groups active in all high-tech marine industry sectors; and RINA, a multinational inspection, certification and engineering consultancy, have signed an agreement to develop joint initiatives for the energy transition. The partnership formalizes the commitment to develop joint projects, in line with the partners' strategies, to decarbonize the maritime sector in the medium to long term, with the goal of net zero by 2050. Additionally, the establishment of a permanent global observatory regarding future technological, regulatory and market developments will be evaluated.

Carbon Offsets Market Needs Regulation

The carbon offsets market, which allows companies to compensate for their carbon emissions by investing in projects that reduce or remove greenhouse gases elsewhere, has seemingly emerged as a pivotal player in mitigating climate change. However, recent developments indicate a troubling trend: the potential for greenwashing, rather than genuine sustainability, to dominate the landscape, according to some energy and sustainability experts. With the EU's directive to ban misleading environmental claims on the horizon, these experts are sounding the alarm on the urgent need for independent sustainability certification in the carbon offsets market. The market's current valuation surpasses \$2 billion and is growing rapidly.

ASA-SNEC Highlights Piracy, Sustainability

The Asian Shipowners' Association Safe Navigation and Environment Committee (ASA-SNEC) urges the shipping industry to continue to highlight the maritime security situation in the Red Sea. While the heightened geopolitical tensions in the region have resulted in increased military presence and maritime patrols to ensure the safety of vessels passing through the area, there is a renewed threat of piracy off the African coasts.

The ASA-SNEC also calls for an industry-wide support for ambitious net-zero targets through the adoption of

the Zero Emission Shipping Fund (ZESF). Proposed to the International Maritime Organization, the ZESF aims to accelerate the industry's transition to net-zero emissions by 2050. It mandates contributions from shipowners based on emissions, raising substantial annual funds to drive the rapid development and adoption of zero-emission marine fuels and technologies, particularly in developing nations.

Private Equity Buys Acteon

Acteon Group has been acquired by private equity investors Buckthorn Partners and One Equity Partners (OEP). The investors will develop Acteon's capabilities across survey, foundations, moorings, decommissioning and consulting engineering services that support and differentiate the business in the offshore renewable and offshore oil and gas market sectors.

UN Recognizes Ocean Census

The Nippon Foundation-Nekton Ocean Census, a global alliance dedicated to the discovery and protection of marine life (*Sea Technology*, January 2024), has been officially endorsed as a UN Ocean Decade Program.

Vision 2030 of the UN Ocean Decade aims to strengthen momentum for ocean knowledge-based solutions, identifying gaps in scientific information and opportunities to enhance our collective impact.

An estimated 75 to 90 percent of the approximately 1 million to 2 million marine species remains undiscovered. Ocean Census is a moonshot to discover ocean life, aiming to reach the next important milestone of 100,000 new species for the end goal of conservation.

Silverstream Retrofit

Silverstream Technologies has successfully completed another retrofit of its air lubrication technology, the Silverstream System, on a large LNG carrier at Seatrium's Admiralty Yard in Singapore. The retrofit was completed in just 30 days, reinforcing the role that Silverstream's technology can play as a near-term decarbonization solution for existing ships. It is the 11th retrofit of the Silverstream System that the company has delivered worldwide.

The Silverstream system releases a carpet of air to reduce the frictional resistance between the hull and the water, reducing average net fuel consumption and greenhouse gas emissions by 5 to 10 percent.

Hydrogen Ferries for Arctic

Two hydrogen-powered passenger ferries ordered by Norwegian transport company Torgshatten Nord are set for Lloyd's Register class following the approval in principle awarded August 2022. Designed to operate in the challenging waters of the Vestfjordstrekninga fjord in the Arctic Circle, the two vessels will be built at Norwegian shipyard Myklebust Verft.

At 117 m long with a 120-car capacity, the duo will be the world's largest hydrogen-powered ships, operating on green hydrogen at least 85 percent of the time. Operating at an average speed of 17 kt. in often chal-

lenging conditions, the vessels will navigate the 278-km-long Vestfjordstrekninga ferry route connecting Bodø, the islands of Røst and Værøy, and Moskenes.

A hydrogen storage unit on board each vessel will feed gas to the fuel cells, creating electricity to propel the vessels and power their auxiliary systems, reducing CO₂ emissions on the route by around 26,500 tons each year.

The H₂-powered ferries join another set of LR-classed vessels currently being built in Norway: two construction support offshore vessels that will enter service late in 2025 or early 2026.

Startup for AI in Ship Operations

Berlin-based venture studio Flagship Founders has spun-off its fifth startup. The company, called Sealenic, is developing an information retrieval and management platform powered by artificial intelligence (AI). Development partners include the shipping companies Reederei F. Laeisz, Fairplay Towage Group and Harren Ship Management. The launch of the solution for the broad market is planned for this summer.

Offshore Wind Site Investigation

TDI-Brooks has conducted an extensive site investigation program in two offshore wind blocks in state and federal waters. The projects involved surveying in excess of 20,000 line-km of analog and either single- or multi-channel seismic in lease blocks and cable routes along the coasts of New York and New Jersey. Various tasks were carried out at different stages, including offshore geophysical surveys, ultrahigh-resolution seismic detailed surveys, archaeological identification surveys, light geotechnical coring, and benthic sampling. TDI-Brooks utilized three survey vessels.

L3Harris Divests Antenna Businesses

L3Harris Technologies has signed a definitive agreement under which an affiliate of Kanders & Co. Inc. will acquire its antenna and related businesses for \$200 million. The businesses L3Harris will divest offer a variety of airborne and ground-based antennas and test equipment. They are part of the Space & Airborne Systems segment and employ approximately 375 people.

New Pipeline Monitoring Facilities

PipeSense, a provider of advanced continuous pipeline monitoring technology, has opened two testing facilities in Houston, Texas, and Clearbrook, Minnesota. With the aim of pursuing new research and development opportunities, the facilities will provide PipeSense's engineering team the ability to pursue technological advancements by testing its pipeline monitoring and leak detection solutions in practical conditions.

The Houston facility features a 4-in. continuous test loop providing options for diverse demonstrations, including the ability for clients to choose and actuate leak points.

The Clearbrook test facility features a custom-built, 24-in. pipeline test rig to test and demonstrate PipeSense's real-time pig-tracking technologies. **ST**

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Expandable Entry-Level ROV



Mission Specialist Ally offers a baseline platform that enables users to add to their vehicle's capabilities and add to their fleet as their budgets and needs evolve. The four-thruster ROV has a 4-kt. forward speed with lateral thrust capability. The 300-m-rated Ally can be adapted to accept a round or square float configuration. The square float allows for additional payload. The round configuration is ideal for pipe and tunnel inspections. VideoRay LLC.

Digital Multimeters

390B Series True RMS digital multimeters includes four models that deliver stable and accurate readings with a display count of up to 100,000. Model 390B supports Bluetooth connectivity for wireless measurement monitoring and data logging from a compatible Android/iOS mobile device. Model 394B combines the capabilities of an mA loop calibrator with a full-featured True RMS multimeter in one package. Measurement data can be exported to a PC via included software. B&K Precision Corp.

App Inspection

INSIGHT simplifies rope abrasion inspections for the mooring and workboat industry. The app, powered by an AI machine learning model, provides instant abrasion scores, helping users quickly and accurately assess the condition of their ropes and make informed decisions about replacement. Using

a mobile device camera to capture images of the rope, INSIGHT analyzes the photos, assigns the rope an abrasion score based on the severity of wear, and recommends further action. Samson Rope Technologies.

Aquatic Animal Research



NexTrak provides 40% greater range than previous receivers. This reduces the number of receivers required to cover the same area. NexTrak R1's advanced processor is better at filtering out noise and decoding pings from transmitters for reliable fish tracking in challenging acoustic environments. Signal strength data and enhanced post-processing capabilities enable researchers to tackle deeper questions about animal behavior and positioning. Innovasea Systems Inc.

Threat Detection Sonar

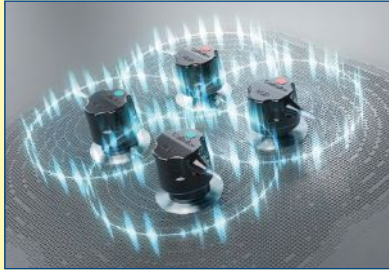
DogFish is designed to autonomously detect, track and classify underwater threats, such as submarines, mini-submarines, semisubmersible vehicles, moored mines, AUVs/UUVs, and underwater drones at a range of sea depths in both littoral and deep waters. Operating in active or passive mode, or simultaneously in both active and passive modes, the system is suitable for tactical scenarios and a wide range of ASW and HLS missions. DSIT Solutions Ltd.

3D Sonar

Sonar 3D-15 provides real-time 3D imaging with point cloud generation, enabling live, precise and

comprehensive visualization of underwater environments. Because of its high resolution and short-range capabilities, it is ideal for close-proximity operations, such as identification and classification of target types and inspection of hard-to-inspect areas, such as ship hulls. Water Linked AS.

Ultrasonic Anti-Biofouling



Ultrasonic protection (USP) DragGone reduces drag and improves fuel efficiency, lowering fuel consumption and associated emissions by up to 13%. USP is a proactive solution, complementary to anti-fouling paint, which ensures the hull remains clean from day one for a newbuild, or as soon as it has been cleaned for existing vessels. With DragGone, transducers are attached to the inside of the hull and emit ultrasonic waves to disrupt biological attachment to a hull surface. Cathelco, part of Evac Group.

Acoustic Navigation for Divers

The system facilitates map-based navigation for divers on a mission,

offering the flexibility of seamless two-way communication between divers and the dive supervision team, as well as pre-mission and real-time waypoint setup. A team of divers can exchange short messages with each other and the surface, with real-time tracking of each other's positions. Map waypoints can be added before or during the mission to coordinate operations and mark discovered objects or infrastructure for further investigation. EvoLogics GmbH.

X-Band for Navigation

NACOS Platinum Solid State X-Band Radar features the latest solid-state transceiver technology with compact housing and gearbox, eliminating the need for traditional magnetrons. Benefits include optimized target detection in all environmental conditions, improved target tracking with independent signal processing, and adaptive pulse transmission for enhanced hazard recognition. Wärtsilä ANCS.

Digital Fleet Management

KR e-FleetV3 is an upgraded version of the existing fleet management system, featuring an integrated vessel status display with survey and audit information, a new thickness measurement menu for tracking hull corrosion, and PSC Guidance with VR technology (KR-Real360) to assist in customer responses. KR-DAON serves as a one-stop hub for all

of KR's digital services. Nexawave, a data exchange platform, ensures seamless integration of KR's data with customer systems, focusing on survey, audit and GHG verification information. Korean Register.

AI Surveillance

V.Sight offers maritime camera surveillance with AI video analytics, behavioral analysis, environmental monitoring and real-time alerts. It features cloud-based data storage and secure data transmission through a combination of encryption, authentication, and secure protocols. iO3 Pte Ltd.

Autonomous-Manual Drone

SELKIE 7 is a 7-m USV, powered by the SM300 autonomous command and control system, that can readily switch between two modes: autonomous unmanned or manned manual. Applications include hydrographic surveying, offshore asset inspection and persistent on-water operations, such as security and environmental studies. Sea Machines Robotics Inc.

AI-Based Planning

The Deployment Planner for shipping liners suggests deployment adjustments to maximize efficiency; identifies underperforming vessels; guides emissions compliance; and simulates the impact of service schedules on fuel consumption and vessel performance. Bearing Inc. **ST**

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Rotor Sail for Cement Carrier

Baltrader Capital GmbH & Co. KG, Hamburg, and Norsepower have signed a contract for delivery of one 24-by-4-m Norsepower Rotor Sail in summer 2024. The product will be fitted on the newest cement carrier of the Baltrader fleet, MV *Cemcommander*. It will be delivered from Jiangsu Zhenjiang Shipyard (Group) Co. Ltd. The ecological ship design was made by SDC Ship Design & Consultants GmbH, Hamburg.

The Norsepower Rotor Sail is a radically modernized version of the Flettner Rotor. It uses the ship's electric power to actively rotate the cylinder-shaped rotor on the deck, producing powerful thrust. The product meets the funding objectives by saving fuel and thus enabling emission reductions of up to 14 percent. The wind propulsion system will be

classified by Bureau Veritas, and the ship will receive the WPS2 class notation.

The installation of the Norsepower Rotor Sail is supported by funding from the German Federal Ministry for Digital and Transport as part of a directive to improve the energy efficiency of coastal vessels.

Equinor Advances New York Offshore Wind

New York State Energy Research and Development Authority (NY-SERDA) has announced Equinor's Empire Wind 1 project as one of the conditional winners in its fourth offshore wind solicitation round. The award is an important milestone for the advancement of the project, which can deliver 810 MW of renewable energy to New York. An already highly mature offshore wind project, Empire Wind 1 aims

to deliver first power to New York in 2026.

Equinor and NY-SERDA will now negotiate an offshore wind renewable energy certificate purchase and sale agreement, with contract execution expected in the second quarter of 2024.

In January 2024, Equinor announced a swap transaction with bp, under which Equinor will take full ownership of the Empire Wind lease and projects and bp will take full ownership of the Beacon Wind lease and projects.

USV Survey for NOAA Fisheries Research

Exail's DriX USV has completed a first-of-its-kind fisheries research survey to assess the impact on biomass and fish stock before, during and after wind farm construction. Equipped with a SeapiX-R 3D high-resolution multibeam echosounder from Exail, two Kongsberg EK80 single-beam echosounders

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Autonomous Security Boats

Kraken Technology Group and Auterion have announced a partnership to exponentially develop autonomous capabilities in the high-performance littoral security boat sector. The partnership is focused on the development and implementation of modular, low-cost autonomy software and UxV systems for the maritime domain. The agreement's initial focus is on integrated autonomy architecture for Kraken's K3 SCOUT and K4 MAN-TA uncrewed platforms.

Auterion's Skynode X, Auterion-OS and numerous capability apps have already been developed and integrated into Kraken's K3 SCOUT USV, which is currently undergoing open-water sea trials. AuterionOS's open-software architecture unlocks the ability to create new apps as needed, continuously expanding

Kraken's ability to serve the wide variety of maritime use cases.

UK's First Commercial Electric Workboat

Coastal Workboats and EST-Floattech have agreed to collaborate, with EST-Floattech to provide the battery system for the purpose-built Electric-Landing Utility Vessel (E-LUV) to be built at Coastal Workboats' new yard, Stornoway, and the Shore-based Power Supply System (SPSS).

The collaboration will lower emissions in the U.K.'s maritime industry with EST-Floattech's technology. Funding comes from Coastal Workboats' receipt of a £6 million grant to demonstrate the U.K.'s first commercial electric workboat and charging station. This grant, provided by the Clean Maritime Demonstration Competition, underscores

the industry's recognition of the pressing need for cleaner, greener maritime operations.

The E-LUV is set to be the U.K.'s first commercial electric workboat. This innovative vessel, a Ro-Ro and dry-cargo transportation ferry, will be equipped with 2,400 kWh of EST-Floattech's Octopus high-energy battery system. The system will comprise two independent battery systems on board to power a range of equipment and be used for fully electric sailing. After a short trial in the Shetland Isles, the E-LUV will operate between West Burrafirth and Papa Stour.

EST-Floattech will also supply 1,200 kWh of the Octopus system to support the charging of Coastal Workboats' E-LUV.

Partnership to Prepare for New Ship Inspection Regime

Kaiko Systems, a pioneer in mobile-first ship inspection technology, and i.safe MOBILE, an innovator of

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explosion-proof mobile devices and solutions, have formed a partnership aimed at transforming the landscape of ship inspections, particularly in preparation for the upcoming SIRE 2.0 regime, the first update to the Ship Inspection Report Programme since 1993.

Providing an innovative approach to onboard inspections, Kaiko Systems offers an intelligent and user-friendly app that utilizes AI to streamline data collection and analysis on vessels. The solution provides real-time insights into fleet conditions, identifies potential risks, and facilitates informed decision making for ship managers and crew members.

Kaiko Systems has selected i.safe MOBILE as its preferred provider for tablets for its mobile-first Self-Assessment Tool, with i.safe MOBILE's tablets also being chosen by OCIMF for its inspectors.

This collaboration will ensure that users of the Kaiko Systems' app have access to top-tier hardware

that enhances the functionality and efficiency of the inspection process. The digital tool empowers vetting managers and superintendents to identify risks across their fleets by highlighting areas of concern. This enables technical managers to be assured of the vessel's condition and that all required processes are in place and all crew members are optimally prepared to answer any question the SIRE 2.0 vetting inspector may ask.

Amazon Supports ASEAN Maritime Digital Hub

Singapore, one of the world's smallest city-states, saw a record-breaking 3 billion vessel arrival gross tonnage in 2023 and is the busiest trans-shipment port in the world. The Singapore government plans to strengthen its maritime status by constructing the Tuas Port by 2040, which will be one of the world's largest fully autonomous container port. Beyond the port, the government is exploring new ways

to harness cloud technologies, such as generative artificial intelligence (AI), automation, and data analytics to tackle local and global challenges, such as climate change.

To deliver on this vision, the Maritime and Port Authority of Singapore (MPA) has signed a memorandum of understanding with Amazon Web Services (AWS) to establish the Association of Southeast Asian Nations' (ASEAN) first maritime AI and Machine Learning (ML) Digital Hub to enable MPA and industry players to build and test AI/generative AI solutions. For example, new maritime AI solutions could be deployed on ships to analyze weather patterns and port traffic data on a daily basis to plot optimal routes, adjust sailing speeds, and moderate fuel consumption, helping ships reduce journey time and carbon emissions for a more efficient and sustainable maritime industry.

MPA will also have access to the Amazon Sustainability Data Initiative. **ST**



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Green Hydrogen Marketplace

In 2022, Lhyfe launched the building blocks of Heroes, the first digital platform for green hydrogen, and it has since been regularly enhanced with new services. Now, Lhyfe has launched the Green Hydrogen Marketplace, bringing producers and consumers closer together and facilitating access to this clean gas.

Beyond digitalization, in a rapidly developing sector, the first phase of this marketplace will enable buyers with their own hydrogen transport solutions and producers to cooperate to strengthen the green hydrogen offer across Europe.

The marketplace features: better regional coverage, increasing supply sources, production optimization and a green guarantee.

Eventually, the marketplace will be available to all hydrogen buyers requiring delivery (fuel stations, logistics centers, etc.). Many more features will be added in the coming weeks and months.

The first version of the platform is free. The marketplace already has 10 partners, including other green hydrogen producers.

Sustainable Fuel Viability

Sustainable shipping fuels could reach cost parity with fossil fuels as early as 2035 with the help of decisive emissions policy, such as carbon taxes and emissions limits, according to a new report by Wärtsilä. The report reveals that the EU Emissions Trading Scheme (ETS) and FuelEU Maritime Initiative (FEUMI) will see the cost of using fossil fuels more than double by 2030. By 2035, they will close the price gap between fossil fuels and sustainable fuels.

Transporting 80 percent of world trade, shipping is the engine room of the global economy. However, despite being the most efficient and environmental way to transport goods, it emits 2 percent of global emissions, equivalent to the annual emissions of Japan. Without action, this could increase by more than 45

percent by 2050. The International Maritime Organization (IMO) has set a target of achieving net-zero emissions by 2050. Existing decarbonization solutions, such as fuel efficiency measures, could cut up to 27 percent of emissions. Wärtsilä's report argues that sustainable fuels will be a critical step in eliminating the remaining 73 percent, but radical action is needed to scale them.

Shipowners won't commit to a fuel today that is expensive, only produced in small quantities, and may be usurped by another fuel that scales faster and more affordably. Meanwhile, it is difficult for suppliers to scale production without clear demand signals.

Wärtsilä has produced new modeling that shows a timeline of which fuels are likely to become widely available on a global scale, when and at what cost. To accelerate this timeline, the report argues that decisive policy implementation, industry collaboration, and individual operator action must coalesce to scale the production of these fuels.

Support for STEM Returners To the Workforce

Global Underwater Hub, representing the diverse range of businesses in the U.K.'s £8 billion underwater industry, and the Engineering Construction Industry Training Board (ECITB) have come together with STEM Returners to launch a new partnership to drive equality and diversity across the underwater industry. A sector-wide STEM Returners program will be conducted within Global Underwater Hub's membership network for professionals who are on a career break or transferring their skills. The aim of the 12-week program is to provide candidates with real work experience and mentoring during their placement, as well as supporting them to adjust seamlessly to a return to work life.

STEM Returners will engage the candidates for roles, including subsea controls engineer and electrical engineer, which will be based

around the U.K. and offshore. Subsea7, J+S Subsea, PD&MS and Ver-volume are some of the organizations that have already committed to the program.

The underwater industry offers an extensive range of career opportunities where science, technical, engineering or mathematical skills can be applied to help drive innovation, develop new technology and support the U.K.'s drive to net zero.

The program also aims to address the growing skills gap and need for diversification of skills to adapt to the ocean economy.

Since STEM Returners launched in 2017, there have been more than 475 STEM Returners candidates (www.stemreturners.com/placements).

Investment in Space-Based Surveillance

Unseenlabs, a France-based specialist in maritime surveillance via detection and geolocation of radio-frequency signals from space, has closed a fundraising round of €85 million from the investors Supernova Invest, ISALT via its Strategic Transition Fund, and UNEXO.

The funds will finance: consolidation of activity in private sector segments, such as oil and gas, insurance, shipowners, economic intelligence, and offshore energy; significant expansion of observation capabilities with the launch of multiple satellites; strengthening Unseenlabs' international presence, particularly in the American and Asian markets; recruitment of new talent; and innovation and deployment of new products and solutions.

Underwater Metal Detectors

JW Fishers' Pulse 8X underwater metal detector is a "go to" tool for public safety dive teams, police departments, government agencies and other forensic teams around the world. For example, the Pulse 8X was used to find evidence that led to the capture of a serial killer on Long Island.

The Charles County Dive Rescue Team uses the SAR-1, a variation of the Pulse 8X, to search in zero-visibility conditions. **ST**

contracts

Bordelon Marine LLC, Lockport, Louisiana, has renewed the charter agreement for the MV *Brandon Bordelon*, a 260-ft. DP2 Jones Act-compliant ultralight intervention vessel, for an additional two-year firm term, plus one-year additional option. Oceaneering International Inc.

NAPA, Helsinki, Finland, will provide NAPA Voyage Optimization on board two vessels equipped with Norsepower Rotor Sails. Weather routing will maximize the fuel savings delivered by wind propulsion and minimize greenhouse gas emissions. IINO Lines.

TechnipFMC, Newcastle, U.K., has been awarded a contract in Guyana's Stabroek Block to supply subsea production systems for the Whiptail project. TechnipFMC will provide project management, engineering, and manufacturing to deliver 48 subsea trees and associated tooling, plus 12 manifolds and associated controls and tie-in equipment. ExxonMobil Guyana Ltd.

Opsealog, Marseille, France, has extended its partnership contract with a shipowner operating in the offshore sector in the Gulf of Mexico for data-driven efficiency initiatives. Jackson Offshore Operators.

Rio Tinto, London, U.K., has selected OceanGlide fluidic air lubrication for one of its bulk carriers as part of its focus to boost vessel energy efficiency and decarbonize shipping. Alfa Laval.

Herberg Systems, Hamburg, Germany, has entered into a sales partnership combining its experience in developing and selling software products to the Northern European shipping market with Kpler's powerful software suite Marine Traffic Inbox. Marine Traffic/ Kpler.

Exail, Brest, France, will supply its Phins Compact C3 INS for Eelume's new S-Series all-terrain AUVs, designed for mapping and operating

in challenging underwater environments using 360° of maneuverability in roll and pitch. Eelume.

Steerprop, Rauma, Finland, will provide a comprehensive Polar Class 4 propulsion package for the Canadian Coast Guard's Multi-Purpose Vessels (MPVs) renewal program. The contract entails the supply of propulsion packages for the initial six MPVs, integral to Canada's National Shipbuilding Strategy, for operational demands in Arctic waters. Canadian Coast Guard.

Ulsan Port Authority (UPA), Ulsan, South Korea, has signed a memorandum of understanding with an international environmental organization to support the design and development of decarbonization policies for shipping ports in Asia-Pacific and the construction of green shipping routes. Pacific Environment.

Subsea7, Houston, Texas, has been awarded a contract for the Sunspear development in Green Canyon Block 78 in the Gulf of Mexico. The project involves the subsea tie-back of one production well at Sunspear to the Prince platform, 12 km to the north. Subsea7 will install the flowline and related subsea equipment at 500-m water depth. Talos Energy.

ANB Sensors, Toft, U.K., the creator and manufacturer of pH sensor technology that requires no calibration, has entered a distribution agreement with a specialist in real-time environmental monitoring systems. Adroit Environmental IoT.

Cobham Satcom, Copenhagen, Denmark, will make the largest delivery of SAILOR XTR Ku VSAT antennas to the Chinese market thus far, supported by a training and global service program. China TransComm Technologies Co. Ltd.

The Indian Register of Shipping, Mumbai, India, will collaborate on hydrodynamic studies and model testing for new construction projects. Maritime Research Institute Netherlands (MARIN). **ST**

meetings

JULY

July 9-11—AAPA Smart Ports Seminar & Expo, Seattle, Washington. <https://aapa.getregistered.net/2024-smart-ports-seminar-and-expo>.

AUGUST

August 26-29—SEG-AAPG Image, Houston, Texas. www.imageevent.org.

SEPTEMBER

September 11-12—Oil Spill India, New Delhi, India. <https://oilspillindia.org>.

September 16-20—Marine Electronics Conference & Expo, Providence, Rhode Island. <https://expo.nmea.org>.

September 17-19—South America Offshore Wind, Rio de Janeiro, Brazil.

September 23-26—OCEANS 2024 Halifax, Halifax, Canada. <https://halifax24.oceansconference.org>.

OCTOBER

October 2-3—Sustainable Marine Fuel Fest, Porto, Portugal. <https://ship.energy/events/smf-fest-2024>.

October 7-10—Marine Imaging Workshop, Monterey, California. <https://miw2024.org>.

NOVEMBER

November 4-7—EURONAVAL, Paris-Nord Villepinte, France. www.euronaval.fr.

November 7-10—Europort, Rotterdam, Netherlands. www.europort.nl.

November 12-14—International WorkBoat Show, New Orleans, Louisiana. www.workboatshow.com.

November 19-21—MAST Australia, Adelaide, Australia. Mastconfex.org.

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

people

Bigyellowfish, specializing in behavioral risk management for safety-critical frontline industries such as maritime, has appointed **Dr. Linda Sorensen** as co-founder and chief commercial officer as the company aims to relocate its global headquarters to the maritime hub of Singapore. She has held senior positions in Frontline, BW and Lloyd's Register, and she serves on several boards. She holds a Ph.D. from the University of Southampton in human factors and an M.B.A. from London Business School.



Cellula Robotics Ltd., specializing in fuel cell-powered AUV systems, has promoted **Neil Manning** from corporate development officer to CEO. This promotion reflects Manning's exceptional leadership qualities and the company's confidence in his ability to drive forward its mission and vision. Manning joined Cellula

Robotics initially as corporate development officer, bringing with him over 30 years of experience in the

submarine telecommunications, offshore wind, and oil and gas industries.

Dr. Kristine Beran has joined Teledyne Marine as sales manager for the instruments and imaging technology verticals. Based in Seattle, she will serve customers in the ocean science and academic community in the U.S. She began her career in the international fisheries and aquaculture industry, serving in progressive roles in research, operations, management and sales.

The National Ocean Industries Association (NOIA) Board of Directors has elected **Jonathan Landes**, president of subsea at TechnipFMC, as the NOIA Chair for the 2024 to 2025 term. **Joe Leimkuhler**, COO of Beacon Offshore Energy, was elected as vice chair.

GF Piping Systems has appointed **Óscar Ovejero** as the global head of marine, responsible for expanding the marine business footprint and increasing customer proximity in the Swiss flow solution provider's team. He has a master's in naval architecture and 18 years of experience in maritime sales management.

Chartwell Marine has added **Christophe Rident** as senior naval architect as it aims to expand into the fast ferry market in 2024, the next key sector for decarbonization. Rident will support the design and eventual commercialization of vessels.

Brookes Bell, a marine and energy technical and scientific consultancy, has expanded its naval architect team in Glasgow with the appointment of **Dr. Kaan Ilter**, a specialist in vessel design, hydrodynamics and structures. With more than 12 years' experience in the maritime sector, Ilter has worked at leading shipyards and consultancies in Turkey. Brookes Bell has also added **Capt. Hisyam Haron** to its Asia-Pacific team as master mariner, based in Singapore, and **Dhaneshwar Nath** as managing marine engineer, based in Shanghai.

World Ocean Council (WOC) has appointed **Stewart Sarkozy-Banoczy** as managing director, a new leadership role for the organization based out of WOC headquarters in Barcelona, Spain. He brings a mix of NGO, for-profit and government management experience and was previously acting executive director at the Ocean Sewage Alliance.

GeoAcoustics Ltd. has appointed **Dave Holland** as CTO. He is a hydrographic, geophysical and oceanographic survey industry veteran who will steer development of the GeoSwath bathymetric sonar, GeoPulse sub-bottom profiler and Pulsar side scan sonar product ranges.

ASL has appointed **Matus Hodul** as a remote sensing scientist. Working previously on Canada's smartWhales initiative, he published the first ever example of an individual animal being identified using satellite imagery: the North Atlantic right whale "Ruffian." **ST**

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Steve Esau is the chief operating officer at SEA-LNG. Previously, he was head of energy at Xyntéo. He began his career as a geophysicist at BP, subsequently working in a variety of business development, strategy, and analysis roles in the company's gas, power, and renewables and energy trading businesses. Esau has also led the development of financial instruments for the energy sector.



The shipping industry is in a uniquely challenging position. It's one of the most critical sectors in global trade and one of the most heavily regulated. These two factors can often feel like they're in direct conflict with one another.

By 2030, the International Maritime Organization (IMO) has set a target for fleet operators to cut their greenhouse gas (GHG) emissions by at least 20 percent; 80 percent by a decade later, until their operations are net zero by 2050. This timeline presents no simple task for a sector historically reliant on fuel oils or a global economy so reliant on that sector's continued growth.

The urgency and pressure to find a cure-all has resulted in a misalignment between the perception of future fuels and their reality. But if the shipping industry is going to transition to a net-zero future, it must strive to understand the practical realities of the new fuels and new solutions.

The new Maritime Alternative Fuels Barometer aims to support filling in this knowledge gap: <https://sea-lng.org/2024/01/thetius-sealng-pathways-study>.

Commissioned by SEA-LNG and conducted by maritime tech consultancy Thetius, the Barometer provides a critical look at fuel availability, supply, technological readiness and impact on emissions, as well as how current views differ

from the facts and stats. Its findings demonstrate just how wide the gap between perception and reality can be.

To state the obvious: The need and want in the industry to drastically reduce emissions does not reflect widespread adoption, and misconceptions are a significant contributor to this.

The Thetius report indicates that methanol, ammonia, and LNG are some of the highest regarded solutions for 2030 and 2050, and many key stakeholders have acknowledged the potential of each, but they all have their challenges.

Methanol, for example, has a good backing and is often cited as a future fuel. But it can offer differing results based on its production. Blue and green methanol can significantly reduce GHG emissions but aren't yet available at the scale needed.

Ammonia is similarly perceived very positively but has the challenge of being highly toxic in its current form. Training and safety measures would be significant, meaning investment could be seen as high risk: a cost that may be passed to owners, operators and consumers.

LNG was also found to be perceived positively in the Barometer, and supply-side and demand-side developments are at near-equal levels. The number of LNG-powered vessels and bunkers are far higher than most alternative fuels, which means that the market is already primed to use this resource. Methane slip is arguably the main drawback to LNG here. However, according to the report, technologies to address this potential for environmental harm are already underway.

The conclusion to draw is that, while we're faced with huge challenges, they are not insurmountable, but they will require investment—and time—to resolve.

And if there's one thing that's clear, it's that we cannot wait for a

silver bullet. The time to act is now.

LNG provides a commercially viable, operationally realistic solution to the pressing regulations we're facing. Where other candidate fuels are not yet available at scale, require infrastructure investment, or have other critical obstacles, LNG provides a pathway for the decarbonization journey to start, now.

LNG can drive down GHG emissions by up to 23 percent today. As the industry accelerates its efforts, bio-LNG adoption can result in reductions of typically 80 percent or more, depending upon the source of biomass. As stated in the Barometer, bio-LNG is low cost, and requires little change to land use and does not impact food production. It provides GHG emissions reduction of up to 188 percent compared to traditional marine fuels when produced from anaerobic digestion of manure.

And then there's the goal of net zero. To achieve this by 2050, the industry can adopt synthetic LNG (e-LNG) to realize carbon-neutral operations. Where investment is an ongoing discussion for many in the industry, bio- and e-LNG allay some concerns. Both fuels are compatible with today's LNG-ready vessels and bunkers and are already in use with existing infrastructure.

What the Maritime Alternative Fuels Barometer has made clear is that as the shipping industry heads into the future, shipowners, operators, regulators and investors must come together to establish a more collaborative sector to address common challenges, such as mobilization of biomass and renewable energy for green fuels production.

The process of collaboration must involve looking critically at our most viable options and seeking out the latest scientific facts and figures. Stakeholders must share insights willingly and transparently, and we must act accordingly with the results of the process. **ST**

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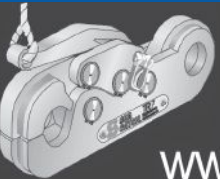
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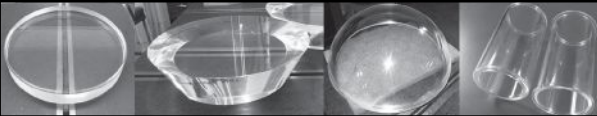
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