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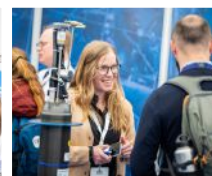
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COVER IMAGE

Heritage National Park, Nassau, Bahamas. (Credit: Aileen Torres-Bennett)

NEXT MONTH

Hydroacoustic data processing software for water column research ... AutoNaut wave-propelled vehicle ... Imaging and acoustic sensors ... USVs with instrumentation ... Sensors, data transmission on research vessel.

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CONTENTS

JANUARY 2025
Volume 66, No. 1

FEATURES

- 11** **NOAA INVESTMENTS TO BUILD NATIONAL CLIMATE RESILIENCE**
By Dr. Rick Spinrad, NOAA
- 13** **INTERDISCIPLINARY SOLUTIONS AND PARTNERSHIPS IN OCEAN RESEARCH**
By Dr. Elaine Shen, U.S. National Science Foundation
- 14** **MAINTAINING MASTERY OF THE SEA AT ALL DEPTHS**
By Mark Dalton, U.S. Naval Undersea Warfare Center, Newport Division
- 15** **BALANCING TECHNOLOGY TENSIONS IN NAVAL UNCREWED MARITIME SYSTEMS**
By Chris Haugen, Forcys
- 17** **ADVANCING ASV/USV NAVIGATION CAPABILITIES FOR EXPANDING MISSIONS**
By Matthew Zimmerman, FarSounder Inc.
- 19** **PLOTTING THE COURSE FOR MARITIME DECARBONIZATION**
By Eirik Ovrum, DNV
- 20** **OFFSHORE ENERGY IS CRITICAL TO AMERICAN ECONOMIC, ENVIRONMENTAL LEADERSHIP**
By Erik Milito, National Ocean Industries Association (NOIA)
- 22** **THE WORLD CURRENTLY LACKS THE ABILITY TO GOVERN DEEP-SEA MINING**
By Julian Jackson, The Pew Charitable Trusts
- 23** **OPTIMIZING BIG DATA, TECH AND AI TO TACKLE MAJOR ENVIRONMENTAL PROBLEMS**
By Professor Icarus Allen, Plymouth Marine Laboratory and PML Applications
- 25** **ADVANCING OCEAN TECH FOR SUSTAINABILITY**
By Nora von Xylander, Tunley Environmental
- 27** **THE STATE OF OCEAN PLASTICS**
By Carl Nettleton, OpenOceans Global
- 28** **MORE ACCURATE CLIMATE MODELS TO PREPARE FOR ESCALATING HEAT EVENTS**
By Cosimo Enrico Carniel, ETH Zürich

DEPARTMENTS

- | | | |
|--------------------------|--|---|
| 6 Soundings | 34 Product Development | 41 Soapbox |
| 7 Editorial | 36 Marine Electronics | 42 Professional Services Directory |
| 30 International | 38 Offshore Oil & Ocean Engineering | 43 Advertiser Index |
| 32 Capital Report | 39 Environmental Monitoring | |
| 33 Navy Currents | 40 Contracts/Meetings | |

)) Assessing Feasibility of AI Onboard Sensor, Data Network. The BOSS LEVEL project will investigate the feasibility of an onboard sensor and data acquisition network with AI-based analytics to address the challenges of ship-port interfaces in the era of future decarbonized vessel fleets. The project, which is part of the Smart Shipping Acceleration Fund, funded by the UK Department for Transport and delivered by Innovate UK, will focus on onboard battery energy storage systems, which are becoming major cost centers on many low-carbon vessels. There is a growing realization that future decarbonized vessel fleets will require a dramatic increase in the level of onboard instrumentation, data assimilation, and analytics because optimized vessel efficiency will be essential to meet environmental and economic levels of performance, and this in turn depends on data-driven control systems that can optimize ship operations against multiple goals: carbon and pollutant emissions, fuel use, adherence to schedule, drive train degradation, etc. In addition, low-carbon electric and hybrid drive trains incorporate technologies, notably batteries, whose long-term degradation of state-of-health is not well understood and which require very extensive monitoring to ensure integrity and optimize maintenance. The added dimension of smart shipping trends toward de-crewing and, ultimately, autonomy will also depend on instrumentation to provide situational awareness to a shore station that advises the ship's master and mitigates risks arising from onboard fault or hazard conditions.

)) Black Sea Reoxygenation Project. Flexens, Lhyfe and Stockholm University are moving forward with the Baltic Sea Oxygenation and the Super-Green Hydrogen Economy (BOxHy) offshore project. BOxHy is expected to last around six years; baseline measurements will be made before oxygen will be injected for at least three years, and the area will be observed for another year after the experiment is completed. With detailed survey, 19 coastal sites in the Baltic Sea were studied for the project, and three were identified as potentially suitable for a pure oxygen injection pilot. Criteria for site selection included: the presence of anoxia, a pre-existing observation program, the feasibility of installing the pilot infrastructure, existing high-resolution bathymetry, assessment of the local socioeconomic situation, applicable regulations, human presence, the accessibility of the site, etc. The next phase of the project is the Baltic Sea Pilot for Pure Oxygen Injection (BOxIn). The final location, size and duration of the project will depend in part on the funding obtained (expected project cost is €5 million to €6 million). This project will also explore the industrial phase of reoxygenation. With the emerging production of offshore wind energy and the growing demand for renewable hydrogen, the development of offshore production sites for the co-production of hydrogen and oxygen has been deemed feasible. The partners welcome the growing interest among scientists, industry, and institutions in ocean deoxygenation and the option of reoxygenation, with the United Nations endorsing this project as part of the UN Decade of Ocean Science for Sustainable Development 2021 to 2030.

)) UK Electricity Superhighway. A £2 billion funding package has been awarded to build a proposed new subsea and underground 196-km cable between Scotland and the north of England to boost energy security and hit green targets. Flagged by the National Energy System Operator (NESO) as an essential element to achieve the U.K. government's Clean Power 2030 ambition, Eastern Green Link 1 is a high-voltage electricity superhighway that will be able to transport 2 GW of homegrown wind-generated electricity between Torness, East Lothian and Hawthorn Pit, County Durham. Most of the cable will be under the North Sea, with the remaining 20 km of cables underground linking the cable to substations and converter stations in Scotland and England. The project will reduce the U.K.'s reliance on volatile international gas markets by further harnessing the power of local North Sea wind. NESO's recent Clean Power 2030 Report has shown the project will deliver an annual savings of more than £870 million by reducing the need to compensate British wind generators that are currently asked to turn off production during times of high wind due to lack of grid capacity. This in turn will lower consumer energy bills.

)) City of Rotterdam Invests in Decarbonization Tech. The Rotterdam-based sustainability innovator Value Group (comprising Value Maritime and Value Carbon) has secured Energietransitiefonds Rotterdam (ETF-R) as an investor. Value Group also has a new shareholder, InnovationQuarter, the regional economic development agency for South Holland and ETF-R's fund manager. With ETF-R, the city of Rotterdam aims to reduce CO₂ emissions, improve air quality and reduce the use of raw materials. The fund's investment will enable further development of the Value Hub for CO₂ offloading and processing in Rotterdam. The technology captures CO₂, stores it, and allows it to be effectively reused or stored elsewhere. In the Port of Rotterdam, the maritime industry benefits from emissions reduction enabled by the technology. Value Maritime, part of the Value Group, is the innovative developer and installer of one of the first commercially viable hybrid CO₂ capture and exhaust gas cleaning systems, known as Filtree. In addition to CO₂, this system cleans sulphur and ultra-fine particulate matter from ships' exhaust emissions, as well as oil residue and particulate matter from the vessels' washing water, supporting compliance with current and future environmental regulations. Filtree's integrated carbon capture feature enables ships to store the CO₂ they collect on board in dedicated fixed tanks or nonfixed battery containers. These onboard storage facilities can then be sustainably offloaded in port for reuse or further storage, managed by Value Maritime's sister company, Value Carbon. **ST**

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Advancing Science for Ocean, Climate Sustainability

We face an uncertain future. The effects of climate change are becoming increasingly apparent, and the complex and interconnected nature of the climate system makes prediction very difficult.

The importance of the ocean in regulating and influencing the climate is becoming clear. We are now halfway through the UN Ocean Decade, a mission to stimulate and coordinate global efforts in ocean science to support sustainable development and improve ocean health.

While time doesn't always feel like it's on our side, we have many reasons to be positive. We are collecting more data about the oceans than ever before, and past investments in long-term ocean observing systems are delivering vital information. This is critical to see how our ocean is behaving and responding to climate change and to create predictive models and understand potential tipping points.

This year, for example, is 50 years since the first Ellett Line was run using a ship to take repeated observations to monitor changes in the properties and circulation of the North Atlantic. Stretching between the Scottish Continental Shelf to Rockall, then to the Iceland Shelf, it was developed into the Ellett Array and is one of the longest deep ocean observing systems in the world.

It's also 50 years since the start of the Porcupine Abyssal Plain Sustained Observatory, one of the longest running open-ocean observatories in Europe. In addition, last year saw the 20th anniversary of the RAPID array of instruments monitoring the Atlantic Meridional Overturning Circulation at 26° N.

These sustained observations are supplemented by advances in technology, including sensing and autonomy, helping to deepen our insights into critical ocean processes, such as the biological carbon pump. In 2024, for example, one of the U.K. National Oceanography Centre's (NOC) Autosub Long Range vehicles, carrying a suite of sensors, many developed at NOC, conducted the first country-to-country mission investigating the role of marine life in ocean carbon storage as part of a joint Future Marine Research Infrastructure program and BIO-Carbon mission.

We're also seeing advances in the use of other platforms, such as satellites, to gather data. Satellite measurements provide global-level data, from sea surface temperature, salinity, and wave height to color (to spot algal blooms) and more.

The data produced by all of these observing systems are crucial to create the climate models we rely on to improve predictions of ocean behavior and climate impacts. With better models, we can better predict and safeguard the sustainability of the ocean.

To do this at scale, it's critical that science and policy actors make all these data easier to access globally. At NOC, we host the British Oceanographic Data Centre, which plays a leading role in this effort. We are also developing novel approaches for combining and interrogating large and diverse data, including using artificial intelligence.

All of these digital advances will help the global science community extract more value from ocean data. We want to make sure that the best decisions are being made about our ocean and climate, informed by the best data.

To achieve this, NOC is part of a global collaboration that is developing "digital twins" of the ocean, promoted by the UN Ocean Decade, to enable scientists, businesses, and policymakers to test ideas, design solutions, and monitor impacts. This initiative and others will enable society to understand and share knowledge about the changing ocean to improve the future. **ST**

SEA TECHNOLOGY® 2025

JANUARY

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FEBRUARY

Instrumentation: Measurement, Processing & Analysis

****Undersea Defense Technology (UDT)**, March 25-27, Oslo, Norway

MARCH

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

****Ocean Business**, April 8-10, Southampton, U.K.

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

****MAST AUKUS (USA)**, May (dates TBD), Waikiki, Hawaii

MAY

Communications, Telemetry, Data Processing

****OCEANS 2025 Brest**, June 16-19, Brest, France

JUNE

Seafloor Mapping/Sonar Systems/Vessels

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Deck Gear, Cable, Connectors, Power Systems & Salvage

****IMAGE 2025**, August 24-29, Houston, Texas

AUGUST

Ocean Resources Development & Coastal Zone Management

****MAST AUKUS (UK)**, September (dates TBD), Glasgow, U.K.

****OCEANS 2025 Great Lakes**, September 29-October 2,
Navy Pier, Chicago, Illinois

SEPTEMBER

Geophysical Exploration/Seafloor Engineering

OCTOBER

Environmental Monitoring, Remote Sensing & Pollution Control

****CLEAN GULF**, November 18-20, New Orleans, Louisiana

****Offshore Energy**, November 25-26, Amsterdam, The Netherlands

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For the 59th year, leaders in ocean technology, research, business and policy give their perspectives on promising new developments and critical changes in the ocean world.

Review&Forecast

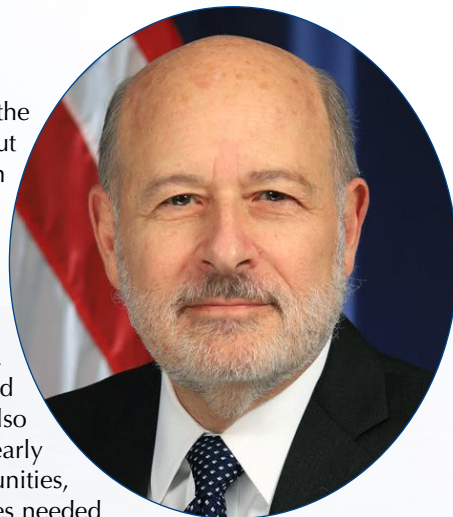
NOAA Investments to Build National Climate Resilience

*By Dr. Rick Spinrad
Under Secretary of U.S. Commerce for Oceans and Atmosphere
NOAA Administrator*

NOAA had a record-breaking year in 2024. Bolstered by the largest climate investment in U.S. history, NOAA put out more climate-focused grant money to U.S. communities than ever before. We accomplished our core mission and accelerated our efforts to lay the groundwork for a climate-ready future for our nation.

We forged new relationships and strengthened existing partnerships with communities, states, tribes, academia, international partners, nonprofit organizations and industries, including insurance and reinsurance, retail, architecture and construction, ocean technology and transportation. We also partnered with Climate Mayors, a bipartisan network of nearly 350 mayors demonstrating climate leadership in their communities, to provide cities nationwide with the tools, data and resources needed to address the growing threats of climate change.

By the end of the 2024 fiscal year, we invested \$4.3 billion of the \$6.3 billion granted to NOAA from the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Act. These investments include: high-impact projects to build resilience to coastal hazards, such as sea level rise and extreme weather events, and to reduce pollution and marine debris; restoring coastal habitats that help wildlife and humans thrive; building the capacity of underserved communities to support community-driven restoration; creating climate solutions by storing carbon; supporting economic development in environmental products and services; and providing employment opportunities through climate-ready workforce training and job placement. We also added supercomputing capacity for weather and climate research, and we continue to strengthen our fleet of ships and aircrafts and to replace aging port facilities.



Industry Partnerships for Climate Resilience

With \$85 million in funding from the IRA, NOAA established the Industry Proving Ground program to bring together NOAA scientists with key industry leaders to deliver more modernized products and services and help build climate adaptation. We are working with industries to ensure they have high-quality, accessible, and actionable data to ensure sustainable growth as the climate changes and extreme weather increases.

NOAA is fueling economic opportunity across the new blue economy by supporting innovation in new tools and technologies to gather ocean, weather, and climate data needed to operate effectively in the present and to plan for future climate impacts. NOAA supports the development of uncrewed systems that can track hurricanes; map the seafloor; help site wind power; monitor fisheries; and inform climate models to prepare society for higher sea levels, more precipitation and intensifying tropical cyclones, as well as the impacts of these phenomena on humans and the environment.

New Ships, Aircraft, Piers

Novel uncrewed systems complement the monitoring and research done with NOAA ships and aircraft. We are building two new oceanographic research ships that will go online over the coming years, and two new coastal mapping and charting ships are in the design phase.



On May 8, 2024, NOAA Administrator Rick Spinrad visited NOAA Ship Thomas Jefferson while it surveyed the approaches to Savannah, Georgia, using a DriX USV. The NOAA Uncrewed Systems Operations Center recently transitioned the DriX into operational status. It primarily supports NOAA's ocean mapping. From left to right are: General Vessel Assistant Stephanie King, NOAA Administrator Rick Spinrad, NOAA Corps LTJG Abby Letts and Ensign Genesis Beaz Nieves. (Credit: NOAA Corps LT Michelle Levano)

In 2024, we contracted for two specialized Lockheed C-130J Super Hercules aircraft to become the next generation of NOAA hurricane hunter aircraft. The planes will be modified to serve as flying laboratories in support of NOAA's hurricane and environmental research. The fully instrumented aircraft are expected to join NOAA's fleet in 2030. They will replace the long-serving WP-3D Orions, which have operated since the mid-1970s. We also ordered a second Gulfstream G550 aircraft that will support atmospheric research and hurricane surveillance.

We broke ground in 2024 for a new marine operations center in Newport, Rhode Island, and for major renovations to the NOAA pier facility in North Charleston, South Carolina.

Next-Generation Satellite, Space Weather Sensor

We also continued to add to our next-generation satellite fleet in 2024, launching GOES-19, a satellite that provides high-definition, real-time observations to improve the accuracy and timeliness of our weather, climate, and ocean forecasts. The new satellite carries the

first operational satellite solar coronagraph, an instrument that will improve the detection of hazardous space weather that could disrupt power grids, navigation systems and communications.

Climate Planning Tools

In 2024, NOAA released a sea level calculator to provide the public with the best available data to understand and plan for sea level rise at the community level.

NOAA's investments in climate-ready fisheries are bolstering efforts to incorporate climate and ecosystem data into fisheries research and quota management to help fishing communities adapt to climate impacts on resources.

New National Marine Sanctuaries

NOAA designated two new national marine sanctuaries in 2024. Chumash Heritage National Marine Sanctuary, off the California coast, will celebrate the indigenous people's connections to the region and conserve marine diversity. Lake Ontario National Marine Sanctuary in the state of New York will celebrate maritime culture and provide new opportunities for tourism, recreation, research, and education. The two sanctuaries help advance the America the Beautiful Initiative to support locally led conservation and conserve 30 percent of U.S. lands and waters by 2030.

Seafloor and Coastal Mapping

NOAA made continued progress mapping both coastal and deep seawaters in 2024, including autonomous mapping with the Exail DriX uncrewed surface vehicle, which was deployed off the NOAA Ship Thomas Jefferson.

son. Mapping to improve navigation, resource management, and our understanding of ever-changing ocean environments took place in the Arctic, Great Lakes, Pacific, Gulf of Mexico and Atlantic. NOAA partnered with the U.S. Coast Guard to successfully map a new Arctic shipping route leading to the North Slope of Alaska that has opened up because climate warming is accelerating sea ice melt. The Arctic mapping will help inform the locations of a series of meteorological and oceanographic data buoys to deliver observations for navigation and to ensure increased vessel traffic does not harm the region's marine life and coastal communities.

Strengthening the NOAA Corps

In workforce progress, Vice Adm. Nancy Hann became the first woman in NOAA history to achieve the rank of three-star admiral this past year. As the director of the NOAA Corps and Office of Marine and Aviation Operations, Hann led efforts to improve NOAA Corps policies, practices, and working conditions, putting in place policies to prevent sexual assault and harassment and raising pay for mariners. In late 2024, I was thrilled to name Hann as the deputy under secretary for NOAA Operations, the highest ranking career leader in the agency.

As we look to this new year, 2025, NOAA's investments in climate resilience, infrastructure improvements and expanded partnerships have positioned the dedicated NOAA workforce to build on the many achievements of the past year. **ST**

Review&Forecast

Interdisciplinary Solutions and Partnerships in Ocean Research

By Dr. Elaine Shen
Sea Grant John A. Knauss Marine Policy Fellow
Division of Ocean Sciences
U.S. National Science Foundation

The U.S. National Science Foundation (NSF) delivers curiosity-driven and solutions-oriented research for discoveries that benefit the nation. This mission is underpinned by recognizing that investments in climate and resilience research and innovation are necessary to ensure a livable and equitable planet.

"Every part of our nation has been impacted by the changing climate," said NSF Director Sethuraman Panchathan. "We build a sustainable future for all by investing in climate resilience research and solutions across our country."

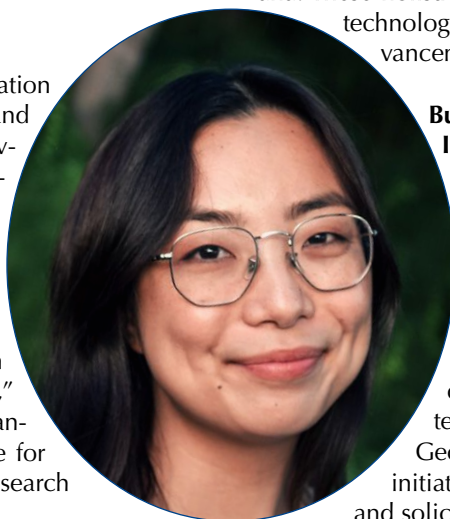
NSF continues to invest in partnerships across disciplines and industries that advance convergent approaches and the commitment to finding ocean-climate solutions, including those informed by environmental

equity and justice principles and efforts in workforce development and education. This work addresses the multifaceted challenges the ocean faces, as well as opportunities for current and future generations.

Advancements in Ocean Technology and Ethics

NSF is funding state-of-the-art technologies for ocean observations, as well as workshops to discuss the ethical and social implications of climate interventions. Earlier this year, NSF and NOAA funded the Woods Hole Oceanographic Institution to design and build two medium-size remotely operated vehicles (mROVs). These mROVs will enable researchers to study rapidly changing nearshore ocean and coastal environments to create fundamental knowledge critical for national security, environmental restoration and economic progress. Additionally, the vehicles will be able to visit depths of 4,000 m and have more sampling and payload capabilities than smaller ROVs that focus mostly on observations.

As researchers and policymakers consider using more advanced ocean technologies, they must think of how to use these technologies responsibly and assess their impact on people. This year, NSF funded a series of workshops on the ethical and societal implications of climate intervention, with a specific focus on solar radiation management and carbon dioxide removal (CDR). These funding efforts complement other agency work, including involvement in the Marine CDR Fast Track Action Committee and the National Oceanographic Partnership Program. Additionally, through the NSF Responsible Design, Development, and Deployment of Technologies program, NSF has invested in multisector teams of researchers to ensure that ethical, legal, community, and societal considerations are embedded in the life cycle of technology creation and use. Inaugural investments included projects related to developing decision-making tools to enhance coastal community resilience in response to coastal storm events in Texas and Louisiana. These holistic considerations in ocean and climate technology innovation serve to strengthen its advancement and benefits to society.



Building a Resilient (Ocean) Planet In Collaboration with Communities

The work of the NSF Division of Ocean Sciences shares a broader thematic focus that NSF has advanced over the past few years to "Build a Resilient Planet." This initiative seeks to accelerate the development of solutions to the interconnected challenges of achieving climate-resilient ecosystems and communities. Led by the NSF Geosciences Directorate, this NSF-wide initiative has spurred exciting new programs and solicitations where researchers can explore how ocean climate modeling, nature-based solutions, and other related topics help address climate hazard and mitigation strategies. Importantly, the NSF Build a Resilient Planet initiative encourages solutions to serve histor-

ically underserved and disadvantaged communities and be just, inclusive, and equitable.

The NSF Confronting Hazards, Impacts and Risks for a Resilient Planet program supports community-driven research partnerships on Earth system hazards to develop actionable solutions that reduce risk and increase social and ecological resilience. The NSF Civic Innovation Challenge is a competition that accelerates the transition to the practice of foundational research and emerging technologies in communities through civic-engaged research. NSF Regional Resilience Innovation Incubators support community-engaged team science to co-design high-impact solutions to climate-related societal challenges that leverage recent advances in fundamental climate change and Earth system science research. These solicitations are designed to fund projects highlighting local knowledge, co-producing research questions and more equitably realizing community resilience outcomes.

Growing a Capable, Diverse STEM Workforce

NSF continues to address the talent shortage in the STEM workforce by strategically investing in new institutional capacity-building and student-focused initiatives in 2024 and beyond. For example, the NSF Geosciences Directorate's Focus on Recruiting Emerging Climate and Adaptation Scientists and Transformers program funds emerging research institutions to create student-centered professional development opportunities that emphasize building entrepreneurial and innovation capacity in geoscience and climate-related fields. In addition, the new NSF Established Program to Stimulate Competitive Research (NSF EPSCoR) Graduate Fellowship Program expands the reach of the hallmark NSF Graduate Research Fellowship Program (NSF GRFP) by providing funding for new or continuing students in NSF EPSCoR jurisdictions who received NSF GRFP honorable mentions within the last three years. With many emerging research institutions and EPSCoR jurisdictions engaged in ocean and coastal research, these opportunities can provide additional support for early-career scientists on the cusp of innovative research.

Looking Ahead

In 2025, NSF will commemorate 75 years of investing in ideas and innovations across all fields of science and engineering. As the agency moves forward in its thematic focus to Build a Resilient Planet and broaden the STEM workforce, insights from the ocean science community will play an important role. Partnerships and advancements in the ocean science and technology enterprise will involve and support increasingly diverse users and sectors, including local communities and those with environmental justice concerns.

Interagency partnerships are also crucial to advancing ocean science and technology. As a member agency of the White House Ocean Policy Committee, NSF helps ensure that the federal collaboration to tackle ocean problems is informed by sound science and diverse perspectives. In 2024, NSF co-authored the National Strat-

egy for a Sustainable Ocean Economy, a whole-of-government approach to ensure that economic, social and environmental benefits from the ocean are realized by all communities.

NSF continues to sustain the ocean research enterprise with innovation and funding for community-engaged and interdisciplinary ocean research that translates cutting-edge ideas into actionable solutions. **ST**

Review&Forecast

Maintaining Mastery of the Sea At All Depths

By Mark Dalton

Head of Strategic Planning Office

U.S. Naval Undersea Warfare Center, Newport Division

Throughout history, a nation's ability to master the sea has been crucial to develop and safeguard prosperity. Imagining mastery of the sea likely conjures quaint images of the Age of Sail, yet the concept remains relevant. In the modern era, a nation's ability to project sea power is essential to deter adversaries and protect trade for economic development. Since the end of World War II, the U.S. Navy has taken on this role, mastering the sea to provide security for maritime trade worldwide.

Today, two factors challenge the U.S. Navy's longstanding technological and operational superiority in the sea. One is new warfighting domains that add complexity; technologies that exist from the ocean floor to space now play a significant factor in maritime and economic affairs. The other is that great powers (China and Russia) seek to challenge the international rules-based order.

To counter these threats, the Navy is developing new concepts of operation and integrating emerging technologies into its systems-of-systems. Commander of the U.S. Navy Submarine Forces Vice Adm. Robert Gaucher has outlined four major areas where the government, industry, academia, and the Submarine Forces need to collaborate on development efforts. These focus areas provide insight into what work is needed for the U.S. Navy to retain mastery of the sea at all depths.

UUVs and Subsea, Seabed Warfare

The deployment of unmanned systems, mainly un-



manned aerial systems (UAS), has changed the character of war. While unmanned undersea vehicles (UUVs) have been slower to achieve a UAS level of adoption due to the challenging undersea environment from a communications standpoint, recent developments have made UUVs more common, and the Navy can now leverage UUVs more frequently in the undersea domain.

UUVs offer submarine crews greater capacity to conduct operations, such as intelligence, surveillance and reconnaissance; acoustic collections; and oceanographic surveys. UUVs also extend the reach of the Submarine Forces to areas too dangerous for a manned platform to operate, expanding the range from the shallows to the depths of the seafloor.

Additive Manufacturing

Additive manufacturing (AM), or 3D printing, has matured in the past decade and could address some of the challenges the U.S. Submarine Forces face when it comes to accessing spare parts. Instead of manufacturing parts at a central location and staging spares, plans can be sent to the end-user for production at remote facilities or even on the platform itself. As the Navy operates in theaters that are far from support activities, the ability to produce parts locally and remain on station adds tremendous value.

Early efforts have focused on polymer printing—demonstrated on six submarine deployments to date—with metallic printing becoming more common. For example, the submarine tender USS *Emory S. Land* deployed to Australia with a metal AM capability, which expands the level of support provided to submarines in the Indo-Pacific.

Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) are software techniques that are now used broadly in industry and government, and the Navy is no exception. A foundational task for developing AI/ML algorithms at the speed of relevance is to establish a common development environment (CDE) that provides developers with tools and integration pipelines to design, test, secure, and deploy algorithms.

In the past year, an AI/ML initiative by the Submarine Forces known as Task Force Turing established a CDE for a project known as Harbinger to develop, test and field ML algorithms for use on submarine-relevant acoustic data. Building upon the CDE, the team is exploring use cases outside of acoustic data, including using large language models to assist submarine support activities with creating engineering repair packages and interactive technical manuals.

Cross-Domain Command and Control

The most significant operational characteristic of the Submarine Forces is stealth, as it provides the ability to project power without detection. It is critical for commanders to have the ability to command and control all military assets within their area of responsibility. For the Submarine Forces, assets must remain hidden but retain

the ability to communicate. To resolve this tension, the Submarine Forces are pursuing technologies that enable cross-domain command and control (C2) while reducing the time spent at periscope depth.

Conclusion

As it stands, the U.S. Navy—specifically, the Submarine Forces—is well poised to address challenges to our nation's ability to master the sea at all depths, from emerging domains and global competitors. It is imperative to improve the operational capability of our forces through technological development because what is sufficient today may be insufficient tomorrow.

The Submarine Forces are focusing on the technology areas of UUVs, subsea seabed warfare, AM, AI/ML, and cross-domain C2 to remain ready and able to deliver warfighting capability to combatant commanders. Progress in these areas requires effective collaboration among the Navy, other government organizations, commercial industry, and academic partners to advance the state of the art and transform technological promise into operational capability. **ST**

Review&Forecast

Balancing Technology Tensions In Naval Uncrewed Maritime Systems

By Chris Haugen
Business Development Manager, North America
Forcys

The story of uncrewed and autonomous maritime systems in 2024 is one of contrasts. The need for advanced autonomy that can reliably conduct independent missions in remote locations is balanced with the need to rapidly develop and deploy focused capability that is attributable or expendable at scale with speed and affordability. Progress in 2024 with uncrewed undersea vehicles (UUVs) responded to the tension between these two needs, in light of the U.S. objective to prepare for a major conflict with China by 2027, which requires both capability and capacity growth.

Forcys, working with our technology partners Sonardyne, Wavefront Systems, Voyis, EIVA and Chelsea Technologies, is privileged to be at the forefront of developing and delivering such undersea capability.





EIVA's C-ROTV provides rapidly deployable multi-mission capability with a flexible sensor payload.

data rates, will facilitate emergence—the phenomena exhibited by schooling fish moving in unison—needed to overwhelm adversary defenses.

Rapidly Deployable Systems

Another area that saw continued growth and advancement in 2024 was developing means of delivering capability to areas of need within hours.

One such system was designed by EIVA: the Containerized Remotely Operated Towed Vehicle system, or C-ROTV. This system is fully self-contained and can be readily deployed and in operation within hours. The host vessel of opportunity needs only deck space and power.

C-ROTV provides an EIVA ScanFish or ViperFish kitted out with a mission-specific sensor package, integrated launch and recovery system, cable reel and winch, and a two-person operator station—all in a DNV-classed 20-ft. ISO container.

Super-Size It

Two highly capable, long-endurance and long-range vehicles were delivered and entered service in 2024: the Ghost Shark, built in Australia by Anduril, and the Orca, developed by Boeing and Huntington Ingalls Industries in the U.S. Both these extra-large uncrewed undersea vehicles (XLUUVs) can carry a variety of payloads, such as undersea mines, persistent sensors or even smaller UUVs, into contested areas without the liability of risk to crewed systems. Ghost Shark will comprise a class of three vehicles; Orca is under test and evaluation and could be a class of up to four. In addition, Northrop Grumman's Manta Ray is being developed through a Defense Advanced Research Projects Agency program to support a wide variety of mission sets.

Among the challenges faced by these, and smaller UUVs, is precise navigation in GNSS-denied environments. Integrated INS and DVLs, such as Sonardyne's SPRINT-Nav X, offer very precise position tracking over long distances and time, as long the UUV is within DVL range of the seafloor.

However, XLUUVs will conduct open-ocean transits without the benefit of DVL bottom lock. New means of position tracking will emerge in the near term to address this critical need.

Expendable and Attritable

Pulling on the other end of the spectrum is the need for quantity of force. The maritime conflict with China over Taiwan, for which the U.S. and allies are openly preparing, will see the replacement of crewed platforms with large numbers of UUVs, along with seafloor networks of sensors and communications systems.

The proliferation of small startup companies making inexpensive and small UUVs is the direct result of the success Ukraine demonstrated by quickly fielding low-cost and highly effective UUVs and uncrewed surface drones. The asymmetric nature of these vehicles, especially as swarming tactics and other capabilities are added, is daunting, particularly if these systems begin fielding across domains.

Swarming tactics will require robust yet inexpensive communications systems between elements of the swarm. Optical communication systems, such as Sonardyne's BlueComm with its large bandwidth and high

Undersea Intruder Detection and Neutralization

Persistent resident sensor systems, critical national assets along coastlines, shipping ports and naval harbors, and expeditionary forces conducting amphibious operations are all at risk from UUV attack or surveillance. Interest is high for systems that can help defend these vulnerable assets.

Detection systems, such as Wavefront Systems' Sentinel 2 simultaneous active and passive sonar, are purpose built for this mission. Look for continued development of these systems to extend their capabilities to operate in deeper depths and incorporate artificial intelligence (AI) and automated target recognition (ATR), as well as the ability to direct kinetic effects to complete the kill chain where necessary.

Autonomy and AI

Withdrawing warriors from the highest risk areas, particularly in the first phases of the next conflict, will require replacement by masses of UUVs and seafloor networks to provide the intelligence preparation of the operational environment, common operational picture development, and delivery of kinetic effects that will thwart adversary ambitions.

Autonomy required for these missions requires either strict rules for platform behavior, which precludes adaptation to a dynamic environment, or AI-powered systems capable of sensing and understanding how to adapt to accomplish the assigned mission. However, AI algorithms are data- and power-hungry and can stress mission endurance of UUVs. Finding the triple balance point of sensor resolution, data stream width and necessary computing power is key to success. Where "every joule matters," sensors such as a multiple-aperture sonar (MAS) support that triple balance point.

AI-powered systems will ultimately be used to deliver kinetic effects with no human in the loop. This requires unequivocal identification of targets, which depends

on high-resolution systems. Voyis, another Forcys technology partner, has high-resolution, true-color imaging systems that provide precise mensuration and characterization. Coupled with EIVA's software for real-time video simultaneous localization and mapping (VSLAM) 3D model development, high-confidence AI targeting and delivery solutions are possible.

The Year Ahead

The U.S. Defense Innovation Unit—DIU—will extend its Replicator initiative aimed at fielding thousands of autonomous systems in the next few years. The large-diameter UUV contracts have been let, and capable systems will be tuned through selection of sensor suites and payloads. This is a high-end mix with expensive but nominally attritable systems. Expect DIU, and naval acquisition and engineering organizations in the U.S. and in other nations, to increasingly focus on driving the cost of UUVs down to achieve the quantified capacity to carry out missions requiring more units with advanced capabilities.

Technology advances are needed in communications—between vehicles for swarming tactics and between vehicles and operators so that critical data can be harvested in real time. Long-range, secure, covert acoustic and optical systems are required and will necessitate advances in technology. Gateway systems connecting the undersea realm with remote operations centers are needed to breach the subsurface-sky-space interface.

As we close in on the target year of preparedness for a major conflict, the autonomous undersea realm will grow in importance. **ST**

Review&Forecast

Advancing ASV/USV Navigation Capabilities for Expanding Missions

By Matthew Zimmerman
CEO
FarSounder Inc.

Autonomy and uncrewed autonomous vehicle (UxV) systems are hot topics across a variety of industries and vehicle types. For example, it is clear that the pace of adoption and development of drone technology in the maritime sector is increasing dramatically. The confluence of greater at-sea broadband connectivity, artificial intelligence (AI)-based vehicle control systems, the limited pool of mariners, and the success of uncrewed systems in the war in Ukraine has created an enormous opportunity for autonomous/uncrewed surface vessel (ASV/USV) platforms.

Now that the utility of USVs, including their value as a force multiplier, has been demonstrated, the industry is ripe for widespread adoption of these vehicles in

not only defense applications but also hydrographic survey, search and rescue, environmental monitoring, and (soon) cargo/passenger transport. As more applications come online, there is one key factor that must not be overlooked: What is underwater, ahead of the vessel, in real time?

It is fairly common to use the information captured in electronic navigation charts (ENCs) to generate a vessel route that avoids the shallows and other underwater obstacles shown on an ENC. However, there is a fundamental problem with this approach: It assumes that the chart's underlying hydrographic survey data are comprehensive and complete. ENCs may be valuable within the primary shipping channels and in popular locations, but only about 50 percent of coastal waters worldwide has been surveyed by modern standards. This means that as USV missions and applications move into remote coastal locations, nautical charts cannot be relied upon to provide accurate information about underwater hazards.

Historically, USV development focused on the use of above-water sensors (such as GPS, AIS, radar and optical/thermal sensors) and ensuring compliance with U.S. Coast Guard Rules of the Road (COLREGS). Testing of initial platforms took place either in well-charted areas or deepwater locations where concerns about underwater hazards could be minimized. Therefore, the limitations of ENCs could be largely ignored.

However, as ASVs/USVs move out of these simplified environments, that is no longer a valid assumption. Given the limited resources of hydrographic offices around the world, it will take a long time to fully survey all areas of interest. Even the U.S. has only mapped about 52 percent of its territorial waters. Seabed 2030, a joint project of GEBCO and The Nippon Foundation, supported by the International Hydrographic Organization and endorsed by the UN, is working to compile a comprehensive map of the seafloor. However, even when including crowdsourced measurements and data from private survey operators, the definitive global map thus far only covers about 26 percent of the seafloor at a maximum resolution of 100 m.

One method by which traditional, crewed vessels overcome charting limitations in littoral waters is by relying on local knowledge and observations from skilled bridge crew. Such capabilities are nonexistent with uncrewed systems, leading to a lack of situational awareness. Also, charts can't account for transient obstacles, changes to the seafloor caused by seasonal conditions or natural disasters, or GPS-denied environments. These points are particularly salient when one considers the commercial, military, and scientific pushes into the Arctic, where the environment changes daily, and the various coastal regions of conflict where GPS spoofing and jamming are commonplace.

Above-water sensors can't detect the uncharted rock pinnacle or coral head.



“3D FLS is a mature technology that excels at many of the tasks that limit the effectiveness of above-water sensors.”

They can't detect debris that has blocked a previously well-charted channel after a hurricane. They are very limited in their ability to detect the keel of an iceberg or bergy bits. Above-water sensors can't sense the bathymetry in an austere environment. They are very limited in their ability to detect whales, especially since they spend most of the time below the sea surface.

In the case of whale avoidance, navigating around these creatures is not only important for the vessel's safety, it is critical for marine mammal protection, as ship strike is one of the leading causes of death for the great whales, including the critically endangered North Atlantic right whale.

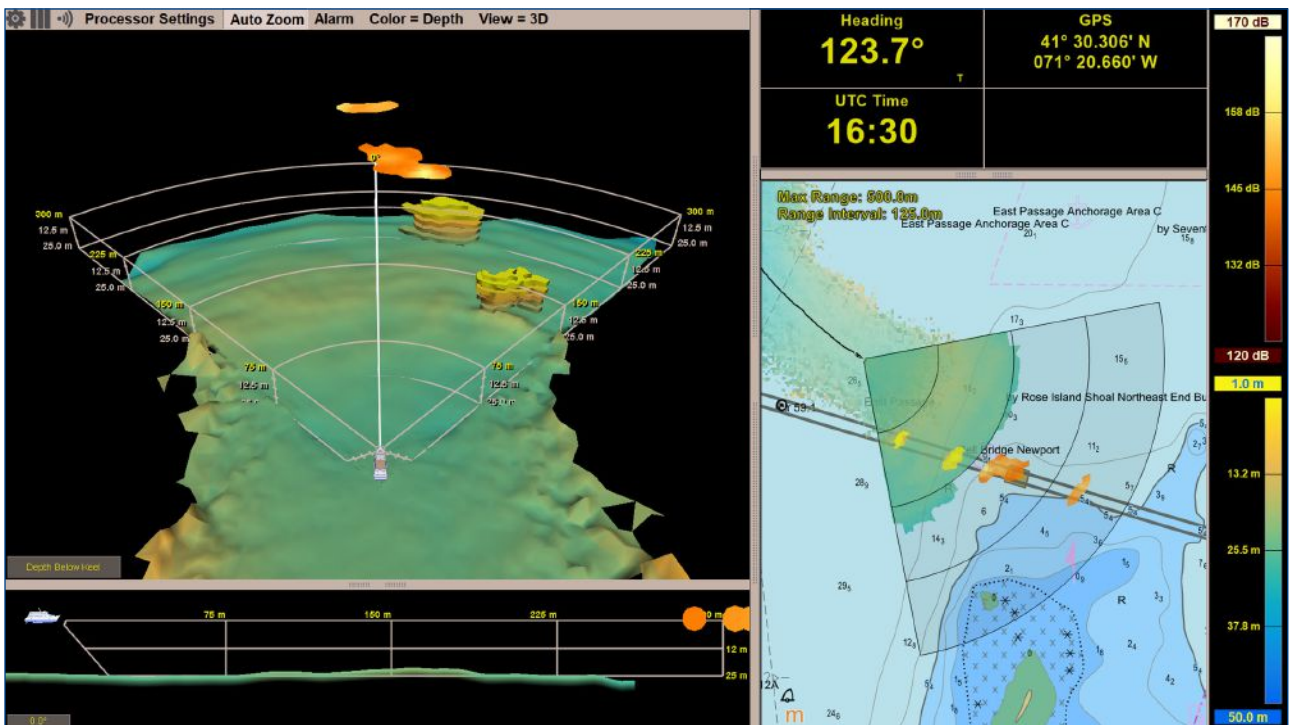
Fortunately, above-water sensors are not the only tools available to the ASV/USV community. Their underwater complement is 3D forward-looking sonar (3D FLS). Having first entered the commercial maritime market in 2005, 3D FLS is a mature technology that excels at many of the tasks that limit the effectiveness of above-water sensors. When working in conjunction with other traditional navigation sensors, a vehicle's control system (and/or remote operators) can employ 3D FLS to build a more complete understanding of the navigational environment, including uncharted bottom features, dynamically changing sandbars and transient objects.

FarSounder's line of Argos sonars is the market leader in 3D FLS, and they have been installed worldwide on a wide range of vessel types. Though FarSounder's original focus was on midsize crewed vessels, Argos 3D FLS systems have been in use on uncrewed vessels since 2021. Currently, they are deployed on a variety of defense and civilian USVs, from 14 m in length and longer. Depending upon the model, Argos 3D FLS can operate from 350 m (more than 1,100 ft.) to 1,000 m (more than half a nautical mile) ahead of the vessel.

Argos series sonars provide real-time capabilities, build a bathymetric map of everywhere they go, and have the ability to share a map optionally and anonymously across the FarSounder fleet and contribute to Seabed 2030. The sonar's output can be accessed through a machine interface for vehicle control systems and via a graphical display for human-in-the-loop operators.

The FarSounder team is currently working on designs for new hardware models focused specifically on USVs less than 14 m in length, which will feature lower power, small footprint and lower cost.

The team envisions that these expanded options will enable even more USVs to take advantage of 3D FLS technology, facilitating safer navigation across a wider range of vehicle types. **ST**



Sample depiction of seafloor and bridge pilings via FarSounder Argos 500 3D FLS.

Review&Forecast

Plotting the Course For Maritime Decarbonization

By Eirik Ovrum
Maritime Principal Consultant, DNV
Lead Author, Maritime Forecast to 2050

The decarbonization of shipping is a complex puzzle. Due to its nature, shipping is one of the world's "hard to abate" sectors, which means that reducing emissions and contributing to stopping man-made global climate change requires ingenuity and out-of-the-box thinking.

The goals, at least, are clear. Following the conclusion of the International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC 80) summit in 2023, the maritime industry has set its course toward full decarbonization "by or around" 2050, a 20 percent reduction in emissions by 2030, and a 70 percent reduction by 2040, all compared to 2008 levels.

These goals are, at best, highly ambitious, and, at worst, impossible. Nonetheless, the spirit of maritime exploration is alive and well, and a range of different technologies, fuels and operational strategies are already being explored across the industry.

A Roadmap for the Maritime Industry

At DNV, we are at the forefront of these efforts, summarized in the annual publication of our Maritime Forecast to 2050 report. In 2024, we released the eighth edition to continue to provide maritime stakeholders with a pragmatic assessment of the decarbonization road that lies ahead, helping them make the appropriate choices for their own fleet.

With every publication, the report provides an overview of the latest technological and regulatory developments in shipping. Both are dynamic elements that inform DNV's forecasting models, demonstrating the different pathways to meet the IMO's greenhouse gas (GHG) emissions targets.

Short Supply of Carbon-Neutral Fuels

Taking the longest view, full decarbonization of shipping will require the large-scale transition to carbon-neutral fuels. The scale of this task is difficult to exaggerate. Today, about 93 percent of the global fleet (in gross tonnage) is powered by conventional fossil fuel oil without onboard carbon capture. For full decarbonization, a brand new fleet, with the ability to be powered by alternative fuels, such as ammonia, hydrogen and methanol, or with the ability to capture carbon on board, needs to be constructed over the next 2.5 decades. The cost of constructing these vessels will be greater than for conventional vessels, and shipowners are understandably re-

luctant to commit to this based on an even greater issue, that of fuel supply.

Today, the supply of fuels such as ammonia, hydrogen and methanol is minuscule, with global supply chains, including bunkering infrastructure, almost nonexistent. Developing carbon-neutral versions of these fuels to fulfill shipping's theoretical needs will require sustained, multibillion-dollar investment on a global scale over the next 25 years.

However, with demand uncertain, and clarity lacking around which will be the "winning" fuel, few fuel producers are reluctant to make this kind of commitment. Moreover, while some supply of these carbon-neutral fuels is available today, they are significantly more expensive than regular fuels, reducing their appeal even more for shipowners.

Energy Efficiency Plugs the Gap

Although the scale of the fuel transition seems almost insurmountable, a number of solutions—green shipping corridors; financial mechanisms, such as the Poseidon Principles, a global framework to integrate climate considerations into lending decisions; carbon pricing regulations—are being put in place to make the ground more favorable in the years ahead. Nonetheless, action is imperative today, and shipping needs to show a 20 percent reduction in GHG emissions within the next five years, so other avenues need to be explored. The most obvious of these is energy efficiency.

The latest Maritime Forecast to 2050 estimates that energy reductions of up to 16 percent can be achieved through a combination of operational and technical energy efficiency measures. This can start with instilling cultural changes throughout an organization. Encouraging crew members to seek efficiencies in their day-to-day operations has already been proven as a low-cost, risk-free way of achieving results, with some companies showing that this can deliver fuel and emissions savings of up to 5 percent.

Taking energy efficiency to the next level and reaching double-digit results requires technological solutions. Energy efficiency technologies such as wind-assisted propulsion systems, waste-heat recovery, and shaft generators, to name just a few, are already in use and have been proven to reduce emissions, with even greater potential in the future.

Other Technological Solutions Can Reduce Demand For Carbon-Neutral Fuels

Aside from energy efficiency measures, the new Maritime Forecast to 2050 report also demonstrates how a range of other technological solutions can contribute to a reduction in GHG emissions while reducing the dependence on carbon-neutral fuels.

Onboard carbon capture is a good place to start. Supported by sustainable and credible reception and storage



schemes, this would enable the continued use of conventional fuels and technologies while contributing to emissions reductions. The technology required for this is developing quickly. However, there is not yet sufficient infrastructure developed to receive and store the carbon captured on board ships. Ideally, this would be done at major ports, and the Maritime Forecast to 2050 report explains how this could happen.

Digitalization is also crucial. Digital tools and systems are already unlocking operational efficiencies, for example, by facilitating speed and route optimization. Digitalization can also be used to show vessel performance, providing vital data on the impact of energy-saving measures and facilitating design of the next generation of energy-efficient ships.

Technology is developing quickly, and other solutions, such as shore power, batteries, fuel cells and nuclear propulsion, are also examined in detail in the new report.

The Advantages of Pooling

While technology is developing quickly, the conditions for decarbonization need to be supported by progressive and goal-oriented regulations. A good example of this is the pooling mechanism, which forms part of the FuelEU Maritime regulation, effective January 2025.

Pooling provides shipowners with the option to attain compliance across a fleet of ships—even belonging to different companies—as a means of meeting stricter well-to-wake requirements imposed under the new regulation. This means that in a pool, a vessel with compliance surplus can sell excess emission units to several vessels with compliance deficits, compensating for the extra costs associated with investing and running an over-compliant vessel on costly carbon-neutral fuels.

Using a detailed simulation of an e-methanol vessel, the new Maritime Forecast to 2050 report shows how pooling can drive fleet-wide strategies, reduce investment risk, and help to accelerate the uptake of new fuels and technologies.

Possible Futures

With so many options on the table, it is understandably difficult for shipowners to know what the best solutions are for them and where to invest their money. Building on and updating our GHG Pathway model, the report presents four exploratory scenarios for achieving decarbonization: biofuels and onboard carbon capture, methanol, ammonia, and hydrogen. The report investigates the conditions under which the uptake of these different fuel types and technologies will accelerate toward 2050.

No single scenario dominates, and it is likely that the future energy mix will comprise a diversity of fuels and technologies. However the future unfolds, the cost of decarbonization will be high, including a potential doubling of the cost of transport for container shipping by 2050, compared to a business-as-usual scenario. This will have to be passed along the value chain, bringing the realities of maritime decarbonization all the way to

the households of end-consumers.

Shipping's Greatest Challenge

Decarbonization is probably the greatest challenge ever facing the maritime industry. Goals have been set, but the road ahead is full of uncertainty, and there is no guarantee of success.

Nonetheless, the pioneering spirit of shipping is alive and well, and no stone will be left unturned as we embark on this great transition. **ST**

Review&Forecast

Offshore Energy Is Critical to American Economic, Environmental Leadership

By Erik Milito

President

National Ocean Industries Association (NOIA)

Amid sensational headlines, election hyperbole and some questionable policy decisions from Washington, D.C., the U.S. offshore energy sector remains resilient. This vital industry not only powers our nation with reliable energy but also supports hundreds of thousands of jobs across all 50 states and strengthens national security. From the Gulf of Mexico to the burgeoning offshore wind farms along the East Coast to the potential of carbon sequestration, hydrogen, critical minerals, and other emerging energy segments, the resilience and innovation of this sector are crucial for driving economic growth and ensuring our nation's energy security.

The Gulf of Mexico has long been a cornerstone of U.S. offshore oil and gas production, producing nearly 2 million barrels of oil per day with a small footprint. Last year's decisions from Washington may have cast a shadow over the region, but 2025 offers a bright outlook.

This past year marked the first since 1958 without an offshore oil and gas lease sale in the Gulf of Mexico. Only three lease sales are scheduled over the next five years. These policy decisions are inconceivable given the Gulf's role as a wellspring of stable, affordable, and lower-carbon energy that drives economic growth and generates billions in government revenues.

Moreover, litigation has clouded the Gulf of Mexico. The recent ruling by the U.S. District Court for the District of Maryland, siding with environmental activists against



“As the U.S. moves past the elections, it is crucial for Congress and the White House to quickly align on advancing an all-of-the-above offshore energy policy if the U.S. wants to continue to be an energy leader.”

the National Marine Fisheries Service Gulf of Mexico Biological Opinion (BiOp), demonstrates the uncertainty of the regulatory and permitting process. Without an active BiOp, nearly every permit or plan could be adversely impacted. While the court has granted a reprieve, it has become clear that changes are needed in our laws and regulations to shield against continued arbitrary disruptions to energy projects in the Gulf of Mexico and elsewhere.

Originally, the judge set a vacatur of the BiOp for December 20, 2024—a time frame that both industry and the federal government agreed was infeasible and would potentially lead to a bottleneck of almost every oil and gas permit in the Gulf of Mexico. Such a decision could open the door to an unpredictable regulatory environment, deterring investment and jeopardizing economic growth, tax revenues, and jobs.

After dozens of companies and several federal agencies provided declarations to the court, explicitly expressing how a December vacatur would severely impact their operations, the court granted a remedy and delayed the vacatur until May 2025.

Thankfully, the Gulf of Mexico will not be starting the new year with a permitting logjam.

Industry is also closely watching the anticipated December 2024 release of the expanded Rice's whale critical habitat. At the time of writing, based upon the government's proposal, the new habitat designation is expected to be significantly expanded through an effort that leaned heavily on incomplete science. Fixing this issue should be a major priority for Congress and the incoming administration.

Without a solution, the designation could reintroduce mitigation measures that harm energy, industrial, commercial and every marine activity in the Gulf of Mexico without providing effective protection for the whales. Potential restrictions could impact ships bringing fuel to Florida's Gulf Coast, cargo ships from Houston, and food exports from the Mississippi, disrupting vital supply chains and economic activities.

Despite these challenges, the Gulf of Mexico continues to innovate and produce the energy that fuels society. New projects in the deepwater Gulf are advancing with groundbreaking techniques. Chevron's Anchor project, which achieved its first oil in August 2024, exemplifies the industry's commitment to innovation, safety and efficiency. As the first deepwater high-pressure development to begin production, Anchor uses 20,000-psi subsea technology to tap into reservoirs at depths of 34,000 ft.

This achievement required the collaboration of numer-

ous companies. For instance, Chevron contracted Transocean's newly built *Deepwater Titan*, an eighth-generation drillship, to drill and complete the project's subsea high-pressure production wells. The *Deepwater Titan* and its sister ship are the first rigs in the world equipped with a 1,700-ton hoisting system, a 20,000-psi well control system and a 10,000-psi mud system.

Other frontier high-pressure, high-temperature projects, including Beacon Offshore Energy's Shenandoah project and bp's Kaskida project, are poised to follow and build upon the Gulf region's impressive resilience and status as a premier global energy basin.

There has also been progress in developing new offshore wind projects in the U.S. The South Fork Wind project, a joint venture between Ørsted and Skyborn Renewables, is New York's first offshore wind farm and the first commercial-scale offshore wind farm in federal waters. With 12 turbines generating 132 MW of renewable energy, South Fork Wind will power approximately 70,000 homes.

Other offshore wind projects are not far behind, which is great news for local onshore residents and workers throughout the nation. While the power generated from offshore wind projects may be local, the economic significance, including the supply chain, has a national footprint. States such as Louisiana, Texas, North Carolina, and Florida have already realized jobs and investments from supporting offshore wind projects.

Consider the *ECO Edison*, the first-ever American-built, owned and crewed offshore wind service operations vessel, constructed by Edison Chouest. This vessel will play a pivotal role in the operation and maintenance of wind farms, serving as a base for technicians and equipment. Built by more than 600 workers across shipyards in Louisiana, Mississippi and Florida, and sourcing components from 34 states, the *ECO Edison* exemplifies the significant financial investments and collaborative efforts driving the U.S. offshore wind industry forward.

Furthermore, there is a pipeline from the offshore wind industry of more than \$4 billion in proposed investments to ports, manufacturing, vessels, workforce development and research.

As the U.S. moves past the elections, it is crucial for Congress and the White House to quickly align on advancing an all-of-the-above offshore energy policy if the U.S. wants to continue to be an energy leader. One example of such alignment could be the pursuit of policies to mandate offshore oil and gas lease sales. This would create certainty for investment and pave the way for new

American energy projects, thereby reducing reliance upon antagonistic energy suppliers, such as Russia and Iran, in the global marketplace.

Ensuring a stable and predictable regulatory environment and regular access to new energy opportunities through lease sales are essential for attracting the investments needed to maintain and expand our offshore energy capabilities.

Offshore oil and gas and renewable energy projects offer significant benefits, including job creation, energy security, and environmental stewardship and conservation. By seizing this moment, policymakers can drive forward the innovation and investment required to keep the U.S. at the forefront of global energy leadership. **ST**

Review&Forecast

The World Currently Lacks the Ability To Govern Deep-Sea Mining

By Julian Jackson
Seabed Mining Project Director
The Pew Charitable Trusts

Despite continued negotiations in 2024, the regulatory framework meant to govern commercial-scale deep-sea mining is still years from being finalized by members of the International Seabed Authority (ISA), the United Nations-affiliated body tasked with governing the mineral resources of the ocean floor in international waters. And because of a legal loophole in the United Nations Convention on the Law of the Sea, it is possible that the ISA could provisionally approve a submitted mining application even in the absence of regulations. This might cause irreversible damage to the seabed and threaten both the greater marine ecosystem and Earth's vital systems.

Although the ISA has been negotiating the framework for a number of years, numerous gaps in the regulations remain, including many documented in a study that The Pew Charitable Trusts co-authored in *Marine Policy* in 2024 (www.sciencedirect.com/science/article/pii/S0308597X23005006). These gaps include fundamental issues, such as lack of agreement on environmental baseline data requirements; what constitutes permissible environmental harm; compliance, monitoring and enforcement mechanisms; how to address underwater cultural heritage; and insurance and liability requirements.

The negotiators also have not yet considered a significant number of subsidiary instruments, or complementary rules, that are required to accompany the main regulations and would govern important topics such as

environmental impact assessments, emergency response and contingency plans, and toxic substances.

One particularly troubling gap is the lack of agreed-upon limits on hazardous mining impacts, which include sediment plumes, noise and light pollution. For example, mining equipment on the seafloor may generate clouds of debris, and as mined material is pumped to the surface and metals and minerals are filtered out, the unwanted sediment and waste are expected to be dumped back into the ocean. These plumes could travel thousands of kilometers from the mining site and have potentially devastating effects on deep-sea ecosystems. Among the potential hazards of plumes is the spread of toxic chemicals, polluting large swaths of ocean at the seabed and throughout the water column. Failing to set standards and limits for the kinds of sediments and waste that can be permissibly returned to the ocean, and when and at what depth this disposal is allowed to occur, is a fundamental gap in the environmental management regime for seabed mining.

Similarly, lack of noise restrictions could harm deep-sea species and wider ocean ecosystems. Recent research supported by Pew and published in July 2022 in *Science* (www.science.org/doi/10.1126/science.abo2804) found that a single deep-sea mining operation could produce noise extending hundreds of kilometers, dramatically increasing the environmental footprint of mining—and potentially affecting the ability of marine creatures to use sound to navigate, communicate, find mating partners, locate food, and detect predators and other dangers.

A small ISA working group has only recently started to develop thresholds to limit levels of toxicity, turbidity and settling of resuspended sediments, as well as underwater noise and light pollution. However, limits for other impacts of mining, such as habitat removal, have yet to be considered.

Deep-sea mining companies are not the only parties with an interest in the seabed. But there is no mechanism in place to foster coordination between mining companies and other users of the seabed, such as the owners of undersea internet cables. That means there is currently no clear path for other stakeholders, including industries that operate in the same areas, to raise concerns about proposed mining plans—and no clarity on what recourse they would have if their concerns are not addressed. Similarly, there is no framework for how these stakeholders could participate in the ISA's decision making around environmental planning.

Deep-sea mining could have consequences beyond destroying and polluting habitat for marine life. Given the likely vast spatial and temporal scales of its detrimental impacts, there is potential for substantial effects on carbon storage and carbon cycling in the deep ocean, as well as on other ecosystem services, such as vital fisheries.

An increasing number of governments, scientists, and organizations are raising concerns about the potential



harm that deep-sea mining would cause and are urging caution. During the ISA's meetings in summer 2024, five more countries committed to a precautionary pause or moratorium on large-scale, commercial deep-sea mining, bringing to 32 the number of countries that agreed with this position in the past two years.

There are also companies that favor a moratorium on seabed mining. For example, automakers such as BMW and Rivian have said they will not use materials harvested from the deep sea to create batteries for electric vehicles—one of the main uses promoted by prospective miners. Tech companies, such as Apple and Google, also support a moratorium. And more and more investors, insurers and re-insurers have expressed significant concerns about deep-sea mining, threatening the industry's viability. That includes Deutsche Bank, which, in September 2024, updated its ocean-related policies and joined 15 other financial institutions in saying it will not directly finance deep-sea mining projects.

The ISA's last negotiating session ended in August 2024, and debate is slated to resume in March 2025. With so many gaps in the regulatory framework remaining, it is difficult to see a path toward completing these negotiations anytime soon.

As many questions remain, it would be irresponsible to allow a commercial deep-sea mining application to move forward. It is imperative that member countries at the ISA heed these concerns and establish a precautionary pause or moratorium on seabed mining before one of Earth's most pristine and fragile ecosystems is opened to a new extractive industry clouded by uncertainty. **ST**

Review&Forecast

Optimizing Big Data, Tech and AI To Tackle Major Environmental Problems

*By Professor Icarus Allen
Chief Executive
Plymouth Marine Laboratory and PML Applications*

This past year has been another exciting and productive one for Plymouth Marine Laboratory (PML), with significant advancements using, and optimizing, the latest technological developments as part of our quest to better understand the ocean and all it provides to society.

Climate change is clearly one of the biggest challenges currently facing the world. The reduction of carbon emissions remains paramount, and there has been a recent flurry of interest around the development of approaches to remove atmospheric carbon dioxide via the marine environment and its chemical and biological processes.

To ensure these initiatives truly achieve

what is intended without causing negative impacts on the environment, society or the economy, it is crucial that any proposed projects, such as those relating to ocean carbon dioxide removal (oCDR), are properly and robustly monitored and evaluated. Scientists at PML have been working on a number of projects to do just that.

The SeaCURE project, a collaboration between PML, University of Exeter, Brunel University and the SEA LIFE Centre in Weymouth, U.K., is building a pilot plant that could pave the way for large-scale, ocean-based removal of CO₂. The SeaCURE system, which is due to be operational in early 2025, removes CO₂ from piped-in seawater, then releases that seawater back to the ocean, where it naturally replenishes the lost CO₂ by effectively “sucking” carbon from the atmosphere.

In another first-of-its-kind study, scientists from PML and PML Applications provided independent monitoring and analysis of a pilot oCDR trial by Planetary Technologies in St Ives Bay, U.K. This study involved adding magnesium hydroxide to wastewater before releasing the wastewater into the sea, where natural chemical processes reduced the concentration of CO₂ in the released water, thereby increasing the water's capacity to absorb CO₂ from the air. The monitoring, reporting, and verification performed by PML for the study provides strong evidence that oCDR is a viable approach to actively remove CO₂ from the atmosphere and help combat climate change: <https://pml.ac.uk/news/q-a-and-video-on-the-ocean-alkalinity-enhancement>.

Another aspect that is important in tackling climate change is offshore renewable energy. In 2024, PML scientists led or were involved with numerous research projects exploring the impact of wind farm developments on marine life and ecosystems. One such study showed that during construction, impacts were predominantly negative, whereas, once operational, the impacts were more balanced, depending on the site conditions. The conditions of the site also played a significant role in what would be the least detrimental approach for decommissioning: <https://pml.ac.uk/news/focus-on-offshore-wind>.

Broadening the scope to wider environmental issues, PML scientists have been fully embracing the recent advancements in artificial intelligence (AI) to facilitate environmental research and application. AI algorithms have been trained to detect the invasive Pacific oyster along U.K. shorelines and floating plastic litter on the sea surface from drone footage, potentially providing a new fast, cost-effective and simple monitoring capability.

AI is also being used in the identification of plankton, through a cutting-edge, in-water imaging system that, when combined with machine learning, can be used to rapidly identify and classify plankton species present in the water without the need for manual analysis. The high-frequency data produced help scientists to understand the changes that are occurring in our marine environment on a much finer scale.





This identification approach is also being used to detect harmful algal blooms (HABs), which can have a significant negative impact upon environmental and human health, as well as the economy through reduced productivity and income in the marine sector. PML has studied algal blooms for decades by looking for color signatures in satellite images. Now with AI, the team can build more complex models incorporating other data, such as temperature, chlorophyll levels and turbidity, to help detect different species and predict when and where a HAB may occur. Improving HAB predictive capability could provide seafood farmers early warning of encroaching blooms, potentially giving them time to respond to save stock: <https://pml.ac.uk/news/how-is-pml-using-ai-new-video-and-q-a-with-pml-s-a>.

Another issue where progress has been made this year is that of balancing the needs of multiple marine users. The marine environment provides an extensive range of benefits to society, including food, transport, energy, waste processing, recreation and beneficial environmental processes that require protection. Managing the often conflicting demands of users of the marine environment in a changing climate requires a new approach, and PML scientists have proposed a novel framework for Climate-Smart Marine Spatial Planning (CSMSP).

The PML-led Marine Spatial Planning Addressing Climate Effects (MSPACE) project, in collaboration with the Marine Climate Change Impacts Partnership, published an “early warning system” report, based on CSMSP and incorporating an advanced modeling analysis. This analysis shows where and for how long marine conservation, fisheries and aquaculture could be best supported across U.K. seas. Creating new, climate-adaptive management strategies for marine ecosystems and the various economic sectors reliant on them is vital in order to harness opportunities for effective marine conservation and

economic growth in the long term. MSPACE has been successful in securing additional funding to work more closely with potential end-users within the marine spatial planning sector and the U.K.’s overseas territories: <https://pml.ac.uk/news/new-study-provides-vital-insight-for-climate-smart>.

Diving deeper, PML and Seabed 2030, which seeks to inspire the complete mapping of the global ocean by 2030, signed a memorandum of understanding, recognizing shared endeavors, particularly in ocean bathymetry research, and supporting the UN Ocean Decade. The agreement will see closer collaboration in areas such as joint engagement with the wider geospatial, hydro-spatial, and technology innovation community and the sharing of data.

In Plymouth, identified as Britain’s Ocean City, further exciting developments in the marine R&D sector have been achieved. As part of the National Centre for Coastal Autonomy, a unique proving ground for marine businesses to test, trial, prototype and commercialize new products and services has been enhanced with a new underwater communications network. The Smart Sound Connect Subsurface network, in which PML is a key partner, will integrate into the existing surface networks to deliver a fully connected environment. It combines underwater, surface and aerial platforms to create unrivaled opportunities for research that will advance our understanding of the ocean.

Looking forward to 2025, PML will continue its developmental autonomy and AI work, aiming to deploy the full suite of automatic imaging devices alongside new cutting-edge marine monitoring equipment at sea by the spring. This will likely be the most comprehensive and advanced marine monitoring network in the world, helping to maintain PML and Plymouth’s global reputation as a leading force in marine science. **ST**

Review&Forecast

Advancing Ocean Tech for Sustainability

By Nora von Xylander
Marine Biodiversity and Sustainability Scientist
Tunley Environmental

Innovations in ocean tech supported key advancements in 2024 to sustainably manage our oceans. Developing technologies include acoustic monitoring for marine mammal protection and seaweed farming as a natural method to mitigate climate change.

Ocean Energy and Marine Mammal Protection

The push for marine renewable energy is vital to reduce reliance on fossil fuels and combat climate change. Innovative tech designs, including those for floating wind farms and tidal turbines, are being developed to reduce ecological disruption, maximize energy efficiency and foster sustainable coastal economies.

For example, the Sea Mammal Research Unit (SMRU) at the University of St. Andrews has been instrumental in advancing marine research to assess the impacts of renewable energy structures on marine mammals. This ensures that the transition to cleaner energy remains aligned with marine conservation goals.

Marine mammals rely on vocalizations to communicate, navigate and locate prey through water. SMRU Instrumentation's specialized tagging systems and open-source software for underwater sound monitoring, known as PAMGuard, enable real-time tracking of marine mammal movements and habitat needs, thus providing insight into the potential environmental impacts of marine renewable energy technologies (www.smru.st-andrews.ac.uk/Instrumentation/Overview).

The likelihood of collision between marine mammals and renewable energy infrastructure such as tidal turbines has led SMRU to innovate multibeam sonar systems. The sonar, along with the deployment of ultrasonic hydrophone arrays, has demonstrated the ability to detect and track marine mammals in 3D near tidal turbines. The systems, which the U.K. government will use for conservation, could reduce potential hazards from renewable energy structures and inform policy development for renewable energy expansion.

Passive acoustic monitoring (PAM) is now being used with artificial intelligence (AI) to identify species-specific acoustic signals, such as those from bottlenose dolphins and killer whales (www.pamguard.org). PAM technologies range from hydrophones towed behind boats to stationary recorders on the seafloor to more recent advancements using distributed acoustic sensing along existing underwater fiber-optic cables to detect whales, shipping noise, or seismic activity.

It is the hope of the researchers that temporary shutdowns in offshore energy operations informed by PAM and multibeam sonar systems could reduce negative impacts on marine mammals, similar to how enforced vessel slowdowns in protected areas have reduced vessel collisions with and harmful noise impacts on marine mammals.

Sustainable Fishing, Aquaculture

Smart fishing gear and non-lethal acoustic deterrent devices for aquaculture are being developed to support sustainable practices.

As entanglement in fishing nets remains a leading cause of mortality for small cetaceans, smart fishing gear with the ability to track marine mammals using PAM technology is showing promise to minimize bycatch.

In the aquaculture industry, Genus-Wave's Targeted Acoustic Startle Technology (TAST) is emerging as a potential alternative to traditional acoustic deterrent devices (ADD) to prevent predation (<https://genuswave.com>). Unlike ADDs, TAST, a PAM technology, does not cause hearing damage in marine mammals. It records vocalizing cetaceans, the natural sounds of other marine life, and human-made noises



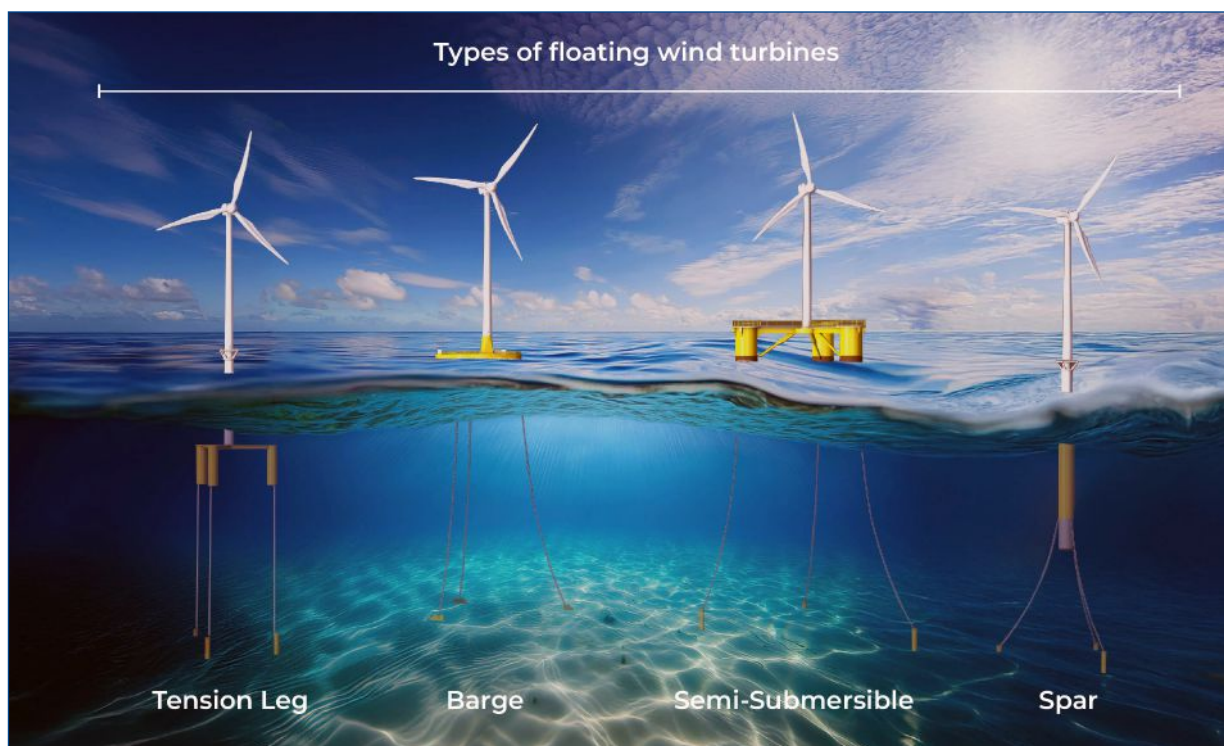
“As a natural solution to climate change, initiatives such as regenerative seaweed farming are gaining traction globally, with new technologies showing promise for enhancing scalability and efficiency.”

from shipping and industrial activities, which provides a holistic soundscape to allow for environmental monitoring.

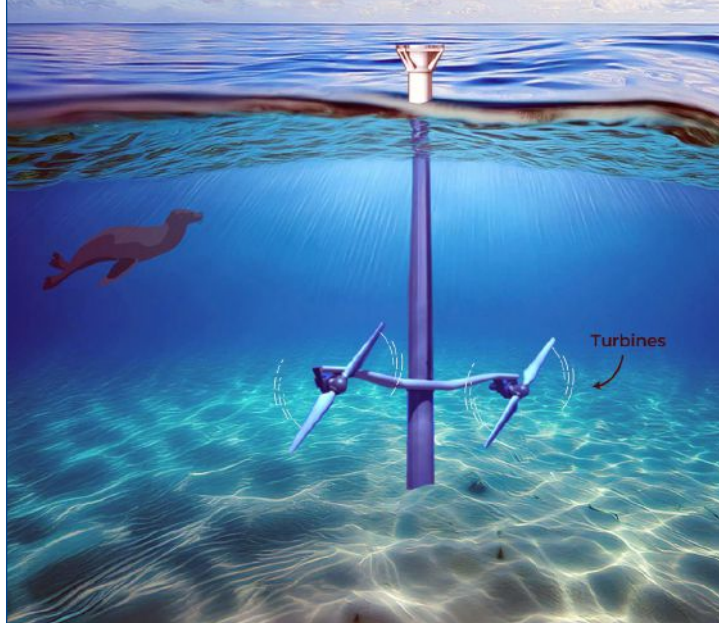
As we move into 2025, integrating AI-driven analysis with expanding PAM capabilities is a promising path forward for more sustainable industry practices that align with international goals for resilient ocean ecosystems.

Blue Carbon Technologies

Coastal marine habitats such as kelp forests and seagrass beds play key roles in carbon sequestration, provide substantial potential for reducing atmospheric CO₂, and contribute to nutrient cycling and support for marine biodiversity. As a natural solution to climate change, ini-



As floating wind turbines and tidal turbines tap into marine renewable energy, protecting the surrounding marine life must be considered for sustainable operations.



automated seeding and harvesting capability. By using the Norwegian company Arctic Seaweed's innovative maritime farming technology (<https://aseaweed.com>), Algapelago aims to answer critical questions about the scalability, impacts, and natural capital value of regenerative ocean farming over four years with the simultaneous cultivation of mussels and kelp at scale.

"We are excited to deploy this new rig, as it will accelerate the development of the Blue Forest initiative," said Algapelago's co-founder and ocean adventurer Olly Hicks. "This effort will help establish strong future credit markets, promote ecological improvements and create large-scale opportunities within the blue economy."

As we look ahead into 2025, regenerative seaweed farming is expected to expand, helping create resilient marine environments that contribute positively to the blue economy and global climate goals.

Conclusion

The intersection of sustainability science and ocean technology has the potential to reshape marine conservation with innovation. By investing in these technologies and fostering collaborative approaches, we can build resilient marine ecosystems that support biodiversity, climate stability and sustainable resource use. The achievements of 2024 illustrate what is possible when interdisciplinary science meets visionary technology, setting the stage for an even more impactful 2025.

References

For a list of references, contact: catherinefoister@tunley-environmental.com. **ST**

tiatives such as regenerative seaweed farming are gaining traction globally, with new technologies showing promise for enhancing scalability and efficiency.

Algapelago is a seaweed farming company that plans for a project in June 2025 in North Devon, England, with a production potential of up to 40 fresh tonnes of kelp (www.algapelago.com). It is uniquely engineered for high energy conditions and offshore scaling, with

Review&Forecast

The State of Ocean Plastics

By Carl Nettleton
Founder
OpenOceans Global

Plastic, from lost fishing gear and land-based sources, significantly impacts the marine environment. Plastic production, waste and leakage into the ocean are expected to double, even triple, in the coming decades, with 11 million metric tons now reaching the ocean annually.

Emerging news about impacts on human health has raised new concerns, with findings that microplastics are seemingly everywhere in our bodies, food and water, and that many plastics contain toxic chemicals. More than 16,000 types of chemicals have been found in plastic, many untested for toxicity. More than 4,200 plastic chemicals are of concern because they are persistent, mobile, toxic and/or bioaccumulate.

One key misperception has disempowered the public from coalescing to find solutions: the belief that most ocean plastic has accumulated into an “island” in the northern Pacific the size of Texas. This is not accurate: 75 percent of ocean plastic is actually on beaches or other shorelines, and most of the rest is in coastal waters.

Technology plays an important role in addressing ocean plastic pollution. An estimated 640,000 metric tons of fishing gear is lost or discarded in the ocean annually, including lines, buoys, nets, pots, traps and floats. Much of it is constructed from plastic. In addition to trashing shorelines, particularly those of island nations, ghost fishing by lost gear has long been a problem. One new technology alerts fishers when a fishing line detaches from its buoy or submerges deeper than intended. The alert allows the equipment to be retrieved before it is lost. Other technologies can track fishing gear by satellite after it is lost.

Rivers bring the majority of plastic to the ocean. The Ocean Cleanup nonprofit has had early success capturing plastic in rivers using its Interceptor technology. The Interceptor is a boom extending across large rivers. The river's flow guides plastic trash along the boom to a barge, where a conveyor belt and shuttle distribute the debris across six dumpsters. When the dumpsters are almost full, it sends a text message to the operator, who moves the barge to a dock, empties the dumpsters, sends the debris to waste management facilities, and returns the barge to the Interceptor.

The Ocean Cleanup has three other technologies deployed in rivers: a smaller unit tending a trash boom, a standalone barrier to capture plastic coming down smaller rivers, and a barrier specifically suited for shallow waters.

Several other plastic barrier technologies have also been developed. A group in Indonesia called Sungai Watch is regularly cleaning 100 rivers by deploying its custom booms in conjunction with teams of workers. The group has expanded its activities to train villagers to stop throwing plastic into local rivers, giving them other options for disposal. A Dutch company makes bubble curtains that stop trash from flowing downriver in slow-moving waters.

Drifters are being deployed that simulate how plastic debris moves across the ocean to identify sources of plastic geographically. ROVs and AUVs are used to conduct surveys to find debris in the water column or on the seabed. Both remotely operated and autonomous equipment are being used to scoop up floating plastic debris in coastal waters.

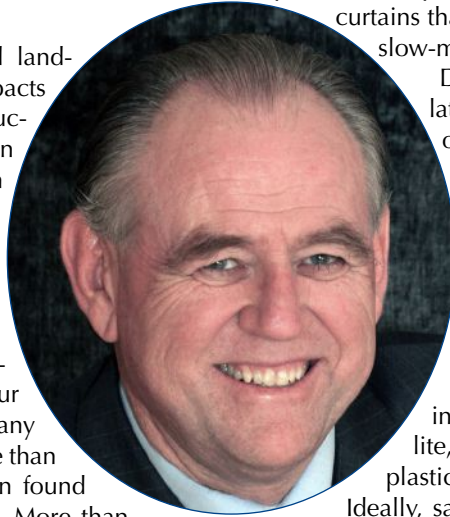
Finding plastic hotspots is becoming a priority. Remote sensing by satellite, airplane, and drone is used to locate plastic on shorelines and in ocean waters.

Ideally, satellites could provide a global assessment of the status of plastic along coasts and on surface waters, but satellite imagery still lacks the resolution to identify plastic debris such as soda bottles and wrappers. Hyperspectral imaging using drones thus plays a role in mapping the extent and concentration of microplastic pollution.

Even when accumulations of plastic are found, the challenge of disposal remains. There are only three options: landfilling, incineration and recycling. Many small, low-lying nations don't have suitable locations for landfills. Environmental groups frown upon incineration, but many residents living on islands or in developing countries have little or no access to waste management collection or landfills. They often resort to open burning or dumping plastic into rivers. Recycling is a growing option, but with less than 10 percent of plastic recycled globally, the infrastructure to improve recycling rates will not expand quickly enough to make much of a difference in the near future. Chemical recycling, a process to break down plastic into raw materials for new products, is being explored but is strongly opposed by environmental groups.

In March 2022, the United Nations Environment Assembly adopted a historic resolution to develop an international legally binding treaty on plastic pollution, including in the marine environment. It requested the UN Environment Programme to convene an Intergovernmental Negotiating Committee (INC) to develop a treaty to address the full life cycle of plastic, including its design, production and disposal. After a rocky start, with little progress in the first three sessions, the INC completed the actual text to start treaty negotiations.

The fifth and final negotiating session concluded in December 2024 with no agreement, other than to meet again in the summer of 2025. The primary obstacle was whether to include caps on plastic production. Oil-pro-



ducing countries, led by Saudi Arabia and including Iran, Russia and other Gulf states, oppose caps. The U.S. took a neutral stance.

If the treaty is finally adopted, its substantive elements will likely address chemicals of concern, problematic product design and financing to implement the treaty. The most important element of the treaty will likely be a framework, as with the Paris Climate Agreement, that calls for an annual gathering of the participating countries to assess new science and make incremental changes in the agreement.

It remains to be seen if and how the global plastics treaty will take shape. **ST**

Review&Forecast

More Accurate Climate Models To Prepare for Escalating Heat Events

By Cosimo Enrico Carniel

Master's Student

ETH Zürich Institute for Atmospheric and Climate Science

Extrême heat events, characterized by prolonged periods of unusually high temperatures, are emerging as one of the most pressing consequences of climate change. These events, which pose significant threats to human health, ecosystems and infrastructure, including military ones, have garnered increasing attention, particularly as their frequency and intensity escalate. Such extreme heat events are particularly dangerous in regions where populations are highly vulnerable to heat stress and the associated health risks, such as India, Pakistan and the Southern Mediterranean Basin. In regions where military tensions are at stake, such phenomena affect the functionality of equipment on land, reducing aircraft performance, limiting payload capacities, and disrupting naval systems by increasing maintenance needs or lowering operational efficiency. No area is truly safe when extreme events occur, as shown by the 2003 European heat wave that tragically claimed more than 70,000 lives, making it one of the deadliest in recent history.

Over the past few decades, research has highlighted a significant upward trend in the occurrence of extreme heat across various regions. For instance, in the Mediterranean region, under an intermediate emissions scenario, heat waves are projected to extend 27 to 67 days per summer by the end of the century, a dramatic increase compared to the mid-21st century, when this value was estimated at 6 to 24 days. Such projections are alarming, especially considering the severe health risks associat-

ed with them. Indeed, human tolerance to heat, already challenged by global warming, is further compromised when both temperature and humidity rise simultaneously. This is particularly concerning in regions where access to air conditioning and other cooling measures is limited, and where public health infrastructures may not be equipped to handle large-scale heat emergencies.

In addition to direct impacts on human health, extreme heat events also exacerbate environmental hazards, such as wildfires. Heat waves can lower the moisture content in plants and soils. Coupled with drought conditions, this creates ideal conditions for wildfires to start and spread rapidly. These fires release massive amounts of carbon dioxide into the atmosphere, further contributing to climate change and amplifying the feedback loop of warming temperatures and more frequent extreme heat events.

One of the key innovations in the study of extreme heat events is the use of wet bulb temperature (TW) or wet bulb globe temperature (WBGT) as a useful indicator for alert thresholds. TW combines temperature and humidity, while WBGT takes into account radiation and wind speed to provide a more accurate measure of human heat stress. Many studies highlight 35° C TW as the threshold at which human survival becomes impossible due to the failure of natural cooling mechanisms such as sweating. However, research increasingly shows that true risk to life begins at much lower TW values. In certain contexts, for example, in the military, strenuous activity is restricted when TW reaches around 31° C, and soldiers need to follow strict hydration and rest protocols. This makes the assessment of TW (or WBGT) vital for evaluating the impact of extreme heat events, particularly in regions with high humidity.

Next-Generation Models And the Role of SRMs

Traditional climate models have been instrumental in identifying broad trends in global and regional climate patterns, but they are limited when applied to localized extreme weather events. Advances in climate modeling now offer new opportunities to quantify changes in extreme heat events. At the forefront of these advancements are the storm-resolving models (SRMs), which operate at high spatial resolutions (between 2 and 10 km). These models capture small-scale atmospheric and oceanic processes critical for understanding extreme weather, including local manifestation of heat events. SRMs, coupled with high-resolution oceanic models, represent a significant leap forward from traditional climate models, which often miss localized coastal and atmospheric phenomena that contribute to extreme heat dynamics. SRMs can potentially better capture complex interactions such as sea breeze circulation, convective processes, land-sea temperature contrasts, mesoscale ocean eddies and sea ice dynamics, which are critical for understanding heat waves, particularly in coastal and topographically complex regions.





For instance, in coastal areas, the interaction between land and sea can significantly influence temperature extremes, with processes such as coastal upwelling and sea breeze circulation playing crucial roles. SRMs are better equipped to capture these dynamics, making them invaluable tools for studying extreme heat in these regions.

To address these challenges the Next Generation Earth Modelling Systems (nextGEMS), a European Union Horizon 2020 initiative, has developed two storm-resolving, fully coupled Earth system models. The goal of these models is to provide climate services through the Climate Change Adaptation Digital Twin developed in the EU's Destination Earth initiative (DestinE). By leveraging these models, the nextGEMS project aims to improve our understanding of the physical processes driving extreme heat events while addressing persistent biases in conventional Earth system models.

As of March 2024, nextGEMS has produced 30-year climate projection simulations at kilometer scales, and a Hackathon, where the produced simulations are carefully examined by several groups of scientists, is scheduled for March 2025.

The evaluation of these models through the integration of observational data and reanalysis products is now the critical step. Reanalysis data, such as provided by the ERA5 data set, offer a comprehensive historical record of atmospheric and surface conditions and serve as a reference for evaluating model performance in simulating extreme heat. Observational data from weather stations also provide essential validation of model outputs. The combination of model simulations, reanalysis data, and observational records enables researchers to assess how well models capture the frequency, intensity, and spatial distribution of extreme heat events.

The Future of Extreme Heat Modeling

While significant progress has been made in developing next-generation climate models, much work remains to predict extreme heat events at the needed spatial and temporal resolutions. Further research is necessary to improve the representation of key physical processes in these models, especially concerning land-sea interactions, convective processes and regional topography—all of which are crucial for understanding heat wave development.

Enhancing the resolution of models, particularly for long-term projections, is essential to accurately predict future occurrences of extreme heat under different climate scenarios. In this context, artificial intelligence (AI) offers a powerful approach to advance our understanding of extreme heat events. AI tools can analyze vast amounts of data quickly and identify patterns that may not be immediately apparent through traditional methods. Machine learning algorithms, for instance, can be trained to recognize precursors to extreme heat events by integrating observational data, reanalysis products and model outputs.

AI-driven approaches can also improve the accuracy of predictions in regions with complex terrain or sparse observational data. These approaches can also assist in directly simulating climate processes at the local level. This enhanced precision will offer policymakers and planners more actionable information to mitigate the impacts of extreme heat.

By improving our ability to predict extreme heat events, we can develop better tools to prepare for the impacts of climate change, particularly in regions with an urgent need for adaptation strategies and in support of timely and effective military operations. **ST**

Navigation Assistance System AiP

ClassNK has issued an approval in principle (AiP) for the Autonomous Navigation Assistance System (SAS) developed by Samsung Heavy Industries Co. Ltd. SAS is partially autonomous, including the functions of situational awareness through sensor fusion and electronic navigational chart information, collision and grounding risk assessment, and collision and grounding avoidance.

New Partners for Seabed 2030

The Nippon Foundation-GEBCO Seabed 2030 Project has a new partnership with Geoscience Australia, an Australian government organization dedicated to geoscientific research, for Seabed 2030's goal of accelerating ocean floor mapping by the end of the decade.

Geoscience Australia will play an active role in supporting Seabed 2030's mission by contributing vital bathymetric data to further enhance the global understanding of the seafloor. A key component of this collaboration is the AusSeabed initiative, a national seabed mapping collaboration that coordinates and publishes seabed mapping data from across the Australian region.

Seabed 2030 has also established new partnerships with Hexagon, a specialist in digital reality solutions combining sensor, software, and autonomous technologies, and Revelare Hydrospatial, a specialist in hydrographic and geophysical surveys.

Seabed 2030 aims to create a seamless digital map of the world's ocean floor as the freely available GEBCO Ocean Map. The project is formally endorsed as a Decade Action of the UN Ocean Decade.

Type Approval for Graphene Hull Coating

Lloyd's Register (LR) has awarded the maritime industry's first enhanced antifouling type approval to GIT Coatings for its XGIT-Fuel graphene-based hull coating.

The development of this new type of approval sets a new standard for antifouling coatings to address the growing need for effective biofouling management, which contributes to decarbonization efforts and protection of marine ecosystems.

LR is the first classification society to offer this service, which provides shipowners and operators with validated assurance for antifouling coatings' performance in relation to hull cleanliness and smoothness, pre- and post-grooming operations. Grooming is the periodical removal of microfouling (slime) to prevent the development of macrofouling.

Vessel Upgrade for Compliance

TDI-Brooks is upgrading the diesel engines on the RV *Brooks McCall* to ensure compliance with the regulations the California Air Resources Board (CARB) has set forth. *Brooks McCall* is a Jones Act-complaint multi-use vessel suited for various comprehensive site investigation surveys and research duties. Plans are underway to deploy the vessel along the U.S. West Coast in May/June

2025 to provide TDI-Brooks' geotechnical expertise to multiple offshore wind developers.

Collaboration for Remotely Operated MCM

CUBEDIN A/S and Forcys will collaborate to advance modular mine countermeasure (MCM) capabilities under a newly signed memorandum of understanding. The companies will integrate Forcys sister company EIVA-designed MCM-in-a-box remotely operated towed vehicle (ROTV) systems into CUBEDIN's modular platform. The CUBEDIN Gateway is a real-time digital interface and data translator that will ensure the Forcys MCM-in-a-box can operate as an integral, ship-compatible module.

This will enhance navies' operational flexibility in MCM; rapid environmental assessment; and intelligence, surveillance and reconnaissance missions.

DNV Spin Out Attracts Investment

Ofiniti, formally known as FuelBoss, a platform for managing marine fuel bunkering operations, has attracted investment from private and venture capital investors as part of its successful spin out from DNV. With port authorities stepping up their requirements for "digital bunkering," the new corporate structure will enhance agility.

This marks a significant milestone for DNV Ventures, which has a mandate to invest in and nurture digital-first companies that are fast growing and disruptive in their sector. DNV remains the largest shareholder of Ofiniti, with new investment led by a Nordic family fund and Singapore-based venture capital firm ShipsFocus.

Support for Decarbonization Design

The MarineShift360 project is driving sustainable innovation with enhancements to its pioneering life-cycle assessment (LCA) tool and the introduction of an impact accelerator and a university outreach program to advance the marine industry's transition to net zero.

Led by Marine Futures and supported by 11th Hour Racing, MarineShift360 is designed to deliver measurable impact and fast-track decarbonization across the sector.

With an estimated 80 percent of a product's environmental impact determined in the design phase, the MarineShift360 tool helps businesses identify and address their impact hotspots early, reducing their environmental footprint and operational costs through more efficient resource use.

The accelerator will offer selected companies free consultancy for one year to develop and scale sustainability projects that will support the industry's transition to net zero.

The university outreach program will offer students from undergraduate to Ph.D. levels free access to the LCA tool, alongside dedicated training and support.

Trilateral Cooperation for Icebreakers

Canada, Finland and the U.S. have created the Icebreaker Collaboration Effort (ICE Pact) to produce polar icebreakers and other regional capabilities. This collaboration intends to strengthen each partner nation's ship-

building industry and industrial capacity. It also aims to build closer security and economic ties via information exchange and mutual workforce development.

Unmanned Survey Solutions Rebrands

Uncrewed Survey Solutions (USS), formerly Unmanned Survey Solutions, has unveiled its new corporate identity, alongside new messaging and enhanced offerings, reflecting the rapid development of the business, the sector, and associated technology, particularly across maritime autonomous surface ships (MASS).

USS builds and operates a fleet of USVs and delivers customized marine data collection projects and missions primarily in the hydrographic and geophysical domains.

Investment in USV Company

Open Ocean Robotics has closed a \$2.8 million CAD investment round to scale its sustainable ocean monitoring technology. The round was co-led by Antares Ventures, a deep-tech venture fund based in Singapore, and Spring Impact Capital, alongside global investors Katalpult Ocean, Alacrity Canada, and others. These funds will finance expansion of Open Ocean Robotics' USV technology into Southeast Asia, scaling of manufacturing, and continued advancement of solar-powered solutions for real-time ocean monitoring.

HII Mission Technologies Restructures

HII's Mission Technologies division has consolidated

its six operational groups into four. The changes are designed to optimize the division for continued long-term growth. The four groups are: All-Domain Operations, comprising C5ISR operations, platforms and logistics support, and intelligence analysis; Global Security, comprising live, virtual, constructive solutions, fleet sustainment, nuclear and environmental services, and Australia business; Warfare Systems, comprising cyber and mission IT, electronic warfare and C5ISR systems; and Uncrewed Systems, comprising UUVs, USVs and autonomy software.

Mission Technologies will align the four groups via a common operating model with specialized roles: operations leader, growth leader, portfolio leader(s) and quality leader.

Successful Testing of ROV Edge Navigation

Greensea IQ has announced the successful completion of field testing for the IQNS edge processing and navigation system on the VideoRay Defender ROV (*Sea Technology*, November 2024). Greensea IQ worked closely with Water Linked AS, integrating the IQNS with the DVL A125 to create a standalone underwater navigation solution. Developed in collaboration with the U.S. Defense Innovation Unit, this navigation and stability upgrade provides expanded capabilities for subsea operations in demanding environments, including those in long-distance navigation, target search capabilities and underwater mapping. **ST**

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New Fast Response Cutter

The U.S. Coast Guard has commissioned its 57th fast response cutter (FRC), *Florence Finch* (WPC-1157), the second of three planned FRCs to be homeported in the Pacific Northwest.

The cutter is named in honor of a Filipino-American who was a member of the World War II resistance against the Japanese occupation of the Philippines. During the war, she assisted the movement by diverting fuel destined for enemy use, falsifying documents to obtain supplies, and using her position to facilitate acts of sabotage. In 1944, she was discovered, arrested, tortured, tried and sentenced to three years of imprisonment. She remained in captivity until early 1945, when American forces liberated the Philippines. Finch moved back to the U.S. following the war and joined the U.S. Coast Guard Reserves. She was awarded the Medal of Freedom in 1947 and was posthumously awarded the Congressional Gold Medal during the new cutter's commissioning ceremony.

New EPA Clean Ports Program Funding

The U.S. Environmental Protection Agency (EPA) has announced \$3 billion in funding from the new EPA Clean Ports Program to decarbonize American ports. This comprises 55 grants across 27 states and territories with funding to support the purchase of zero-emission equipment.

The equipment will include over 1,500 units of cargo-handling equipment; 1,000 drayage trucks; 10 locomotives; 20 vessels; shore power systems; battery-electric and hydrogen vehicle charging and fueling infrastructure; and solar power generation.

US Offshore Wind Industry Advances

The U.S. Bureau of Ocean Energy Management (BOEM) has offered areas in the Gulf of Maine as part of the first commercial sale for floating offshore wind on the Atlantic Coast.

The sale resulted in two provisional winners on four lease areas and more than \$21.9 million in winning bids.

Avangrid Renewables LLC won Lease OCS-564 at \$4,928,250, which comprises 98,565 acres, and Lease OCS-568 at \$6,244,850, which comprises 124,897 acres. Both lease areas are approximately 29.5 nautical mi. (nm) from Massachusetts.

Invenergy NE Offshore Wind LLC won Lease OCS-562 at \$4,892,700, which comprises 97,854 acres and is approximately 46.2 nm from Maine, and Lease OCS-567 at \$5,889,000 which comprises 117,780 acres and is approximately 21.6 nm from Massachusetts.

Together, the leased areas have the potential to power more than 2.3 million homes with clean energy.

As the wind energy industry develops in U.S. waters, BOEM has announced a memorandum of understanding with the U.S. Department of Defense (DOD) to support the coordinated development of wind energy generation on the U.S. Outer Continental Shelf. This will help further institutionalize the deep collaboration between

BOEM and DOD to ensure that offshore wind lease areas and project plans strengthen the nation's energy security in ways that are compatible with military operations.

U.S., Japan to Collaborate on S&T

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) has signed a joint statement of intent (JSol) for collaborative research, development, and foreign technical exchanges with Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). This applies across maritime and aerospace domain research areas.

The U.S. and Japan have previously committed to strengthening their shared role as global leaders in the development and protection of next-generation critical and emerging technologies such as AI, quantum technology, semiconductors, and biotechnology through research exchange, as well as reaching new frontiers in space.

Developing Supply Chain for Algae Products

The U.S. Department of Energy's Bioenergy Technologies Office and Office of Fossil Energy and Carbon Management have announced \$20.2 million in funding for 10 university and industry projects to advance mixed algae development for low-carbon biofuels and bioproducts. Located in seven states, these selected projects will address high-impact research and development (R&D) focused on converting algae, such as seaweeds and other wet waste feedstocks, to low-carbon fuels, chemicals, and agricultural products that can decarbonize domestic transportation and industry.

These types of feedstocks represent an emerging resource and are critical to the development of biofuels and bioproducts. However, they are underutilized and difficult to convert due to their variability, unique chemical makeup, and storage instability. These research projects will help overcome feedstock conversion challenges, support building biomass supply chains, improve carbon dioxide conversion to algae, and enable greater volumes of sustainable aviation fuel.

Communities Can Apply for Heat Resilience Help

NOAA's Center for Heat Resilient Communities (CHRC) is accepting applications from communities in the U.S. to get support to develop Heat Resilience Roadmaps.

Funded through the Inflation Reduction Act, up to 10 selected communities will receive \$10,000 and technical assistance to help determine and communicate the impacts of extreme heat in their communities, assess their capacity to respond, and design a locally tailored blueprint for heat resilience.

Participating communities will craft local strategies for planning, funding and decision making to prepare for and respond to extreme heat events. These strategies will help protect communities from harmful heat impacts, such as heat-related deaths and infrastructure damage.

The application window for this opportunity closes on January 24, 2025 at 11:59 p.m. EST. **ST**

NAVSEA SBIR Contract for Greensea ROV

Greensea IQ has been awarded a phase two contract from the U.S. Naval Sea Systems Command (NAVSEA) as part of Small Business Innovation Research (SBIR) Topic #N211-066. The contract spans up to three years if all options are exercised.

The objective of this contract is to significantly enhance the capabilities of the MESR Mk20 Expeditionary ROV platform by integrating manipulators and providing intuitive, one-operator control of the ROV and manipulator system. This integration will enable ROVs to perform increasingly complex tasks in marine environments, using a single control system for both the ROV and manipulator. This innovation aims to optimize performance, reduce operator workload and simplify control station complexity.

Deepwater AUVs for French Navy

The French defense procurement agency (DGA) has chosen Exail to supply a new AUV depth-rated to 6,000 m to provide the French Navy with its first sovereign ultra-deep-sea exploration and surveillance capability.

Ensuring control of the seabed, as set out in the France 2030 investment plan, has become a major challenge for protecting the country's strategic and economic interests. AUVs and ROVs will be acquired for situational awareness, environmental monitoring and taking action in the deepwater domain.

Exail's AUV is based on the architecture of Ulyx, the AUV co-developed by Exail and Ifremer (France's national institute for ocean science and technology). It will carry out reconnaissance and surveillance missions on the seabed, as well as on sensitive underwater infrastructures, such as submarine cables.

Vessel Battery Systems Orders

Echandia, a supplier of battery systems tailored for maritime applications, has received orders for two additional option frigates, marking a significant follow-up to its first naval order in 2022, which included four frigates for a European NATO member country.

This latest order comes from a large systems supplier in the maritime industry, requesting robust and reliable battery systems that meet the stringent demands of maritime defense operations.

Echandia's maritime battery systems will ensure that naval vessels operate efficiently while minimizing their environmental impact.

W&O Europe Contributes to German Frigates

W&O Europe has made a framework agreement with Damen Naval to supply manual valves, filters and other specialized instrumentation for the Frigate Class 126 construction program. The four F126 frigates are being built by Damen Naval for the German Navy at shipyards in Hamburg, Kiel and Wolgast. W&O Europe joins an international group of companies from across Europe that

are working on the project. W&O Europe's project team, based in the Netherlands, will work closely with Damen Naval's design and engineering teams to provide technical expertise and advice on product selection for the new frigate program.

Submarine Rescue NATO Exercise

JFD, part of James Fisher and Sons plc, has participated in Dynamic Monarch 24 by mobilizing the NATO Submarine Rescue System (NSRS) as part of a multi-nation exercise to test and refine submarine intervention and rescue capabilities in some of the most challenging environments.

Conducted off the coast of Norway, Dynamic Monarch 24 was the first in cold waters since 2014, providing an opportunity for participating navies to demonstrate the latest submarine rescue technology and operational procedures within a complex and challenging scenario.

Having managed the NSRS in-service support contract since 2015, on behalf of NSRS participant nations the U.K., France and Norway, JFD is responsible for maintaining the system in a rescue-ready state.

Satellite Comms Acquisition

Cohort plc has acquired EM Solutions, an Australian developer and producer of high-end satellite communication terminals for global navy and other defense customers. The acquisition will reinforce Cohort's market position in Australasia. **ST**

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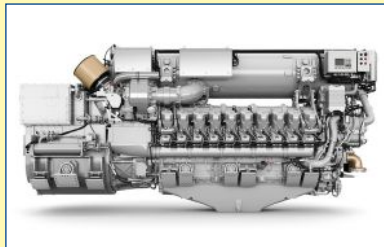


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Submarine Charging, Automation



The new mtu onboard power generator is driven by the future 20-cylinder version of the mtu Series 4000 submarine engine. Batteries can be charged much faster, minimizing surface time for the submarine. The NautIQ Master automation system controls the propulsion system and power supply, monitors the condition of the units, and can be expanded with a range of modules. Rolls-Royce Power Systems AG.

Accuracy for Subsea Inspection

The Bureau Veritas-certified Discovery Stereo Vision System provides accuracy in subsea metrology and mooring chain inspections. The system's linear accuracy has been validated at less than 0.3 mm error per meter. Voyis Imaging Inc.

Weather Data for Ports

Port-Log Forecasting Extension can be integrated into existing Port-Log systems to enable proactive decision-making, enhanced safety and an improved understanding of forecasted weather conditions alongside real-time live data. The integration of weather forecast data and real-time weather feeds also enhances a port's environmental monitoring data. OceanWise Ltd.

Synthetic Connector

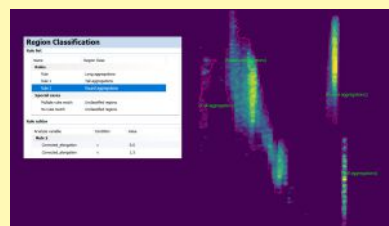
AeroLock can handle loads up to 176,400 lb. with breaking strengths over 880,000 lb. Its design significantly reduces the risk of recoil and failure, providing a safer alternative to traditional steel and knotted connectors. Lighter and tool-free for rapid rigging, AeroLock is engi-

neered for quick, repeated use. Corland International.

AIS Transponder

McMurdo M6 Class A gives mariners the ability to view at a glance the AIS status of vessels all around them and provides access to a host of detailed vessel navigation information. A color 4.3-in. screen and integrated forward-facing pilot plug offers ease of use. Seas of Solutions.

Data Processing Software



Echoview 15 is the latest release of the water column research tool. It can convert raw measurements from a wide range of echosounders and sonars into meaningful metrics for ecosystem monitoring, behavioral studies, stock assessment, habitat mapping and more. Among the new features are more analysis variables to describe the shape of aggregations, such as fish schools. Echoview Software Pty. Ltd.

Bearing Wear Measurement

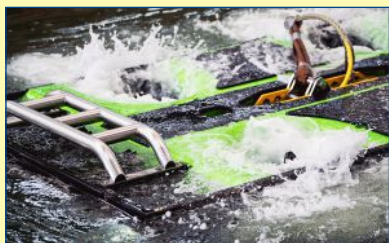
Bearing Condition Monitoring – Wireless (BCM-W) is a system that adopts patented electromagnetic field signaling technology to transfer data from underwater sensors to monitors positioned above the waterline. The technology eliminates the need for the wired monitoring systems typically used to indicate the bearing clearance of seawater-lubricated propeller shaft bearings. Thordon Bearings Inc.

AR for Situational Awareness

Building on its ability to detect hazards, day or night, with state-of-the-art computer vision, LOOKOUT has added three new features: AIS

flags, navigational aid annotations and points-of-interest pins. The augmented reality (AR) software upgrade is available for free. LOOK-OUT.

Electric Work-Class ROV



SR20 eWROV is an advanced fully electric work-class remotely operated vehicle. This environmentally friendly ROV is designed for operational concepts such as resident deployment and over-the-horizon control. The vehicle uses limited oil (reducing its environmental footprint) and features exceptional thrust and performance, electric manipulators, and impressive efficiency compared to hydraulic systems. Saab UK Ltd.

Methane Slip Control

While operating on liquefied natural gas (LNG), the NextDF feature for the 25DF dual-fuel engine reduces methane emissions to less than 2% of fuel use across all load points, achieving as low as 1.1% in a wide load range. LNG is considered an important transition marine fuel, bridging the gap between conventional diesel fuels and future carbon-neutral or carbon-free alternatives. Wärtsilä Corp.

Combined Countermeasures

Ancilia Powered by C-Guard MKII will provide a broader range of vessels and fleets access to the latest countermeasures technology to enhance the survivability of naval vessels in modern combat scenarios. The latest in countermeasures capability works alongside C-Guard threat evaluation processing with advanced engagement algorithms. This provides the end-to-end capability to easily integrate with a ship's combat management system. SEA and Terma A/S.

Enhanced Maps in Europe

C-MAP's updated and improved coverage is now available across inland France, the U.K. and Denmark, plus coastal bathymetry around the U.K., Ireland, Denmark, Portugal and France. These updates include an additional 40 lakes in France, Denmark and the U.K., and improvements to inland waterways for northwestern France related to shorelines, bridges and lock information. The new data enhance the DISCOVER, REVEAL and X Generation charts. This is a free upgrade for those who purchased and registered their chart in the past year. Navico Group, a division of Brunswick Corp.

Precision Naval Fire

SeaEagle FCRO (Fire Control Radar and Electro-optical system) is designed to deliver precision fire control for any in-service naval gun, with applicability to other types of weapons as well. SeaEagle FCRO

provides live geo-coordinates of both air and surface targets to the combat management system of the warship, enabling precision targeting of naval guns and other weapons against air, surface, and shore targets at ranges up to 30 km. Chess Dynamics, a Cohort PLC company.

Oxygen Forecasting

Low dissolved oxygen (DO) levels can stress fish populations. The environmental monitoring system has been updated to use a combination of regional weather models, physical and biogeochemical oceanographic models, and advanced AI-powered algorithms that ingest real-time data from Innovasea's environmental sensors and open data. This allows for in-pen predictions of DO levels and can warn farmers of low DO events up to 48 hr. before they occur. Innovasea Systems Inc. and BioOceanOr.

Seismic Data

MNode is a next-generation ocean bottom node with a compact design and an extended battery life that allows high-resolution data recording for longer than most nodes on the market. It is ideal for the high-resolution seismic acquisition sector. Manta.

Naval, Marine Pressure Regulators

Type 436 regulators are available in sizes ranging from 1/4 to 8 in. They apply from small-scale setups to larger shipboard systems. Pressure classes comprise 150, 250 and 700. Warren Controls. **ST**

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Digitizing Trade Paperwork

ICE Digital Trade, a part of Intercontinental Exchange Inc., has announced that GIGA Shipping, a Malaysian roll-on, roll-off (RoRo) shipping operator, has adopted the ICE CargoDocs Local Law eBL solution to digitize all its ocean and house bills of lading.

GIGA Shipping commenced its digitalization journey with ICE Digital Trade as it sought a solution to the major delays caused by using paper-based bills of lading across its supply chain, with a view to adopting a fully paperless process to accelerate, streamline and centralize documentation processes for itself and its customers.

The company selected ICE CargoDocs to digitize the entirety of its approximately 10,000 ocean and house bills of lading processed annually, relating to intra-Malaysia automotive shipments.

GIGA Shipping's adoption of ICE CargoDocs marks a major milestone for digital trade, as it becomes the first company to operationally roll out Local Law eBLs. GIGA Shipping chose U.K. law to govern its electronic bills of lading, leveraging the U.K.'s Electronic Trade Documents Act 2023 (ETDA), which recognizes eBLs as the legal equivalent of paper bills of lading.

ICE CargoDocs Local Law eBLs, which are approved by the International Group of P&I Clubs, are compliant

with the U.K. ETDA and, as such, GIGA Shipping's supply chain is able to swiftly adopt eBLs since they are not required to sign a multilateral users' agreement.

Innovation Comes with Risk

A new report published by DNV reveals that the majority (61 percent) of maritime professionals believe the industry should accept increased cyber risk from digitalization if it enables innovation and new technologies. The sector's appetite to take on emerging risks arising from digital transformation is notably higher than other critical infrastructure industries, including energy, manufacturing and healthcare.

The industry's increasing appetite for cyber risk comes at a time when it must manage a growing volume of vulnerabilities. Seven in 10 (71 percent) of the almost 500 maritime professionals surveyed by DNV believe their organizations' industrial assets are more vulnerable to cyber attacks than ever before, while the same proportion (71 percent) say the leaders of their organizations consider cybersecurity to be the greatest risk their business faces.

"In the maritime industry, we must match our ambitions for digital transformation and decarbonization with a steadfast commitment to securing our people, the vessels and the systems we rely on," said Knut Ørbeck-Nilsen, Maritime CEO at DNV.

DNV's new report "Maritime Cyber Priority 2024/25: Managing Cyber Risk to Enable Innovation" identifies

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four key challenges for the sector: ensure access to experienced knowledge of how to build and implement cybersecurity resilience into the design of new systems and vessels; enhance detection and response capabilities to minimize risk for marine operational technology (OT) systems; assign clear roles, responsibilities, and resources to handle OT cybersecurity in a continuous manner on board and onshore; and secure the many interdependencies and components in complex supply chains.

Faster Data Transfer

Minerva Marine Inc. (managing 54 oil tankers), Minerva Gas Inc. (managing five LNG carriers), and Minerva Dry Inc. (managing 11 bulk carriers and three container vessels) have strengthened their ability to transfer data from their fleet vessels to their offices by deploying Dualog's data transfer service Dualog Drive. With this update, all three ship management companies can now automatically send up to 1 million files to and from their fleet vessels every week.

The fleets of vessels managed by Minerva Marine Inc., Minerva Gas Inc. and Minerva Dry Inc. operate worldwide, so a fast and reliable file sharing system is vital to their operations. Minerva's daily data exchange needs include software distribution to keep all onboard systems up-to-date; shore-to-vessel enterprise resource planning database synchronization; the ability to distribute large training videos; and prompt access to other types of data, such as videos from CCTV on board, VDR and ECDIS playback data.

Minerva has been using Dualog's maritime email service for a year and, thus, was able to adopt a new file transfer tool easily into its fleet.

Hydrofoil Ferry for Lake Tahoe

With Lake Tahoe, the second deepest lake in the U.S., attracting more than 15 million outdoor enthusiasts year-round, road congestion has become an ever-increasing problem. Travelers often find themselves stuck in long car lines, especially in winter, due to road closures caused by heavy snowfalls.

Local company FlyTahoe and the tech company Candela are set to solve this by introducing a revolutionary zero-emission vessel that will make its U.S. debut: the world's first flying electric ferry, the Candela P-12, which recently launched on Stockholm's waterways. FlyTahoe will feature a 30-min. cross-lake service, cutting the travel time in half compared to the daily 20,000 car trips along the same route.

The P-12 uses hydrofoil technology (computer-guided underwater wings) to fly above the water's surface at high speeds, unaffected by waves and winds. The wings lift the hull above the water, significantly reducing drag and cutting energy consumption by 80 percent compared to conventional vessels. This is what allows the P-12 to be fully propelled by renewable electricity instead of fossil fuels while providing a silent and smooth ride above the waves, even at high speeds.

Because Lake Tahoe does not freeze over, the ferry can operate year-round. **ST**

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Floating Dock Ship Repair Facility in Ghana

Interocean Marine Services is supporting a groundbreaking floating dock ship repair facility project in Ghana, Africa. In partnership with Prime Meridian Docks Ghana, this major initiative involves the building and operation of the facility at the port of Takoradi.

Project Shiprite represents a significant step forward for the maritime industry in the Gulf of Guinea. With a total capital requirement of \$137 million, the project has already secured full financial backing. When finished, Project Shiprite will feature a state-of-the-art 13,500-tonne lift-capacity floating dry dock; 18,000 sq. m of reclaimed land; a 200-m jetty; and modern workshops, offices and an array of heavy marine equipment. These features will provide world-class ship repair and maintenance services to vessels trading in the Gulf of Guinea, positioning Takoradi as a hub for maritime operations in the region.

One of the key advantages of this facility is its ability to boost intra-African trade and strengthen regional economic growth. The project is expected to play a vital role in retaining foreign currency that would have otherwise been lost to overseas shipyards by providing local alternatives for ship repair.

In addition to enhancing local industry, Project Shiprite aligns with the broader goal of fostering economic integration across Africa. By offering essential services within the continent, the facility will also contribute to reducing downtime and operational costs for shipowners in the Gulf of Guinea region.

Geotechnical Survey in Turkey

TDI-Brooks has completed its fifth geotechnical investigation for DenAr Ocean Engineering S.A.

The RV *Nautilus* was dispatched to the Black Sea from the U.S. East Coast to facilitate this operation. The investigation included 49 gCPTs, 50 JPCs, 48 CPTs and 41 BCs. In addition, an environmental component

comprised 27 BCs, 28 CTDs, 19 water samples and 180 km of marine fauna transects.

Jack-Up of 22,000-Ton Rig

Mammoet was contracted by Damen Shiprepair to assist with a jack-up leg repair for the Noble Corp. drilling rig Noble Regina Allen. Initially planned to be completed using one of Mammoet's PTC large ring cranes, the project was instead performed by jacking-up the 22,000-t drilling rig. With time ticking, Mammoet resourcefully navigated the project and came up with a solution to get the vessel back in service as soon as possible.

With offices in Rotterdam, Mammoet and Damen Shiprepair have a longstanding relationship that goes back more than 20 years.

The project involved prepping a drydock and installing support blocks on its base before the rig was floated inside. The dock was then drained, and the rig lowered onto the blocks. The team was then able to install the equipment underneath.

A configuration of six towers of the Mammoet Mega Jack 5200 were used, each with a capacity of 5,200 t. Small mobile cranes and forklift trucks were used to assemble this equipment. Once all the jacks were in place, the rig was lifted to a height of 35 m.

Because the leg section measured 70 m tall, it was cut into two parts to fit underneath the rig. Each section was moved into position using Mammoet Self-Propelled Modular Transporters.

The first section was driven into position under the rig and then lifted by the rig's jacking mechanism. The process was then repeated for the second section, which was welded to the first by Damen Shiprepair, forming the complete jacking leg.

Mobilizing the equipment and people needed to carry out the job took only three months, so the downtime of the rig was significantly less than what it could have been.

The work has opened opportunities for similar projects to be carried

out in the future, having showcased that this methodology is possible.

NOR Offshore Rental Pool

NOR Offshore Rental (NOR) has made a significant investment in high-performance navigation and positioning systems from Exail, marking the beginning of a partnership that will enhance its rental pool for its subsidiaries in both the U.K. and Norway.

The order includes: 25 INS and attitude and heading reference systems (AHRS) for subsea and surface navigation, including the Rovins 9-DVL all-in-one INS/DVL system; two Gaps M5 USBL positioning systems; and four Oceano MT912S acoustic transponders.

Exail's INS and AHRS systems are engineered to operate at depths of up to 6,000 m, providing reliable and precise navigation data for both shallow and deep-sea operations.

The Gaps M5 USBL system offers exceptional horizontal tracking capabilities in shallow-water environments all the way to 995-m depth. It is ideal for underwater inspections, construction and surveys where precision is critical.

NOR has also selected Teledyne Valeport's Bathy 2, Midas SVX2, miniSVS, miniIPS2 and Model 106. The order was made for NOR's subsidiary in Aberdeen, NOR Ltd., to equip NOR Ltd. with the same state-of-the-art capabilities available from NOR's headquarters in Norway, enabling the company to mobilize equipment and services with greater speed and efficiency from both sides of the North Sea.

Tech to Improve UXO Surveys

SAND Geophysics has invested in applied acoustics' Easytrak Pyxis INS + USBL system to decrease calibration times by a factor of up to three.

This will enable SAND Geophysics to increase its accuracy and data collection for unexploded ordnance (UXO) surveys and diver positioning.

SAND Geophysics works in a difficult splash zone to conduct high-resolution seismic, side scan and magnetometer surveys. **ST**

environmental monitoring

Questioning Hypoxia Models

A study led by scientists at William & Mary's Batten School and the Virginia Institute of Marine Science (VIMS) has demonstrated surprising variability in the results of different modeling methodologies for predicting future hypoxic conditions (dead zones) in the Chesapeake Bay. The findings suggest that current approaches used to establish environmental goals may overestimate future hypoxia by not fully accounting for environmental variability caused by climate change.

Hypoxic conditions form in the Chesapeake Bay following the introduction of excess nutrients from polluted runoff, which contribute to the growth of naturally occurring algae. The decomposition of this algae removes oxygen from surrounding waters, creating dead zones that suffocate marine life. The annual extent of these dead zones is monitored as a key indicator of bay health, and the Chesapeake Bay Program (CBP), the regional partnership that manages bay restoration efforts, uses computer models based on climate projections to establish future nutrient management goals.

Published in *Scientific Reports*, the study used land- and ocean-based climate projections and historical data to perform the first continuous simulation of environmental conditions within the Chesapeake Bay and its watershed from 1980 to 2065, requiring more than 40 days of supercomputer efforts. The researchers' goal was to compare the continuous methodology to the less computationally demanding delta and time-slice methods.

The delta method is the most commonly used approach for developing future projections of estuarine conditions in the region, and it is used by regulatory agencies and the CBP to meet established water quality goals. This method combines historical data and climate projections to predict environmental changes within the Bay. However, it bases its predictions on the average dif-

ference between historical weather patterns and future projections to avoid the extensive calculations required by the continuous method.

The time-slice method applies the same future conditions, such as air temperature and precipitation, used in the continuous method, in addition to the same baseline data used in the delta approach, but the method avoids simulating the intervening years to save time.

The results showed similar increases in mean annual hypoxic volume for the time-slice and continuous methods, increasing 9 percent and 11 percent, respectively. However, the delta method doubled those results, producing a 19 percent increase.

The biggest difference between the methods was the way in which precipitation was shown to impact nutrient runoff into the bay. Because it bases future patterns of rainfall on historical patterns, the delta method failed to accurately account for changes in future precipitation caused by climate change. While the overall amount of precipitation is predicted to increase, and that total was factored into all experiments, the continuous method more accurately represented predictions of heavier individual rain events with longer dry periods between them. The delta method spread the precipitation more evenly.

The researchers point out that predicted hypoxia can be more than offset by reducing the amount of nutrients entering the watershed.

UNESCO Call for Better Tsunami Preparedness

UNESCO has gathered the world's leading tsunami experts and policymakers in Indonesia to mark 20 years since the deadly 2004 Indian Ocean Tsunami and present a roadmap for the future. Experts acknowledged that the world is "significantly better prepared today," thanks to actions implemented under the coordination of UNESCO and its partners in tsunami science, warning systems and communi-

ty preparedness, "but there is still much work to be done."

The UNESCO conference adopted the Banda Aceh Statement, a commitment by global experts and policymakers to improve the global tsunami warning and mitigation system for the next decade. This statement calls on states and civil society to drastically step up their investments and efforts in order to achieve 100 percent of tsunami-ready communities around the world by 2030.

More than 700 million people live in coastal regions vulnerable to tsunami events.

Recommendation for UK NDC

The U.K. Climate Change Committee (CCC) has recommended that the U.K.'s nationally determined contribution (NDC) for the Paris Agreement on climate change should commit to reduce territorial greenhouse gas emissions by 81 percent from 1990 to 2035.

This is based on the CCC's advice for the U.K.'s Seventh Carbon Budget, due to be published in February 2025. It is informed by the latest science, technological developments and the U.K.'s national circumstances.

Blue Carbon Assessment Of Venice Marshes

A study published in *Earth's Future* has analyzed organic matter content in salt marsh soils of the Venice Lagoon in Italy from 60 sediment cores to 1-m depth.

Organic carbon stocks and accumulation rates varied highly in different marshes, affected by organic and inorganic inputs and preservation conditions.

The study estimates that these marshes store $17,108 \pm 5,757$ tons of carbon per square kilometer in the top 1 m of soil and can accumulate 85 ± 25 tons of carbon per square kilometer per year.

However, flood regulation may reduce the annual marsh CO₂ sequestration potential by more than 30 percent.

These results inform regional carbon assessments with local and methodological variations. **ST**

contracts

ASL Environmental Sciences Inc., Victoria, Canada, has been awarded a research and development subcontract as part of a metocean data needs assessment for the development of offshore wind projects in Atlantic Canada for Natural Resources Canada. Gavin & Doherty Geosolutions Ltd.

Evoy, Florø, Norway, will jointly develop Singapore's first fully electric high-speed passenger harbor craft. Lita Ocean, SeaTech Solutions and Pascal Technologies.

The University of Southampton, Southampton, U.K., has made a groundbreaking licensing agreement to bring an innovative underwater sampler to market to facilitate autonomous collection at depths of up to 2,500 m. ecoSUB Robotics.

VIKING Life-Saving Equipment, Esbjerg, Denmark, has signed an exclusive worldwide agreement to provide certified services for marine fire systems and equipment. FAIN Co. Ltd.

Telemar, Oslo, Norway, has signed an agreement to support plug-and-play data collection for vessel operators by offering installation, service and maintenance of a type-approved solution. Sealution.

Silverstream Technologies, London, U.K., a maritime clean technology company specializing in air lubrication systems, has signed a memorandum of understanding with one of the largest ship repair yards in China to drive retrofit installations of the Silverstream system. Yiu Lian Dockyards (Shekou) Ltd.

ABB, Helsinki, Finland, has secured an order with a shipbuilding company to supply a hybrid-electric propulsion system for the new ocean sampling catamaran for the Orange County Sanitation District in California. The vessel is expected to be delivered in 2027. All American Marine.

TechnipFMC, Newcastle Upon Tyne, U.K., has been awarded an integrated engineering, procurement, construction, and installation contract for the GranMorgu project on Block 58, the first oil and gas development offshore Suriname. TotalEnergies.

ABS Wavesight's, Spring, Texas, eLogs has been chosen as the solution for enhancing digital recordkeeping in offshore operations. Noble Corp.

OSM Thome, Arendal, Norway, has signed an agreement to deploy Kaiko Systems' software across its entire fleet, streamlining inspection processes, data collection and reporting for seafarers. Kaiko Systems.

Auramarine Ltd., Turku, Finland, will collaborate to develop innovative solutions that will support maritime decarbonization with a focus on emulsion fuels, biofuels and fuel supply systems. Quadrise Plc. **ST**

meetings

FEBRUARY

February 5-6—Ship Recycling Congress, Hamburg, Germany. www.wplgroup.com/aci/event/ship-recycling-congress.

February 10-12—Geo Week, Denver, Colorado. www.geo-week.com.

February 10-13—Blue Innovation Symposium, Newport, Rhode Island. <https://blueinnovationsymposium.com>.

February 25-27—BoatUS Turning the Tide on Waste Summit, Virtual. www.boatus.org.

MARCH

March 12-13—European Green Steel Industry Summit, Dusseldorf, Germany. www.wplgroup.com/aci/event/the-european-green-steel-industry-summit.

March 25-27—Undersea Defence Technology (UDT), Oslo, Norway.

<https://udt-global.com>.

March 26-27—Digitalised Smart Ports Conference, Valencia, Spain. www.wplgroup.com/aci/event/digitalised-smart-ports.

March 30-April 1—Canadian Underwater Conference & Exhibition: Man & Machine Underwater, Vancouver, Canada. www.cuce.ca.

APRIL

April 2-4—NOIA Annual Meeting, Washington, D.C. www.noia.org.

April 8-10—Interspill, London, U.K. www.interspill.org.

MAY

May 20-21—TugTechnology, Antwerp, Belgium. www.ast-reygar.com.

JUNE

June 16-19—OCEANS 2025 Brest, Brest, France. <https://brest25.oceansconference.org>.

June 19—East Med Maritime Conference, Athens, Greece. <https://emmc.me>.

June 24-26—Electric & Hybrid Marine Expo, Amsterdam, Netherlands. www.electricandhybridmarineworldexpo.com/en.

SEPTEMBER

September 10-12—INMEX SMM India, Mumbai, India. www.inmex-smm-india.com.

September 15-19—London International Shipping Week, London, U.K. www.LISW.com.

OCTOBER

October 7-9—International Boat Builders' Exhibition and Conference, Tampa, Florida. www.ibexshow.com.

October 22-24—WISTA International AGM & Conference, Barcelona, Spain. <https://wistainternational.com>.

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

The 100% Alliance Will Lead to Sustainable Ocean Management—Dr. Tom Pickerell

Dr. Tom Pickerell is the global director of the World Resources Institute's Ocean Program and the head of the Secretariat for the High Level Panel for a Sustainable Ocean Economy. He is a marine biologist with more than 20 years of experience in ocean sustainability, including in fisheries and aquaculture, research on climate change impacts, and policy development. Pickerell is based in London.



Humanity's well-being depends on the health of the ocean. As the world's largest ecosystem, the ocean provides the oxygen necessary for marine life, absorbs 25 percent of our excess carbon dioxide emissions and feeds billions globally.

Like any ecosystem, no matter how large, it's susceptible to the negative impacts of human activity. The ocean is showing signs of the immense pressure from climate change, pollution and overfishing. This past year saw record-high global temperatures, while the ocean's oxygen levels are decreasing, and it is becoming more acidic as it absorbs and reacts with increasing CO₂ in the atmosphere. All this has repercussions for ocean and planetary health.

A degraded ocean will have a significant economic impact as ecosystem services fail. In fact, it could eventually cost the global economy trillions annually. Yet, of all the UN Sustainable Development Goals, SDG 14 (the ocean goal) is by far the least funded, representing just 0.01 percent of all SDG funding.

The solution to tackling these challenges lies in a series of interconnected actions, commitments and agreements of how the ocean should be managed sustainably, from national waters to the high seas. This means combining *national* action to effectively manage and

sustainably use the ocean along with *international* agreements that are already in play, such as the UN High Seas Treaty.

The 19 member countries of the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) have committed to 100 percent sustainable management of their national waters. As a group, the Ocean Panel holds substantial influence, led by serving heads of government and representing 50 percent of the world's coastlines and 45 percent of the world's exclusive economic zones (EEZs).

This commitment is guided by Sustainable Ocean Plans, which act as a unifying umbrella for ocean governance and a policy framework that facilitates holistic sustainable use of the ocean while allowing for effective protection and equitable sharing of opportunities. Member countries are making strong progress, with half of them currently implementing and updating their Sustainable Ocean Plans and four member countries finalizing theirs at the time of writing.

Research shows that actionable ocean-based climate solutions can deliver up to 35 percent of the annual greenhouse gas emission cuts needed by 2050 to limit global temperature rise to 1.5° C.

However, we cannot address the ocean's sustainability challenges if some areas are managed while others are left open to exploitation.

In September 2024, the president of France, Emmanuel Macron, launched the 100% Alliance, a new campaign calling on all coastal and ocean states to commit to sustainably manage 100 percent of ocean areas under their national jurisdictions by 2030. Led by the government of France, in partnership with the Ocean Panel, and coordinated by the World Resources Institute, the campaign will lead ambitious global action as we approach the next UN Ocean Conference (co-hosted

by France and Costa Rica) in Nice, France, in June 2025 and beyond.

Progress is being made on this holistic approach. At COP28 in Dubai, the leaders of the Pacific Islands committed to the goal of 100 percent effective sustainable management of their region; an area five times the size of the United States. In Samoa in October 2024, 56 countries of The Commonwealth adopted a declaration that includes more support for a sustainable blue economy with sustainable ocean plans, recognizing the need for 100 percent management of national waters. Also, Sustainable Ocean Plans are becoming increasingly recognized as critical to ocean governance, for example, through the Intergovernmental Oceanographic Commission of UNESCO.

Ensuring national governments adopt this holistic approach to managing their national waters will complement global commitments to protect and conserve at least 30 percent of the world's ocean by 2030 (known as 30 by 30) and cooperation to sustainably manage areas beyond national jurisdiction (known as the High Seas Treaty). After all, to effectively protect 30 percent, you need to manage the other 70 percent.

Countries joining the 100% Alliance will receive access to the support of leading global institutions dedicated to providing technical and financial assistance to develop and implement Sustainable Ocean Plans.

It has long been thought that the ocean is too big to register the effects of human activity, but it is increasingly clear that the ocean is saying "*enough*." It's evident that a global approach is needed to get ocean health back on track.

As the next UN Ocean Conference approaches, the 100% Alliance has sounded a rallying cry: The ocean gives us so much—let's give it 100 percent. **ST**

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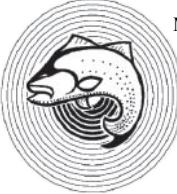
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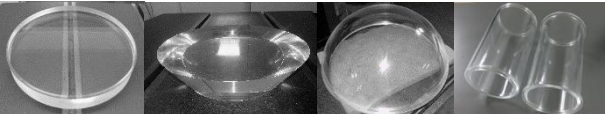
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A group of divers in a pool, with one diver in a blue suit in the center. The divers are positioned around a central figure who is wearing a bright blue wetsuit. The pool has a dark bottom and a wooden slatted border.

