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Marines with the Maritime Raid Force (MRF), 11th Marine Expeditionary Unit (MEU) climb a ladder to board the amphibious transport dock ship USS *John P. Murtha* (LPD-26) in July 2019 during a visit, board, search and seizure training exercise in the Arabian Gulf. (Credit: U.S. Marine Corps, Matthew Teutsch)

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Dr. Daniel Sternlicht, Naval Surface Warfare Center Panama City

Maintaining Maritime Military Advantage

In this emerging era of great-power competition, the goal of outpacing potential adversaries in developing military technology takes on a new urgency. As emphasized by the late Shawn Brimley in his strategic analysis "While We Can," recent history teaches that each lead in technological capability is fleeting at best. The U.S. experienced roughly a decade of advantage in the early nuclear era and several decades during the evolution of precision-guided weapons—what defense analysts refer to as the first and second offset strategies. Today's trends are not conducive to maintaining a decisive edge as the rapid proliferation of technology in the global marketplace will continue to compress the duration of any military technology advantage. It's possible the emergence of any disruptive technology will be matched within a decade.

The race for military advantage, well underway in the maritime surface, air, space and cyber domains, is also accelerating undersea. In "The Operational Environment, 2035-2050: The Emerging Character of Warfare," the U.S. Army Training and Doctrine Command (TRADOC) categorizes the development of future weapons systems, many relevant to the undersea domain, for example, range and lethality versus close engagement and survivability; finders versus hiders; connection/aggregation/centralization versus disconnection/disaggregation/decentralization; and planning and judgement versus reaction and autonomy. Consistent with current doctrine, the force with the greater range-lethality will maintain a battlespace advantage, enabled by long-range precision sensors—active and passive, above and below the surface. Active sensors, with the advantage that comes with illuminating targets but the drawback of revealing the emitter's position, will continue to have utility, depending on the degree of battlespace control and adversarial sophistication.

An exception to the range-lethality paradigm is the ability to employ survivable (hardened, concealable) or expendable assets that operate forward in contested environments without requiring full control of the physical space or sensing/communications spectrum. With respect to finders versus hiders, in future land and air engagements, concealment will be very difficult, although that advantage will likely be maintained for the mid-term in the undersea domain—given the cost of operating in harsh conditions, opacity to electromagnetic radiation, and challenges to acoustic reconnaissance/surveillance that include high clutter and propagation ambiguity. Eventually, for offboard platforms to remain concealed, passive-only sensing, combined with artificial intelligence-based information processing, will be key enablers.

Cooperative networks of offboard systems will be essential to future battlespace operations—and this is where the final two TRADOC categories come into play. The trade space between maintaining control with full communications and accepting the risk of acting without (or with limited) communications will continue to evolve with technology. Centralized control of these networks in the challenging maritime environment will rely heavily on improvements in communications range, resilience and bandwidth; while game-changing modes of independent operation will be enabled by advances in navigation, perception and autonomy. Both centralized and decentralized control will require the processing of large, incomplete and rapidly changing data; faster-than-human decisions; and automation of key decision processes.

Clearly, the formulation of a third offset strategy for maritime superiority will rely on evolutionary and revolutionary progress in sensing and automation. Key developments will be in the areas of advanced sensors; multisensor fusion; signal and information processing; environmental/target modeling and physics; communications and navigation; cooperative autonomy; quantum computing and sensing; big-data analytics; and machine perception, reasoning and intelligence. These will help realize a networked force of manned and unmanned systems that can sense, comprehend, communicate, predict, plan and take appropriate action in the future operational environment. **ST**

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)) Public-Private Alliance for Climate Resilience. As part of the UN Secretary General's Climate Summit in September 2019, an initiative by the insurance and finance sectors, governments and environmental civil-society organizations has been launched to build resilience to ocean risk in the communities and regions most affected by climate-related changes to the ocean. The Ocean Risk and Resilience Action Alliance (ORRAA) will pioneer groundbreaking finance and insurance products that unlock investment in coastal resilience; accelerate research to better understand and manage ocean risk; and inform policy, governance and public understanding. ORRAA's founding members include: AXA, Ocean Unite, the Global Resilience Partnership and the government of Canada, which will provide initial support of more than CAD\$2 million to help build ORRAA. ORRAA's early work will include developing innovative and scalable projects to build resilience in areas most vulnerable to climate change.

)) Coastal Situational-Awareness Tool Available for Free. NOAA's nowCOAST is a free online interactive map viewer that provides situational awareness on present and future weather and oceanographic conditions for mariners and other coastal users by integrating data from across NOAA and regional observing systems. Users can assess present conditions by creating maps of the latest in-situ weather/marine-weather observations, weather-radar mosaics, cloud images from GOES weather satellites, and surface wind and sea-surface temperature analyses for the last few hours. Users can also obtain maps of critical weather/marine-weather advisories, watches and warnings, weather forecasts, tropical cyclone track and intensity forecasts, and forecast guidance of water levels, water temperature, salinity and currents from NOAA oceanographic forecast models. Users can display these maps using the nowCOAST map viewer or by connecting to map services. Learn more at nowcoast.noaa.gov.

)) Swimming Robot Saves Lives. A day after Hurricane Dorian finished lashing Abaco Island in the Bahamas earlier this year, responders had a tool to get ashore, so they could provide medical care and supplies to stricken islanders. It was EMILY the robotic lifeguard—officially known as the Emergency Integrated Lifesaving Lanyard—a remote-controlled unmanned surface vehicle that has proven its mettle saving imperiled swimmers during natural disasters and humanitarian crises. Equipped with high-definition sonar and sophisticated sensors, EMILY revealed underwater debris that posed navigational hazards. It also used specialized software to enable disaster responders to map a safe passage through Marsh Harbor. Within 2 hr., the relief ship was ashore distributing much-needed supplies. Throughout the following week, EMILY mapped more channels in other storm-ravaged areas of the Bahamas. EMILY's inventor is Tony Mulligan, CEO and president of Hydronalix, a maritime robotics company. The vehicle is the successful culmination of a collaboration among Mulligan, the Office of Naval Research (ONR) and the Navy's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. SBIR provides the Navy with innovative advances in technology created by small firms, while STTR transitions products developed by both small businesses and research institutions to the Navy and Marine Corps. To solicit additional small business partners, SBIR recently announced an expanded funding opportunity. Learn more at navysbir.com.

)) US Navy's Longest Serving Senior Executive Service Member Retires. Mark Honecker, who until recently was U.S. Fleet Forces (USFF) Command's executive director and chief of staff, has retired as the Navy's highest-ranking, longest-serving senior executive service (SES) member, equivalent to the Navy's O-9 rank or vice admiral. He was honored during his retirement ceremony aboard the decommissioned battleship USS *Wisconsin* (BB-64) in September. Honecker was born overseas into a military family. He grew up in Alexandria, Virginia, and began his career as a financial management intern with the assistant secretary of the Navy. Throughout his 34 years of service to his country, he worked in a variety of commands that included the offices of the deputy chief of naval operations (logistics), deputy director for business and civilian resources, the chief of naval operations, and commander of the Naval Network Warfare Command. Summarizing his career journey, Honecker shared his "executive truths," or guiding principles: follow your passion; create space on your calendar to meet needs that aren't being met; begin with the end in mind; and prioritize service over self.

)) Call for Marine Renewable Energy Tech Developers. The EU-funded Ocean DEMO project has opened its second call, following the close of the first call in July 2019, which resulted in the award of recommendations of support to 12 offshore renewable energy projects. Funded by Interreg North-West Europe, Ocean DEMO is a €13 million project aiming to accelerate ocean energy's transition from single prototype to multi-device farms by providing free access to test centers: EMEC (U.K.), DMEC (Netherlands), SEM REV (France) and SmartBay (Ireland). Successful applicants will receive free access to test their ocean energy products and services in real sea environments at the project's network of test centers. Technology developers can apply for support packages to test multi-device farms or single devices that can scale up to multi-device in the future. Preference will be given to technologies ready to test by spring 2020. Ocean DEMO's second call for applications is open until January 31, 2020. Learn more at www.oceandemo.eu. **ST**

Unmanned Maritime Systems

An Update on Core Technologies

By Robert D. Holzer

The U.S. Navy's plans to develop advanced and diverse fleets of unmanned surface and undersea vehicles and vessels clearly demonstrate the service's growing interest in this emerging area of naval warfare. Unmanned systems will play a significant role in the future of surface and undersea warfare. Fifty percent of the new ships identified in the Navy's Surface Capability Evolution Plan (SCEP), which lays out the four major shipbuilding pillars for the future, will be unmanned vessels. Likewise, the Navy's submarine force envisions manned submarines deploying and operating with growing numbers of extra-large unmanned vehicles that independently deploy from pier-side in future operations.

The emphasis on autonomous maritime systems could be as historically important for the future Navy as the service's investment in the nascent field of naval avi-

ation proved to be in the early 20th century. Significant increases in funding, as evidenced by the dramatic total sought for unmanned maritime systems in the Navy's fiscal year (FY) 2020 budget request—about \$400 million was initially requested for two large unmanned surface vessels to be purchased in 2020—show the important bet Navy leaders are placing in the unmanned arena.

Unmanned Umbrella

Over the last several years the Navy has been developing and refining its “family” approach to the acquisition of unmanned surface vessels (USVs) and unmanned undersea vehicles (UUVs) as the breadth of both portfolios continues to grow. This framework has proven to be an effective mechanism for clearly articulating how each of the portfolios will change over time and how

A view of the UUV Knightfish being recovered by Military Sealift Command's expeditionary sea base USNS Hershel “Woody” Williams (T-ESB 4) while the ship was at anchor in the Chesapeake Bay in September 2019. Knightfish is a mine-countermeasure platform, and the evolution was the first time a UUV was launched and recovered by an expeditionary sea base.



(Credit: U.S. Navy, Bill Messia)

A sailor and civilian technicians monitor a USV after it was launched from Military Sealift Command's expeditionary sea base USNS Hershel "Woody" Williams (T-ESB 4) into the Chesapeake Bay in September 2019. The USV is a mine-countermeasure platform, and the evolution was the first time a USV has been launched and recovered by a Military Sealift Command ship.



(Credit: U.S. Navy, Bill Mesta)

each new system “fits” into their respective “families.” Currently there are more than a dozen separate USV and UUV programs under development or in acquisition across the Navy. The majority of these unmanned programs are under the management of the Navy’s Program Executive Office for Unmanned and Small Combatants (PEO USC), which was officially established in March 2018, at the direction of James Geurts, Navy acquisition chief. The PEO’s Unmanned Maritime Systems office (PMS 406) is responsible for the day-to-day program development, management and oversight of the USV and UUV portfolios.

Significant programs in the USV segment include the Large USV (LUSV), which is a new FY 2020 program; the Medium USV (MUSV); and the Mine Counter-Measures USV (MCM USV). In the UUV segment, the Orca Extra Large UUV, the Snakehead Large UUV and the Knife-fish mine-hunting UUV are the dominant programs. All of these USV and UUV efforts are either well along in development, in low-rate production or gearing up for production in the near term. None of the programs listed above are mere PowerPoint fantasies.

LUSV is truly a bold departure. The Navy intends to rapidly procure 10 or so ships based on commercial ship-building standards and outfit them with autonomy software for navigation and vessel operations integrated with remotely operated standard Navy combat and missile systems. Using a novel approach, these ships will develop the concept of operations for large USVs and conduct experimentation with various technologies and systems, which is not how traditional acquisition usually works. With the LUSV, the Navy is seeking to rapidly accelerate the fleet’s learning and interactions with large unmanned systems by procuring an initial tranche of vessels to conduct serious and sustained at-sea experimentation.

The Orca Extra-Large UUV is already under contract to Boeing to build five systems based on the company’s

Echo Voyager UUV design. The initial production run of these extra-large UUVs begins delivering in 2021. Each Orca is more than 80 ft. long, contains a large payload bay and will deploy from pier-side to conduct autonomous missions that could be months in duration.

The future operational and mission success of the Navy’s unmanned USV and UUV fleets hinges heavily on the technical maturity and expansion of a core set of critical technology enablers. These are the essential technology building blocks that will drive the Navy’s expansion into the unmanned maritime domain. The Navy is currently making healthy investments in each of these technical areas. The list of critical technology enablers includes: autonomy and precision navigation; platform integration; endurance; payloads and sensors; and command, control and communications.

Autonomy is arguably the most salient of the technology enablers since it is the linchpin to unlocking the full potential for conducting long-range and high-end missions for unmanned naval systems. Autonomy is what enables USVs and UUVs to execute missions successfully. It is the special sauce that opens the operational aperture to allow unmanned systems to navigate for days, weeks or even months on open-ended missions. Autonomy, using secure communications, allows sailors to launch all types of payloads from these vehicles and ensure they are successful. Given its significance to the future capability enhancement and expansion of both USVs and UUVs, the Navy’s acquisition community intends to speed autonomy development by using an innovative two-pronged strategy.

Unmanned Maritime Autonomy Architecture

The first piece of the process is the development of the Unmanned Maritime Autonomy Architecture (UMAA). The purpose of UMAA is to define standards for how different pieces of autonomy, called services, can interface

with one another. It is not to define autonomy technology itself. This is a cardinal point. Autonomy services examples could be: mission autonomy, payloads, navigation, or ship-to-ship or ship-to-shore communications. How these services are developed and how they interact with one another determine the defining characteristics of the vehicle's autonomous behavior. Because UMAA defines how these different services will interface, new and updated software or services can be easily inserted into existing solutions to improve USV or UUV capabilities. In addition, since the services are common across multiple autonomy solutions, they can be reused.

Each of these are separate and distinct elements within any USV or UUV's autonomy architecture. UMAA seeks to allow any of these disparate elements of a USV's or UUV's autonomy to be upgraded or replaced without having to simultaneously upgrade or change every other piece of the USV or UUV's

overall architecture. UMAA seeks to do away with the "big black box" of autonomy and move to a modular architecture that is not dependent on any single company or approach. By standardizing how each of these separate elements of autonomy talk to each other it allows the rapid upgrade and refresh of critical new technology without having to upgrade the entire system's architecture.

The intent with UMAA is akin to what the American automobile and aerospace industries experienced during their rapid development in the early decades of the 20th century. Car and airplane manufacturers quickly realized that instituting a system of standards and relatively interchangeable parts that applied to their respective industries would help fuel their growth and expansion. Now in the 21st century, as the U.S. Navy moves aggressively into the new and expanding domain of unmanned surface and undersea vessels, there is a need for a similar, but bold, form of system stan-

dardization. Today, however, the standards will apply to computer architectures and autonomy and not the spare parts and avionics that the aviation industry had to create. The future growth and evolution of unmanned systems in the Navy could well hinge on getting this critical process right.

To help ensure UMAA's success, the Navy is seeking information, insights and innovative ideas from a wide swath of industry and academia. PMS 406 has issued a Request for Information on UMAA and has held a series of Industry Days with interested government, industry and academic organizations. The Industry Days provided an opportunity for PMS 406 to solicit new ideas and broaden the discussion on UMAA to determine what areas of USVs and UUVs are ripe for the application of common interfaces and standardization.

Autonomy Integration Lab

The second prong of the Navy's autonomy strategy for unmanned maritime systems is the development of an Autonomy Integration Lab (AIL). The purpose of the AIL is to serve as a rapid pipeline to get new software quickly to the unmanned fleet, reducing traditional software deployment timelines of months and years to days, hours, or even minutes. It will do this by employing modern DevOps culture and processes to automate the required performance testing, cyber hardening and software deployment for new software. The automated tests not only speed up the development process but build more visibility, assurance and, ultimately, trust into the software—a crucial element if the Navy is going to fully embrace unmanned technology. Establishing this key process will help speed the application of UMAA across the entire Navy unmanned systems enterprise.

The AIL will not develop actual software itself. Instead it will work closely with third-party software developers, such as commercial developers and Navy warfare centers. The AIL will receive those services, test them and integrate them with

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current solutions, providing a secure and fast pathway to seamlessly push new and updated autonomy services to the Navy's fleet of unmanned vehicles. UMAA will be a key enabler for the AIL, reducing a lot of the intensive upfront work typically required with integrating software produced by different companies or developers.

Endurance

Significant progress is also being achieved in the other key technology-enabler areas over the last year, including batteries, sensors and communications.

To boost endurance, the Navy is working multiple efforts to develop and implement more energy-dense power solutions to increase the capability of the entire unmanned systems portfolio. Near-term efforts are focused on establishing efficient and technically acceptable requirements for testing rechargeable lithium-ion battery systems; establishing updated, informed submarine "hostability" requirements; and developing propagation-resistant battery architectures to enable safe integration and deployment from Navy platforms.

Significant progress has been made recently by adopting a more balanced approach focused not only on prevention of battery casualties, but also on detection and mitigation. This effort is coordinated across multiple program offices and Navy labs, has the endorsement of the NAVSEA technical community and is informed by close collaboration with the automotive industry and NASA. The Navy has committed to lithium-ion battery technology for UUV programs intended for submarine integration in the next several years.

In parallel with these near-term efforts, the Navy is continuing to invest in other energy-dense technologies. In addition to focusing on UUV-centric energy efforts, additional research work is required to develop hull, mechanical and electrical solutions to support the long-range deployment of USVs without onboard operator monitoring and intervention.

Payloads and Sensors

In developing payloads and sensors, there is significant interest in enhancing the warfighting capabilities of unmanned vehicles using a mix of unique and complex payloads to effectively support a broad range of missions. Current mission sets include intelligence, surveillance and reconnaissance; mine countermeasures; electronic warfare and others. PMS 406 and the Advanced Undersea Systems program office (PMS 394) have established a Payload Integration Group (PIG) to develop, maintain and oversee a standard, rapid and cost-effective payload integration process for both USVs and UUVs. Establishment of the PIG helps to streamline efforts across multiple organizations, enhance commonality of systems between USVs and UUVs, and ensure the development of modular payloads capable of being used by either surface or undersea systems.

Command, Control and Communications

Similar to efforts underway in autonomy, the Navy is working to define and standardize the architectures and

interfaces for command, control and communications in order to deliver unmanned maritime systems that can be rapidly and effectively integrated with and operated from fleet units. The unmanned aviation community has already adopted a Common Control System in their unmanned aerial system portfolio to provide commonality, interoperability and multi-domain mission management. Other agencies and warfare domains have been working on unmanned control architectures for a number of years.

PMS406 is leading another Integrated Product Team to leverage the good work already done and identify the specific maritime domain components and interfaces required for Common Control System-compliant solutions that will integrate with surface, submarine and aviation assets. PMS 406 is working with Naval Air Systems Command, Naval Information Warfare Command, PEO Integrated Warfare Systems and PEO Submarines to define government-managed, open-architecture control solutions compatible with existing fleet command-and-control systems.

The key to success is to ensure all the concept lighting bolts in PowerPoint slide decks actually work without the use of numerous specialized and proprietary control interfaces.

Experimentation and Testing

While much of the current autonomy and enabling technologies work is focused on the medium-future horizon, the state of USV and UUV development is not stagnant. A fulsome experimentation and testing program is emerging that will provide ready vehicles for transitioning successive iterations of autonomy software for at-sea testing.

The Navy established a UUV Squadron, based at Keyport, Washington, in late 2017 to begin experimenting with prototypes of large UUVs. This work focused on developing procedures for how to move these large systems, how to put them into and out of water, maintenance routines and other logistical processes. This testing and experimenting continues apace.

To jump-start experimentation with medium and large USVs, the Navy established a new Surface Warfare Development Squadron (SURFDEVRON) in May 2019 at San Diego. The Defense Advanced Research Projects Agency-developed Sea Hunter unmanned vessel, which has been successfully conducting transits between San Diego and Hawaii, was scheduled for transfer to the SURFDEVRON in October 2019. Two more experimental large USVs will also eventually transition to SURFDEVRON to accelerate fleet experimentation with unmanned systems and develop concepts of operation. **ST**

Robert D. Holzer is a senior national security manager with Cryphon Technologies in Washington, D.C., with more than 25 years of experience working for various Department of Defense and Navy organizations and offices. The views expressed here are his own and not those of either Cryphon Technologies or the U.S. Navy.

Long-Range UUV

Solus-LR to Enhance Canada's Maritime Domain Awareness

By Jacqueline Nichols • Adrian Woodroffe • Eric Jackson

Current unmanned underwater vehicles (UUVs) are ideal for short durations in the range of 24 to 48 hr. and normally require support vessels for launch and recovery. This proves difficult in areas such as the Arctic, where long-range surveillance is a priority and the environment does not lend well to manned vessels.

Defence Research and Development Canada (DRDC) was looking for a UUV that can deploy for longer periods to enhance Canada's maritime domain awareness. It turned to Cellula Robotics in Burnaby, Canada, to design and build a long-range UUV, called Solus Long Range (Solus-LR).

The contract is under DRDC's All Domain Situational Awareness Science & Technology Program. Objectives of this program include enhancing the domain awareness of air and maritime surface and subsurface approaches to Canada, in particular those in the Arctic.

With the long-range capabilities of Solus-LR, the vehicle can be deployed from a port, travel hundreds of ki-

lometers to a work site, and then complete a multi-week mission. This provides a feasible, low-cost alternative to launching and recovering UUVs from large, manned vessels.

The long-range capability of Solus-LR makes it ideal for a variety of defense missions. Military surveillance capabilities subsea can be extended in remote locations through the range and anchoring capabilities of Solus-LR. Utilizing the modular payload section of Solus-LR, anti-submarine warfare patrols can be undertaken using a low-drag, very-low-frequency (VLF) towed array. The UUV can then communicate back to headquarters if a defined signature is observed and optionally switch into active mode to further locate the target. Bay doors within the payload module can be used to deploy a variety of packages. When deployed, the variable-buoyancy engine is used to offset the payload mass.

In addition to defense missions, Solus-LR can reduce the cost of commercial port-to-port missions. Significant-

Solus-LR UUV integrated with fuel cell and suction anchor modules, ready for integration testing at Cellula headquarters in August 2019.





(Top) Solus-LR base UUV configuration in Cellula's test tank for early testing of controls and telemetry. (Bottom) Solus-LR fuel cell module, with hydrogen, oxygen and wastewater tanks shown.



ly smaller and more cost-effective vessels or autonomous surface vessels can be used to provide navigation updates as required without the use of large vessels.

System Configuration, Advantages

The Solus-LR is approximately 8.5 m in length, 1 m in diameter and displaces 3,700 kg. A fuel cell provides more than 250-kWh of usable energy. When operating at speeds of 0.7 to 1.0 m/s, Solus-LR is capable of carrying out underwater missions over 2,000 km in range. Integrated into the power system is a 4-kWh battery for fuel cell start-up and to provide the ability to reduce the vehicle's acoustic profile while cruising or at anchor. The subsea anchor is used to further increase the vehicle's endurance, enabling submerged multi-month missions.

Solus-LR is built on a modular and reconfigurable architecture, with a control system based on Robot Operating System (ROS) middleware. The vehicle can be operated with or without the fuel cell, suction anchor or other payload modules. The UUV is also equipped with actively controlled forward planes, for low-altitude maneuver-

ability and a variable-buoyancy system to offset any payload modifications during a mission.

Underwater navigation is built around a Sonardyne inertial navigation system (INS) with integrated Doppler velocity log. Inertial drift can be reduced with the integrated ultrashort-baseline (USBL) and long-baseline (LBL) beacons, enabling position corrections. USBL and LBL correction from a support vessel, seafloor node and surface buoy will all be demonstrated as part of the DRDC program. If further navigation improvements are required for a mission, drop-in upgrades are available with tiered INS performance levels.

Fuel Cell for Port-to-Port Missions

The Solus-LR fuel cell is built around a commercial PEM stack with high-pressure hydrogen and oxygen gas bottles. These bottles are fueled prior to launch and provide more than 250 kWh of usable energy. The fuel cell operates as a closed system, with wastewater captured in ballast tanks, maintaining the UUV buoyancy throughout the mission.

Station-Keeping

To enable long duration and low-power station-keeping, a novel anchoring solution was developed for Solus-LR. The anchor, based on a suction-caisson design, is lowered by a winch via a powered umbilical from the payload bay when anchoring is required. Once the caisson makes contact with the seafloor, the pump turns on to pull water from inside the caisson, sucking it into the seafloor. The pump is then sealed, and a solid anchor is formed. On board the UUV, a buoyancy engine provides positive trim, enabling the vehicle to float back on the umbilical well away from the seafloor. The anchor is designed to hold the vehicle in currents up to 2 m/s, depending on the soil conditions.

While anchored, the UUV enters into a low-power mode. The fuel cell shuts down, and the battery becomes the primary power source in this state. The UUV continues monitoring the anchor while undertaking the primary surveillance mission.

To unanchor, the pump simply reverses flow, pushing the caisson from the seafloor. The anchor is then winched back into the UUV and the mission continues. As a backup, the anchor line can be cut to ensure Solus-LR can always return home.

Testing and Validation

The testing and validation program for Solus-LR comprises two sets of sea trials and a pilot program. The initial set of sea trials, which began mid-October, is focused on the base vehicle functionality, without the modular fuel cell and suction anchor integrated. During these trials, the core navigation, vehicle behavior and autonomy capabilities are to be validated.

For the second set of sea trials, scheduled for January/February 2020, the fuel cell and suction anchor modules will be integrated. Testing will focus on these new systems, demonstrating extended mission endurance and autonomous anchoring.

The project will culminate in a month-long pilot program, scheduled for the second quarter of 2020. This program will see Solus-LR completing a total submerged distance of 2,000 km in Indian Arm, British Columbia, Canada. Two seafloor nodes will be positioned 10 km apart, providing both navigation updates to the UUV and communication to a remote monitoring station. The primary node with a surface buoy is outfitted with a USBL system and blue-light modem. This suite of equipment is used for tracking, telemetry and control, and has the corresponding devices located on Solus-LR. The secondary node contains an LBL beacon for navigation updates.

During the pilot program, Solus-LR will operate submerged and truly autonomously without a chase boat. Solus-LR will check in with the operations center approximately every 6 hr. as it passes the primary node, with low-bandwidth status updates. Solus-LR can also receive mission updates and transfer large log files using the high-bandwidth, blue-light modem.

As the Solus-LR completes its autonomous mission in British Columbia waters, the primary buoy will provide connectivity to an offsite monitoring station. A secure web application is under development for approved users to check for updates on the system. This will include

information such as the last check-in location, the current expected location and system status. Future features will enable payload data download, such as hydrophone data.

Next Steps

The modularity of Solus-LR allows for easy incremental upgrades. Within Cellula's XLUUV program, work has already started on the next-generation vehicle, with further research and development in the fuel cell.

Initial work aims to improve the energy density of the current system to enable missions up to 4,000 km from the same vehicle form factor using 10,000-psi hydrogen (developed in the automotive industry) and to evaluate replacing high-pressure oxygen with hydrogen peroxide or liquid oxygen. The fuel cell's energy output will also be increased to enable a burst speed of over 5 m/s. **ST**

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Eric Jackson, PEng, is the founder and president of Cellula Robotics. He has more than 40 years of project experience in the operation and development of advanced robotic systems, primarily within subsea environments.

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Preventing Ship Downtime

A Submariner's Perspective on Predictive Maintenance

By Bryan P. Van Itallie

Dive! Dive! Two simple words, punctuated with the familiar “ah-OOG-ah” alarm, were the signal throughout the ship that we were about to embark on another adventure under the sea.

For many sailors, this quickly becomes routine, but in reality, there is nothing routine about submerging an 18,000 ton, 560-ft. vessel like the USS *Nevada* (SSBN-733) with 165 people hundreds of feet beneath the surface of the ocean. One small defect or fault in any of dozens of systems or one valve out of position and our crew would find itself on a one-way trip to the bottom of the ocean.

Remarkably, since the Navy's nuclear submarine program began, only two subs have been lost at sea, the last being USS *Scorpion* (SSN-589), which sank in 1968,

over 50 years ago. This kind of uptime record is worth investigating. Let's see what a nuclear submarine can teach today's manufacturers in their quest to avoid costly downtime.

Lessons Aboard the *Nevada*

In the mid-1990s, I served as an officer on board the *Ohio*-class nuclear submarine USS *Nevada* before my career in manufacturing. In recent years, preventing downtime has created abundant interest in the industry to utilize technology to make better maintenance decisions.

At the heart of this technology are the fundamental principles of predictive maintenance: gathering data, analyzing it, predicting failures and taking proactive mea-

A photograph of a nuclear submarine surfacing at sunset. The submarine is dark and sleek, with its conning tower and various antennas visible. It is moving through the water, creating a white wake. The sky is a mix of blue and orange, with scattered white clouds. The ocean is a deep blue with some whitecaps.

A submarine surfacing at sunset.



(Top) Ohio-class submarine transiting the Strait of Juan de Fuca. (Bottom) Control room inside a nuclear submarine.



asures to prevent downtime. These fundamental principles are unchanged from how we operated the *Nevada* 20 years ago.

A crew of 165 people living in an underwater vessel for months at a time amplifies the meaning of hazardous conditions. Consider for a moment a transmission-bearing failure causing a loss of propulsion, or a reactor coolant pump malfunction causing a meltdown, or a valve failure flooding the vessel with seawater. Clearly, nuclear submarine downtime costs lives—not just profits.

The U.S. Navy has never had a death on board a U.S. submarine due to a radiation accident. With all the complexities of multiple systems crammed into a tiny space, operating in harsh environments, how has it maintained such an amazing safety record?

Two submarine tragedies in the 1960s resulted in the U.S. Navy's SUBSAFE (Submarine Safety) program, which covers all systems exposed to sea pressure or critical to flooding recovery. SUBSAFE and the Navy's Nuclear Power program are based on a foundation of quality in design, material, fabrication and testing. They span the submarine's life, from initial design and construction through ongoing maintenance and updates. Strict adherence to these programs has ensured safe and successful missions for half a century. The SUBSAFE program has been so successful that it was implemented throughout NASA after the Space Shuttle Columbia disaster in 2003.

For the most part, sailors don't think about all the factors that go into the design and construction of a submarine. They are far more focused on keeping it operating safely and efficiently. Navy submarines are always in a hostile environment. In addition to facing the potential threat of attack from another nation, the ship is also completely surrounded by saltwater, and storms at sea can be extremely hazardous, not to mention the explosive ordnance being carried on board. When you are depen-

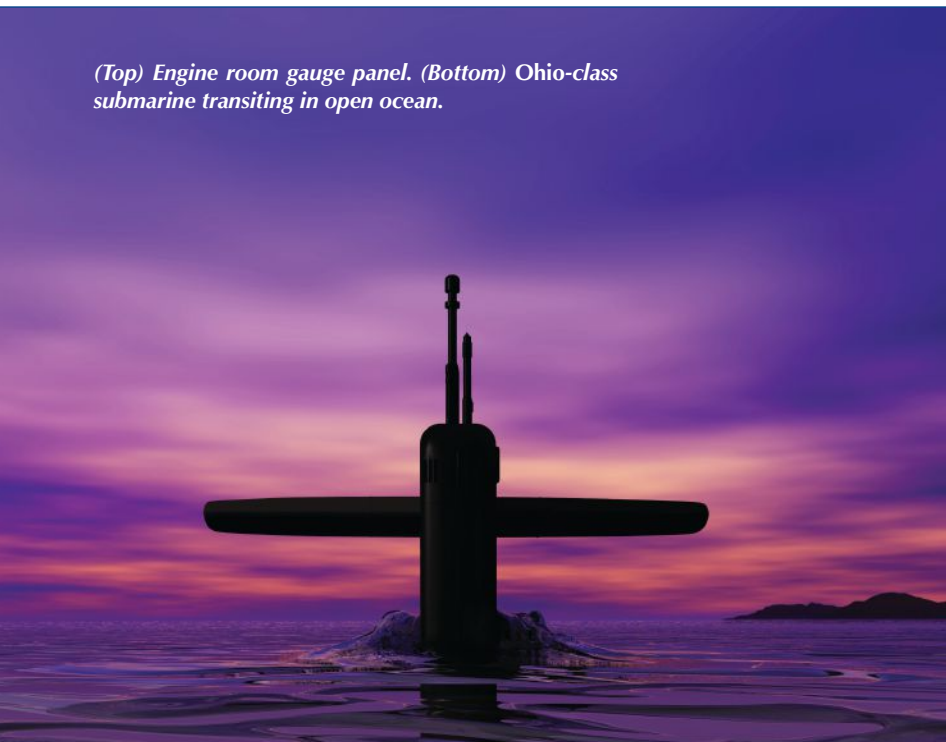
dent on every system running smoothly to harvest your oxygen and freshwater, and generally keep water out of the "people tank," downtime must be hunted down and eliminated.

On my submarine, we used a variety of different maintenance practices to ensure everything worked at peak performance, including: weekly and monthly preventative maintenance (PM) inspections and check-off sheets for routine items like oil-filter changes or motor-generator brush repair. The principle here is to do the maintenance at a specific interval, whether or not it really needs to be done. When set up properly, this can be an effective, though conservative (and potentially wasteful), approach to doing maintenance.

However, there is no guarantee that just because you did the weekly or monthly PM nothing would go wrong between the cycles that would result in a system failure. So, we added another feature into our daily operations: ongoing data collection and trend analysis. This is essentially how predictive maintenance works in industry today—continuously evaluating how your equipment is working so you know when and how to maintain it optimally.



(Top) Engine room gauge panel. (Bottom) Ohio-class submarine transiting in open ocean.



We had a team of 10 trained personnel who were responsible for operating the reactor plant, electrical and propulsion systems for 24 hours a day, all the time we were underway. This team worked together in 6-hr. shifts (watches). When an issue or complex process arose, this team was there to address it, often with the help of another team of 10 people that were “off-duty.” The watch team would record the readings of all of the hundreds of gauges, dials and indicators throughout the engine room at least every hour, and in some cases every 15 min. The watch team supervisors were expected to review these log readings every 3 hr., and the division officer (DO) and engineering officer (ENG) would review them daily. At first, this vast collection of numbers was overwhelming, but with experience the team gained a sense of what was normal and could quickly identify readings that signaled something amiss.

A key example of this is the bearing temperatures and oil-flow bubbleblers of the main reduction gears. The reduction gears take the power generated by steam turbines turning at thousands of RPM and use it to drive the propulsion shaft at much slower speeds, which turns the screw and propels the submarine through the water. These gears are machined to extremely precise measurements and are carrying a lot of power. They are massive and can only be replaced in an extended dry-dock period, requiring cutting open the hull of the submarine. They are lubricated and cooled in a continuous flow of purified oil. If something were to happen to contaminate or stop the flow of oil, the gears could break or seize together, effectively shutting down the submarine’s propulsion system and rendering us “dead in the water.” There are dozens of bubbler sight glasses on the reduction gears that visually show both the flow and condition of the oil. These are recorded every hour along with bearing temperatures to see that the reduction gears are being properly lubricated at all times. Using trend analysis to find a problem in this system before it necessitates downtime could determine whether or not we would make it back home.

What was the point of writing down and reviewing all these numbers? There are multiple things that come about by doing this.

One is that the operator writing them down has to look at the gauges at regular intervals. This ensures that someone is paying attention, and if the numbers are way out of their expected

position, the operator would see that something is wrong before a long period of time passes, enabling a quick response.

The supervisors are looking to ensure that this is being done, but more importantly, they are looking at trends. What is changing over the course of the watch period or the last day? Is there a bearing temperature that is slowly rising? Is something changing with the electrical system? Is pressure in the reactor coolant system changing? Is the temperature in the condenser rising? Do these changes match what I expect based on changing plant conditions?

The DO and ENG are looking at longer trends to see that the plant is operating normally. Additionally, regular analysis is done on the chemistry of the reactor coolant and radiation readings throughout the ship to verify that nothing unusual is happening in the reactor vessel. We used this data collection process as a training tool as

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“The importance of predictive maintenance for life-critical systems on a nuclear submarine translates easily to modern manufacturing facilities.”

well. Occasionally the ENG would replace normal log sets with artificial ones (for a drill or test) that had anomalies or other indications that something was happening, and then the watch team would be evaluated on their ability to detect the problem and respond in the correct way.

While this is a very manual process for collecting and analyzing data, it is a rigorous and detailed system to evaluate what is going on in the entire engine room. While some of this labor-intensive version of predictive maintenance is being replaced with today's digital technology, such as electronic logs and automated data analysis, the core principles remain unchanged.

The Manufacturing World

The importance of predictive maintenance for life-critical systems on a nuclear submarine translates easily to modern manufacturing facilities.

For decades, companies have introduced process improvements like Lean Six Sigma and Just-in-Time manufacturing to streamline their operations, improve quality

and minimize expenses, thus becoming more efficient and profitable. But maintenance has always lagged behind operations in terms of improvements. Many major manufacturers still rely on scheduled maintenance or run-to-failure approaches to managing maintenance. This strategy can result in wasting maintenance resources doing unnecessary repairs, or significant costly downtime when unexpected failures occur.

Recently, companies have started to consider smarter ways of doing predictive maintenance. The strongest trend in this area is to use data to develop indications and predictions of failure before they occur, which is exactly what we were doing by hand with the data logs on the submarine. Today, this process is done with sensors that are linked to an analytics platform that often resides in the cloud or local servers. The data can then be evaluated and used to identify changes or anomalies that could be precursors to failures. This linking of data and machines is what is referred to as the Industrial Internet of Things (IIoT), or Industry 4.0.

Technology has now reached a point where remote condition monitoring and analysis can be done affordably and reliably. Rather than having an army of personnel manually recording gauge readings every hour and taking the time to study the data looking for trends, this can now be done with sensors, machine learning and analytics. More advanced sensors now exist that enable detection of changes in vibration, indicating early symptoms of a future problem. These devices can also now communicate their findings directly to anyone who needs to know and take appropriate actions. Computing power continues to grow by leaps and bounds, enabling better and faster analysis and decision making.

It's been more than 20 years since I deployed on a nuclear submarine, and the U.S. Navy has since taken advantage of new technology and data to make smarter, timelier decisions in maintaining and operating equipment. The same principles and processes can be applied to manufacturing plants. The benefits of predictive maintenance go well beyond the submarine world. **ST**

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EUROMARITIME

For the first time ever, EUROMARITIME, the European exhibition for blue growth, has chosen Marseille as its homeport, at the Parc Chanot. This new location for the trade show strengthens the international maritime vocation of France's number one port, which is a true maritime hub on the Mediterranean. From February 4 to 6, 2020, Marseille will host this key biennial meeting of all the national and regional players in the cutting-edge sectors of the marine and waterway economy.

EUROMARITIME is more than just a standard trade show; it serves as a meeting place for the exchange of valuable information among maritime and river-ecosystem industries for all the countries bordering the Mediterranean. It also encourages the development of future industry professionals. EUROMARITIME 2020 will highlight key sectors of activity in the maritime and river industries: construction, repair and equipment; passenger and goods transport; ports and waterways; technologies of the future; and environmental concerns. A large number of conferences and workshops at the 2020 show will provide an opportunity to take stock of the main issues facing the maritime world.

Because of its strategic position on the Mediterranean Basin, Marseille and the larger region also have the advantage of a vibrant maritime economic and industrial fabric, supported by committed institutional partners.

As a true bridge between the maritime economies of Europe and the Mediterranean, EUROMARITIME will bring together the industrial and institutional actors of the two banks of the Mediterranean Sea, continuing the spirit of the Summit of the Two Shores, which was hosted by France's president, Emmanuel Macron, in Marseille in June 2019.



Bridging the banks, EUROMARITIME will host Mediterranean ports of the MedPort association, as well as leaders of scientific and technical cooperation programs in Europe and the Mediterranean

regions.

Among the new features of the 2020 show will be the Trade Vessel segment, dedicated to focusing on activities of the future, including training, by presenting the full range of professional perspectives in the maritime and waterway sectors to students and future industry workers.

SEAnnovation

EUROMARITIME launched a call for applications to recruit maritime start-up companies for SEAnnovation, another new feature of the 2020 show. The SEAnnovation segment will present about 15 start-ups that offer innovative technology that can be applied to one of the four key sectors of blue growth: naval activities, port activities, transport and technologies of the future (related to environmental protection and conservation, including marine renewables and bioresources). The start-ups will participate in pitches and roundtables. The selected companies will benefit from interacting in meetings with potential industrial partners and investors. Participating in EUROMARITIME will boost the start-ups' visibility with major actors in the maritime sector that can contribute to accelerating their development.

Prominent industry players—GICAN, the French Shipowners Association, the French Ports Union, and the Mediterranean and Brittany-Atlantic Sea Clusters—are offering their support for SEAnnovation by studying applications and selecting the candidates.

To learn more about SEAnnovation and the EUROMARITIME show, visit the website: euromaritime.fr. **ST**



Locating Offshore Sediment Resources

Bubble Gun Reduces Environmental Impact

By Fred Hegg • Brian Caccioppoli • Carol Gibson

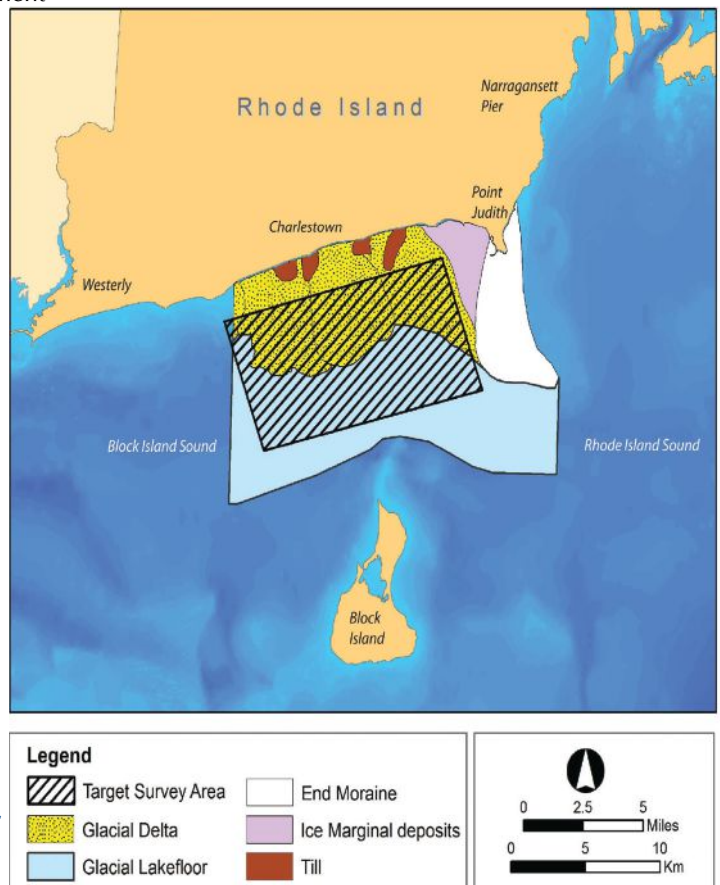
Diminishing sand resources in state waters and the growing demand for coastal infrastructure projects in response to more frequent strong storms have increased interest in the U.S. Outer Continental Shelf (OCS) as a source for sand and gravel. Recent sand replenishment projects in the U.S. Northeast have indicated a cost benefit of offshore-sourced sediment for beach replenishment, compared to traditional upland-sourced sediment.

While there have been no offshore-sourced sediment replenishment projects conducted in Rhode Island (with the exception of tidal inlet dredging), for context, a post-Hurricane Sandy upland-sourced replenishment project in Rhode Island costs \$47 per cubic meter of sediment. This cost greatly exceeded recent average costs for offshore-sourced replenishment projects in New Jersey, where the most expensive project costs \$20 per cubic meter of sediment.

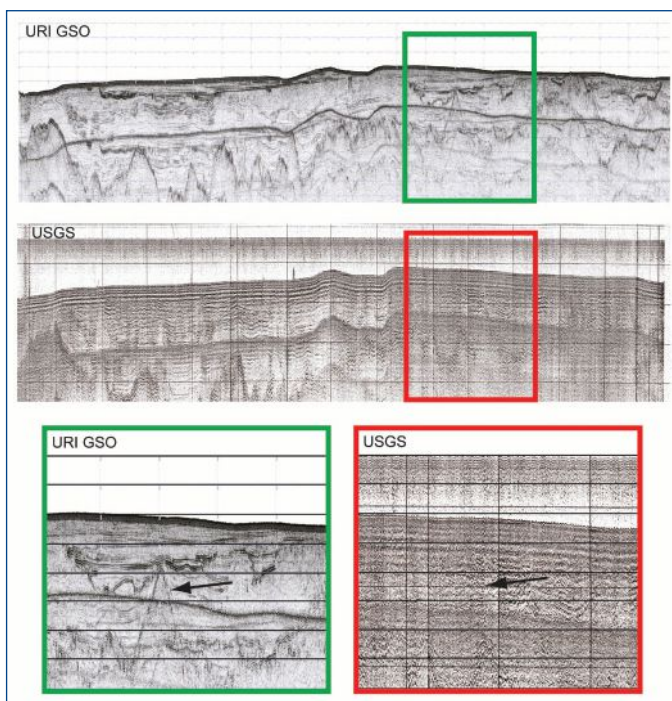
Identifying viable offshore sources of sediment is critical for a more cost-effective response to storm-driven shoreline erosion, enhanced by projected sea level rise. In the last few years, such a project was undertaken as part of a cooperative agreement between the U.S. Bureau of Ocean Energy Management (BOEM) and the Graduate School of Oceanography at the University of Rhode Island. The project falls under the BOEM Marine Minerals Division and its development of the National Offshore Sand Inventory and the supporting Marine Minerals Information System (<https://mmis.doi.gov/BOEMMMIS>) to locate and quantify sand resources on the OCS for coastal protection and restoration purposes.

The primary goal of the project was to identify offshore sand and gravel resources suitable for beach

replenishment within federal waters 3 to 8 nautical miles offshore Rhode Island. To qualify as a viable sand and gravel resource suitable for beach replenishment, the identified sediment needed to exist at or very near the seafloor, exhibit lateral continuity and lie in suitable water depths, namely less than 90 ft. below mean lower low water (MLLW). The project leveraged existing geophysical and geotechnical data collected by the U.S.



Area of interest for sand resources off the coast of southern Rhode Island.



(Top) Archived boomer data of the area collected by USGS compared to current URI GSO survey with the HMS-620 Bubble Gun. (Bottom) Comparison of data collected by the URI GSO with a CHIRP sub-bottom profiler and the HMS-620 Bubble Gun, with 20-m scale bar for reference.

Geological Survey (USGS) in the 1980s as well as other ongoing projects to assist in the identification of borrow areas and reduce the need to collect new geophysical survey data. After thorough review of existing data, new reconnaissance-scale geophysical surveys were conducted using a modern digital seismic reflection system and interferometric sonar.

Geologic Setting

The southern coast of Rhode Island has been classified as a microtidal, wave-dominated, mixed-energy coastline. Although the mean wave height is 0.8 m, the coast is susceptible to storms, including tropical cyclones during the summer and fall and powerful nor'easter storms during the winter and spring.

The southern coast of Rhode Island comprises several barrier spits and headlands. Headlands composed of till and stratified sand and gravel deposits are connected by sandy barrier spits 0.8 to 8 km in length and 175 to 300 m in width. The sediment that makes up the shore face and inner shelf of southern Rhode Island was deposited during the advance and retreat of the Late Wisconsinan Laurentide ice sheet and was modified and reworked by marine transgression during the Holocene epoch.

Much of the geologic environments in coastal and nearshore Rhode Island were deposited during the advance and retreat of the Late Wisconsinan Laurentide ice sheet. The ice sheet advanced just south of Block Island, Rhode Island, approximately 26,000 years before the present, coinciding with a lowstand in global sea level. A terminal-end moraine marks the farthest extent of the ice sheet and is characterized by an area of very coarse, shallow seafloor in its submerged segments between Long Island, New York; Block Island, Rhode Island; and Martha's Vineyard, Massachusetts.

As the ice sheet retreated north, meltwater from the ice margin was dammed north of the terminal-end moraine, forming glacial lake Block Island and depositing large quantities of sediment in present-day Block Island Sound. The distal sediment in this glacial lake depositional environment is composed of fine-grained laminated sediment tens of meters thick.

The more proximal deposits underlying Rhode Island's coastal lagoons, shoreline and inner shore were identified as prograded glacial deltas. These glacial deltaic deposits were hypothesized to contain significant volumes of sand and gravel and were identified as the primary area of interest for the project.

Marine transgression across the OCS continued through the Holocene epoch, eventually submerging glacial deposits and draping deeper basins with estuarine and marine muds.

Sediment-transport processes along the southern Rhode Island shore face and inner shelf affect the present day geographic distribution of sediment. There are three primary types of sediment transport identified along the Rhode Island southern coast: onshore, offshore and long-shore sediment transport.

Onshore sediment transport is a long-term depositional process on the shore face and is the post-storm recovery phase of the beach cycle. In Rhode Island, onshore sediment transport occurs during periods of fair weather and is usually associated with low-amplitude waves generated by a sea breeze, typical of the summer months.

Offshore sediment transport occurs during storm events, when downwelling return flow resulting from asymmetric wave orbital motion and storm surge trans-

ports shore-face sediment offshore as bedload. These storm-induced downwelling currents have the ability to transport sediment beyond the 12-m return depth, a threshold where on-shore sediment transport processes are unable to return sediment back to the shore face.

Longshore transport is the lateral movement of sediment along a shoreline. Longshore transport along the southern Rhode Island coast has been estimated based on vertical accumulation rates from the Point Judith Harbor of Refuge and historical dredging records from Point Judith Pond, Narragansett, Rhode Island. It was determined that the source of this sediment is predominantly from an eastward longshore sediment transport.

Methodology

Existing publicly available geophysical and geotechnical data from Block Island and Rhode Island Sounds were synthesized and organized into geographical information systems (GIS) file geodatabases. New Federal Geographic Data Committee-compliant metadata were also produced if no metadata existed for the original data sources. A comprehensive review of the available data helped to guide new geophysical surveys, illuminating the shortcomings of the existing data with respect to characterizing sand and gravel resources in the study area.

The analysis of the data compilation indicated that the glacial deltaic deposits satisfied the criteria for a suitable sand and gravel beach-replenishment resource. In particular, the glacial deltaic deposits straddle the state/federal waters border, outcrop at (or near) the seafloor and are in water depths between 35 and 90 ft.

It was determined that further characterization of the glacial deltaic deposits, including volume estimates, necessitated additional geophysical surveying, using a seismic reflection system offering adequate seismic penetration through coarse sediment without sacrificing resolution.

High-frequency CHIRP seismic reflection systems are commonly employed in shallow-water sub-bottom surveys when vertical resolution is a priority. However, seismic signal attenuation often occurs in sandy depositional environments, limiting total seismic penetration. Previously acquired CHIRP seismic reflection profiles in suspected glacial deltaic depositional environments revealed internal reflectors consistent with the geomorphology of deltaic deposits; however, they did not achieve adequate seismic penetration to determine the total thickness of the deposit.

A common dilemma in geophysical surveying is the trade-off between seismic penetration and achieving the highest vertical resolution. The data reviewed from older sparker and boomer seismic reflection systems achieved deep seismic penetration with poor resolution, making it difficult to distinguish changes in sediment character-



Complete Bubble Gun standard single-source system shown with the single-channel hydrophone and system shipping case.

istics. Seismic images from these systems allowed researchers to broadly characterize the OCS, but with little information about the internal characteristics of each depositional sequence.

Newer CHIRP seismic reflection systems offer submeter vertical resolution, allowing researchers to make new inferences about subseafloor sediments. However, the seismic penetration of these systems is very dependent on the seafloor geology, with very little seismic penetration in

coarser sediments. In reconnaissance-scale geophysical surveys where a geological framework is poorly defined, interpretations of CHIRP data can be difficult due to a lack of geologic context.

Bubble Gun System

To work around these shortcomings, the Falmouth Scientific (FSI) HMS-620 Bubble Gun system was selected for acquiring new seismic reflection data since the Bubble Gun had been used successfully during exploration and planning phases of the Block Island Wind Farm project, the first offshore wind farm project in U.S. coastal waters.

The Falmouth Scientific HMS-620 Bubble Gun seismic reflection profiler is purpose-built for penetration through coarse sediment. There are three standard Bubble Gun systems that can be used to meet different surveyor applications. These systems consist of a single plate source for portability (HMS-620), a dual-source system for higher energy and more penetration (HMS-620D), and a larger (200 kg) low-frequency source for bigger vessels and much greater penetration due to the low-frequency output.

The system used for this project was the HMS-620 single-source system. The system includes an electro-mechanical seismic source that includes contained air producing a 70- to 1,700-Hz sound pulse. The HMS-620 Bubble Gun source is mounted to a surface catamaran-style tow vehicle with a single channel 24-element hydrophone array. The tow vehicle is designed to operate with the sound source 1 m below the surface (approximately 1/4 wavelength at 400 Hz), which is near the peak frequency of the source-output spectrum.

The Bubble Gun source has a frequency spectrum where the low-frequency energy rises very fast then tapers out to form a broadband acoustic signal. The comparatively low energy, short pulse length of the Bubble Gun acoustic output also makes the Bubble Gun operation less intrusive to marine mammals than other conventional profiling sources.

The Bubble Gun data were collected aboard the University of Rhode Island's RV *Endeavor* from August 23 to 28, 2015 and aboard the university's RV *Shanna Rose* from May 13 to May 23, 2016. Trackline length totaled 237 mi., with seven shore-parallel transects at 1,500-m spacing and 62 shore-perpendicular transects at 300- to

600-m spacing. Seismic reflection data were acquired using a 250-millisecond (ms) trigger rate with a 125-ms record length (the complete 250 ms is capable of being stored) and 9 to 12 decibel gain.

Positioning data were collected using a Hemisphere Crescent VS101 differential global positioning system (DGPS). Seismic reflection and DGPS data were recorded in Chesapeake Technology Inc.'s SonarWiz 5 sonar acquisition software and stored in standard .SGY file format.

Seismic reflection data were processed using SonarWiz 5 sub-bottom processing software. Several processing steps were employed to improve image quality, including the application of automatic gain control, bottom tracking and water-column blanking, bandpass filtering and navigation corrections (towfish layback). An assumed seismic velocity of $1,524 \text{ m s}^{-1}$ was applied to all data files, a value suitable for unconsolidated, saturated sediments, translating the data from time to vertical distance domain.

Identified glacial deltaic deposits were then digitally traced and exported as georeferenced xyz delimited text files containing positions and corresponding thickness along each transect. A 5-m gridded interpolated surface representing the thickness of glacial deltaic deposits throughout the study area was generated using Global Mapper software. Sand and gravel resource volumes were calculated in Global Mapper using the gridded surface, with values reported in cubic meters.

Results

The FSI HMS-620 Bubble Gun seismic reflection system, where crystalline bedrock was not encountered, provided full seismic penetrations through the entire 125-ms record length (approximately 90 m below sea level, assuming a $1,524 \text{ m s}^{-1}$ seismic velocity). A variety of post-glacial depositional environments were interpreted from the seismic reflection profiles, including marine and estuarine muds, glacial deltaic sediment and laminated glacial lake-floor sediment. Each depositional environment is truncated by a geological unconformity (an erosional boundary separating superimposed depositional environments).

For the purposes of this study, the ability to map the geographical extent and thickness of the glacial deltaic deposits resulted in four separate sand and gravel resource areas identified within the study area. All four resource areas were found to contain glacial deltaic deposits that were spatially continuous and, in many places, exceeding 10 m in thickness.

Determining the thickness of the glacial deltaic deposits required the ability to resolve internal bedding features. Reflectors interpreted as dipping foreset beds were observed in the Bubble Gun seismic reflection profiles and are good indicators of sand- and gravel-size sediment, deposited as the delta prograded into the glacial lake. Flat-lying bottomset beds are indicative of a lower energy glacial lake-floor depositional environment with a finer sediment grain size.

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The foreset-bottomset contact represents the lower boundary of the sand and gravel resource, above which the thickness of the deposit was calculated. The upper boundary of the sand and gravel resources was primarily the modern-day seafloor, though portions of the resource areas were covered by thin and localized marine mud deposits.

The ability to identify both the top and bottom of the glacial deltaic deposits was critical for accurate volume estimations of the resource areas, requiring adequate seismic penetration in coarse sediment and the ability to resolve small-scale internal bedding features.

The purpose of this BOEM project is solely to identify and inventory sand and gravel resources in federal waters that could be used in the future for sand replenishment projects. The URI-BOEM cooperative was one of many projects of its kind, spanning the U.S. East Coast, with each coastal state represented by a university conducting a similar project. Subsequent project phases aim to refine resource-volume estimates and collect vibracores to ground-truth and obtain physical characteristics of the sand and gravel resources.

Disclaimers

This research was prepared under a cooperative agreement between BOEM and the University of Rhode Island. Opinions and conclusions expressed herein do not necessarily represent those of BOEM. Any use of trade, firm or product names is for descriptive purposes

only and does not imply endorsement by the U.S. government. **ST**

Fred Hegg is the vice president of business development at Falmouth Scientific Inc. He is also the founder of Hegg Marine Solutions, now a division of Falmouth.



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Structural Changes at DeepOcean Group

DeepOcean Group intends to split DeepOcean UK into two entities, creating DeepOcean Subsea Cables and a new division with a standalone brand for its seabed intervention and trenching business. The changes are scheduled to be finalized this year.

The existing cable-lay and trenching division (DeepOcean CL&T) will be divided into a seabed intervention unit under a new brand and a subsea cable installation specialist, DeepOcean Subsea Cables.

Pierre Boyde, managing director of DeepOcean CL&T, will head the seabed trenching division.

ESA Supports Green Shipping Alliance

Smart Green Shipping Alliance Ltd. (SGSA) has been accepted into the European Space Agency Business Incubation Centre United Kingdom (ESA BIC UK). Part of the business support package awarded to SGSA by ESA includes a grant to develop a prototype digital tool that will enable the accurate quantification of available wind for any ship, on any route.

The digital evaluation software system will provide projected annual fuel savings accrued by retrofitting any ship with SGSA's FastRig wingsail technology or by integrating the technology into a newbuild ship design.

Kongsberg Partners with SeaCross

Kongsberg Digital and SeaCross have partnered to develop products and end-to-end solutions for high-speed navigation and fast-craft simulation.

The training aspect is comprehensively covered by Kongsberg Digital's K-Sim Fast Craft Simulator technology. The SeaCross navigation system can be used in craft that can attain speeds of up to 100 kt. in littoral waters or open seas.

Electric Solution for Ferries in Marseille

With ABB's shore connection technology, three Corsica Linea ferries will cut emissions and noise pollution when berthed at the Port of Marseille, France. Instead of running diesel-fueled auxiliary engines, the ferries will use electricity for power at berth. The vessels are being modified to feature ABB's power-compensation solution, Dynacomp, which allows electricity available from the local grid in Marseille to be stepped down to 11 kV.

WOC, LNG MFI Push for LNG

The World Ocean Council (WOC) and LNG Marine Fuel Institute (LNG MFI) have forged a partnership to collaborate in advancing LNG as a marine fuel and in the research and development of technical standards, regulations and management strategies for LNG in the global shipping trade.

LNG MFI is a members-based organization committed to establishing LNG as a primary fuel for marine transportation. Its membership comprises the full LNG marine-fuel supply chain.

App-Based Professional Development Pilot

The International Marine Contractors Association (IMCA) has launched its pilot Continuing Professional Development (CPD) scheme for diving supervisors. The app-based scheme has the latest in training techniques and is available in iOS, Android, tablet and PC formats.

A representative cross-section of diving supervisors from leading contractors are being invited to participate in the consultation and testing process to ensure the system is user-friendly, appropriate and effective. Full launch is expected in the second quarter of 2020.

Consultancy, Personnel Partnership

GAC UK and Orcades Marine have joined forces to offer an array of consultancy services and specialist personnel to the industry. The partnership was formed in response to rapid developments in offshore and shipping technology and the growing marine and offshore renewable energy sector.

The GAC UK-Orcades Marine team of consultants cover the U.K., North Sea and Northwest Europe ports and beyond. Consultancy services include: auditing of workboats, terminals, cargo operations and surveys, navigation assessment, mooring design and analysis, and offshore and marine renewable installation support. Specialists include: tow masters, rig movers, mooring masters, marine warranty surveyors and naval architects.

CSS to Acquire Connector Business

Connector Subsea Solutions (CSS) in Bergen, Norway, has signed an agreement for the acquisition of Hydratight's MORGRIP Connector business in Walsall, U.K.

The MORGRIP Connector business will become an integral part of CSS's extensive repair and modification services for subsea and deepwater pipeline repair. The consolidated entity will consist of 60 employees dedicated to pipeline repair products and services.

Brookes Bell Acquires Oil, Shipping Consultancy

Brookes Bell announced the acquisition of Associated Petroleum Consultants (APC), an association of consultants to the oil and shipping industry. APC has more than 30 years of experience investigating disputes and claims arising from the various technical aspects in the quantity and quality control of bulk liquid-oil transport.

Digital-Focused Oceanographers Join Artelia

The Open Ocean team is joining the Artelia Group, a European engineering firm specializing in building construction, infrastructure, water, industry and the environment.

Open Ocean comprises a team of oceanographers with a passion for digital technology. Its Metocean Analytics is a web platform that provides analysis of marine conditions anywhere in the world in just a few minutes.

Acquisition of BMT Data Collection Firm

GreenSteam has acquired SMART, BMT's data collection and performance optimization subsidiary firm. GreenSteam leverages machine learning and AI to pro-

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The purchase of SMART follows a strategic business review by GreenSteam to expand its portfolio of services, extend its data collection capabilities and expand its service team.

AIP for SVESSEL Ship Digitalization

Samsung Heavy Industries Co. Ltd. has received an approval in principle (AIP) from Bureau Veritas for its development of the SVESSEL smartship solution.

SVESSEL focuses on complete digitalization of a ship and its applications to efficiently and safely assist operations. The digitalized ship, a digital twin, is reconstructed from building specifications, design drawings and test reports.

Indigenous Peoples Present Declaration To Ocean-Observing Community

At OceanObs'19 in September, the Aha Honua Coastal Indigenous Peoples' Declaration was presented to the executive secretary of UNESCO's Intergovernmental Oceanographic Commission. The declaration calls on the global ocean-observing community to formally recognize the traditional knowledge of indigenous peoples worldwide and the articles within the United Nations Declaration on the Rights of Indigenous Peoples, and to advance the UN's Sustainable Development Goals and the goals of the UN's Decade of Ocean Science for Sustainable Development.

BIO-UV Group Gets Full Stake In Triogen and Subsidiary

BIO-UV Group, the manufacturer of the BIO-SEA ballast water treatment system, has acquired a 100 percent stake in Scotland-based Triogen Holdings and its subsidiary Suez Purification and Disinfection Systems from Suez Water Technologies & Solutions. Triogen supplies water-treatment solutions based on ozone, ultraviolet and advanced oxidation process technologies.

Warning Against Delaying BWMS Installation

ClassNK has updated its 2018 analysis of the retrofitting status of ballast water management systems (BWMS) on its registered ships and confirmed that installation deadlines based on the Ballast Water Management Convention for many of them are still highly concentrated in the year 2022.

ClassNK warns that difficulties are expected if BWMS installation continues to be delayed, and ClassNK recommends installing well in advance.

Gavia AUV for Belgian Institute

Teledyne Gavia has completed the sale and sea-acceptance testing of a Gavia AUV to the Flanders Marine Institute (VLIZ) in Oostende, Belgium.

The VLIZ Gavia is rated to 1,000-m depth in a low-logistics form factor and includes an array of scientific instruments to meet current and future VLIZ research requirements. **ST**



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Agreement for Survey Skid for Small ROVs

2G Robotics and iXblue have signed a memorandum of understanding to offer a new survey skid for inspection-class ROVs to enable survey and inspection on low-cost assets. Using 2G Robotics' ULS-500 micro laser scanner and OBSERVER still camera and iXblue's Rovins Nano inertial navigation system, this new skid is suitable for small ROVs and AUVs.

Corvus Opens in Norway, Expands in Vancouver

Corvus Energy has celebrated the grand opening of its automated battery factory in Bergen, Norway. It will supply Corvus's largest market—the growing European market. The factory comprises a robotized and digitized production line with nine robotic stations and a capacity of up to 400 MWh per year. From unpacking incoming parts to testing the finished battery module, the entire factory is completely automated.

The Vancouver facility will continue to supply North American and Asian markets, where demand for hybrid and zero-emission solutions is emerging and expected to grow rapidly. Corvus is also expanding its Vancouver R&D center.

New Toll Structure Approved for Panama Canal

The Cabinet Council of the government of Panama has officially approved the modification of the Panama Canal tolls structure, following a recommendation from the Panama Canal board of directors.

The new structure enhances the canal's ability to provide competitive service and reliability for the global shipping and maritime community. The approved modifications include the tolls charged to Neopanamax dry-bulk vessels carrying iron ore, Neopanamax dry-bulk vessels transiting in ballast, the vehicle carrier/Roro segment and the liquid-bulk segment.

Kongsberg Joins COVE

Kongsberg Maritime has expanded its Canadian operation by establishing a presence at COVE (the Centre for Ocean Ventures & Entrepreneurship) in Dartmouth, Nova Scotia. The open culture at COVE is vital to sharing ideas that can improve performance and sustainability across the Canadian and global ocean economies.

HydroComp Anniversary

HydroComp Inc. is celebrating 35 years of serving the global marine community with technological innovations. HydroComp is best known for its contributions to naval architecture companies and organizations in more than 65 countries via its engineering design software, including NavCad, PropCad, PropExpert and PropElements.

Port of Savannah Marks Record 2019

Port-related announcements of expansions and new business accounted for nearly \$5 billion in investment

and 12,000 jobs across the state of Georgia in fiscal year 2019, which ended in June, a year in which the Port of Savannah moved a record 4.5 million 20-ft. equivalent container units. The Port of Savannah grew its containerized trade by 7.3 percent. Total tonnage reached 37.5 million, up 4.2 percent.

Delivery of ThunderFish AUV

Kraken Robotics Inc.'s wholly owned subsidiary, Kraken Robotic Systems Inc., has delivered its ThunderFish 300 AUV to its test partner, Defense Research and Development Canada (DRDC) in Halifax, Nova Scotia. Final sea-acceptance testing was completed in August.

The delivery to DRDC was facilitated by a \$1 million contract award under the Canadian government's Build in Canada Innovation Program.

SPBES Appoints Sales Representative for Norway

Ålesund Maritime AS has agreed to provide sales and solutions support for SPBES maritime customers in Norway. SPBES is based in Vancouver, Canada. The SPBES energy storage system has been designed to seamlessly integrate with virtually any electrical infrastructure.

New Acoustic-Testing Facility

SensorTech has acquired an acoustic test tank as the primary test facility for prototype acoustic evaluation of underwater devices. The facility will be located at SensorTech's hydrophone and transducer manufacturing facility at COVE in Nova Scotia.

Earlier this year, SensorTech created the Atlantic Acoustics Collective (AAC) with members of the ocean-tech community to identify common obstacles in testing and calibrating products. The SensorTech testing facility will fill a gap identified by AAC and include a fully automated data-gathering system and mechanical support equipment. The new facility will be able to measure the acoustic characteristics of sonar system components, with the potential of full system and vehicle testing.

Fluid Imaging Technologies Turns 20

As part of its 20th anniversary celebration, all 30 employees of Fluid Imaging Technologies traveled together to hand deliver two new models of their flagship instrument, the FlowCam, to the lab where the FlowCam was invented: Bigelow Laboratory for Ocean Sciences (BLOS) in East Boothbay, Maine.

Originally invented at BLOS in 1996 by Chris Sieracki, the FlowCam, the world's first imaging flow cytometer, was initially deployed in 1997 to capture phytoplankton images aboard the RV *Edwin Link*.

Certus Works with TracPhone

The Iridium Certus service is now available from KVH Industries Inc. as a companion for KVH's TracPhone mini-VSAT BroadbandSM systems. Iridium Certus is a next-generation L-band solution providing pole-to-pole global coverage and featuring small-form-factor, cost-effective antenna terminals. KVH's TracPhone HTS series provides data speeds as fast as 20/3 Mbps (down/up). **ST**

productdevelopment

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

Updated AUV



The new Bluefin-12 uses shared Bluefin Robotics' core capabilities, increased mission modularity and embedded intelligence to complete long-endurance, high-consequence and changing missions. The base Bluefin-12's extended modularity supports the integration of user-designated sensors and payloads. General Dynamics Mission Systems.

Helical Antennas

The expanded helical antenna family now extends beyond dual-band GNSS and Iridium support to include single and triple GNSS frequency bands. This family of products now also features: a single-frequency HC771; dual-frequency (plus L-band corrections) HC882; and a triple-band (plus L-band corrections) HC975. Tallysman Wireless Inc.

Wireless Internet Booster

Stream uses Shakespeare's marine cellular-booster technology to amplify weak cell signals along in-shore, coastal and popular cruising routes, enabling boaters to use data on their cellular devices more reliably by placing the devices within 1 to 2 in. of the black helm antenna. Shakespeare Marine.

Center-of-Gravity Software

Insight is designed for use with large-capacity load cells, and it allows users to quickly report weight and center of gravity wirelessly before the lift when moving heavy items, for example, jackets, topsides, skids and other support structures offshore. Straightpoint UK Ltd.

Camera Housings

Designed for the Sony RX100 III/IV/V/VA cameras, the FRX100 VA vacuum housing includes an integrated Hybrid Vacuum Safety System, with a pre-dive vacuum check and on-dive leak detector. The FRX100 VA M16 housing features an M16 port for the separate Hybrid Vacuum Safety System. Fantasea Line Inc.

Tool-Chain Connection

Connecting Orca3D (a Rhino3D

plug-in for naval architectural design) and NavCad (for hydrodynamic and propulsion system simulation), the new capability allows Orca3D to launch NavCad with relevant hull data and defined performance once a hull-form design has been developed. HydroComp Inc. and Orca3D LLC.

Navigation Sonar Upgrade

Broadening the field of view to up to 120°, the series of forward-looking sonars in both the 100- and 200-m-range modes enables users to see more of the environment around the ship, helping avoid obstacles such as icebergs, reefs, large whales or other floating objects. FarSounder Inc.

Vessel with Autonomous Option



Offering advanced capabilities such as active control and collision avoidance, the Sharktech 29 Defiant welded-aluminum monohull pilothouse vessel allows for traditionally manned, reduced crew or unmanned autonomous operations to deliver "human-in-the-loop" navigation during both line-of-sight

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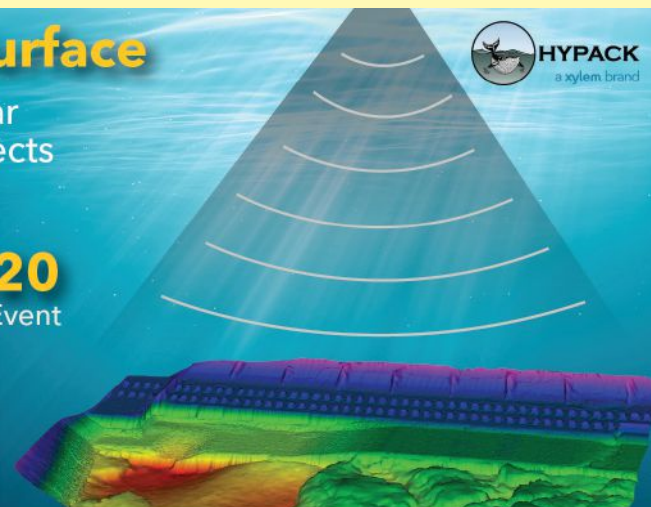


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Modular Spreader Beams

With improved integrity, the beams can now withstand pressures down to 150-m depth. They are available in a series of four: MOD 70, MOD 110, MOD 250 and MOD 400, with three applications per product: 50, 100 and 150 m. Modulift UK Ltd.

Mini-Penetrrometer



For exclusive in-field seabed strength profiling of box core samples, the T-bar measures the resistance of sediment to continuous penetration at a slow steady rate using a cylindrical rod (T-bar) at the end of a perpendicular push rod or thruster. It is small enough to fit atop a box corer sample box to allow for on-site sampling on the back of a vessel. OSIL.

Construction Positioning Software

Enabling contractors to conduct pre-/post-construction hydrographic surveys, the software includes single-beam echosounder acquisition, data editing and dredge-volume calculations. It supports subscription electronic charts, open-source charts and AIS for improved safety and navigation in congested waterways. Trimble Marine Construction.

Towed-Array Sonar

Complementing the BlackFish HMS (hull-mounted sonar) system,

the SwordFish can be used at various sea depths for different mission types. The SwordFish connects to the vessel's stern via a light winch. It is suitable for frigates, corvettes, OPVs and small vessels such as fast patrol crafts. DSIT Solutions Ltd.

VSAT Antenna System

The world's first Ku- to Ka-band-convertible 85-cm VSAT displays RF capabilities well on par with larger, heavier and more costly VSAT antenna system alternatives. The v85NX is a viable alternative to 1-m VSAT systems, with better link capabilities than current 80-cm antenna systems. Intellian Ltd.

USV Update

Featuring new advancements to shoreside operations and in-water performance, the latest version of the Wave Glider has a six-fold increase in computing power, higher power solar panels, simplified pre-launch operations and a more ruggedized platform. Liquid Robotics Inc.

Engine-Cooling Pump

Crank-mounted, the JPR-CP25UH replaces a wide range of OEM and aftermarket models. It is designed to deliver massive flow and fits engine brands such as Crusader, Ford, GM, Indmar, Marine Power, PCM and Volvo Penta. JMP Corp.

Firmware Update

For the Ellipse product line, this update includes: body-velocity and slip-angle outputs, DVL support and a new magnetic-calibration algorithm. Novel features are geared toward autonomy. SBG Systems.

Downhole Safety Valve

As an improved well-control solution for cable-deployed electric submersible pumps retrofitted to production wells, the valve will enable on- and offshore installations to meet all safety regulations while improving the operational footprint at the well site during installation and retrieval by reducing time, cost, personnel and risk. Pragma Well Technology Ltd. **ST**

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- ▶ Added LOD support for point cloud rendering, can handle +100 million data points for better visualization
- ▶ Improved processing of sub bottom display — optimizing sound velocity through sediment for better reports
- ▶ Process data from WASSP WMBF, SSAM SAS sonar and PDR1200 SBES
- ▶ Helm Display improved and easier to use

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Scrubber Systems Can Cut Global GHG Emissions

Members of the Clean Shipping Alliance 2020 welcome a new addition to the canon of scientific literature on exhaust-gas cleaning systems (EGCS), the latest of which indicates that continued use of residual fuels with a scrubber can help toward global CO₂ reduction.

In a study by Norway's SINTEF, one of Europe's largest independent research organizations, Chief Scientist Dr. Elizabeth Lindstad concluded that from well-to-wake the continued use of HSFO (heavy sulphur fuel oil) or HFO (heavy fuel oil) with an EGCS is the most environmentally beneficial means of meeting global greenhouse gas (GHG) emissions targets.

After detailing findings from research involving full-scale testing on a number of newbuild vessels, Lindstad said that studies "indicate that two-stroke engines with ex-

haust-gas recirculation and scrubbers represent the most cost- and GHG-effective way of meeting both IMO Tier 3 NO_x rules and the 2020 sulphur cap."

Climate Change Affects Coastal Flooding, Erosion

New research finds that a warming planet will also alter ocean waves along more than 50 percent of the world's coastlines. This has significant implications for coastal flooding and erosion.

As part of the Coordinated Ocean Wave Climate Project, 10 research organizations, including the U.K. National Oceanography Centre (NOC), combined to look at a range of different global wave models in a variety of future climate scenarios

While they identified some differences between different models, they found if the 2° Paris Agreement target is kept, changes in wave pat-

terns are likely to stay inside natural climate variability, but in a business-as-usual climate, where warming continues in line with current trends, the models agreed the planet is likely to see significant changes in wave conditions, varying by region. Similarly, climate change-induced alterations to the direction of waves can change how much sand they move along the coast. Infrastructure built on the coast or offshore is sensitive to these different characteristics of waves.

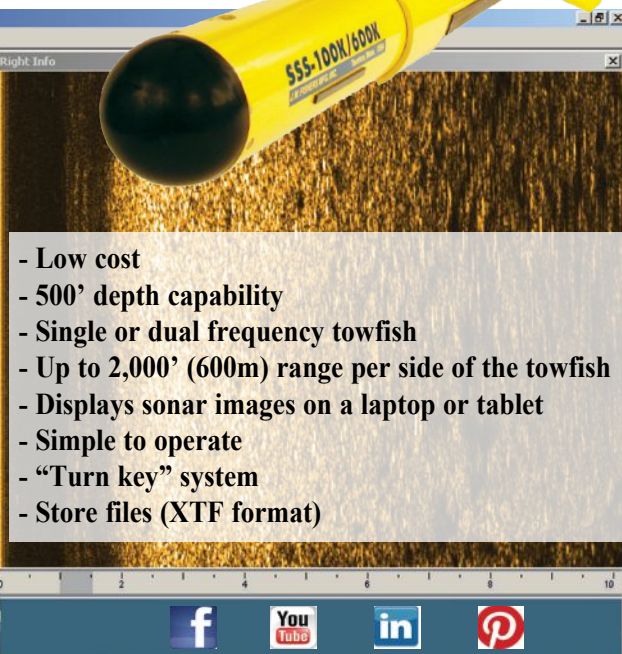
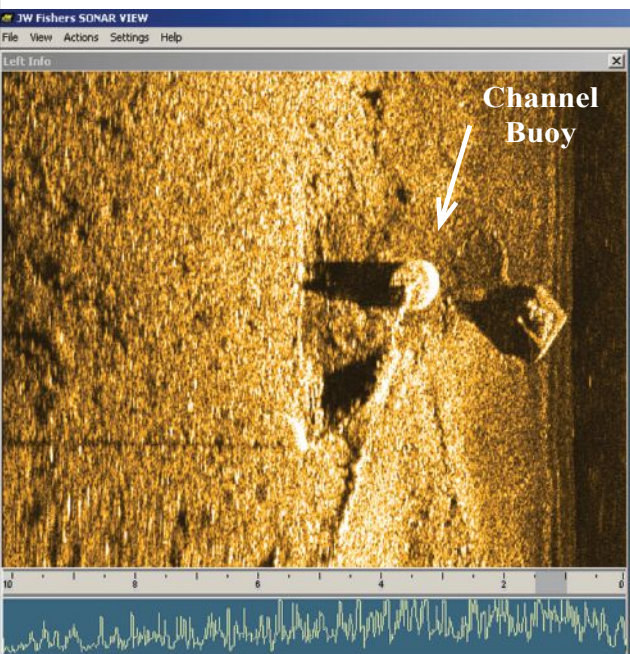
Buoys Installed in Africa For Coastal Management

As part of the Monitoring for Environment and Security in Africa (MESA) program, funded by the European Union and implemented by Mauritius Oceanography Institute (MOI), MSI was awarded a contract for the installation of AXYS TRIAXYS directional wave buoys in Comores, Seychelles and Madagascar. These buoys will enhance the decision-making and planning capacity of institutions mandated for marine



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and coastal management, and the data will be used for monitoring and mitigation of oceanographic risks, such as sea level rise, swells and storm surges that may lead to coastal hazards.

Each of the three buoys deployed in water depths ranging from 32 to 90 m is fitted with GSM, radio and satellite telemetry, enabling MSI to receive the data in real time for display on a website, local display on a PC and monitoring of buoy position/status.

AWI Contributes to Global Climate Change Database

For the first time, researchers from the Alfred Wegener Institute (AWI) are feeding the results from their global models directly into the Intergovernmental Panel on Climate Change database. The underlying model, developed at the AWI, depicts the sea ice and the oceans with far greater definition than conventional methods. The results are used by climate scientists and stakeholders around the world to determine the effects of climate change on humans and the environment.

Sensor to Track Microplastics, Harmful Algal Blooms

The Marine Renewable Energy Collaborative (MRECo) assisted installation of a groundbreaking microplastics (MPs) and harmful algal bloom (HAB) sensor called HABStats to track MPs and HABs through the Cape Cod Canal and Buzzards Bay that may have originated in the region around the Deer Island Treatment Plant in Boston.

As part of a NOAA Phase II SBIR contract, Dr. Scott Gallagher, scientist at the Woods Hole Oceanographic Institution and president of CoastalOceanVision Inc., installed the HABStats sensor on the Bourne Tidal Test Site (BTTS) at the end of September to photograph and analyze the molecular structure of HABs and MPs as they flow by the BTTS.

UK, South Africa Partner To Tackle Marine Litter

Experts from the Centre for Environment, Fisheries and Aquaculture

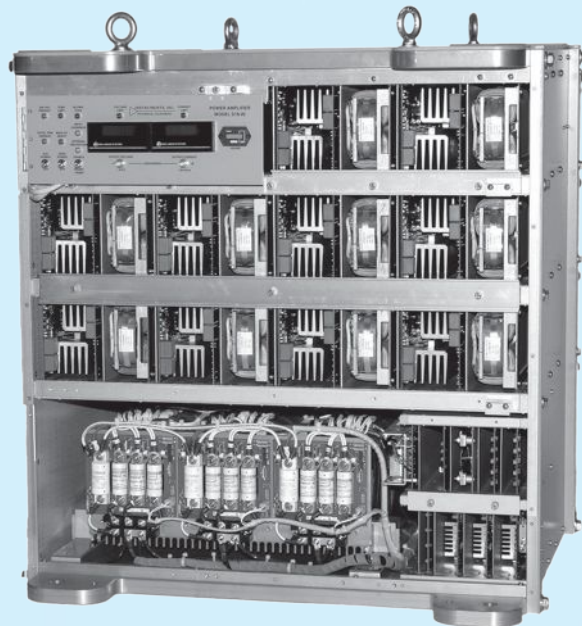
Science (Cefas), part of the U.K. government, are partnering with the South African government and working alongside research colleagues in South Africa to identify solutions to problems posed by marine litter.

These include: reducing reliance on single-use plastics, improvements in waste management and moving toward a more circular economy for plastics.

The Commonwealth Litter Programme (CLiP) launched with a community beach outreach event in Cape Town, where Cefas scientists demonstrated scientific monitoring techniques and held an exhibition on marine litter challenges and solutions. The U.K. royal family's duke and duchess of Sussex met with Cefas's principal marine-litter scientist, Thomas Maes, during the event. **ST**

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Robots to Clean Biofouling For Renewable Energy Tech

The second phase of an Innovate UK project has been launched to develop an automated fouling management system for the marine energy industry.

The 24-month RoBFMS (Robots to Inspect, Maintain and Repair in Extreme and Challenging Environments) project will develop an automated robotic system to monitor, identify and clean biofouling from subsea structures, building on the learning gained from the development of a prototype robot in phase one.

Led by Innovative Technology & Science Ltd. (InnoTecUK), the project consortium brings together the European Marine Energy Centre (EMEC) and Brunel University London to explore and define the marine renewable energy (MRE) sector's requirements of cleaning hardware in tackling biofouling.

The RoBFMS system will comprise sensors, navigation systems and camera equipment to monitor and detect fouling on submerged structures. RoBFMS will also be capable of identifying defects with-in technologies in environments where human intervention presents high safety and cost concerns.

Testing will occur at EMEC sites in Orkney, Scotland, in spring 2020.

Data Management Support For Sat-Derived Bathymetry

EOMAP has been awarded by the German Aerospace Center (DLR) to further develop its physics-based method of mapping sea depths from satellite observations.

Satellite-derived bathymetry (SDB) uses data from satellites and aircraft to generate depth measurements and seafloor characteristics for shallow waters. Developed 20 years ago by EOMAP scientists, then at DLR (Germany) and CSIRO

(Australia), SDB's potential to create a continuously updated global database of shallow-water bathymetry is hampered by the heavy computing power required to process the large amounts of data now available. The new funding will allow EOMAP to advance new SDB procedures based on high-performance scientific computing employing field programmable gate arrays (FPGAs).

Iridium, OneWeb to Offer Combined Service

Iridium Communications Inc. and OneWeb have entered into a memorandum of understanding to work together toward a combined service offering to make it easier for their mutual partners to offer bundling and co-marketing opportunities for the Iridium Certus L-band services and OneWeb's Ku-band service. The offering would leverage the strengths of their respective low-Earth-orbit (LEO) networks.

This is the first time that LEO operators have collaborated to deliver services in L-band and Ku-band.



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The agreement creates opportunities for manufacturers of both OneWeb and Iridium Certus terminals, and providers will be able to offer combined equipment or dual-constellation terminals.

IMCA Promotes Maritime Carbon Reduction

The International Marine Contractors Association (IMCA) is promoting ways of reducing carbon emissions in the marine environment as part of its strategic theme of environmental sustainability.

Battery technologies are benefitting the offshore marine construction market. Some of IMCA's member companies have taken the lead by incorporating hybrid-power technologies on DP ships, and the initial feedback is very positive for carbon reduction and economic benefit.

Partnership to Ensure Quality of Digital Twins

TechnipFMC and DNV GL have entered into a partnership to develop the oil and gas industry's first methodology for qualifying the integrity of digital-twin technology.

The methodology aims to bring a level playing field to varying technical definitions of, and expectations toward, digital twins. It will set a benchmark for oil and gas operators, supply-chain partners and regulators to establish trust in digital-twin-generated data for performance and safety decision making.

Digital twins connect 3D models with real-time field data and enable operators to gain more insights and simulate the behavior of an asset based on operational conditions.

Biomimicry Could Curb Invasive Mosquitofish

An interdisciplinary team from New York University (NYU) and the University of Western Australia is utilizing robotic fish to curb the damaging effects of invasive species by scaring the invaders enough so that they reproduce less, Inhabitat.com reported. The study focused on mosquitofish, listed among the world's most harmful invasive exotic species.

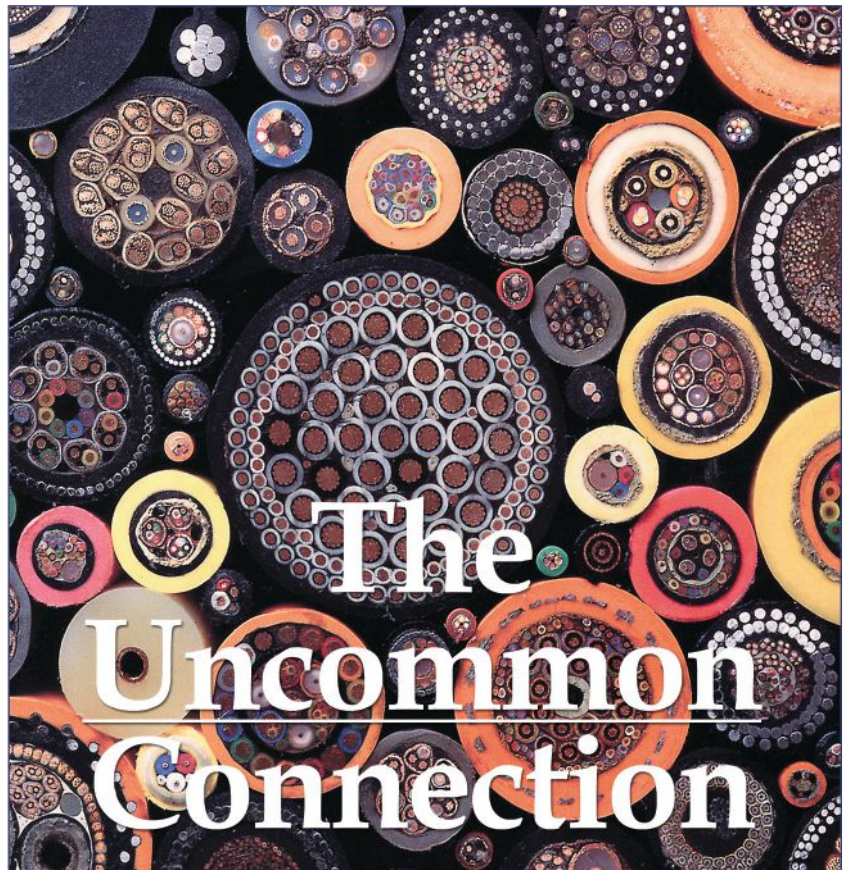
The robot fish act as predators, simulating largemouth bass, to provoke mosquitofish stress responses, which depletes their energy reserves and, in turn, disrupts their reproduction rates.

ROV Examines Submerged Car, Revolutionary War Artifacts

The Marine Patrol and Underwater Search and Recovery Team of James City County in Virginia re-

cently used its JW Fishers SeaOtter-2 ROV to inspect a submersed vehicle in a retention pond. The ROV conveyed that no bodies were inside and helped divers see the make and model of the vehicle and its condition prior to getting in the water. The vehicle was found to have been stolen two years earlier.

The ROV was also used in another project to identify ship remains from the Revolutionary War. **ST**



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US District Court Strikes Down Obama-Era WOTUS Rule

During the Obama Administration, the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) adopted a rule amending the regulatory definition of “waters of the United States” (the WOTUS rule).

The rule has far-reaching implications for project development and landowners across the energy, water, agricultural, construction and transportation sectors, and it has been the subject of extensive litigation, as well as rule making by the Trump Administration.

In August 2019, the United States District Court for the Southern District of Georgia ruled in *Georgia v. Wheeler* that the WOTUS rule impermissibly extended USACE’s authority beyond the scope of the Clean Water Act and failed to comply with the Administrative Procedure Act. The court remanded the WOTUS rule back to USACE and extended its preliminary injunction of the rule, Van Ness Feldman reported.

Funding Awards from Sea Grant

Sea Grant announced \$2 million in federal funding to support the Sea Grant American Lobster Initiative to address scientific and stakeholder needs for this fishery. The landing value of the American lobster fishery is estimated at about \$666.7 million today, one of the largest and most valuable fisheries on the Atlantic coast.

In fiscal year 2019, the National Sea Grant Office launched the American Lobster Initiative to support a national research competition on basic science on the species and a Northeast Regional Lobster Extension Program to support a four-year program designed to work with communities to link lobster research with the industry, resource managers and other stakeholders across the region. The research will address critical gaps in knowledge about how American lobster is being impacted by environmental change. The regional extension program will work to meet emerging needs among American lobster stakeholders and link lobster research with the industry.

In more funding news, three awards totaling \$2 million in federal funding were recently awarded through the 2019 Sea Grant Highly Migratory Species (HMS) Research Initiative. The projects include: two targeted studies focused on refinement of a bycatch reduction device for sharks and determining post-release mortality of bonnethead sharks and one broader consortium program that will complete several projects focused on bycatch reduction, increased understanding of life history, post-release mortality and other objectives for multiple species of highly migratory fish.

BOEM Agreements on Sand Replenishment

The Bureau of Ocean Energy Management (BOEM) has partnered with the U.S. Army Corps of Engineers Jacksonville District, Brevard County, and the U.S. Air Force

45th Space Wing to replenish portions of the shoreline in Brevard County, Florida. BOEM and its partners signed two separate agreements for the use of up to 1.9 million cubic yards of sand from federal waters to construct three Brevard County project segments, located at Mid-Reach, South-Reach and Patrick Air Force Base.

NSF Chooses Operator for New Oceanographic Research Vessel

The National Science Foundation (NSF) has selected the Gulf – Caribbean Oceanographic Consortium, cooperatively led by The University of Southern Mississippi (USM) and the Louisiana Universities Marine Consortium (LUMCON), to operate the third new oceanographic research ship to carry out regional-scale research in the Gulf of Mexico, Caribbean Sea and Atlantic Ocean.

Owned by NSF and valued at over \$100 million, this *Regional*-class research vessel (RCRV) was scheduled to begin construction in late 2019, with delivery to the consortium in 2023 after a year of rigorous sea trials. The ship will have dual home ports in Mississippi and Louisiana to support scientific research and vessel maintenance, respectively.

US Coast Guard Launches Formal Investigation Into *Conception* Disaster

The U.S. Coast Guard has convened a formal Marine Board of Investigation (MBI) to investigate the loss of the small passenger vessel *Conception*, which caught fire and sank in September off Santa Cruz Island in California. Only five of the 39 people on board survived.

A commandant-directed formal Marine Board of Investigation is the highest-level marine casualty investigation in the Coast Guard. The board consists of four members who will investigate all aspects of the casualty, including, but not limited to, the pre-accident historical events, the regulatory compliance of the *Conception*, crewmember duties and qualifications, weather conditions and reporting, safety and firefighting equipment, and Coast Guard oversight.

Separately, the Coast Guard Investigative Service, the Federal Bureau of Investigation, and the Bureau of Alcohol, Tobacco, Firearms and Explosives are supporting a Department of Justice investigation and will work in close coordination with the U.S. Attorney’s Office.

Anyone with information about the vessel or the marine casualty can email: accidentinfo@uscg.mil.

Knauss Fellowship Application Season Open

The 2021 Knauss Marine Policy Fellowship is now open for applications. The fellowship provides a one-year, paid experience for highly qualified early-career professionals to work on issues related to coastal, marine and Great Lakes science and policy in offices within the executive or legislative branch of government in Washington, D.C. A student must be enrolled toward a degree in a graduate program as of the application deadline of February 21, 2020. Domestic and international students at accredited U.S. institutions may apply. Learn more at: seagrant.noaa.gov/Prospective. **ST**

contracts

AecorLink AB, Stockholm, Sweden, has been awarded a communication contract with a ferry operator that will significantly improve the internet connectivity on board its ferries. Viking Line.

Damen Shipyards Group, Gorinchem, Netherlands, signed a contract for the delivery of an ASD Tug 2813 to SAAM Mexico for operations in the port of Veracruz. SAAM Towage.

Oceaneering International Inc., Houston, Texas, has been awarded contracts to supply subsea umbilical control systems for a deepwater field development in the Bay of Bengal. Baker Hughes.

VARD, Alesund, Norway, has signed an agreement to provide a stern trawler. The new vessel, with a length of 80.4 m and a beam of 16.7 m, is based on the VARD 8 02 design. It will operate out of Petropavlovsk-Kamchatsky in the Far Eastern Russian Economic Fishing Zones and Bering Sea and is scheduled for delivery in the second quarter of 2021. Luntos Co. Ltd.

Lloyd's Register (LR), London, England, has signed an agreement for a joint development project to design an LNG-fueled very large crude carrier (VLCC). The project will evaluate design options that use a prismatic GTT Mark III membrane LNG tank. LR will conduct risk assessment and design review in accordance with the latest regulations. China Merchants Energy Shipping Co. Ltd. (CMES), CNOOC Gas and Power Group, Dalian Shipbuilding Industry Co. Ltd. (DSIC), and Gaz-Transport and Technigaz SA (GTT).

A/S Norske Shell, Tananger, Norway, is launching a 10-year seabed subsidence monitoring campaign at its Ormen Lange field in the Norwegian Sea that will run to at least 2029 and employ 50 Fetch subsea sensor logging nodes as pressure-monitoring transponders in 800- to 1,100-m

depth. The data will help to detect changes that might be caused by ongoing gas extraction and inform reservoir management strategy. Sonardyne International Ltd.

ECOSubsea, Bakkasund, Norway, has won contracts to clean in two northern Europe ports. Its hull-cleaning technology can remove all hull fouling from the water. Ports of Antwerp and Zeebrugge.

ShipServ, London, England, has signed an agreement for the ShipServ TradeNet platform to be seamlessly integrated into enterprise-wide systems to optimize the management of an entire fleet. Hanseaticsoft GmbH. **ST**

meetings

DECEMBER

December 3-6—Marintec China, Shanghai, China. marintecchina@126.com or www.marintecchina.com.

December 4-5—Maritime Security & Coastal Surveillance, Singapore. +65 6722 9388, KunLim.Lau@iqpc.com.sg or <https://bit.ly/2XqMelu>.

December 4-5—West Coast Small Business Defense Contracting Summit, San Diego, California. 202-552-0179 or <https://tinyurl.com/y3z9jvmj>.

December 4-6—International WorkBoat Show, New Orleans, Louisiana. 508-743-8567, info@workboatshow.com or www.workboatshow.com.

December 10-12—Chesapeake Technology's Annual Training Workshop, Savannah, Georgia. 650-967-2045 or workshop@chesapeaketech.com.

2020

JANUARY

January 6-9—HYPACK 2020, Jacksonville, Florida. 860-635-1500, Brittany@hypack.com or www.hypack2020.com.

January 7-9—Challenge of Science Leadership, Totnes, England. www.scienceleadership.co.uk.

January 14-16—Blue Innovation Symposium, Newport, Rhode Island. 401-847-6650 or <https://salve.edu/blue-innovation-symposium>.

January 15-16—Coastal Futures, London, England. bob.earll@coastms.co.uk.

January 21—iXblue Users Conference, London, England. www.ixblue.com/users-conference.

FEBRUARY

February 4-6—EUROMARITIME, Marseille, France. +33 1 56 59 15 07, anne-charlotte.micca@gican.asso.fr or www.euromaritime.fr.

February 4-6—Underwater Intervention, New Orleans, Louisiana. ui@naylor.com or www.underwaterintervention.com.

February 11-13—Subsea Expo, Aberdeen, Scotland. www.subseaexpo.com.

February 17-21—European Shipping Week, Brussels, Belgium. Smoloney@elabor8.co.uk.

February 24-27—Canadian Hydrographic Conference, Quebec, Canada. chc2020@conferium.com or www.chc2020.org.

MARCH

March 9-10—World Ocean Summit, Tokyo, Japan. +971 552215208, oceansummit@economist.com or www.woi.economist.com/world-ocean-summit.

March 17-19—Oceanology International, London, England. +44 (0)20 82712133 or www.oceanologyinternational.com.

March 23-25—International Lidar Mapping Forum, Washington, D.C. www.lidarmap.org.

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

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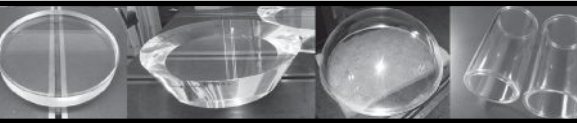
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He has master's degrees in engineering and international business and advises fisheries ministries, regional commissions and fishing-fleet owners on sustainable fisheries management. His passion is bringing the latest innovations in data analytics to fisheries.

Marine fisheries support billions of people around the world and contribute \$100 billion each year to, as well as support about 260 million jobs in, the global economy, according to the United Nations Development Program. But, increasingly, fisheries are subject to overexploitation, pollution and habitat loss. Sustainable fisheries management has never been more urgently needed, yet it faces a significant challenge: data management.

New technologies are introduced for industrial vessels every day: fuel and gear sensors, cameras, electronic catch reports and more, all in addition to the existing VMS transponders. It is a challenge to know which equipment to choose, and, often, new hardware is added without a clear plan of how to use the data it will provide.

Moreover, there is a global push to track small-scale fishing vessels. In the next few years, fisheries monitoring centers will have to adjust from tracking a few hundred vessels to tens of thousands of vessels. Such a massive increase, together with more equipment on large vessels, means huge quantities of data.

To make sense of all this information, it must be properly analyzed and correlated. Yet data management has been a neglected subject compared to high-tech equipment,

even though data are just as valuable an asset. The future of fisheries depends on big-data analytics.

Big data offers vital tools for managing fisheries. For example, fishing trips could be tailored to meet quotas in the shortest time frame, reducing fuel consumption and crew costs. Real-time catch data could help administrations close a fishing zone immediately once quota is reached, rather than weeks later using paper logbooks and hours of human analysis. Fishing ministries could use big-data analytics to move fast to preserve marine protected areas and their fish stocks.

Effectively making use of data means more than installing software. Anyone applying big data has to address the five "V"s: velocity, variety, volume, veracity and value. This means that to generate useful information, you must address the velocity (speed) of processing, handle the wide variety of types of data, manage a massive volume, ensure accuracy, and confirm that the data have value for the output desired.

Fisheries data are typically still recorded on paper or in Excel files, with the associated risks of being lost, incomplete, inaccurate or difficult to use. A fleet manager examining multiple spreadsheets will find it hard to identify what decisions to make.

Furthermore, big data may require a cultural shift, as fishermen have traditionally been reluctant to share information. Knowledge and fishing spots are closely guarded, and in increasingly difficult market conditions, fishermen want to keep their data secure as a competitive advantage. Flag states want to protect their resources and the sovereignty of their EEZ (exclusive economic zone), making data security a crucial issue for them as well. This barrier can be overcome by choosing analytics providers that guarantee data security and client ownership of data.

As just one example, in 2018, CLS Fisheries worked with a client to develop a business intelligence platform, DOLFIN. The client, one of the biggest fishing companies in North America, had a wealth of information generated by its vessels, which carry more than 100,000 tons of yellowfin tuna annually. The first step was identifying the client's primary output need: an intuitive dashboard offering clear insights. The next challenge was to see which data would provide that result. CLS quickly realized that incorporating vessel data, catch data, VMS, logbooks and sensor data was not enough; oceanographic data were needed as well—a massive amount to process. Data-mining techniques were then used to identify the most interesting correlations.

The resulting dashboard allows users to search by zone, species type, vessel and period. DOLFIN mines 20 years of ocean and fisheries data, allowing fishermen to optimize fleet strategy. Captains can decide where to go before leaving the harbor, optimizing the time spent to reach quotas. Fisheries administrations can monitor catch efforts over an entire region and decide which zones to close, improving management of stocks and fishing licenses. In addition, some governments give fuel allowances, which could be better managed and distributed according to a vessel's behavior.

The insights provided by big data and advanced analytics offer a valuable way forward for both regulators and fishermen, enabling them to capitalize on their data—an asset just as valuable as technology. Fisheries information needs more attention as we transition not only to a more sustainable blue economy but also to the knowledge economy.

Neglecting data assets means losing efficiency and resources. Adopting advanced data analytics is the key to succeeding in the future of fisheries. **ST**

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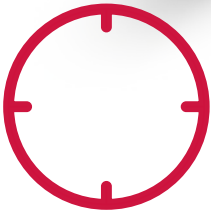
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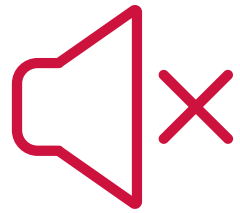
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4 WEEK CALIBRATION



SILENT OPERATION



The RBR/legato³ C.T.D offers a new world of measurement opportunities for gliders and AUVs. The CFD-optimized, low aspect ratio design is self-flushing and does not require a pump. Using only 18mJ/sample, the power requirement is 90% lower than the traditional pumped CTD. Totally silent operation improves passive acoustic listening. Improving your integration efficiency, RBR/legato³ can seamlessly integrate and control additional sensors, such as the RBRcoda T.ODO optode. Contact RBR or your trusted vehicle manufacturer for more details.

RBR

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SENSORS | LOGGERS | SYSTEMS | OEM